Reducing Household Carbon Footprints in Newton

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the degree of Bachelor of Science by:

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Abstract

Green Decade Newton has set a goal to reduce 25% of Newton households' carbon footprints by 25% by 2012. This project aimed to provide a mechanism for Green Decade and its members to monitor and achieve their carbon footprint goals. Recommendations included a design for a new carbon calculator, motivational tools to encourage carbon data collection, carbon footprint reduction materials for members to utilize, and overall recommendations for the usability and content of Green Decade's website.

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Executive Summary

Recent estimates show that humanity's overall footprint exceeds Earth's biocapacity by 23% (Venetoulis and Talberth, 2006). Earth's biocapacity is its ability to process the waste we produce on a daily basis. Greenhouse gases are a significant portion of the waste we produce and a study from 2006 showed that the average US household produced 55,000 pounds of carbon dioxide emissions per year; by contrast, German households produced 27,000 pounds and Swedish households produced 15,000 pounds of carbon dioxide (Gershon, 2006). Although not all greenhouse gas emissions are from individual homeowner lifestyles, a significant amount comes from this source and that is the focus of this project. Main household contributors to carbon footprints include excessive traveling, dietary choices, and overusing utilities such as water and electricity. If everyone took small steps to reduce their greenhouse gas emissions, such impacts would slow down dramatically.

Green Decade is a non-profit organization that focuses on reducing the carbon footprints of residents within Newton. Green Decade has collaborated with the Massachusetts Climate Action Network and adopted their EcoTeam program. Through this program, Green Decade is aiming to reduce 25% of Newton household's carbon footprints by 25% by 2012. In order to keep track of their progress towards their goal Green Decade asks EcoTeam participants to use a carbon calculator found on their website and enter their utility and transportation information. Green Decade reports that users are either having difficulties or are simply unwilling to enter this information.

The overall goal of our project was to provide a mechanism for Green Decade members and the organization as a whole to monitor and achieve their carbon footprint goals. To achieve this goal, this project had three main objectives. First, we identified methods to reduce household carbon footprints specific to the City of Newton. Second, we identified ways to keep Green Decade members involved with the process. Third, we analyzed the results and provided suggestions about how to improve the existing carbon collection and reduction process.

Resource Materials for the EcoTeams Website

We first set out to determine what resource material should be included on the EcoTeam website. To determine this we researched carbon reduction strategies in the *Low Carbon Diet workbook* and on websites devoted particularly to carbon reduction. To determine which reduction strategies we should suggest for the Green Decade website, we established a set of criteria.

- **Feasibility**: Each reduction strategy needs to be practical for an average household to implement.
- **Return:** Each strategy needs to offer a reasonable amount of CO_2 reduction based on the amount of effort/money spent on it.
- **Range:** The strategies need to cover a wide range of tips to appeal to a variety of households.

Once the criteria were established, we researched the methods provided in the *Low Carbon Diet* workbook to investigate common reduction strategies. We also looked at other carbon calculators and resources, such as the Environmental Protection Agency's website to determine the most common carbon reduction strategies that fit our criteria. We then compiled each of the reduction strategies into

reduction strategy pages that are easily transferrable to the Green Decade website. We divided these pages into five categories: electricity, heating, water, transportation, and miscellaneous. In total, we compiled over forty possible reduction strategy pages for Green Decade to use.

Data Collection Mechanism for the EcoTeams Website

We also set out to assess why users were having difficulties with Green Decade's current carbon calculator and to design a new calculator, as well as what motivational tools would get them to continue to enter their carbon emissions information. One challenge associated with the data collection tool is that it needs to balance accuracy and usability. In order for the calculator to be more accurate, it needs to ask the user to enter more information, but in order for the calculator to be easier to use, it needs to be quick and painless to fill out, therefore asking less questions.

To determine how much time and effort people were willing to put into the data collection process we interviewed ten past EcoTeam leaders and sent out a survey to over 250 Green Decade members. The interviews consisted of showing EcoTeam leaders multiple sample web forms and asking them to give their opinions about the layout, wording, and questions on each form. We also asked EcoTeam leaders questions about their previous experience with carbon calculation as well as how frequently they would be willing to enter their information. After analyzing their feedback, we designed a data collection mechanism with the following features:

- **A profile section:** In order to limit the amount of data users have to enter every time they return to the calculation, the profile section will save information, such as the size of users' houses and the number of residents in their house.
- **A tabbed layout:** With tabbed pages, the user only has to see a fraction of the questions asked at a time. This allows the calculator to still ask the necessary amount of questions without looking too overwhelming to the user.
- **User-friendly questions:** When asking about waste, we learned that every Newton resident had the same type of garbage bin. In order to make the process as easy to answer as possible, we asked how full their garbage bin was every week. When asking about food consumption, we learned that users were able to report how many four-ounce servings they had consumed in the average week.
- **Help features:** To help users locate the necessary information on their utility bills, we have included sample utility bills that highlight the relevant areas. To help users determine how many air miles they traveled, we provide a link to an air mileage calculator.
- **Comprehensive feedback:** A results page will display a user's carbon footprint broken down into categories. This will help users take note of which areas contribute most to their carbon footprint. Interviewees also voiced interest in seeing graphical representation of their carbon footprint. The results page will also include carbon reduction strategies to further reduce their carbon footprint. Although some consumption questions presented in the calculator do not output concrete carbon emissions data, they will help further personalize carbon reduction actions for the user.

Recommendations

Based on our interviews, web survey, research, and comments from Green Decade leaders we have compiled a set of recommendations for Green Decade. The first set of suggestions is short-term recommendations that Green Decade can accomplish within a reasonable time frame using their current resources. The short-term recommendations are as follows:

1. **Provide carbon reduction strategies on Green Decade's website:** Carbon reduction strategies will not only provide users with helpful carbon reduction information, but it will also give the EcoTeam members an alternative to the Low Carbon Diet workbook. We have researched carbon reduction strategies and have created over forty strategy pages to be included on the website. The pages can be found in Appendix J, and have also been provided to Green Decade in a compressed folder (.zip file) including each individual page.
2. **Implement the new design for the carbon data collection tool:** Through research and testing via interviews with EcoTeam members, we have created a new design for the data collection tool that can make it easier for EcoTeam members to enter their carbon data, while still providing a reasonably accurate carbon footprint estimation. The final design for the collection tool is included in Appendix E. We also researched new conversion factors for each of the questions in the tool. The conversion factors have been provided to Green Decade in a spreadsheet, and are also included in Appendix H.
3. **Provide a graphical representation of the carbon footprint result:** Through our interview feedback, we found that most EcoTeam members would like to see a graphical representation for their carbon footprint data. A recommended graphical representation of the carbon footprint data can be found in Appendix G. Graphical representation is a good tool for not only comparing between previous results to show an increase or decrease in the user's carbon footprint, but it also helps make comparisons between separate household footprints. When speaking with the web development team at Green Decade, they stated that creating a graphical representation would be easy to implement on the current website.
4. **Provide a reminder email:** Emails sent when a user needs to input their data for the period helps remind the user to continue with the program. From our interviews with EcoTeam participants, we have learned that many people would be interested in receiving a reminder email.

The second set of recommendations is long-term recommendations that Green Decade can use when they obtain more resources. The long-term recommendations are as follows:

1. **Provide an option for data entry frequency:** We recommend allowing users to choose the input frequency of data entry between monthly, quarterly, semi-annually, and annually. Through our interviews, we have determined that participants have a wide variety of opinions as to how frequently they would be interested in entering their data. To cater to this variety, we suggest making frequency an option when the user registers for the site. This needs to be a long-term goal because the database in which the carbon emissions information is stored needs a new design to support different time intervals of data collection.

2. **Provide personalized recommendations for carbon reduction strategies:** Recommendations based on carbon footprint results will reduce the amount of work for users to find strategies that specifically suit their lifestyles. Once users calculate their carbon footprint and the results are displayed, the results of each category will be compared to the Newton average for each category. Whichever group deviates from the average the most will be the area that needs the greatest improvement. The site can then provide strategies specifically in that area. The current platform cannot support this function, however all interview subjects showed interest in the personalized recommendations. Eventually personalized recommendations can also be included in reminder emails.
3. **Allow for user-created strategy pages:** To expand the number of reduction strategy pages, we recommend allowing users to create their own strategy pages. These strategy pages would then be available for all users to access. In this way, the amount of strategy pages could continue to increase as users recommend their own strategies to the community. Through research, we have learned that allowing user-generated content can also increase participation in the site and allow the user to feel like an active member in a community. User-generated strategy pages have yielded positive results from our interview subjects and survey participants. To implement this feature, the web development team would have to create a user-friendly content creation page. The new pages would also require an editor to review them for content and accuracy.
4. **Implement a leader board system:** Many EcoTeam participants have said that they would be interested in seeing leader boards on the website. A leader board will show the top carbon reducers in the given time period. The leader board can display top individuals or top EcoTeams. A rank of the top carbon reducers can motivate participants to continue reducing their footprint in order to be on the leader board. Some concerns expressed by some interview subjects is that some people would be disinterested in turning the process into a competition, so we recommend giving the user the option as to whether or not they would like to be included in the leader board process.

These recommendations cover ways to increase both the usability of the website and the participation of its users. With the recommendations we have provided, Green Decade can go forth and design a website that is both easy to use and effective as a carbon reduction tool. The Massachusetts Climate Action Network as well as other community organizations around Massachusetts may also benefit from the recommendations we have provided.

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1 – Introduction

Everyone produces a carbon footprint – the amount of carbon dioxide associated with a person or group of people in a given time. Greenhouse gases are gases produced that are harmful to the environment. Although all greenhouse gases are harmful, carbon dioxide is the main contributor and is the main focus. Recent estimates show that humanity's footprint exceeds Earth's biocapacity by 23% (Venetoulis and Talberth, 2006). Earth's biocapacity is the ability for it to process waste produced. Right now the combined carbon footprint being produced is affecting the atmosphere and ecosystems in many harmful ways, such as global warming and global dimming (Stanhill and Cohen, 2001). There is growing consensus that the environment cannot withstand that much abuse (Venetoulis and Talberth, 2006).

A study from 2006 showed that the average US household produced 55,000 pounds of carbon dioxide emissions per year; by contrast German households produced 27,000 pounds and Swedish households produced 15,000 pounds of carbon dioxide (Gershon, 2006). Although not all greenhouse gas emissions are from individual homeowner lifestyles, a significant amount comes from this source and that is the focus of this project. Main household contributors to carbon footprints include excessive traveling, dietary choices, and overusing utilities such as water and electricity. If everyone took small steps to reduce their greenhouse gas emissions, such impacts would slow down dramatically.

The Massachusetts Climate Action Network set a goal in 2009 to reduce carbon emissions in 25% of the households in the state by 25% by 2012. Reducing the carbon footprint from Commonwealth households in large part depends on getting people to change their lifestyles. However, experience shows that many people are hesitant to change their lifestyles (Shackley and Gough, 2004). In their 2006 study on ecological footprints, Venetoulis and Talberth concluded that some individuals refuse to make the necessary changes to improve the environment for various reasons. Numerous studies have been conducted to determine the best way to stimulate change in the household (Van den Bergh and Verbruggen, 1999). These studies show that individuals respond to vivid personalized messages, observe what their friends are doing, trust in reputable sources and are guided by their personal beliefs. One program that draws upon these strategies is EcoTeams, a project of Green Decade in Newton, Massachusetts.

Green Decade is a non-profit organization in Newton at the forefront of efforts to implement the Commonwealth's goal for reducing carbon emissions. They have created EcoTeams to help Newton residents reach this goal. These EcoTeams are comprised of 5-8 households and use the *Low Carbon Diet* workbook. Leaders of Green Decade and EcoTeams have identified several gaps in their program. First and foremost, to document their progress Green Decade needs approximate carbon footprint data from EcoTeam members. Having baseline carbon footprint estimates as well as ongoing carbon footprint data gives Green Decade the necessary information to track advancement toward their goal. The way for members to enter this data is through the organization's carbon calculator online. However, members are finding difficulties entering their carbon data into this calculator, preventing Green Decade from getting the information they require. Impediments with navigating through the website itself and completing the carbon data calculator also deter residents from returning and

reentering data. A more user-friendly data collection process would enable Green Decade to get the data they require to track their progress. In addition, while some EcoTeam leaders enjoy using the *Low Carbon Diet* workbook, others would prefer to use alternative resources that seem more trustworthy.

The overall goal of our project was to provide a mechanism for Green Decade members and the organization as a whole to monitor and achieve their carbon footprint goals. To achieve this goal, this project had three main objectives. First, we identified methods to reduce household carbon footprints specific to the City of Newton. Second, we identified ways to keep Green Decade members involved with the process. Third, we analyzed the results and provided suggestions about how to improve the existing carbon collection and reduction process. Some of the basis for suggestions came from current carbon calculators and websites, while other factors came from questioning EcoTeam participants who had used both Green Decade's website and carbon calculator. We combined background research with the information gathered in Newton, which enabled Green Decade to provide residents of Newton with a better system to input their carbon data and consequently give the organization a way to monitor their progress.

2 – Background

This chapter focuses on providing background information to invoke a deeper understanding of carbon footprints, how to measure carbon emissions, and techniques to reduce them. In the first section of this chapter we discuss what carbon footprints are and their effects on the environment. We then go on to discuss Green Decade and the *Low Carbon Diet* workbook used by the organization. Afterwards we discuss carbon calculators and the concerns related to them and then discuss ways to calculate and reduce a household's carbon footprint.

2.1 – Carbon Footprints and Their Effects

According to Gershon (2006), "the primary cause of global warming is carbon dioxide emitted into the atmosphere through the burning of fossil fuels." Every object we produce or use on a daily basis that emits carbon into the atmosphere has a carbon footprint. American households are directly responsible for about 8% of the earth's carbon emissions, and indirectly responsible for about 17% (Gershon, 2006). Carbon emissions come from both direct and indirect sources such as industrial manufacturing, automobile exhausts, and daily household activities.

In reality, carbon dioxide is not the only harmful substance released into the atmosphere by human activities. People produce many other greenhouse gas emissions, such as methane and aerosols. However, it is almost impossible to track the emission of all of these greenhouse gases. Carbon dioxide is one of the easier substances to keep track of, and has one of the most substantial impacts on our environment (Wiedmann and Minx, 2007). Therefore, a carbon footprint is only the measure of carbon dioxide emissions produced and excludes other forms of greenhouse gases.

Carbon emissions have a number of detrimental impacts on the global environment by affecting the behavior of the sun's rays in two ways. First, the sun's heat is trapped within the atmosphere resulting in global warming. From 1975 to 2000 the global surface temperature increased 0.5°C and is expected to further increase in the coming decades (Hansen, Sato, Ruedy, Lacis, and Oinas, 2000). A large portion of this temperature increase is due to the increasing levels of greenhouse gas emissions in the atmosphere that trap the sun's heat. An increasing global surface temperature is detrimental to many parts of the environment. For example, sea levels are rising because of melting ice caps, which then leads to low lands becoming submerged in water, and plants dying. As a result, animals that eat these plants also die, creating a ripple effect (Baldocchi et al., 2001). In addition, the heat in the atmosphere warms the water. Algae and other organisms cannot adjust to this climate change in their ecosystem and die off. Again, if these organisms die off, larger organisms that feed on them also die off, and the cycle continues (Baldocchi et al., 2001).

Second, the emissions collecting in the atmosphere not only prevent the sun's light and heat from exiting the atmosphere, but they also block some from coming in. Although some might think this is beneficial, it is now becoming a problem as well. Global dimming is when new light and heat from the sun cannot enter the atmosphere because of layers of greenhouse gases. According to Giannini et al. (2008) in their study of global and planetary change, global dimming was the cause of droughts in Ethiopia during the mid-1980s.

Although drastic changes will not occur during the next few years, if nothing is done about greenhouse gases the world will see many unwelcome transformations. These transformations may already be occurring, although gradually, and actions need to be taken to address the situation (Stanhill and Cohen, 2001). As greenhouse gas levels continue to rise in the atmosphere global dimming and global warming are expected to become even larger problems in the future (Stanhill and Cohen, 2001). Over 90% of Americans believe the government should act to help stop global warming and efforts are being made around the world to reduce the effects of greenhouse gases by using renewable energy sources and cutting down on energy use (Yale University, 2009).

2.2 – Massachusetts' Efforts to Reduce Carbon Emissions

The Commonwealth of Massachusetts has taken action to reduce its carbon footprint. The Massachusetts state legislature passed six state laws in 2008 to help the state address climate change. These laws include the Global Warming Solutions Act, the Green Communities Act, the Massachusetts Environmental Policy Act, the Oceans Management Act, the Green Jobs Act, and the Clean Energy Biofuels Act. The laws are aimed at helping the Department of Energy Resources, the Department of Public Utilities, the Executive Office of Energy and Environmental Affairs, and the Massachusetts Department of Environmental Protection achieve four goals:

> "(1) To implement new and continued programs that will achieve sizable reductions in [greenhouse gas] emissions;
> (2) To help consumers and business with their energy costs by removing the hurdles to energy efficiency;
> (3) To encourage early investment in energy efficiency and renewable energy to reduce demand; and
> (4) To promote new technologies to fight climate change as the economy grows by using less energy."
> (Kimmell & Burt, 2009, p. 298)

While all six acts aim to achieve the goals, the Green Communities Act is most relevant to our research.

The Green Communities Act (GCA) promotes incentives for residents to use more energy efficient products and appliances. First, the "energy pay and save" plan allows people to "purchase and install energy efficient or renewable energy products in their residences or commercial facilities by paying the cost of the system over time through an additional charge on the customer's electricity bill" (Commonwealth of Massachusetts, 2008, sec. 84). Second, incentives are offered to smaller-scale renewable energy suppliers. For example, owners of wind turbines can sell excess electricity back to the grid. Third, the Act established a fund for use by green communities programs and to provide zero interest loans to non-green communities for energy efficient projects (Commonwealth of Massachusetts, 2008). Through such incentives, the GCA is intended to influence the various communities of Massachusetts to reduce their own carbon footprints. This will help the various green programs and organizations throughout Massachusetts reach more individuals and in turn promote the reduction of household carbon footprints.

One green organization in Massachusetts is the Massachusetts Climate Action Network or MCAN. MCAN has partnered with David Gershon, the author of the *Low Carbon Diet* workbook, as well as several communities throughout Massachusetts to help spread carbon reduction techniques. David Gershon approached MCAN with his idea of an EcoTeam program which would help households reduce their carbon footprints by over 25% in a short period of time. Gershon believed this program could penetrate as many as 85% of households in an area if used effectively. These numbers were used to construct MCAN's goal of reducing 25% of households carbon footprint's by 25% by 2012.

2.3 – Green Decade Newton

One community organization that has collaborated with MCAN is Green Decade, a non-profit organization made up of residents from the City of Newton. Green Decade consists entirely of part-time volunteers with a common goal in mind. Green Decade's goals include:

- "Increasing energy efficiency and seeking alternatives to fossil and nuclear fuels
- Using [Integrated Pest Management] and organic alternatives to pesticides
- Promoting high performance (green) building measures
- Preventing pollution through source reduction and reduced consumption
- Promoting reuse and recycling practices
- Improving waste disposal practices
- Conserving water and other resources"
  ("Green Decade Newton", 2010)

The organization promotes education about energy efficiency and common green practices by sponsoring educational programs in elementary and middle schools. They also host workshops on energy saving techniques for the public and establish EcoTeams to reduce the amount of household emissions. Green Decade's current focus is creating EcoTeams with households around Newton and is trying to expand and support this initiative.

2.3.1 – Green Decade's EcoTeam Program

Green Decade Newton aims to reduce residential carbon emissions, which account for 40% of all of Newton's greenhouse gas emissions (Ravin, 2005). In order to reduce the amount of household emissions, Green Decade created EcoTeams. EcoTeams are groups of five to eight households that are committed to changing their lifestyles to reduce their carbon footprints. In 2008, Green Decade sponsored six EcoTeams. In 2009, the number of teams grew to 56 ("Green Decade Newton", 2010). The number of households in the Newton community interested in making a difference to the environment continues to grow.

One member of each EcoTeam is the leader and organizes a set of three or four meetings over the course of a thirty-day period to discuss everyone's progress and to determine an estimated value as to how many pounds of carbon dioxide each household's actions have resulted in saving. These meetings consist of discussing strategies to reduce each household's carbon footprint, as well as offering each other support to continue with their efforts. The last meeting usually consists of each member

discussing who else they could convince to join an EcoTeam and each member may go on to start an EcoTeam themselves.

2.3.2 – The Low Carbon Diet Workbook

To help facilitate the EcoTeam meetings and to guide the teams through the change to a more environmentally-friendly lifestyle, the EcoTeams use a workbook entitled *Low Carbon Diet* by David Gershon. The workbook lays the foundation for the EcoTeam process. It outlines how to form an EcoTeam and what should take place at every meeting. The workbook also has step-by-step instructions on how one can reduce one's own carbon footprint at home, on the road, and at work. After completing each task, the workbook also provides a rough estimate of how much annual CO_2 the team member has saved.

The workbook offers many advantages to EcoTeams and is designed with behavioral change in mind. Green Decade and EcoTeam members agree that the workbook is organized in a way to help behavioral change and that the workbook has several effective carbon reduction ideas. However, even with these advantages there are many EcoTeam participants that are refusing to purchase and utilize the workbook. Many reasons were given for not using the workbook, including the fact that the workbook is, as one EcoTeam co-chair said, "Targeted at the lowest common denominator." What this means is that it is designed for anyone to be able to read and comprehend and ignores more complicated and perhaps more effective strategies to ensure this. The workbook has been described as "cartoony" and many EcoTeam members in Newton are finding it difficult to take seriously. The Green Decade stakeholders are interested in an updated and more sophisticated set of carbon reduction strategies.

Another problem expressed by Green Decade members is that the carbon emissions data given in the workbook only reflect how much carbon dioxide a member has saved, rather than how much CO_2 the member is currently contributing. This is a concern because in order for Green Decade to keep track of their progress towards their goal, they need a baseline of information to work with. In order to make up for the lack of carbon calculation provided by the workbook, Green Decade has created a spreadsheet-based calculator on their website to determine how much carbon dioxide each EcoTeam member is contributing. The calculator has been reported by EcoTeam members as difficult to use and inaccurate. Green Decade needs a more user-friendly calculator; however, actually measuring a carbon footprint can be difficult and confusing because of the multitude of methods available.

2.4 – Carbon Calculations

While the *Low Carbon Diet* workbook lists general values for reducing carbon footprints, it does not actually calculate an individual's total carbon footprint. Carbon calculators can be used to provide an overview of an individual's total carbon footprint instead of the amount that the carbon footprint can be reduced. One problem with carbon calculators is that it can be difficult to find or make the right carbon calculator for a specific community. This difficulty is reflected in the multitude of carbon calculators available. Some of these calculators are relatively simple and only take a few everyday items into account, while others take into account a multitude of factors and become time consuming and difficult to use for the average household. It is important for a calculator to be designed for the people that will

be using it, and not be too broad or narrow in scope. A balance between accuracy and ease of use needs to be reached for Green Decade's purposes. Many factors contribute to an individual's carbon footprint and understanding how much each of these factors contributes can be critical in the understanding of how to measure and reduce it. These concerns will be discussed in the following sections to provide a better understanding of the process involved with calculating a carbon footprint.

2.4.1 – Carbon Calculators

Hundreds of carbon calculators are available across the internet and each calculator asks for different information in different formats. A typical calculator asks for information including a household's electricity usage, natural gas usage, car gas mileage, car miles traveled, number of flights per year, and much more. Some include lesser used items such as coal and wood, and many take into account the types of food consumed by a household on a daily basis. Kenny and Gray (2009), and Padgett et al. (2008) have compared several web based carbon footprint calculators.

Kenny and Gray (2009) entered identical usage data based on usage from a typical household into six web based carbon calculators. What they found was that of the six carbon calculators they used, the carbon footprint given as a result ranged from around 12,000 pounds of CO_2 to over 27,000 pounds of CO_2 a year per household. They attributed this large difference to a discrepancy in one of the conversion factors in two of the calculators and found that by adjusting this conversion factor for each calculator, they were provided with results that are more similar. After the conversion factor was fixed the range of carbon footprints given dropped down from an over 15,000 pound difference to just over a 2,000 pound difference (Kenny & Gray, 2009). This reduces the percentage difference in the actual totals from roughly 125% to roughly 17%.

One of their conclusions was that because each calculator took different variables into account, it made the results from each calculator different from the last (Kenny & Gray, 2009). This creates a discrepancy between calculators as one calculator might account for something another calculator does not account for. Many calculators do not take into account food, clothing, and many other personal products. Not including these factors can lead to a large discrepancy between the calculator's result and a person's actual carbon footprint because every item a person purchases has to be produced, shipped, and stored and all of these variables add to an individual's carbon footprint. In addition many of the calculators used for the test were not region specific (Kenny & Gray, 2009). Not being region specific can affect results because different areas use different sources of energy and import resources from different places. Kenny and Gray (2009) suggest making a standard for carbon calculation, which would help alleviate some of these concerns and help users get a more uniform carbon footprint wherever they go to calculate it.

Padgett et al. (2008) found similar results in their test of the EPA's carbon calculator as well as nine others. While a few of the calculators used in this test allowed region specific data to be entered, the results from each calculator were still different even if the exact same data and region were used. They compared the differences in results within each category the user was asked to input into the calculator. The results for each category were then compared and ranged from a 32,000 pound difference when comparing carbon emissions from propane, to a 3,000 pound difference when

comparing carbon emissions from natural gas (Padgett, Steinemann, Clarke, & Vandenbergh, 2008). The average American household has an annual carbon footprint of roughly 55,000 pounds, so a 32,000 pound discrepancy can be over half of a household's estimated annual carbon footprint. This can be a problem for someone trying to reduce their carbon footprint, because if they change the calculator they are using to calculate their carbon footprint, they might think they are doing worse or better than they actually are.

Other concerns with carbon calculators that Kenny and Gray (2009) had were that some calculators divided home and business use. This punishes those who work at home even though they are contributing carbon emissions from similar work related activities. Another concern they had was that the calculators that asked for food consumption only asked for the consumption at home. This lowers the household carbon footprint for those who eat out a lot, even though eating out should actually raise their overall carbon footprint.

The major concern over a carbon calculator for Green Decade's use is that accuracy and usability conflict when related to carbon calculations. Accuracy is about how many factors are taken into account when a carbon footprint is calculated, while usability is about how quick and easy it is for someone to enter all of the necessary information. Obviously both of these attributes cannot exist at the same time, so a balance of the two is needed. We will seek to determine where this balance should lie and what features allow us to add both accuracy and usability with minimal sacrifices to each.

2.4.2 – Contributions to Carbon Footprints

To understand the most important carbon reducing measures, we will now take a closer look at each contributing factor to an individual's carbon footprint. Obviously, energy and resource usage is one of the largest contributors; however, even minor details like newspapers and bottled water contribute to an individual's carbon footprint and have many variables to consider. This section will discuss two studies; the first of these studies measures the carbon footprints of households in the state of California and looks at the primary contributors to these carbon footprints (Masanet, Kramer, Homan, Brown, & Worrell, 2009). The second of these studies shows how something such as a person's eating habits can contribute towards their carbon footprint (Feenstra & Brodt, 2008).

The California Energy Commission recently did a study of the carbon footprints of households in the state and provided specific information about many of the factors contributing to their carbon footprints (Masanet, Kramer, Homan, Brown, & Worrell, 2009). California has a very different seasonal climate than Massachusetts and for this reason the numbers they obtained won't align directly with those from Newton. However, California has done one of the most comprehensive studies on residential carbon footprints and for this reason their study is important to understand. Residential carbon footprints were divided into two categories: direct and indirect (Masanet, Kramer, Homan, Brown, & Worrell, 2009). Direct contributions include energy sources such as electricity and gasoline, while indirect contributions include sources such as goods and services, food, clothing, healthcare, and many more.

The California Energy Commission found that the majority of a household's carbon footprint comes from indirect contributions, and amounts to over 33,000 pounds of emissions each year (Masanet, Kramer, Homan, Brown, & Worrell, 2009). They also found that while the direct sources contributed to lower overall emissions, they still accounted for over 11,000 pounds of emissions each year (Masanet, Kramer, Homan, Brown, & Worrell, 2009). One reason indirect sources contribute almost three times as much to a household's carbon footprint is that the California Energy Commission included the energy sources used to create, transport, and obtain items such as food and clothing. While indirect sources will contribute more overall, it is impossible to measure each factor that goes into the production of each item a household uses each day. For this reason, carbon calculators typically measure direct sources and try to take into account as many indirect sources as they can without becoming too cumbersome to use.

Feenstra and Brodt (2008) took a closer look at how the carbon footprint for food should be calculated. Food can contribute over 8,000 pounds of carbon emissions to a household's carbon footprint each year. Many factors come into play when considering food for a household's carbon footprint. For instance, transportation, greenhouses, maintenance, and storage all have an impact on the carbon footprint of a single food product and when someone purchases this product in their daily life, it contributes to their overall carbon footprint (Feenstra & Brodt, 2008). Buying locally grown food can reduce several of these areas, such as transportation and storage. However if the local food was grown in a greenhouse, it can require as much as 21 times the energy used in open air production (Feenstra & Brodt, 2008).

2.4.3 – Reducing Carbon Footprints

There are many ways to reduce an individual's carbon footprint and the workbook Green Decade provides to its EcoTeam members gives many examples of these strategies. To better understand how to improve these strategies as well as recommend new ones, in this section, we look at other sources and see what strategies they suggest using to lower an individual's carbon footprint.

The California Energy Commission gives some figures for reducing a household's carbon footprint (Masanet, Kramer, Homan, Brown, & Worrell, 2009). This breakdown primarily consists of upgrading common household appliances to Energy Star certified appliances, using more advanced, front loading washer and dryers, and using compact fluorescent or LED light bulbs. For instance using compact fluorescent light bulbs can cut out almost 50% of the energy a household uses for lighting, while upgrading to an Energy Star certified refrigerator can produce an energy savings of almost 15% compared to an older, non-certified model (Masanet, Kramer, Homan, Brown, & Worrell, 2009).

These suggestions are based on the areas they determined contributed most to a household's carbon footprint. The energy commission broke down the average household usage of many common items and determined the electricity used by each item (Masanet, Kramer, Homan, Brown, & Worrell, 2009). By looking at this breakdown they were able to better determine which areas accounted for a significant portion of a household's carbon footprint and suggest improvements for each area. Figure 1 shows this breakdown.

Using Figure 1 allowed the California Energy Commission to know which areas contribute the most to a household's carbon footprint and make suggestions for the largest areas. The energy commission then essentially gave suggestions for how to reduce emissions in each category. For instance it can be seen that a second refrigerator accounts for over 175kg or over 385 pounds of CO_2 emissions each year and the suggestion for this would be to simply remove the second refrigerator entirely (Masanet, Kramer, Homan, Brown, & Worrell, 2009).

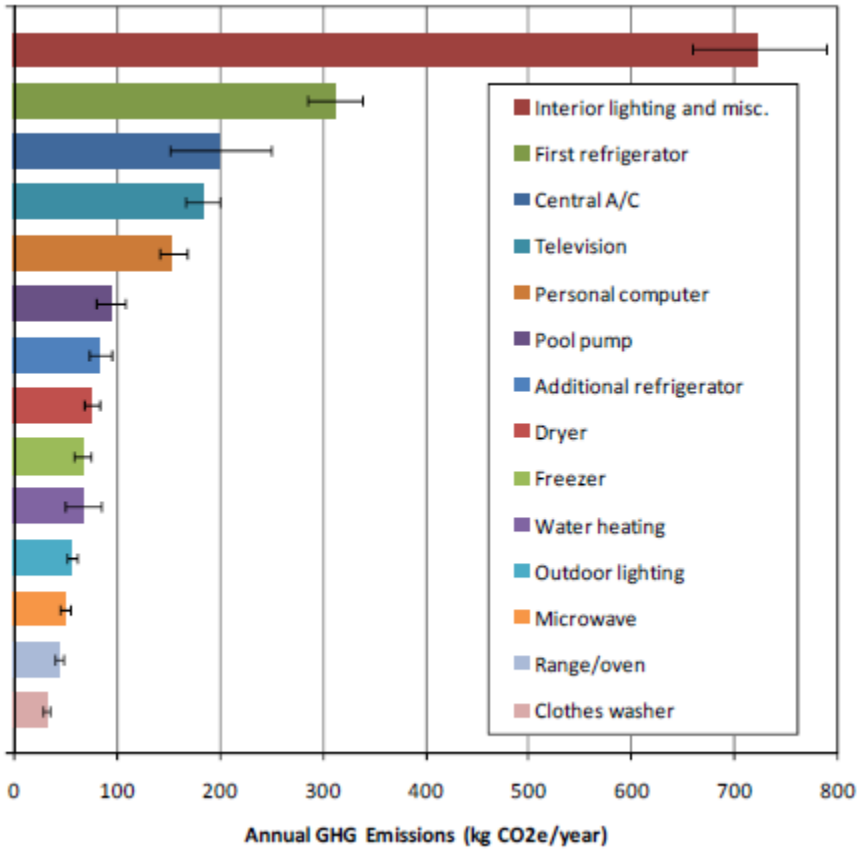


Figure 1: Direct Household Emissions in California (Masanet et al., 2009, p.25) (Public Domain)

As mentioned earlier the direct contributors such as electricity only account for roughly one quarter of a household's carbon footprint. This figure would most likely be higher in Massachusetts due to increased fuel and energy use in the winter season. The California Energy Commission also broke down the values for many indirect contributors as well (Masanet, Kramer, Homan, Brown, & Worrell, 2009). This includes food, clothing, hotel visits, schooling, and many other categories listed in Figure 2.

By using Figure 2 the Agricultural Sustainability Institute was able to provide suggestions to reduce an individual's indirect carbon footprint. While no specific figures were given, buying organic, locally grown foods, avoiding meat products or simply eating foods lower in the food chain, can greatly reduce a carbon footprint (Feenstra & Brodt, 2008). It is clear that indirect sources contribute to a significant portion of a household's carbon footprint, as the majority of categories seen in Figure 2 are

much larger than any category seen in Figure 1. It is also important to note that this study did not include transportation, which is a large direct contributor to an individual's carbon footprint.

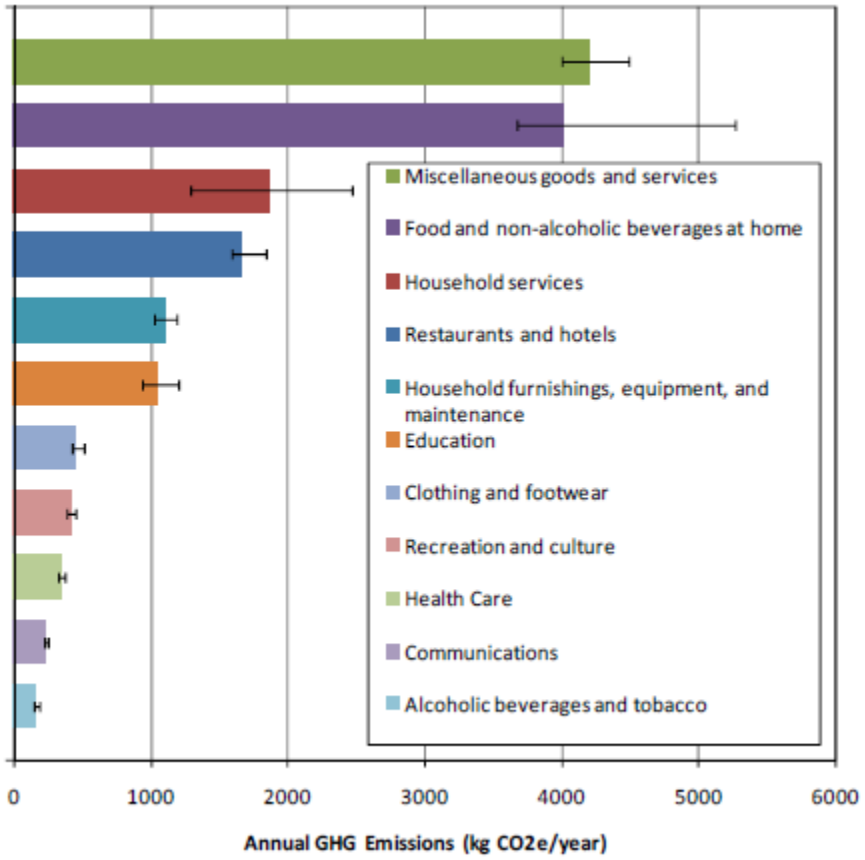


Figure 2: Indirect Household Emissions in California (Masanet et al., 2009, p.26) (Public Domain)

If a typical household were to use all of the energy saving measures that the California Energy Commission recommends it can be expected to reduce its CO_2 emissions each year by as much as 5500 pounds or roughly 10% of their carbon footprint. This gives concern for Green Decade's goal of reducing 25% of household's carbon emissions by 25%. If a household took into account the dozens of strategies suggested by the California Energy Emission it would not even come halfway to Green Decade's expectations. Part of this is because much of the energy use from households in Massachusetts comes from heating and using carbon reduction strategies related to heating will result in larger overall carbon reductions.

The reduction strategies suggested by the California Energy Commission are similar to the strategies recommended by the *Low Carbon Diet* book that Green Decade suggests using. However, just like the carbon calculators, these sources offer vastly different figures for what each carbon reduction technique will provide to the user. The California Energy Commission's figures were all designed specifically for California, taking into account how the electricity is created, how the water is purified, and how the waste is disposed (Masanet, Kramer, Homan, Brown, & Worrell, 2009).

2.4.4 – Motivating Carbon Reduction

Even if we know how to measure and reduce carbon footprints, we must understand how to motivate people to reduce their carbon emissions. Many homeowners would willingly reduce their energy usage or purchase more energy efficient technologies if a financial incentive was involved and many carbon reduction strategies offer reduced utility costs. However, the promise of financial savings becomes less effective when people realize that it takes years just to break even.

Homeowners that purchase environmentally friendly products are usually well educated, knowledgeable about ecological issues, and emotionally involved (Laroche et al., 2001). Individuals that lead green lifestyles often feel that the energy crisis is an important issue and that their actions affect the climate positively. However, the average person requires some motivation to alter their wasteful behaviors. An average homeowner might be aware that heating consumes a lot of energy, but they might also believe that a heated home is essential to the health of their family even though the temperature in their home could be reduced safely. Sometimes monitoring energy use is not as effective as buying more energy efficient equipment. For example, a person who drives conservatively with an inefficiently designed sedan is less effective than a person who drives less conservatively with a hybrid vehicle (Stern, 1992).

Psychology can be used to market green living, much like salespeople and entrepreneurs use it to sell products. Information is “more likely to change behavior when it is specific, vivid, and personalized” (Jamieson & VanderWerf, 1993, p.83). For example, one study showed a group of individuals a video about energy-saving techniques, which resulted in a 20% greater energy usage reduction compared to when the information was presented in writing (Winett, 1982). A strong presentation can further motivate people to reduce their carbon footprint and can help further their understanding of the reduction process.

Another important factor to consider is the source of the information presented. Information seems more valid when it comes from a state organization or a trusted authority. One Minnesota study involved a shared-savings program, in which homes were insulated for free as long as the project was guaranteed a percentage of the money gained from energy-savings. The project was conducted by Hennepin County, which employed a private company to install the insulation. Random homes received letters to participate in the program, with several different wordings to the letters. The letters had three possible letterhead configurations; a letterhead with no mention of the county, a letterhead that mentions the county's involvement, and a letterhead typical of the county office that is signed by a county board chairperson. As expected, 1.7%, 2.7%, and 9.3% of the households requested the installation of insulation, respectively, according to which letters they received (Stern, 1985). People responded better to information presented by a trusted authority figure, which shows how information should be presented in a trustworthy manner to the user.

Many people compare their own actions to the actions of others and to what is perceived as normal. An individual may adjust their behavior to conform to what the community is doing; this tendency can be applied to further influence how energy is consumed in the household. A study was conducted in San Marcos, CA to test the application of normative feedback on energy usage. Two

hundred and ninety random homes were asked to participate in a study in which their energy usage would be monitored and reported. Energy consumption was measured at several stages to see which homes fell above or below the energy-usage average. Some homes received feedback that only reported personal energy consumption and a comparison to the rest of the community. If a person initially wasted more energy than the average participant did, they would usually decrease their energy usage after receiving a report. However, a person that used less energy than normal would usually increase their energy usage after receiving the comparison, reflecting the destructive potential of certain messages. Other homes received a report that delivered a comparison, but added a happy face if they were below the average and a sad face if they were above the average. The combination of the comparison and the smiley face prevented the "backfire" effect seen with the comparison alone. A household that initially used less energy than normal would continue to use less energy than normal because of the happy face. They received a sign of approval, which counteracted the desire to conform (Schultz, 2006).

With the knowledge of what carbon footprints are, how to measure and reduce carbon emissions, and how to motivate carbon reduction in hand, we have a better understanding of how to help Green Decade. The next chapter will discuss the methodology we used to provide Green Decade with recommendations for their website and carbon reduction techniques. These recommendations are based on both the background information we have gathered as well as the information we gathered by completing our methods.

3 – Methodology

In order to help Green Decade monitor progress towards their 25/25 goal, our goal was to recommend user-friendly mechanisms for the website and carbon calculator. To achieve this goal, we had three main objectives:

1. Identify and assess resource material for household carbon footprint reduction,
2. Identify and assess ways to promote carbon footprint data collection from EcoTeam members, and
3. Implement the methods in a user-friendly manner.

Our methods for achieving each of these goals are discussed in the following sections.

3.1 – Objective 1: Identify and Assess Resource Material for Household Carbon Footprint Reduction

Our first objective was to determine what sort of carbon footprint reduction material should be included in the new EcoTeam website. Since Green Decade's web development team was creating a new site from scratch, there was no content on the new website at the time. At the start of the project, the new website was only a frame with some basic information on the home page. While the old site had some carbon reduction resources, they were limited. The main resource the EcoTeams used was the *Low Carbon Diet*; however, Green Decade leaders voiced a desire to provide an alternate source of information for EcoTeam members who chose not to use the workbook. Thus, we set out to research methods of carbon reduction that we can then use to create carbon reduction strategies for EcoTeam users to access on the website.

To determine which areas to research and to provide resource material for, we decided upon the following research questions:

1. What carbon reduction needs are not met by the *Low Carbon Diet* workbook?
2. What are effective ways to reduce the carbon footprint in the household?
3. What are the most common reduction strategies provided by other similar resources, and what are their strengths and weaknesses?

In order to answer our research questions, we researched carbon reduction strategies to create carbon reduction materials; however, in order to determine which reduction strategies we should suggest for the Green Decade website, we established a set of criteria.

- **Feasibility**: Each reduction strategy needs to be practical for an average household to implement.
- **Return:** Each strategy needs to offer a reasonable amount of CO_2 reduction based on the amount of effort/money spent on it.
- **Range:** The strategies need to cover a wide range of tips to appeal to a variety of households.

Once the criteria were established, we researched the methods provided in the *Low Carbon Diet* workbook to verify the carbon reduction strategies. We also looked at other carbon calculators and resources, such as the Environmental Protection Agency's website to determine the most common

carbon reduction strategies that fit our criteria. We then compiled each of the reduction strategies into a carbon footprint reduction strategy page.

3.2 – Objective 2: Identify and Assess Ways to Promote Carbon Footprint Data Collection from EcoTeam Members

In order to motivate EcoTeam members to enter their energy use data into Green Decade's database, we researched ways to make the process easier for the EcoTeam members and ways to motivate the EcoTeam members to return to the site. In order to provide recommendations to promote data collection, we assessed methods for quick and easy data entry and identified motivational factors for data collection. In the following subsections, we outline the ways in which we did so.

3.2.1 – Task 1: Assess Methods for Quick and Easy Data Entry

In order to work with Green Decade's web development team to design a carbon data collection tool that is easy to use, but still asks for enough information to estimate the carbon footprint, we devised the following research questions:

1. How much information are users willing to enter into the collection tool?
2. Which questions are essential to ask, and which questions can be removed if necessary?
3. How frequently would users be willing to enter their data?
4. How should the collection tool be laid out?
5. How should questions be asked?

Through research, we pinpointed which areas contribute most to a household's carbon footprint and what data needs to be collected from users to calculate the carbon emissions in each area. To do so, we looked at many web-based carbon calculators and collected the prevalent questions asked in each one. These areas included electricity, oil, gas, automobiles, air travel, garbage, food, and water, among others. To calculate the most accurate footprint possible , the calculator would ask questions about every activity and resource the user has. Unfortunately, the more data entry fields that are added to the calculation tool, the more time and effort it takes to complete the calculation, and the less likely the user will be to use the tool. It was our goal to find the balance between gathering as much information as possible and not asking too many questions as to become a nuisance.

Our primary method to find this balance and explore the research questions listed above was to design some data collection forms and test them in interviews with EcoTeam members. In order to determine what carbon data questions we could ask while still keeping the tool quick and easy for the user, we created two test forms, included in Appendices B and C, for interview subjects to use. We chose to create two forms because we wanted to test different layouts and different ways to ask specific questions. Two forms were enough to test differences between the forms, while still keeping the interviewee interested enough to complete the forms.

When designing web forms to test, we attempted to apply the following principles stated in *Web Form Design: Filling in the Blanks* (Wroblewski, 2008, pg. 19):

- **Minimize the pain**: The form needs to be as painless as possible.
- **Illuminate a path to completion**: Users are more likely to complete the form if they know how much of the form they have left to complete.
- **Consider the context**: Every question needs to be asked for a reason and needs to be kept in the context of the form.

As Wroblewski explains, nobody *wants* to complete a web form. It is the job of the designer to make the process as easy and painless as possible.

We interviewed a sample of ten EcoTeam participants provided by Green Decade. We chose EcoTeam participants because they have all had experience using Green Decade's old carbon calculator. The individual interview process was chosen because it allowed one-on-one interaction with the subject in order to observe any individual observations and feelings they may have had for each form. With the individual interview process, we were able to schedule interviews based around the particular subject's schedule.

The interview process consisted of each individual meeting with our group at a time. Each meeting took no more than forty five minutes. We sat down with the subject at a computer and explained our project and the purpose of our project. We then asked if they had used the current Green Decade website or calculator before. We then instructed the participant to go through each form, and we observed as they used each one. We instructed the subjects to express any thoughts they had about each form as they went through it. We wanted to know which questions, if any, the interviewees found confusing or were difficult to answer. We also wanted to know which questions were easier to answer. One student was the note-taker and recorded any observations and comments made by the subject. The observations were kept anonymous to preserve privacy. Another student helped with any questions the subject may have had. The third student asked the interview questions following the completion of each form.

We also devised a list of questions seeking the strengths and weaknesses of each form to ensure that we gathered the appropriate data. Once the user finished filling out each form, we asked them specific questions about their experience. The interview questions are outlined in Appendix B. For example, we asked, "The second form included tabbed categories. Did you find the tabs a helpful addition, or did you find it unnecessary?" We asked specific questions in order to gather feedback in the areas we were specifically researching. We also asked more general questions, such as, "Did you find any questions to be too difficult to answer?" Asking general questions gave the interview subject the opportunity to share their thoughts on topics we had not yet introduced. We concluded each interview by asking how frequently each interview subject would be willing to enter their data into the calculator.

After concluding the interviews, we broke the interview responses into categories: what each person liked and disliked, feedback on the layout, willingness to enter their data, ideas they had about the form, and other. Having categories enabled us to better group comments made by the subjects. We then looked for trends in each subject and tallied each response in order to determine the most

common feedback. Once tallied, the responses were then prioritized based on number of tallies and our recommendations were given based on priority.

While gathering feedback from past EcoTeam leaders was beneficial to our project, there were some limitations to our testing. The number one limitation to our interviews was the potential bias. The interview subjects were handpicked by our liaisons at Green Decade. The subjects actively chose to take part in interviews to improve the process and are EcoTeam leaders already committed to making change. Because these subjects are so actively committed, they may have a biased view on what should be included in the calculator and how often data should be entered.

Once we determined which questions should be asked in the carbon calculator, we researched conversion factors to convert the user's entered value into equivalent pounds of CO_2. Our primary source for conversion factors was the local energy provider, NSTAR. A conversion factor from a local provider gave the calculator more regional values to increase the accuracy of the estimation. When local sources could not be found, we researched values from government sources, such as the EPA, and other institutional sources.

3.2.2 – Task 2: Identify Motivational Factors for Data Collection

Motivational factors are an integral part of enticing residents enough to follow the EcoTeam program and keep entering carbon footprint data online. By providing reasons to keep inputting data, people are much more likely to continue to do so. Therefore, we wanted to investigate what would motivate users to continue to use the EcoTeam website. Since different people are motivated by different methods, we wanted to get a sense of the range of features that might attract them.

To determine which motivational tools work best, we established a set of criteria. The motivational tools needed to:

- Convince users to continue to return to the site and enter their carbon footprint data
- Appeal to a large number of people
- Offer an alternative to carbon footprint results for qualitative minded people

Once the criteria were determined, we then created a pool of ideas for motivational tools. We gathered ideas through discussion with Green Decade members and leaders, as well as our peers. We also looked at other popular free sites to determine how other sites kept users coming back. For example, Wikipedia is a free online encyclopedia that is kept up to date by user-generated content. We also looked at sites such as YouTube for ideas on rating and leader boards.

To gather feedback on each idea, we created a web-based survey, which is included in Appendix A. This survey included a list of possible tactics we could use on the website. Questions in the survey asked about possible motivational factors like a leader board on the home page and qualitative equivalents, such as equating the amount of CO_2 savings a user has achieved into the number of trees planted. For example, on the results page, the site could display, "Your savings of 500 pounds is equivalent to planting 5 trees!" Survey participants were asked to rate, using a Likert scale, how interested they would be in using such tools. The survey also asked how comfortable the users were with sharing their carbon footprint data amongst other EcoTeam members.

This survey was completed by Green Decade members and those who are involved with the program, because their feedback was most valuable to us. The link to our online survey was sent out in

Green Decade's E-Bulletin to all EcoTeam members. Once an individual clicked on the link, a page containing a paragraph explaining our project and the survey came up, along with a button to continue. By clicking this button, users were agreeing to complete the survey. All of the survey results were then analyzed to see which areas had common responses, and recommendations were made based off of the results.

The survey in the e-bulletin was sent out to 250 people, however, only fifteen responded. Because the response size of the survey was so small, we did not have a large enough sample to make statistically relevant recommendations based solely on survey results. Instead, we conducted additional research on motivation and social marketing, which we used to support our recommendations. The research findings are coupled with our recommendations in section 5.2.

3.3 – Objective 3: Implement the Methods in a User-Friendly Manner

After exploring how to collect carbon footprint data from users as well as what material might be presented on the website, we then analyzed and determined which ideas should be recommended to Green Decade. This process was divided into two tasks:

1. Determine overall recommendations for the website, and
2. Divide recommendations into short- and long-term goals.

The first step of our process was to pass on the information we have gathered to the web development team. With the design criteria and conversion factors we provided, they can build the data collection tool for Green Decade to keep track of their goal. All of the feedback we provided was determined from analyzing the information we gathered from the web survey, face to face interviews, and research.

To determine which features should be implemented on the website, we evaluated each possible feature against the following set of criteria:

- **Ease of implementation:** The web development team at Green Decade has serious time constraints and may not be able to implement all of the features we would have liked. In order to consider this constraint, we took into account how much time and effort is required from the web development team and decided whether or not implementing each feature would be feasible.
- **Ease of maintenance:** For similar reasons, we took into account the ease of maintaining the features suggested. The web development team will need to keep the website up to date in order for it to maintain its effectiveness long after we gave our recommendations.
- **Benefit to Green Decade:** We also weighed the advantages each feature would provide to Green Decade. For instance, offering users carbon reduction strategies holds more promise for reducing the carbon footprint of residents in Newton than does implementing leader boards on the website. Leader boards may be a heavily requested and desired feature, but they do not offer much additional assistance to Green Decade's goal.

Once we compiled the recommendations for Green Decade using our criteria, we then further broke them down into categories.

- **Short-term recommendations:** Ideas that can be implemented with the least amount of effort or on the current web development platform were considered short-term recommendations. These ideas consist of mostly ideas for the web development team, but it is up to Green Decade as to whether they want to implement them or not. This included any website ideas such as leader boards or a points system.
- **Long-term recommendations:** Ideas that cannot be implemented on the current platform or may take more time to implement.

Once we divided the recommendations into short and long-term recommendations, we presented all of the recommendations to Green Decade, which are presented in the following chapters.

4 – A Carbon Footprint Data Collection Mechanism for Newton EcoTeams

In this chapter, we discuss the criteria we determined for a data collection tool to be used on the new EcoTeam website. The data collection tool tested on the EcoTeam participants is explained more thoroughly, along with various differences between the two forms. We also discuss participants' reactions to different aspects of the tool, and which presented options they preferred.

4.1 – Criteria for the Data Collection Mechanism

Leaders of Green Decade suggested the original criteria for a data collection tool to us. These criteria were intended to help Green Decade record their progress towards their goal of reducing 25% of Newton household's carbon footprints by 25% by 2012. The main criteria given to us by Green Decade were that the data collection tool needed to:

- Have the conversion factors for calculating carbon footprints,
- Take into account all of the carbon emission sources included in by the *Low Carbon Diet* workbook, and
- Should take into account household size and number of residents.

These criteria were used as a starting point and we developed additional criteria based on information gathered through interviews and surveys given to past EcoTeam members. The most common problems users had with the old data collection tool were that the carbon emissions data seemed inaccurate, the calculator itself was just a long list of text that seemed daunting to enter, there is no help if you are stuck with something, and most found it unhelpful for actually assisting their carbon reduction. Keeping in mind the criteria outlined in section 3.2.2, the following criteria were established:

- **The new calculator should provide reasonably accurate estimations for carbon emissions**. Many users researched their own conversion numbers and found them to be different from the values given by the old calculator. Providing reasonably accurate estimations along with their sources will help prevent confusion among users and prevent users from doubting the legitimacy of claims made by both the carbon calculator and the website in general.
- **The new calculator should be relatively short and not daunting to use**. While the calculator should maintain the same data gathering questions to gather useful information, users would prefer if we make the calculator appear simpler and ask questions in a way that makes them seem easier to answer and quicker to complete. This concern relates to the problem of there being no help available if a user is stuck using the calculator. Many interviewees did not know where to find information such as their kilowatt-hours or therms of natural gas used each month. Other sources of confusion were pounds of different types of food purchased each month, or gallons of waste. By providing the necessary help for users when they are confused and also trying to avoid confusion in the first place, we can provide the user with a better carbon calculation experience and keep them entering their data in the future.
- **The new calculator should provide feedback to users about their carbon footprint**. After calculating their carbon footprint, the users are only presented with a final carbon value with questionable accuracy. No context is given to the value and the users have no idea whether

they are doing better or worse than a typical household is. This can cause unrealistic expectations for improvement and makes the users wonder what the purpose of entering their data was in the first place. Another problem with a single final carbon value is that it does not show the users what areas need the most improvement and leaves the users with no feedback about how to improve. Offering the users results that are more comprehensive after calculating their carbon footprint will help provide useful ideas as well as a reason to keep entering data.

These criteria were reinforced by reaction to a draft data collection tool shown at the Massachusetts Climate Action Network (MCAN) Community Workshop that we attended. The tool asked for information such as a user's phone number to sign up to use the tool. No one could provide a reason for this information to be needed, and all participants interviewed agreed that only required information should be requested from users. Participants expressed that the MCAN calculator was very complicated, asking the user to enter 12 months of baseline data before they could start to enter new monthly data and get recommendations from the website. This baseline data asked for information such as pounds of trash and asked for energy use in gallons, not explaining what these gallons might belong to. This lets us know that everything should be explained to the user and that asking for too much information can scare users away from entering their information. By combining all of the above criteria, we were able to design an interface for a data collection tool and specify a set of recommendations for what should be included with the tool itself.

4.2 – Recommended Data Collection Interface

We have created a design for a data collection tool. For a closer look at the design decisions discussed in this section, screenshots of the updated tool can be found in Figures 3,4, and 5. This section will highlight key features of the data collection tool and discuss the reasoning behind the layout, questions, and format. It also explains and justifies why we chose certain features, and why we chose to omit others.

The data collection tool focuses on carbon emissions from transportation, heating, electricity, and water. The questions users are asked, shown in Figures 3, 4, and 5, were picked because they are the easiest fields to convert to carbon emissions. Although indirect sources of carbon emissions add up to quite a bit, it is difficult to quantify those areas such that posing questions would be burdensome. The conversion factors, shown in Appendix H, were used to calculate the carbon emission equivalents from the data entered into the carbon calculator. These conversion factors were taken from Green Decade, along with other credible sources.

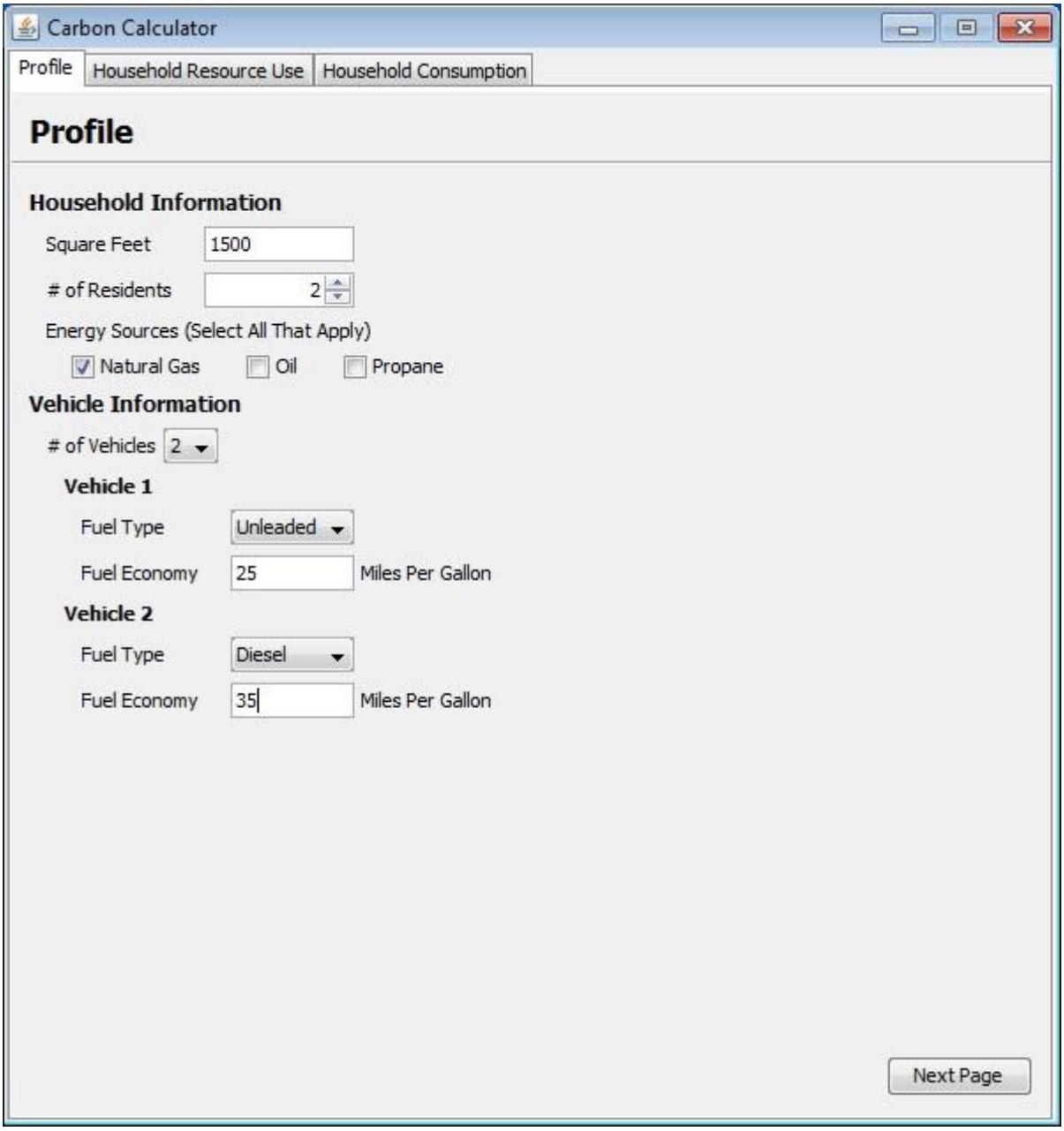


Figure 3: Profile Section of Calculator

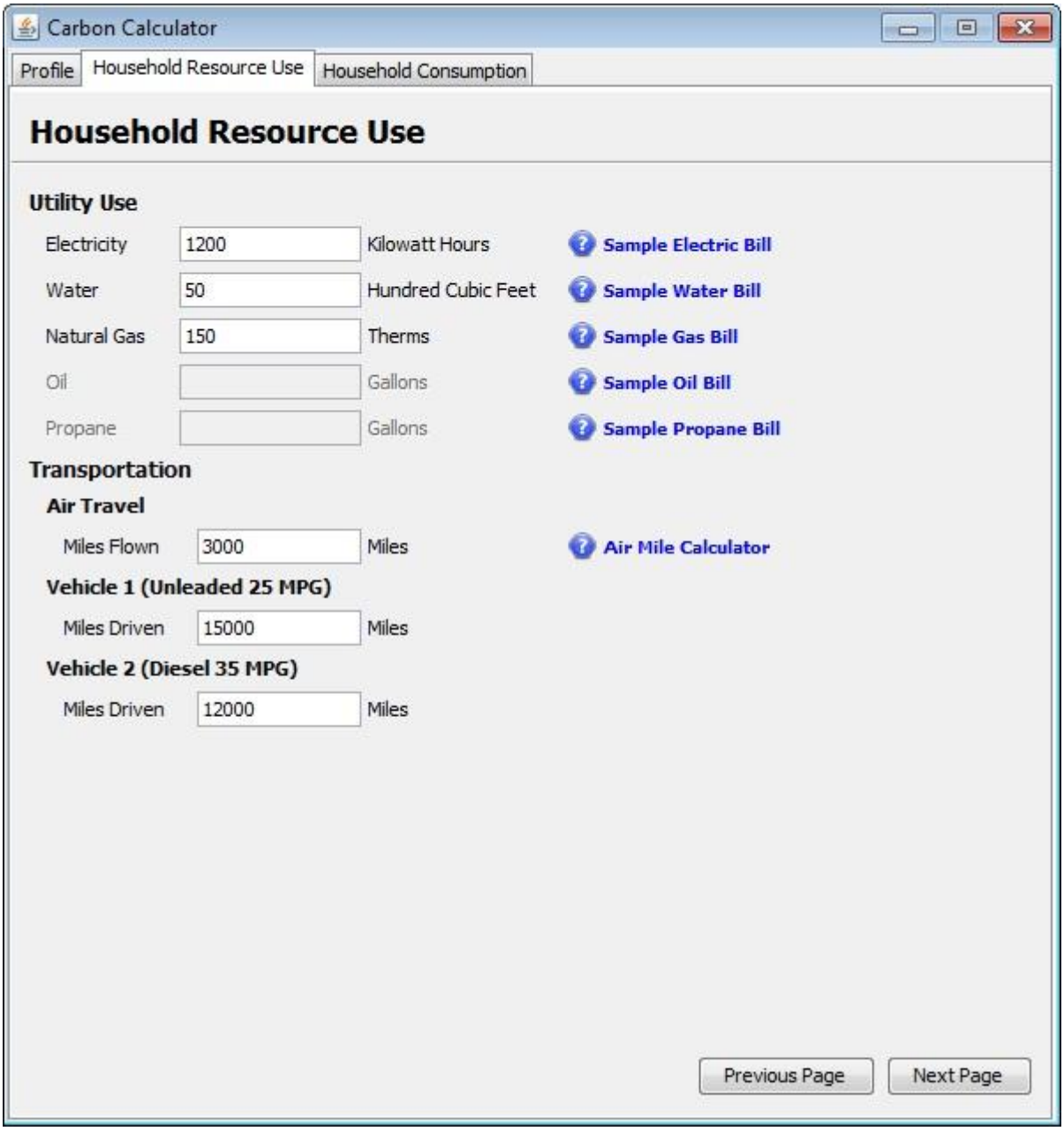


Figure 4: Section of Calculator on Household Resource Use

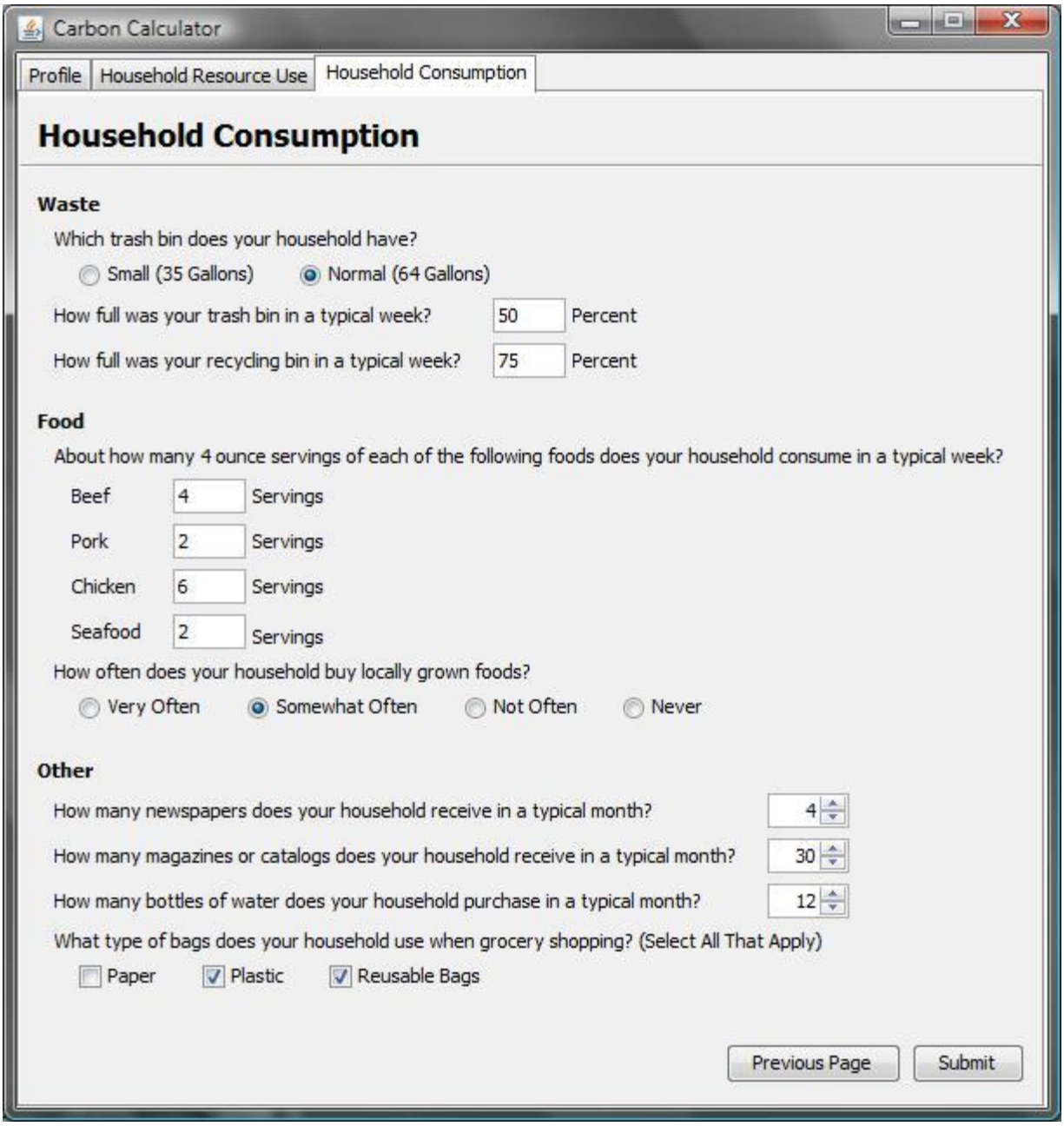


Figure 5: Household Consumption Section of Calculator

Users will be asked to fill out a profile section the first time they complete the calculator. A household profile section will save data entry time. This information will not change often and, by including it in a profile section instead of with the main carbon calculator, it will allow the users to enter less data each time they come to the website. This especially helps if the data collection becomes more frequent than the current annual method offered. By adding a profile section, the calculator becomes shorter and less daunting. As seen in Figure 3, the profile asks for:

- **Household square footage,**
- **Number of residents:** Number of residents is offered as a "spinner", a feature which allows the user to scroll through numbers rather than typing them, which is usually easier for users than a simple blank field. A spinner allows them to change between a small set of numbers quickly.
- **Energy sources of the user's household:** The energy sources are offered as check boxes so the user can select more than one, in case for example the user uses natural gas for heating their home and propane for cooking. This is asked to make the data collection form shorter, because energy sources that are not used will not need to be shown on the final form.
- **Number of vehicles used in the household, fuel type, and fuel efficiency:** Fuel type is asked because different types of gasoline have different carbon emissions, and this helps give a more accurate estimation. Fuel efficiency is asked because most users will not know how many gallons of gasoline they have purchased, but can reasonably estimate their fuel efficiency and number of miles driven, and then the tool can calculate the rest behind the scenes. Asking the number of vehicles is important so the form can adapt to the number of vehicles the user has. For instance, if it always assumes a household has four vehicles, it always contains the fields needed for four vehicles, and this can make the form appear longer and more daunting than it really is. If the form can adapt to the user, it will only show the user the fields they actually need to enter.

The use of tabs for the data collection tool presents less information at once. Interviewees were shown two sample layouts for the data collection tool. The first layout consisted of the entire tool on a single page, while the second layout was divided into tabs, with next and previous page buttons allowing the user to quickly change between tabs. We chose to divide the second form into tabs so the form would seem less intimidating and shorter to the users. While opinions over which layout was better were mixed, the general consensus was that multiple pages made the form seem shorter, as long as the number of pages was disclosed to the users so they would know how far into the form they are. Using tabs helps ensure the user always knows how far into the calculation process they are, as the tabs show which page the user is on.

The layout we recommend is to have the first tab consist of the profile, which could of course be skipped after it was initially entered. The second page would then consist of the utility usage for the household, as well as the air miles flown and miles driven for each of the vehicles saved to the user's profile. Any energy sources that were not previously checked in the profile should be removed from view and the number of vehicles here should match the number of vehicles in the profile. This is to make the form as short as possible and to keep the user from being confused when a field seems unnecessary.

Links to supporting information are provided to make the data entry process easier. The utility use section is comprised of simple text fields with unit labels at the end. On the side of each field will be a help button, which would show a sample utility bill for that utility, outlined in Figure 6. This bill would have the necessary field circled and magnified to help the users quickly check their own utility

bills and enter the correct information. This will not only help the users get through the form more quickly, but also help avoid mistakes when the wrong number is entered.

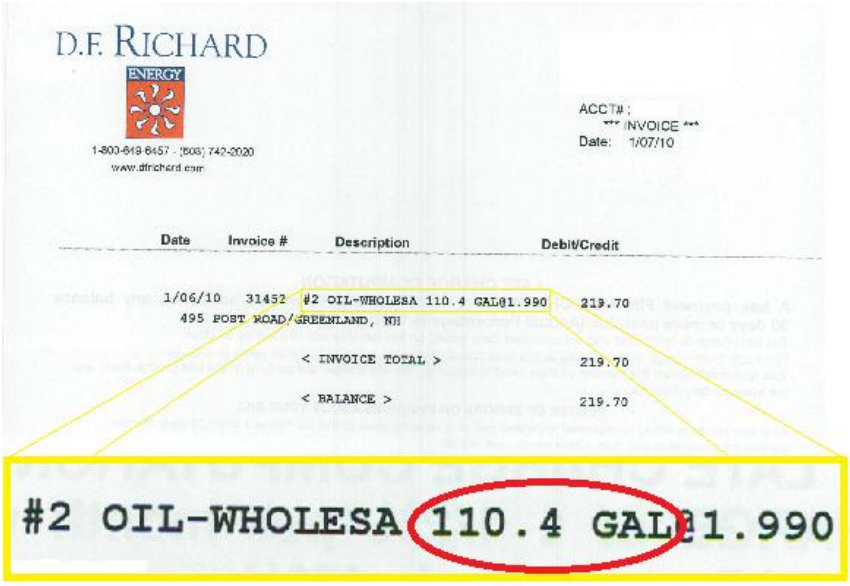


Figure 6: Sample Utility Bill

The second tab also includes transportation divided into air miles and miles driven for each vehicle. Users were shown an air mileage calculator to help them calculate their total air miles for the past month and every user found this to be a helpful addition. This can be provided as a simple link next to the air mileage field, similar to the links to the sample utility bills discussed previously. Miles driven is asked of users for each vehicle, and many users found it difficult to remember which vehicle they entered for each assigned vehicle number. To help alleviate the problem we decided that providing a preview of what the vehicle is would be helpful in reminding the user. For example, instead of saying "Vehicle 1", it would show "Vehicle 1 (Diesel 35 MPG)". This does not require the user to enter any additional information, but helps them with a quick reminder and once again helps prevent any possible calculation errors that entering the wrong information could cause. Right now, the website is designed to handle data entry annually, and because of this, the fields in the recommended data collection tool ask for miles driven. However, we recommend changing this to ask the user for the actual reading on their odometer if the system is changed to monthly. This will require the user to make fewer calculations and would be easier for the user to remember each month. This suggestion was given to us by an interview subject, and other subjects agreed this method was easier than calculating monthly miles.

Regionalizing questions to Newton, such as trash consumption, increases the calculator's user-friendliness. During our interviews we asked subjects to measure their trash in either gallons or bags. One of the subjects informed us that all of Newton uses the same type of trash and recycling bins, and residents are offered either a standard 64-gallon trash receptacle or a smaller 35-gallon version. To reflect this, we have asked the user which bin they have at their household and then simply ask how full their bins are in a typical week. The value entered for each bin can be expressed as percent full every

week. The opinions expressed by interviewees are that this is the easiest and most intuitive method available for asking how much waste a household produces.

Household food consumption is asked in a user-friendly manner to better calculate carbon footprint estimation without complicating the data entry process. Meat and seafood contribute the most to a household's carbon footprint, so those are the areas we focused on. We ask about consumption on a weekly basis because users had trouble doing calculations when asked their monthly consumption. Conversions to annual consumption can then be made by the calculator. Some users also failed to account for monthly and actually entered weekly data instead. Users are asked to enter their meat and seafood consumption in servings because, when presented with both pounds purchased and servings consumed, most users preferred servings because it accounts for food eaten at restaurants and many users are not responsible for the shopping within their household. We also ask how often the household buys locally grown food. This question will not give the user any actual carbon emissions estimations like meat and seafood will since too many assumptions would have to be made, but it will help them think about buying locally grown food.

Although some consumption questions presented in the calculator do not output concrete carbon emissions data, they will help further personalize carbon reduction actions for the user. This includes the number of newspapers, magazines, and catalogs the household receives each month. These questions will also help users think about carbon reduction ideas they might not have previously considered. We also ask how many bottles of water the household purchases, and the types of bags the household uses when grocery shopping. When we asked our interviewees if they felt these questions were unnecessary, they all agreed that the questions were not burdensome but instead helped them think about new reduction strategies and about their overall consumption.

Allowing users to input data frequently would be beneficial to both themselves and to Green Decade. Currently, the calculator collects data on an annual basis. By inputting data more often than annually, users will not have as much information to retain each time. Frequent collection also enables Green Decade to receive current progress reports from their participants. However, because this process can become bothersome over time, an entry method that permits users to choose how frequent they input data could be valuable. During the interviews, subjects gave mixed reactions about data collection frequency. Some participants expressed desire to input data every time they go shopping, while others absolutely did not want to enter data more than once a year. The option for each user to select how frequently data is input allows all parties to be happy while still giving Green Decade the carbon emission data.

A comprehensive feedback page is included with the new calculator to respond to users' desire for feedback. This page, containing a chart, graph, and reduction strategies for the user, breaks down the users' carbon footprint into categories and shows them how much each category affected their overall carbon footprint. These categories are electricity, water, natural gas, oil, propane, transportation, waste, food, and miscellaneous. Each category is shown in a graph comparing their results to the previous data collection period as well as the average for all users. An example of this graph is shown in Figure 7. This helps the users know which areas need the most improvement, helps

the users keep track of their progress, and lets them know if they are improving or falling into old habits. The graph will be modified, based upon factors such as what type of heating is used, and if Green Decade decides to calculate the miscellaneous category, such as calculating the data for plastic bags.

The results page also provides links to carbon reduction strategies the user should take. Ideally, these strategies will be personalized for each user, based upon which categories of their carbon footprint need the most improvement. However, in the short-term, these strategies can just be displayed as links at the bottom of the results page, allowing the users to determine for themselves which areas need the most improvement and find strategies on their own. This will at least give the users feedback about what needs improvement and point them in the right direction to help reduce their carbon footprint.

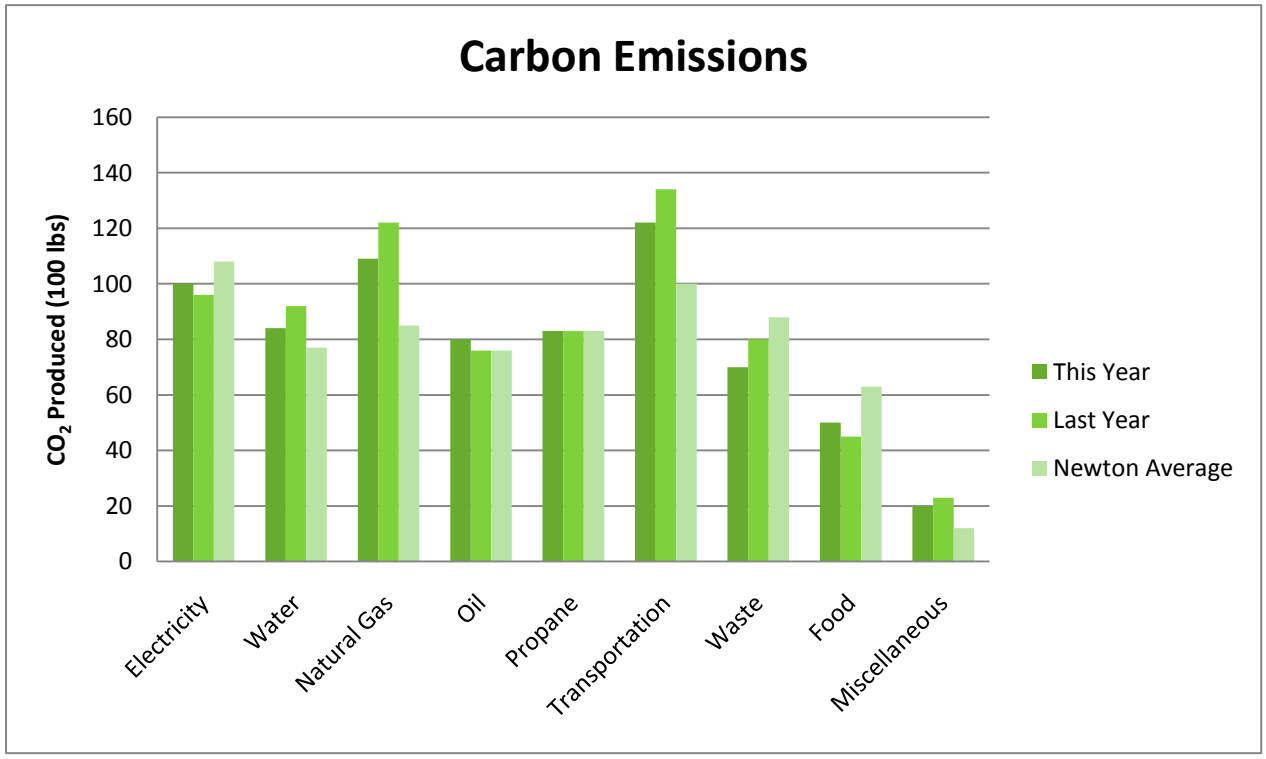


Figure 7: Sample Carbon Footprint Graph that will be returned to users

The data collection tool we've outlined provides an advantageous balance between accuracy and user-friendliness. This is a balance that has been lacking from not only Green Decade's previous data collection tool, but also from many tools we've encountered. Questions asked in the tool are not daunting, yet still successfully gather approximate carbon emissions data from users. Incorporating both factors satisfies Green Decade and its members.

5 – Resources and Recommendations for the EcoTeam Website

In order to improve the EcoTeam process, we have also provided recommendations for content on Green Decade's new website. We first discuss general website improvements that we suggest. The second subsection includes recommendations on how to motivate EcoTeam members to enter data periodically. We finally discuss resource material that we have created to include on the website.

5.1 – General Website Improvements

Many subjects interviewed expressed that they did not have as much of a problem with the calculator as they did with the overall website. When asked what was wrong with the website, interviewees claimed that it was hard to navigate and it took "almost a dozen steps" to get to the calculator. After hearing many complaints about the navigation of the EcoTeams website, we went through the entire web process ourselves and provided the following recommendations:

- **Register the EcoTeams website**. Currently, in order to access the website, users must enter "www.newtonecoteams.org". If the user enters "newtonecoteams.org" into the address bar, the site will not be found. If the site were registered with a Domain Name System, users would not have to type "www" to access the site.
- **Make the "sign in" link larger and easier to locate**. The link on the current website is too small and in the top corner of the page.
- **Allow the users to choose their own password**. A password personally picked by each user instead of one assigned by the website is easier to remember.
- **Eliminate the "@newtonecoteams.org"**. Currently when signing in, the user has to enter "username@newtonecoteams.org". Removing nineteen characters of unnecessary input can make the login process quicker and easier.
- **Include only three main sections on the home page.** The front page of the current website is cluttered with text. Many subjects complained that it was hard to find the calculator through all of the clutter. The first section should include a brief explanation of who Green Decade is and what the EcoTeam Project is. The second section should include top reduction strategies. The third and final section should include a leader board of the top EcoTeams and the top individuals for the month.
- **Include a navigation pane at the top of the page with easy links to navigate to different parts of the site.** Links will make it easier to access the different areas of the site, including the carbon calculator, which subjects reported was hard to find on the current website.

5.2 – Motivational Tools

Offering motivation or incentive can keep users interested and coming back to the website to enter their data. In this section, we discuss recommendations on possible motivational tools including:

- Comparing results to other residents,
- Offering qualitative equivalents to the carbon footprint approximation, and
- Personalized feedback.

As explained in section 3.2.2, our criteria for motivational tools are to convince the users to return to the site and enter their carbon footprint data, to appeal to a large number of people, and to offer an alternative for qualitative minded people. A cautionary note is that the survey was completed by only 16 people, many of whom had been contacted by EcoTeam leaders because of their commitment to the program. Thus, this sample cannot be considered representative of the entire Green Decade community. Nevertheless, the results suggest some directions for Green Decade to consider. Results are explained in the remainder of the section.

- **Compare participant carbon footprint data with other Green Decade members' data**. Most survey respondents said they would be willing to display their carbon footprint data publically, and would be interested in comparing their data with that of other Green Decade members. Of the few that were uninterested, one respondent was opposed to the idea. The respondent said, "This should not be a competition". Although this is a valid concern from an EcoTeam member, the majority of the data suggested we implement some sort of comparing mechanism. In order to avoid discouraging users who do not want to compare their data, we recommend providing the option to set their profile to private, meaning no one else can see their data.

  Studies in the literature reinforce the value of establishing social norms to foster behavioral change. If a user's data is worse than the average, then the user will attempt to improve. However, if a user's data is better than the average, the user may not find any motivation in further improving it. Adding a simple smiley face to the comparison was shown to motivate the user to keep up the good work (Shultz, 2006).
- **Send out a reminder email to EcoTeam participants**. This email would be sent out once a month to remind users to input their data into Green Decade's carbon calculator and would contain carbon reduction strategies. Most users who answered the survey said they were either likely or extremely likely to read this email. This is a significant portion of respondents; however, some said they would not read a reminder email. To please both groups, we also recommend including an option to unsubscribe from the reminder emails.
- **Include a website feature that converts carbon savings to equivalent changes in the environment**. Respondents were asked if they would like to see qualitative results along with the quantitative results already provided. For example, after completing the online calculator a box would appear with the words "Your savings of X pounds is equivalent to planting Y trees". Every respondent was either somewhat interested or very interested in seeing this conversion. This would be an important aspect to include, since this question generated very positive feedback.
- **Implement a leader board, consisting of willing participants, of both the top individual carbon reducers of the month and top EcoTeams of the month**. Our survey included two questions that asked about leader boards as a possible motivational tool. The first asked users if they would like to see a leader board to motivate them to reduce their carbon footprint. The other asked how interested users would be in seeing individual and EcoTeam leader boards. The first question gave mixed feedback; some users were interested while some were not interested. However, when asked about the specific leader boards, the

majority of users said they would be interested. We credit this apparent discrepancy in responses to not properly explaining what a leader board is in the first question.

- **Provide online carbon reduction strategies**. When asked about seeing carbon reduction strategies online, most survey respondents said they would be interested in these tips. The majority of users were also very interested in seeing a list of top carbon reduction strategies for the month, top suggestions from users for the month, and especially newest carbon reduction strategies. The majority of users were very interested in seeing the newest carbon reduction strategies, while the others were somewhat interested.

5.3 – Resource Material for Carbon Reduction

As outlined in section 3.1, the main criteria for the carbon reduction material were feasibility for users, return of time and money spent, and range of users. The carbon reduction strategies provided aim to satisfy all three of these conditions. This section explains how the strategies are constructed and why they contain certain information, along with recommendations to accompany them.

Although the *Low Carbon Diet* workbook is not accepted throughout EcoTeams and Green Decade, it contains useful information. For that reason, the workbook was used as a resource for the carbon reduction strategies along with other resources, such as the Environmental Protection Agency's website. We also built off it with reduction values that were more regionalized.

Based on feedback gathered from Green Decade leaders, interviews conducted, and surveys completed, we created carbon reduction strategy pages that will be uploaded to the new EcoTeam website. The strategy pages, shown in Appendix J, are grouped into: electricity, heating, water, transportation, waste, and miscellaneous to align with areas of the calculator. Each strategy page gives a different tip on how participants can lower their carbon footprint. A strategy page is made up of four parts:

1. The approximate savings values section covers the average amount of CO_2 saved annually, the amount of money saved annually, the initial cost, and the effort required. Initial cost is represented as an estimated range. Effort required is given as none, low, medium, and high. An approximate savings value, Section 2.4.4 explains that financial incentives can often motivate homeowners.
2. Explanation as to why a participant should perform this particular action,
3. How the participant can implement the reduction strategy, and
4. A tips section with bulleted points to help participants improve their carbon reduction efforts.

These parts will show the users how much money and effort is required to complete these tasks. By showing this information, users will be able to decide which strategies are worth their time and funds. Along with providing these strategies, we also present the following recommendations:

- **Upload all of the tips we provide into a "Reduction Strategies" section on the website**. The strategy pages can then be separated into the six categories. Each category can have its own section on the "Reduction Strategies" page. When participants calculate their footprint, they can compare their results to the average Newton household through a graph provided

and determine which areas contributing to their carbon footprint need the most improvement. Once participants determine which categories they need to improve the most, they can go to the Reduction Strategies page, navigate to the correct category, and read about the possible ways to reduce their footprint in the specific categories.

- **Provide users with a list of carbon reduction strategies on the results page based on which areas need the most improvement**. On the calculator results page, a list of five links to recommended personalized strategies could be provided. When asked about how interested they would be in receiving personalized recommendations, all of our interview subjects responded that they would be very interested.
- **Allow EcoTeam participants to provide their own reduction strategy pages**. Through research, we have learned that allowing user-generated content can also increase participation in the Green Decade site and allow the user to feel like an active member in a community. Frank Smadja mentions in his study on incentives provided by user-generated content, that it can "highlight the impact of a specific user on the other users" (2009). In the "Reduction Strategies" section, we recommend a form that users can fill out to create their own strategies. The form would have all five of the reduction strategy page sections, and the user would only have to fill in the fields. In our web survey, the majority of respondents said that they are at least somewhat interested in seeing carbon reduction suggestions provided by other users as well as those provided by Green Decade, with most saying that they were very interested. A concern expressed by an interview subject was that the user-created strategy page may not be factual. To accommodate this concern, we recommend that anything submitted by EcoTeam members be reviewed for accuracy.

6 – Implementation Recommendations

We have divided our recommendations into short-term and long-term suggestions. The short-term recommendations can be implemented immediately, while the long-term suggestions may require more time and resources and can be used as a guide for future progression. While we recommend that Green Decade eventually move to a web platform more suitable to their needs and design a more sophisticated website, we have outlined attainable goals to follow in the meantime, given their current limited resources.

6.1 – Short-Term Recommendations

In this section, we recommend actions that can be carried out in the immediate future, based on Green Decade's current available time and resources. These actions can be implemented with minimal modifications to existing website platform, as we have learned from the web development volunteers.

- **Provide carbon reduction strategies on the website:** Carbon reduction strategies will not only provide users with helpful carbon reduction information, but it will also give the EcoTeam members an alternative to the Low Carbon Diet workbook. We have researched carbon reduction strategies and have created over forty strategy pages to be included on the website. The pages can be found in Appendix J, and have also been provided to Green Decade in a compressed folder (.zip file) including each individual page.
- **Implement the new design for the carbon data collection tool:** Through research and testing via interviews with EcoTeam members, we have created a new design for the data collection tool that can make it easier for EcoTeam members to enter their carbon data, while still providing a reasonably accurate carbon footprint estimation. The final design for the collection tool is included in Appendix E. We also researched new conversion factors for each of the questions in the tool. The conversion factors have been provided to Green Decade in a spreadsheet, and are also included in Appendix H.
- **Provide a graphical representation of the carbon footprint result:** Through our interview feedback, we found that most EcoTeam members would like to see a graphical representation for their carbon footprint data. A recommended graphical representation of the carbon footprint data can be found in Appendix G. Graphical representation is also a good tool for not only comparing between previous results to show an increase or decrease in the user's carbon footprint, but it also helps make comparisons between separate household footprints. The web development team has already shown us their ideas for providing Newton averages and has expressed interest in creating a graph.
- **Provide a reminder email:** Emails sent when a user needs to input their data for the period helps remind the user to continue with the program. From our interviews with EcoTeam participants, we have learned that many people would be interested in receiving a reminder email. The web development team has claimed that creating a reminder email for everyone will be easy to implement, but unsubscribing specific users could be more difficult.

6.2 – Long-Term Recommendations

Once Green Decade obtains additional resources, long-term recommendations can be implemented. These recommendations may require a new web development platform to make

implementation of these recommendations more easily attainable. A new platform will allow for more advanced features that will provide more motivation for users to continue to participate in the program.

- **Provide an option for data entry frequency:** We recommend allowing users to choose the input frequency of data entry between monthly, quarterly, semi-annually, and annually. Through our interviews we have determined that participants have a wide variety of opinions as to how frequently they would be interested in entering their data. To cater to this variety, we suggest making frequency an option when the user registers for the site. This needs to be a long-term goal because the database in which the carbon data is stored is currently designed to support annual data, and would need to be converted to monthly.
- **Provide personalized recommendations for carbon reduction strategies:** Recommendations based on carbon footprint results will reduce the amount of work for users to find strategies that specifically suit their lifestyles. Once the users calculates their carbon footprint and the results are displayed, the results of each category will be compared to the Newton average for each category. Whichever group deviates from the average the most will be the area that needs the greatest improvement. The site can then provide strategies specifically in that area. The current platform cannot support this function, however all interview subjects showed interest in the personalized recommendations. This feature can also be expanded to be included in reminder emails.
- **Allow for user-created strategy pages:** To expand the amount of carbon reduction strategy pages, we recommend allowing users to create their own strategy pages. These strategy pages would then be available for all users to access. In this way, the number of strategy pages could continue to increase as users recommend their own strategies to the community. Through research, we have learned that allowing user-generated content can also increase participation in the site and allow the user to feel like an active member in a community. (Smadja, 2009). User-generated strategy pages have yielded positive results from our interview subjects and survey participants. To implement this feature, the web development team would have to create a user-friendly creation page, which is not supported in the current platform. The new pages would also have to be reviewed for content and accuracy.
- **Implement a leader board system:** Many of the EcoTeam participants that we surveyed said that they would be interested in seeing leader boards on the website. A leader board will show the top carbon reducers in the given time period. The leader board can display top individuals or top EcoTeams. A rank of the top carbon reducers can motivate participants to further reduce their footprint in order to be on the leader board. However, there was some suggestion from our interviews that some participants would be disinterested in turning the process into a competition, so we recommend giving the user the option as to whether or not they would like to be included in the leader board process.

The goal of this project was to provide a mechanism for Green Decade and its members to monitor and achieve their carbon footprint goals. Our recommendations addressed ways to increase both the usability of the website and the participation of its users. With the recommendations we have provided, Green Decade can go forth and design a website that is both easy to use and

effective as a carbon reduction tool. The Massachusetts Climate Action Network has created a similar site and may also benefit from the recommendations we have provided.

7 – Works Cited

Baldocchi, D., Falge, E., Gu, L., Olson, R., Hollinger, D., Running, S., Anthoni, P., Bernhofer, C., Davis, K., & Evans, R. (2001). FLUXNET: A new tool to study the temporal and spatial variability of ecosystem–scale carbon dioxide, water vapor, and energy flux densities. *Bulletin of the American Meteorological Society, 82*(11), 2415-2434.

Feenstra, G., & Brodt, S. (2008). *Reducing our food carbon footprint: Attitudes and procurement strategies among consumers and institutional food service.* Retrieved February 6, 2010, from http://piee.stanford.edu/cgi-bin/docs/behavior/becc/2008/presentations/17-2E-01-Reducing_Our_Food_Carbon_Footprint_-_Attitudes_and_Procurement_Strategies_Among_Consumers_and_Institutional_Food_Service.pdf

Gershon, D (2006). *Low carbon diet: a 30 day program to lose 5000 pounds*. Woodstock, NY: Empowerment Institute.

Giannini, A., Biasutti, M., & Verstraete, M. M. (2008). A climate model-based review of drought in the Sahel: Desertification, the re-greening and climate change. *Global and Planetary Change, 64*(3-4), 119-128.

Green decade Newton. (2010). Retrieved 02/04, 2010, from http://www.greendecade.org

Hansen, J., Sato, M., Ruedy, R., Lacis, A., & Oinas, V. (2000). Global warming in the twenty-first century: An alternative scenario. *Proceedings of the National Academy of Sciences, 97*(18), 9875.

Jamieson, D., & VanderWerf, K. (1993). *Cultural barriers to behavioral change: general recommendations and resources for state pollution prevention programs*. Boulder, Colorado: University of Colorado.

Kenny, T., & Gray, N. (2009). Comparative performance of six carbon footprint models for use in Ireland. *Environmental Impact Assessment Review, 29*(1), 1-6.

Kimmell, K. (2009). Massachusetts takes on climate change. *Journal of Environmental Law, 27*, 295.

Laroche, M., Bergeron, J., & Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing, 18*(6), 503-520.

Masanet, E., Kramer, K. J., Homan, G., Brown, R., & Worrell, E. (2009). *Assessment of household carbon footprint reduction potentials* (Pier Final Project Report No. CEC-500-2009-072). California: Lawrence Berkeley National Laboratory.

Mayhew, D. (1992). *Principles and guidelines in software user interface design*. New York, NY: Prentice Hall PTR.

Padgett, J. P., Steinemann, A. C., Clarke, J. H., & Vandenbergh, M. P. (2008). A comparison of carbon calculators. *Environmental Impact Assessment Review, 28*(2-3), 106-115.

Ravin, A. (2005). *City of Newton energy action plan.* Retrieved 02/04 2010, from http://www.ci.newton.ma.us/sunergy/EAP021005.pdf

Schultz, P. W. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science, 18*(5), 429.

Shackley, S., McLachlan, C., & Gough, C. (2004). The public perception of carbon dioxide capture and storage in the UK: Results from focus groups and a survey. *An Integrated Assessment of Carbon Dioxide Capture and Storage in the UK,* , 117

Smadja, F. (2009). Mixing financial, social and fun incentives for social voting. Toluna. Retrieved 04/19 2010, from http://www.toluna-group.com/files/en/Whitepapers/Web%20Incentives%20Whitepaper.pdf

Stanhill, G., & Cohen, S. (2001). Global dimming: A review of the evidence for a widespread and significant reduction in global radiation with discussion of its probable causes and possible agricultural consequences. *Agricultural and Forest Meteorology, 107*(4), 255-278.

Stern, P. C. (1985). *Energy efficiency in buildings: behavioral issues*. Washington D.C.: National Academy Press.

Stern, P. C. (1992). What psychology knows about energy conservation. *American Psychologist, 47*, 1224-1224.

The Commonwealth of Massachusetts (2008). An act relative to green communities. Chapter 169 of the Acts of 2008.

Van den Bergh, J. C. J. M., & Verbruggen, H. (1999). Spatial sustainability, trade and indicators: An evaluation of the 'ecological footprint'. *Ecological Economics, 29*(1), 61-72.

Venetoulis, J., & Talberth, J. (2008). Refining the ecological footprint. *Environment, Development and Sustainability, 10*(4), 441-469.

Wiedmann, T., & Minx, J. (2007). A definition of carbon footprint. *ISA Research Report.*

Winett, R. A. (1986). *Information and behavior: systems of influence*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc..

Wroblewski, L. (2008). *Web form design*. Brooklyn,NY: Rosenfeld media

Yale University (2009, March 18). Americans Support Action On Global Warming Despite Economic Crisis. *Science Daily*. Retrieved April 20, 2010, from http://www.sciencedaily.com /releases/2009/03/090318140530.htm

Appendix A – Online EcoTeam Survey

Page 1 – About This Study

We are a team of students from Worcester Polytechnic Institute working on a research project with Green Decade to help them improve their EcoTeam carbon calculator and website.

This survey includes questions related to the design and materials for the new EcoTeam website. The survey will ask you questions about various options for the new website. Your responses will help inform the design of the new website. All of your responses are entirely confidential and anonymous. No responses will be able to be traced back to you in any way. This survey should take no more than five minutes. We thank you for your time.

Page 2 – Green Decade

Imagine you just sat down on your computer and went to the new EcoTeam website. You just entered your personal information and created an account. Afterward you enter the required energy use information to calculate your carbon footprint. The following questions relate to how we should handle the information you enter, and your personal opinions on the matter.

1. Would you be willing to let other Green Decade members see the carbon emissions data related to you? (i.e. Your name would be shown with the data you enter.)

- Yes
- No

2. How interested would you be in comparing your carbon emissions data to other Green Decade members?

- Very Interested
- Somewhat Interested
- Not Interested
- Opposed to the Idea

3. How likely would you be to read an email sent every month reminding you to enter your energy data into the website? This email could also include new strategies for the month.

- Extremely Likely
- Likely
- No Opinion
- Unlikely
- Please Do Not Send Me Email

4. How interested would you be in seeing your savings converted to equivalent changes in the environment? (i.e. Your savings are equivalent to planting 50 trees!)

- Very Interested
- Somewhat Interested
- Not Interested
- Opposed to the Idea

5. How important would having a leader board be in regards to motivating you to reduce your carbon footprint?

- Very Interested
- Somewhat Interested
- Not Interested
- Opposed to the Idea

6. Rate each of the following leader boards on how interested you would be to see them posted on the homepage of the website.

- Top Individual Carbon Reducers
- Top EcoTeam Carbon Reducers

Page 3 – Green Decade

After you enter your energy use data the new website could offer a list of suggestions to help you improve your carbon footprint. These suggestions would be related to the categories that are identified as the greatest opportunities for savings based on the energy data you enter. The following questions relate to the suggestions you will receive.

1. How interested would you be in seeing carbon reduction suggestions provided by other users as well as those provided by Green Decade?

- Very Interested
- Somewhat Interested
- Not Interested
- Opposed to the Idea

2. Rate each of the following lists on how interested you would be to see them posted on the homepage of the website.

- Top carbon reduction strategies for the month
- Top suggestions from users for the month
- Newest carbon reduction strategies

3. How interested would you be in seeing comments from other users about suggestions? (i.e. Mark said: Lowe's has a great deal on Energy Star light bulbs this week.)

- Very Interested
- Somewhat Interested
- Not Interested
- Opposed to the Idea

Page 4 – Thank You

We would like to thank you very much for your time. Your input is very important in making this project a success.

The survey can be found at:

http://www.surveymonkey.com/s/VRZJK8L

Appendix B – Sample Web Form Interview Questions

Pre-interview:

1. Have you used the current EcoTeam calculator?
2. Have you used any other carbon calculators?
3. How often do you use the computer?

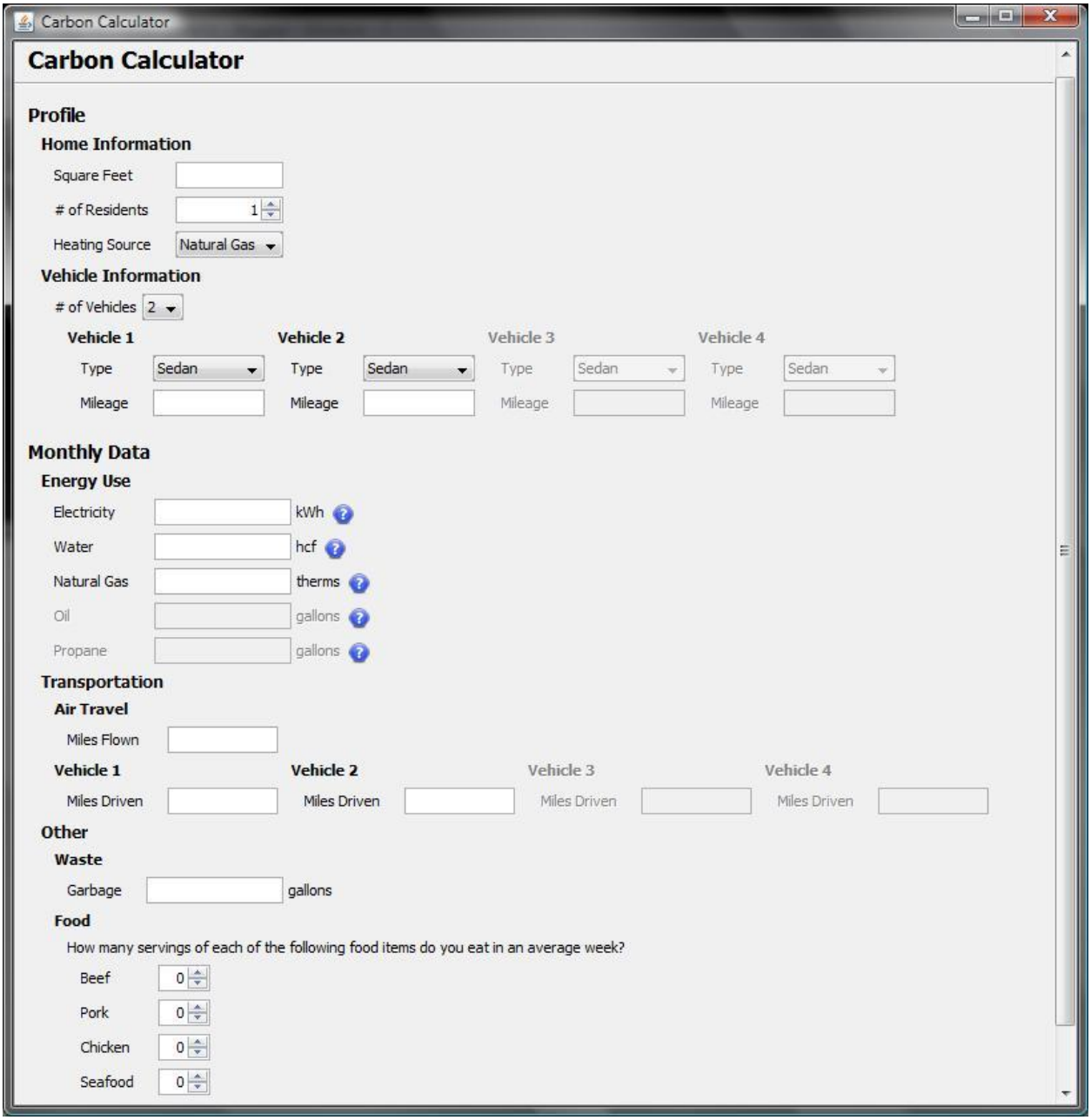
Explain:

We have created two different web forms for you to try. Please fill out the necessary information in each form, and as you do so, continue to talk out loud about your feelings and thoughts about each question. If something is unclear, please let us know as you go through; that is the sort of information we are trying to gather.

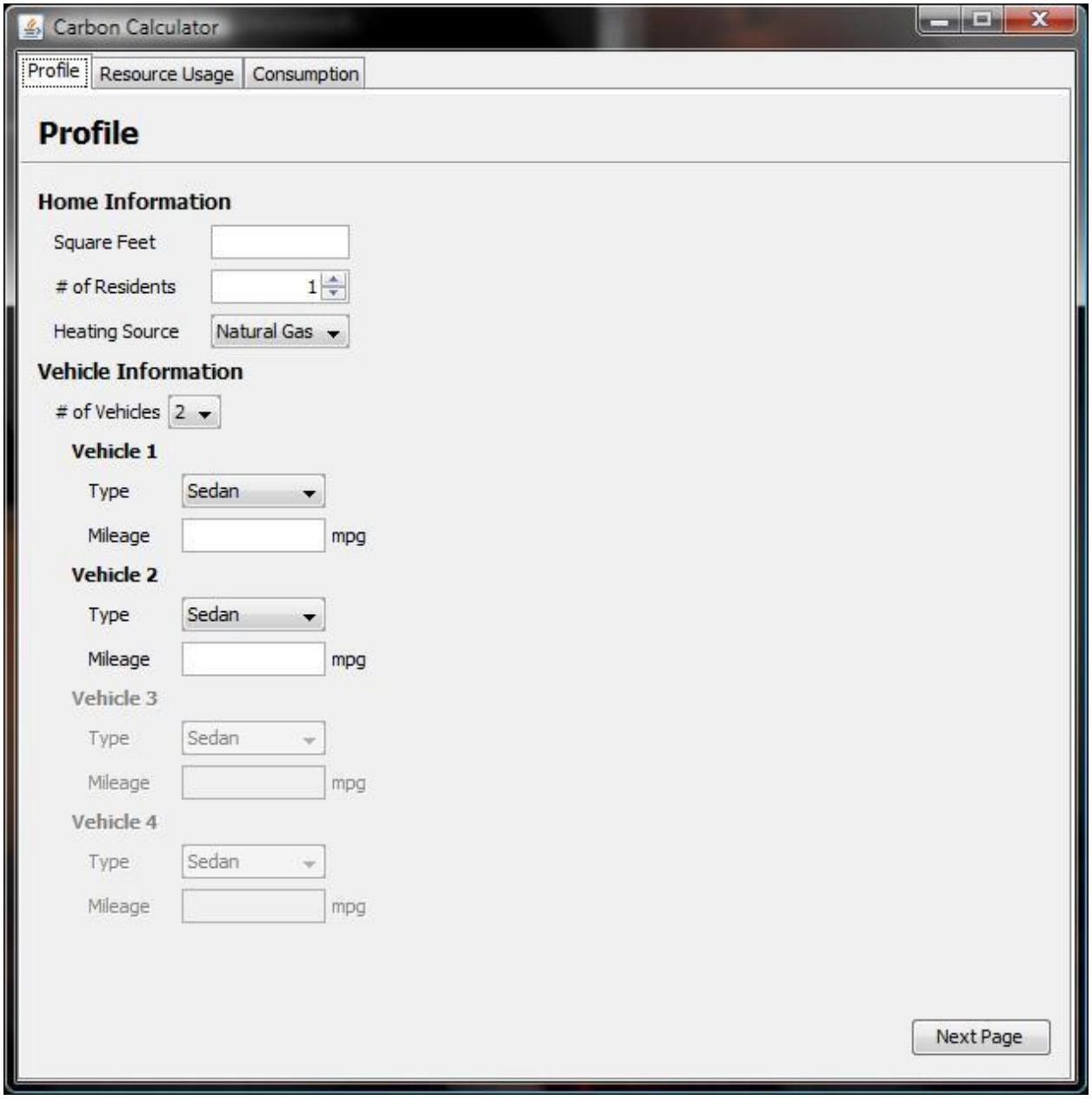
Post-interview:

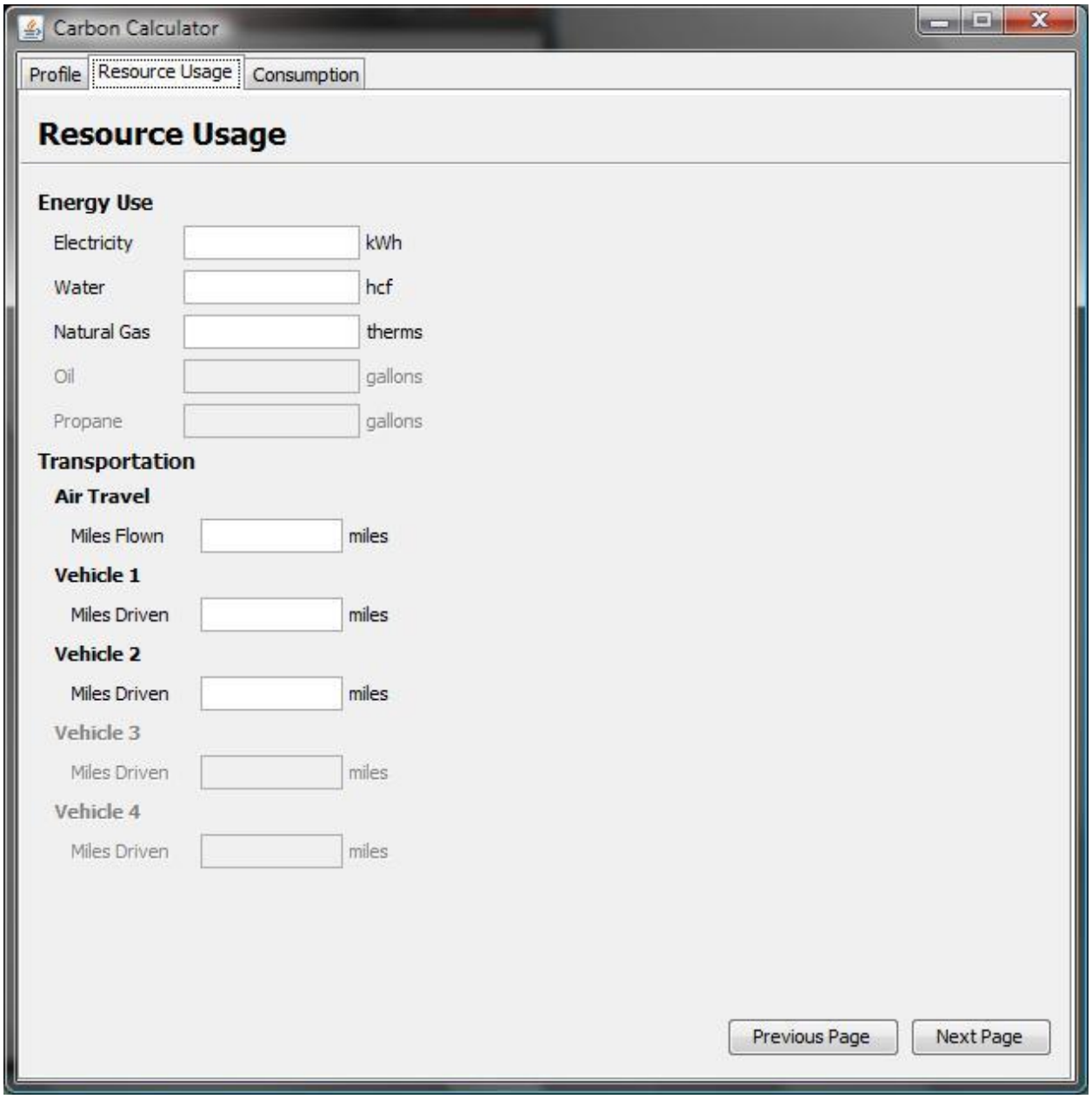
1. What did you like about the first form?
2. Were there any changes you would like to see on the first form?
3. What did you like about the second form?
4. Were there any changes you would like to see on the second form?
5. The first form included hints on where to find certain data. Did you find that helpful at all?
6. The second form included tabbed categories. Did you find the tabs a helpful addition, or did you find it unnecessary?
    a. Or did you prefer having it all on one page, like in the first form?
7. The second form asked more questions in the "Consumption" category. Did you feel that there were too many questions?
8. Did you find any questions to be too difficult to answer? (i.e. Too specific?)
9. Did you find any questions to be too invasive?
10. Did you feel like there were any questions that we should have asked?
11. How often would you be willing to enter your information?
    a. Monthly, quarterly, semi-annually, annually?

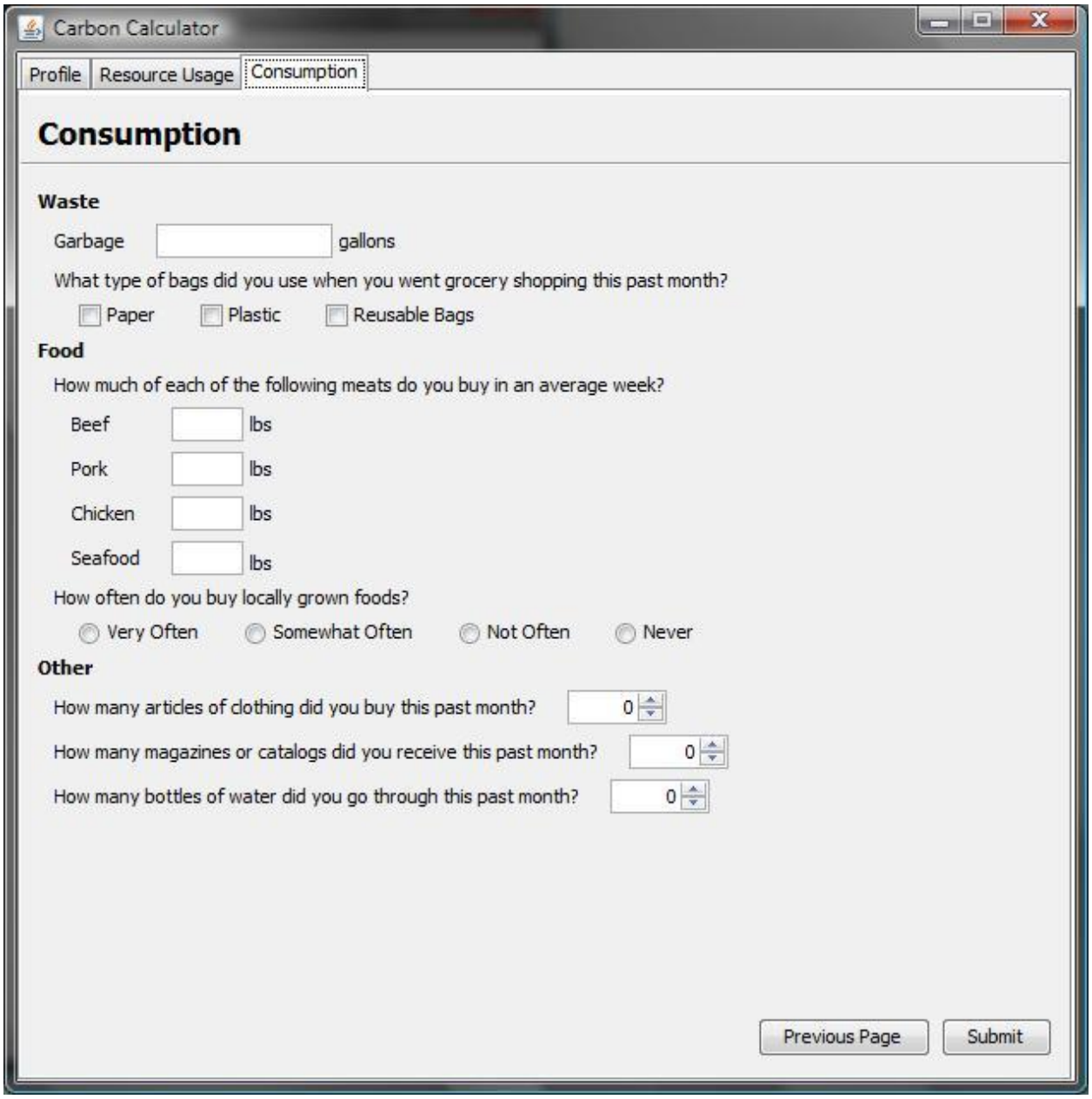
Appendix C – Sample Web Form A



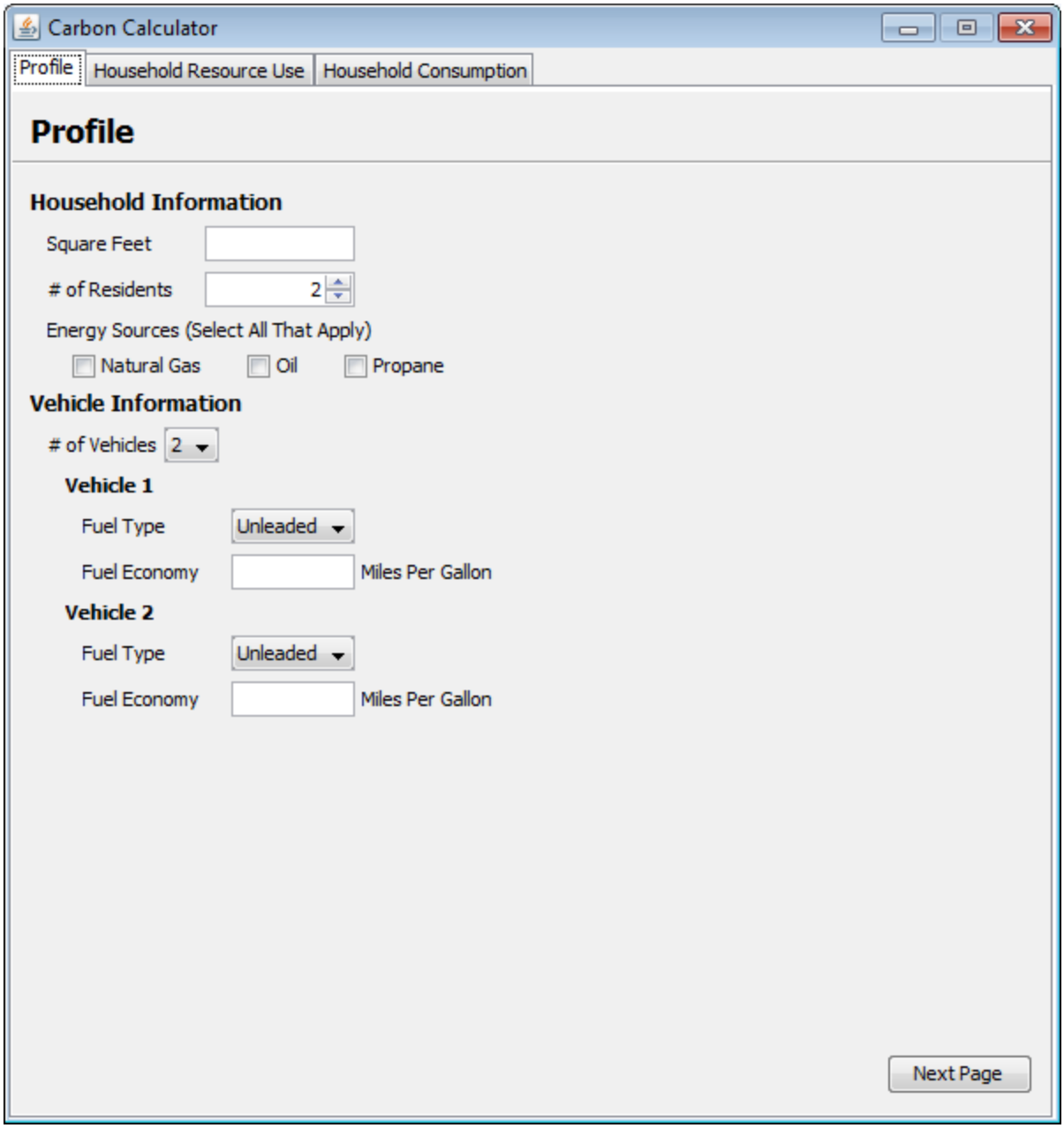
Appendix D – Sample Web Form B




Carbon Calculator
Profile
Resource Usage
Consumption
Resource Usage
Energy Use
Electricity
kWh
Water
hcf
Natural Gas
therms
Oil
gallons
Propane
gallons
Transportation
Air Travel
Miles Flown
miles
Vehicle 1
Miles Driven
miles
Vehicle 2
Miles Driven
miles
Vehicle 3
Miles Driven
miles
Vehicle 4
Miles Driven
miles
Previous Page
Next Page

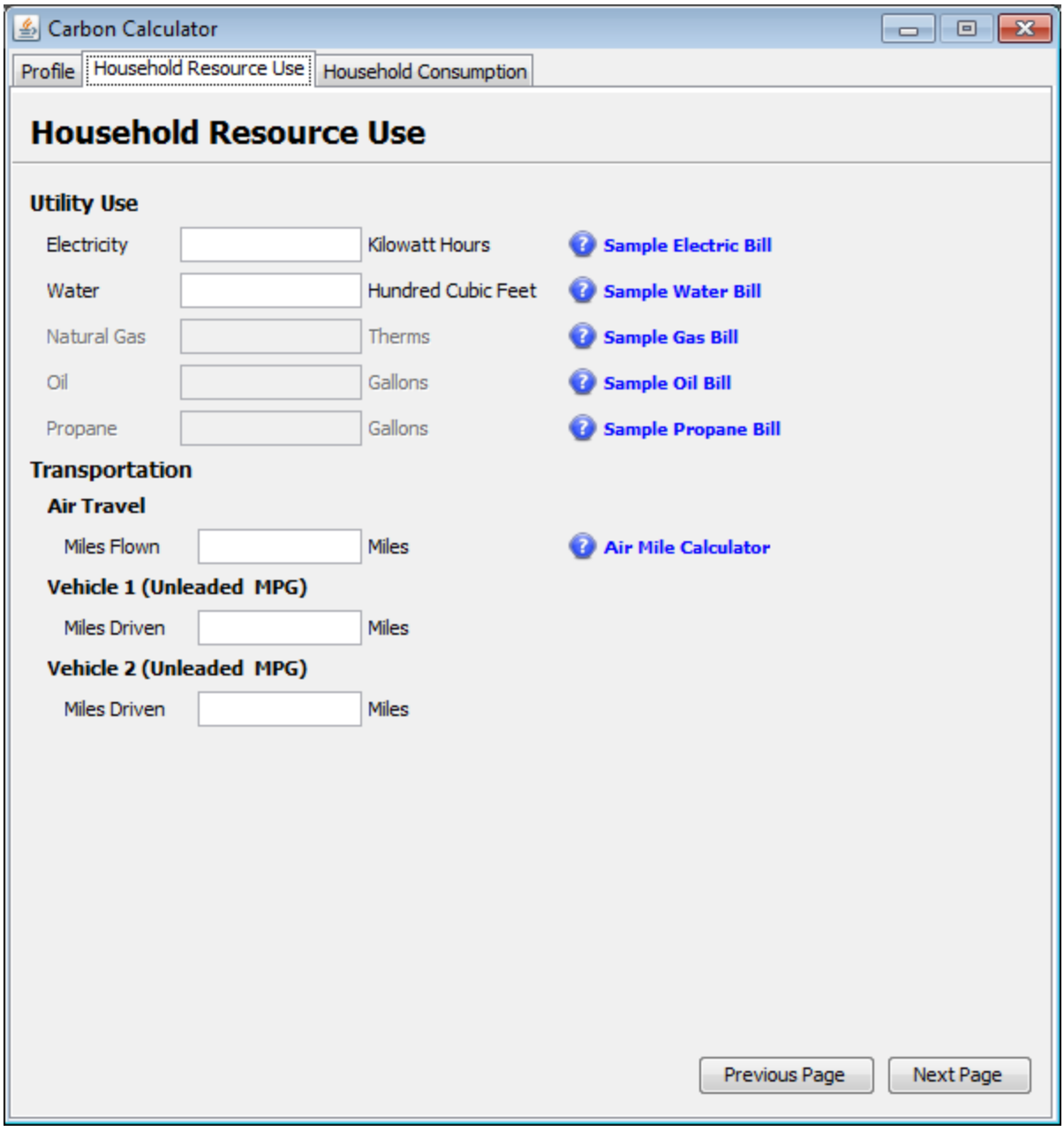

Carbon Calculator
Profile
Resource Usage
Consumption
Consumption
Waste
Garbage
gallons
What type of bags did you use when you went grocery shopping this past month?
Paper
Plastic
Reusable Bags
Food
How much of each of the following meats do you buy in an average week?
Beef
lbs
Pork
lbs
Chicken
lbs
Seafood
lbs
How often do you buy locally grown foods?
Very Often
Somewhat Often
Not Often
Never
Other
How many articles of clothing did you buy this past month?
0
How many magazines or catalogs did you receive this past month?
0
How many bottles of water did you go through this past month?
0
Previous Page
Submit

Appendix E – Recommended Data Collection Interface

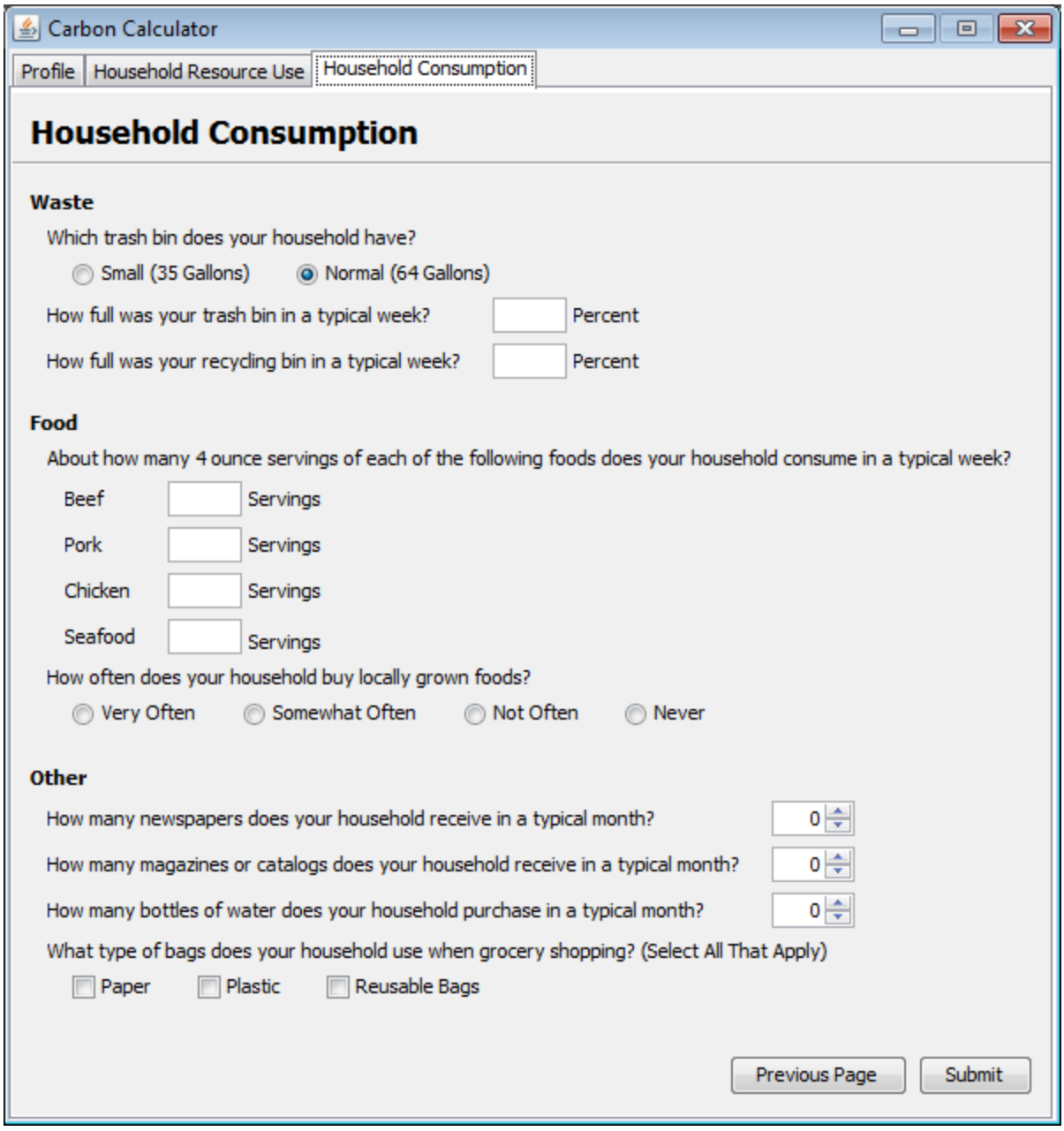


Number of Vehicles: 0, 1, 2, 3, and 4

Fuel Types: Unleaded, Diesel, Hybrid, E85, and Electric



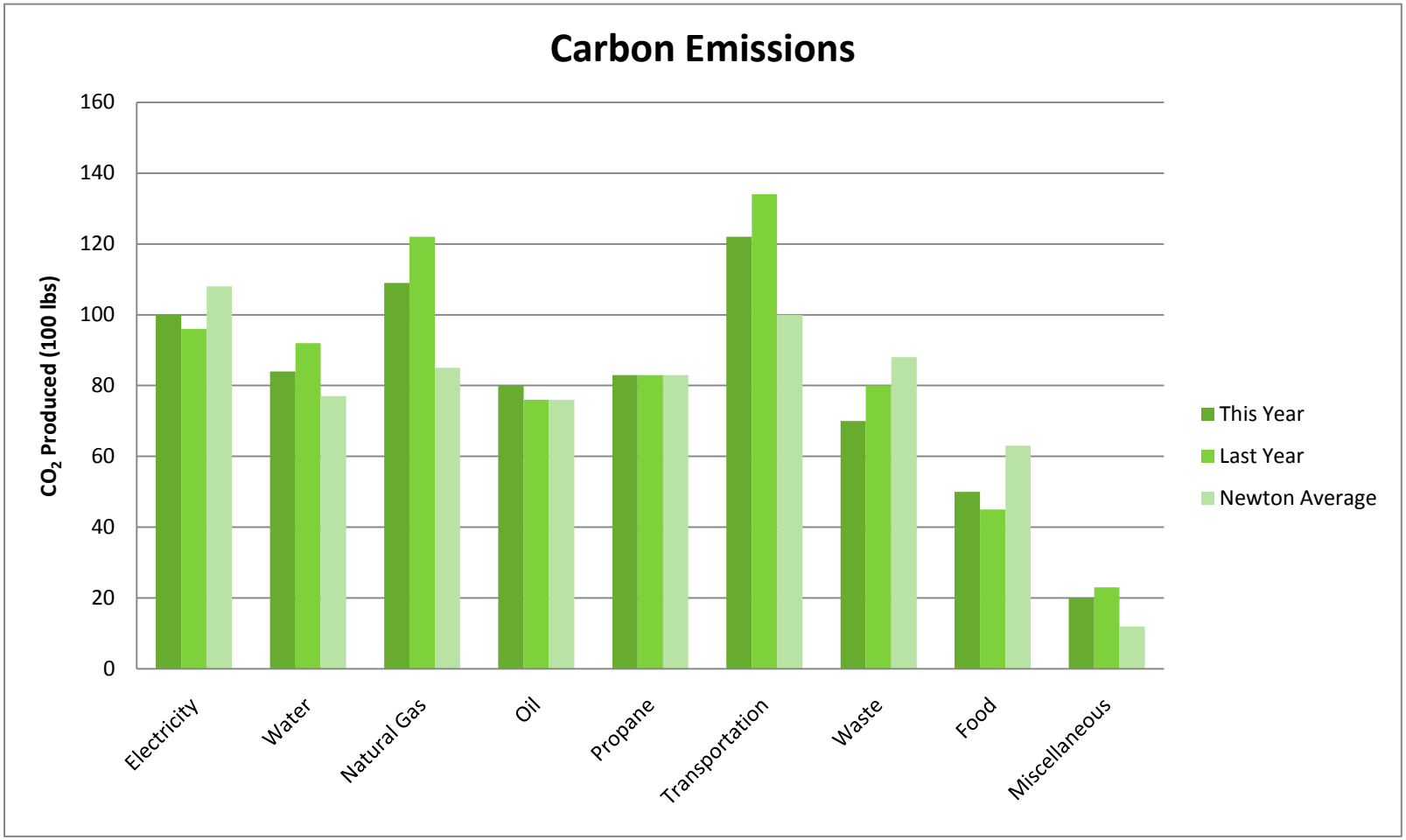
Air Mile Calculator Link: http://www.travelmath.com/flight-distance/


Carbon Calculator
Profile
Household Resource Use
Household Consumption
Household Consumption
Waste
Which trash bin does your household have?
Small (35 Gallons)
Normal (64 Gallons)
How full was your trash bin in a typical week?
Percent
How full was your recycling bin in a typical week?
Percent
Food
About how many 4 ounce servings of each of the following foods does your household consume in a typical week?
Beef
Servings
Pork
Servings
Chicken
Servings
Seafood
Servings
How often does your household buy locally grown foods?
Very Often
Somewhat Often
Not Often
Never
Other
How many newspapers does your household receive in a typical month?
0
How many magazines or catalogs does your household receive in a typical month?
0
How many bottles of water does your household purchase in a typical month?
0
What type of bags does your household use when grocery shopping? (Select All That Apply)
Paper
Plastic
Reusable Bags
Previous Page
Submit

Appendix F – Recommended Results Table

Per Household ▼	This Year			Last Year			Newton Average		
	CO_2 (lbs)	Cost ($)	%	CO_2 (lbs)	Cost ($)	%	CO_2 (lbs)	Cost ($)	%
Electricity									
Water									
Natural Gas									
Heating Oil									
Propane									
Transportation									
Waste		N/A			N/A			N/A	
Food		N/A			N/A			N/A	
Miscellaneous		N/A			N/A			N/A	
Total			100			100			100

Appendix G – Recommended Results Graph



Appendix H – Conversion Factors and Sources

Population and Number of Households in Newton

This information is to help determine what percentage of households the program is reaching as well as to help determine where people stand in comparison to their peers. We were unable to obtain information for 2008 and 2009; however, this information has been estimated from the other data provided. This information comes from both the U.S. Census and the City of Newton. These sources were chosen because they are the most reliable sources available to the public.

- http://quickfacts.census.gov/qfd/states/25/2545560.html
- http://www.ci.newton.ma.us/cdbg/docs/2008-comp-plan.pdf

	Population	Number of Households
2010	83920	32140
2009	83697 (Estimated)	32077 (Estimated)
2008	83481 (Estimated)	32013 (Estimated)
2007	83271	31950
2006	82804	31750
2005	83377	31700

Table 1: Population and Number of Households

Carbon Emissions from Electricity

Each kilowatt-hour of electricity used produces 1.41 pounds of carbon emissions. This information comes from NStar's own carbon emissions calculator. We chose this source because NStar is required to report their carbon emissions to the government and they will know how their electricity is produced.

- http://www.nstaronline.com/residential/home_calculators/carbon_calculator/

Cost Associated with Electricity

Each kilowatt-hour of electricity used currently costs NStar customers $0.0888. This information comes from NStar themselves and we contacted NStar to get historical pricing data going back to 2005. The values shown are the average for the year shown and assume the user does not opt for green energy. The historical pricing information can be found in Table 3.

- http://www.nstaronline.com/residential/rates_tariffs/basic_service.asp
- NStar (customer.service@nstar.com)

Carbon Emissions from Water

Every one hundred cubic feet of water used produces 1.176 pounds of carbon emissions. This information comes from Michael Gilronan, a colleague of Marcel Meth. We were unable to find a more reliable number than Michael had already provided and we believe Michaels data to be reliable.

- Michael Gilronan (gevelber@bu.edu)

Cost Associated with Water

Every one hundred cubic feet of water currently costs Newton residents $4.97. This information comes from the Department of Public Works. We contacted the Department of Public Works for historical pricing information on water going back to 2005 and spoke to Karen Griffey who was very helpful in giving us the information. For more information, contact the Department of Public Works: Water and Sewer Department. The historical pricing information can be found in Table 2.

- Karen Griffey (griffey@newtonma.gov)

Carbon Emissions from Natural Gas

Each therm of natural gas produces 11.02 pounds of carbon emissions. This information comes from NStar's own carbon emissions calculator. We chose this source because NStar is required to report their carbon emissions to the government and they will know how their natural gas is obtained.

- http://www.nstaronline.com/residential/home_calculators/carbon_calculator/

Cost Associated with Natural Gas

Each therm of natural gas currently costs NStar customers $0.7703. This information comes from NStar themselves and we contacted NStar to get historical pricing data going back to 2005. The values shown are the average for the year shown. The historical pricing information can be found in Table 3.

- NStar (customer.service@nstar.com)

Carbon Emissions from Oil

Each gallon of oil burned produces 22.38 pounds of carbon emissions. This information comes from NStar's own carbon emissions calculator. We chose this source because NStar is an energy company and knows the process involved with obtaining various sources of energy.

- http://www.nstaronline.com/residential/home_calculators/carbon_calculator/

Cost Associated with Oil

Each gallon of oil currently costs an average of $2.86. This information comes from the Mass Energy Consumer Alliance website, which has historic oil prices for Massachusetts. We took the average price for each year to provide historical pricing information dating back to 2005. The historical pricing information can be found in Table 3.

- http://www.massenergy.com/oilprices.cfm

Carbon Emissions from Propane

Each gallon of propane produces 12.08 pounds of carbon emissions. This information comes from the EPA. The EPA was chosen because they are the most trustworthy source of emissions information we were able to find.

- http://www.epa.gov/RDEE/energy-resources/refs.html

Cost Associated with Propane

Each gallon of propane currently costs an average of $1.675. This information comes from the Energy Administration Association and is provided as the average cost from Massachusetts for each year dating back to 2005. The historical pricing information can be found in Table 3.

- http://tonto.eia.doe.gov/dnav/pet/pet_pri_wfr_dcus_nus_m.htm

Quick Reference Tables

	CO_2 Produced (Pounds)	Unit of Measure
Electricity	1.41	Kilowatt-Hours
Water	1.176	Hundred Cubic Feet
Natural Gas	11.02	Therms
Oil	22.38	Gallons
Propane	12.08	Gallons

Table 2: Carbon Emissions from Utilities

	Electricity ($ per kWh)	Water ($ per HCF)	Natural Gas ($ per therm)	Oil ($ per gallon)	Propane ($ per gallon)
2010	$0.0888	$4.97	$0.7703	$2.86	$1.675
2009	$0.1096	$5.22	$0.4655	$2.44	$1.877
2008	$0.1186	$4.98	$1.1553	$3.53	$2.042
2007	$0.1135	$4.38	$0.9266	$2.68	$2.389
2006	$0.1083	$4.19	$1.1704	$2.41	$2.026
2005	$0.0715	$4.09	$1.0705	$2.19	$2.261

Table 3: Historical Cost of Utilities

Carbon Emissions from Vehicles

The carbon emissions produced by a vehicle vary depending on the type of fuel it burns. We give these emissions as an inverse proportional model. The source of this information is the U.S. Department of Energy because we believe it to be the most trustworthy source available. To gather the equations you see in table 4 we went to the website shown below and compared vehicles by fuel type from 2005 to 2010. We marked every vehicles fuel economy and carbon footprint as shown on the website and found that the information led us to an inverse equation.

The equations we found are listed in table 4 where X refers to the gas mileage of the car in question. For instance if you were trying to find the carbon emissions from an unleaded vehicle you would use (Y * 24/X) where Y refers to the number of miles the vehicle has driven and X refers to the fuel economy of the vehicle in miles per gallon. It is important to note that unleaded and hybrid use the same type of fuel, which is why the values are the same. We give them as different options because during our interviews, many users wanted to enter hybrid as an option and this helps avoid any possible confusion.

- http://www.fueleconomy.gov/

	CO_2 Produced (Pounds) (Per Mile Traveled)
Unleaded	24/X
Diesel	28/X
Hybrid	24/X
E85	15/X
Electric	60/X

Table 4: Carbon Emissions from Vehicles

Cost Associated with Vehicles

Table 5 lists the historic prices for gasoline in Massachusetts from 2005 to 2010. The prices listed are the average prices for the year shown and 2010 is the average price up to April 1, 2010. This information comes from the Energy Administration Association because it is the most trustworthy source of information we could find.

- http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html

	Gasoline ($ per gallon)
2010	$2.68
2009	$2.31
2008	$3.17
2007	$2.72
2006	$2.57
2005	$2.26

Table 5: Historical Gasoline Costs

Carbon Emissions from Air Travel

Each mile a plane travels produces an average of 244 pounds of carbon emissions. An average passenger plane carries 218 passengers meaning each passenger is responsible for approximately 1.119 pounds of carbon emissions for each air mile traveled. This information comes from a case study done by the Babcock School. The case study's primary source of information was the EPA and took into account the number of departures at different popular airlines as well as the types of planes each airline uses to find the average carbon emissions from a variety of planes.

- http://www.stewartmarion.com/carbon-footprint/html/carbon-footprint-plane.html#casestudy

Carbon Emissions from Food

Table 6 lists the carbon emissions produced per pound of beef, pork, chicken, and seafood. This assumes an average nutrient ratio in the meat because different ratios of fats and proteins can produce different amounts of carbon emissions. Seafood is shown as the average of many types of fish. This information comes from the University of Chicago, whose main source of information was the EPA. We suggest asking users for their food consumption in servings on a weekly basis. As an example, to calculate a final carbon footprint for beef, use the following equation:

((# of servings per week) / 4) * (38.005 pounds of CO_2) * (52 weeks))

- http://geosci.uchicago.edu/~gidon/papers/nutri/nutriEI.pdf

	CO_2 Produced (Pounds) (Per Pound of Meat)
Beef	38.005
Pork	30.702
Chicken	2.338
Seafood	6.040

Table 6: Carbon Emissions from Food

Carbon Emissions from Waste

Each gallon of waste produces 8.417 pounds of carbon emissions. This information comes from Green Progress, a highly regarded energy conservation organization and is the most reliable source we could find for waste. As an example, to calculate the final carbon footprint for a household's waste assuming they have the normal Newton trash container, use the following equation:

((8.417 pounds of CO_2) * (52 weeks) * (64 gallons * X% full))

For instance if they enter their trash bin is 50% full, substitute 0.50 for X% full.

- http://www.greenprogress.com/carbon_footprint_calculator.php

Miscellaneous Carbon Emissions

Each bottle of Fiji brand bottled water produces 1.2 pounds of carbon emissions during production. Each issue of Discover magazine produces 2.1 pounds of carbon emissions during production. A typical newspaper produces 0.384 pounds of carbon emissions during production. These brands were chosen because they were the only brands we could find that did full scientific studies on the carbon footprints that each bottle of water or copy of a magazine produces. We believe these brands represent an average variation of bottled water, or magazines and catalogs and that these numbers could be used to give users a carbon emissions value for these consumption habits.

- (Bottled Water) http://www.treehugger.com/files/2007/02/pablo_calculate.php
- (Magazines) http://discovermagazine.com/2008/may/21-how-big-is-discover.s-carbon-footprint
- (Newspapers) http://teenet.tei.or.th/Knowledge/Paper/carbonfootprintinsupplychain.pdf

Appendix I – Carbon Reduction Strategies

Electricity Reduction Strategies

1. Use the Air-Dry Function on your Dishwasher
2. Replace a 75-watt incandescent light bulb with a 20-watt CFL bulb
3. Enable the Energy Saving Features on your Computer and Monitor
4. Defrost Frozen Foods in the Refrigerator Instead of the Microwave
5. Replace an Old Refrigerator with a New Energy Star Model
6. Purchase Green Energy
7. Reduce your Number of Dryer Loads
8. Remove your Second Refrigerator
9. Turn Lights off when not in Use
10. Unplug Electronics when not in Use

Use the Air-Dry Function on your Dishwasher

CO_2 Saved Annually: 80 – 150 pounds

Money Saved Annually: $6 – $15

Initial Cost: Free

Effort Required: None

Why

By air drying your dishes instead of having them dried with heat, you will cut your dishwasher's energy use anywhere from 15 to 50 percent.

How

If your dishwasher has an air-dry setting, choose it instead of the heat-dry setting whenever you run it. If there's no air-dry setting, turn the dishwasher off after it washes the dishes and open the door to allow the dishes to air-dry. This will dry the dishes without using any extra electricity.

Tips

- If the dishes are still wet after air-drying, open the door and let them sit awhile.
- If you still prefer using the heat-dry setting, open the door afterwards to let the excess heat warm your home.

Sources

- http://www.consumerenergycenter.org/home/appliances/dishwashers.html
- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Replace a 75-watt incandescent light bulb with a 20-watt CFL bulb

CO_2 Saved Annually: 73 pounds per bulb

Money Saved Annually: $7 per bulb

Initial Cost: $3 – $5 per bulb

Effort Required: Low

Why

While compact fluorescent bulbs may cost more at first, they use roughly one fourth the energy and last over 10 times as long. This is partially because they produce 90% less heat while producing more light per watt. Over the life of a CFL bulb you can expect to see over $100 in savings compared to a typical incandescent light bulb.

How

Many stores sell CFL bulbs and they can be found in the same location as typical light bulbs. Simply replace your old incandescent bulbs with CFL bulbs on your most commonly used lamps and lighting. Over time, try to replace every bulb in your home.

Tips

- Start with your most commonly used light sources.
- Replace old bulbs as they burn out.
- Buy bulbs in bulk to save money.

Sources

- http://www.epa.gov
- http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12060

Enable the Energy Saving Features on your Computer and Monitor

CO_2 Saved Annually: 300 – 800 pounds

Money Saved Annually: $20 – $60

Initial Cost: Free

Effort Required: Low

Why

Computers and monitors have built in energy saving functions to dim or turn off the screen and put the computer to sleep when not in use. Using these features puts your devices in a low power state that can be resumed quickly.

How

On laptops you can usually right click on the battery icon in the lower corner of your computer to enter a power management window. On desktops you can type power management into the search bar and enable the sleep function to activate automatically after a certain amount of time.

Tips

- Try replacing using a screensaver with using the sleep function on your device. Resuming from sleep is fairly quick and a screensaver doesn't save you any power.
- Laptops sometimes have the option to enter hibernation as well. Hibernation uses even less power than sleep, but takes slightly longer to resume from.

Sources

- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Defrost Frozen Foods in the Refrigerator Instead of the Microwave

CO_2 Saved Annually: 10 – 30 pounds

Money Saved Annually: $1 – $5

Initial Cost: Free

Effort Required: Low

Why

Microwaves use electricity equivalent to over a dozen light bulbs when running. By using your refrigerator to defrost frozen meat and vegetables you can reduce the amount of time the microwave runs and also thaw your meat more evenly.

How

Simply move frozen foods from your freezer to your refrigerator a day or two before you need them. This will not only save electricity but food may turn out better as well.

Tips

- Make a dinner schedule so you can remember what foods need to be taken out of the freezer and when.
- Try to use already defrosted items if you forget to defrost something the day before.

Sources

- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Replace an Old Refrigerator with a New Energy Star Model

CO_2 saved annually = 435 pounds

Money saved annually = Varies (http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator)

Initial cost = $500 - $1500

Effort required = Medium

Why

Energy Star appliances are rated to by at least 30% more energy efficient than standard appliances. For this reason upgrading an older, energy hogging refrigerator to a newer Energy Star model can save electricity.

How

Go to the store and purchase a newer Energy Star refrigerator. The experts in the appliances department should be able to help you find Energy Star certified models and let you know which models have the best energy efficiency.

Tips

- Many stores will take your old refrigerator away and recycle it when they deliver the new one.

Sources

- http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator
- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Purchase Green Energy

CO_2 Saved Annually: 50% – 100% of your electricity emissions

Money Saved Annually: None

Initial Cost: Free

Effort Required: Low

Why

Electricity production accounts for a large portion of carbon emissions and NStar offers a program for Massachusetts residents to choose green energy. This energy comes from a wind farm in New York which produces virtually zero carbon emissions.

How

Go to NStar's website and enroll in the NStar Green program. This program allows you to choose to have either 50% or 100% of your electricity come from green sources. This is slightly more expensive and can increase your electric bill anywhere from 10% to 20%, however it will greatly reduce your carbon footprint.

Tips

- Use other strategies to reduce your energy usage so your electricity bill can still be reduced.

Sources

- http://www.nstar.com/residential/customer_information/nstar_green/nstar_green.asp

Reduce your Number of Dryer Loads

CO_2 Saved Annually: 350 pounds

Money Saved Annually: $25 – $45

Initial Cost: Free

Effort Required: Low

Why

Clothes dryers use a lot of energy to produce the heat necessary to dry your clothing quickly. By reducing the number of times you use your dryer to dry your clothing you can greatly reduce your energy bills.

How

Instead of using your dryer, place your clothes on a clothesline on a sunny day. Try setting up a clothesline near your furnace or another well heated area that doesn't see much use. Then just place your clothing there for drying instead of dropping them into the dryer.

Tips

- Try doing larger loads of laundry when you can't use a clothesline. This can help reduce the number of dryer loads you do.
- You can try drying your clothes partially in the dryer and then moving them to a clothesline to dry if you aren't ready to fully switch over.

Sources

- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Remove your Second Refrigerator

CO_2 Saved Annually: 2500 – 3500 pounds

Money Saved Annually: $150 – $250

Initial Cost: Free

Effort Required: Medium

Why

Refrigerators are one of the biggest electricity hogs in your home. Having a second refrigerator can double the energy required and may not be entirely necessary.

How

If you have a second refrigerator that you rarely use, think about removing it. There are many companies that can be found online to help remove and recycle these old appliances. If all else fails, try putting it on Craigslist to find it a good home.

Tips

- If you can't go without having a spare refrigerator, think about buying a smaller secondary refrigerator to help give you more space.
- If you don't think you have enough room, try cleaning out your refrigerator and see how much space you really have.

Sources

- http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10040

Turn Lights off when not in Use

CO_2 saved annually = Varies

Money saved annually = Varies

Initial cost = Free

Effort required = Medium

Why

Forgetting to turn off your lights when no one is using them can greatly increase your electricity use. This is a simple way to get some extra electricity reduction without spending any money.

How

Just turn off lights as you leave the room and try to use area lights when you don't need an entire room to be lit. Area lights are lighting sources like table lamps that allow you to read a book or have enough light to see clearly, without using as much energy as a normal light source.

Tips

- Don't forget to use energy efficient bulbs.
- Setup area lighting to further reduce your energy use.
- Try using nightlights if you like to leave a light on at night.

Sources

- None

Unplug Electronics when not in Use

CO_2 Saved Annually: 50 – 200 pounds per device

Money Saved Annually: $5 – $15 per device

Initial Cost: Free

Effort Required: Medium

Why

Estimates say that the energy that many devices draw when they are either off or in standby account for anywhere from 5% to 10% of energy used in a home. Many devices, especially those with power bricks, continue to draw power even when they are turned off. Some newer televisions and cable boxes never actually turn off, but instead enter a low power standby state.

How

By unplugging electronics instead of just turning them off you can avoid this "phantom power draw". This can be easier if you plug electronics into a power strip and then just flip the switch on the power strip when the devices aren't in use.

Tips

- Focus on devices with power bricks. Power bricks are large blocks attached to the cords a device uses. If this brick is warm, it's a sure sign that it's drawing power even when the device is off.
- Unplug cell phone and laptop charges when the device is fully charged.
- Some newer power strips can sense when devices are off and automatically turn off that outlet for you. Think about investing in this technology.

Sources

- http://standby.lbl.gov/ACEEE/StandbyPaper.pdf

Heating Reduction Strategies

1. Purchase an Energy-Efficient Water Heater
2. Replace Your Windows with Energy-Efficient Models
3. Seal Air Leaks and Insulate Your Home
4. Turn Down the Heating Thermostat
5. Tune Up your Furnace
6. Turn Down your Water Heater
7. Wrap your Hot Water Heater
8. Insulate your Heating Ducts

Purchase an Energy-Efficient Water Heater

CO_2 Saved Annually: 300 – 4000 pounds

Money Saved Annually: $200 – $400

Initial Cost: $150 – $1200

Effort Required: Medium

Why

Using a tankless water heater heats water as it is forced through it. Energy is saved because you only heat as much water as you need. This saves energy by not having to keep water in a tank hot. Water in the tank can lose heat, and more energy will be used to heat the water up again. Solar hot water use solar power to heat your water.

How

If you have an old water heater, consider purchasing a new, energy-efficient model. Both tankless water heaters and solar heaters are good options.

Tips

- A tankless hot water heater also provides a constant stream of hot water. No more running out of hot water!
- Solar water heaters rely on a back up heater in case of cloudy days, so you don't have to worry about not being able to generate hot water.
- The average life span for a solar water heater is 20 years, which is much longer than the average gas or electric heater.
- You can also receive Federal tax credit of up to 30% of the cost of your solar heater. For more information, go to: http://www.energystar.gov/index.cfm?c=tax_credits.tx_index.

Sources

- http://www.stopglobalwarming.org/sgw_actionitems.asp
- http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits

Replace Your Windows with Energy-Efficient Models

CO_2 Saved Annually: 1000 pounds

Money Saved Annually: $100 – $400

Initial Cost: $300 – $500 per window

Effort Required: High

Why

As much as half of energy used in your house can go into heating your home. Energy-efficient windows insulate your home and keep the heat inside your house.

How

When replacing windows, choose energy-efficient models. When choosing the model of window, look for models with the lowest U-factor value. The lower the U-factor, the more insulated the windows are.

Tips

- You can apply for tax credit of up to 30% for new windows and doors. Visit http://energystar.custhelp.com/cgi-bin/energystar.cfg/php/enduser/std_adp.php?p_faqid=5760&p_created=1241110856 for more information.
- You can also use window treatments and coverings for the windows you are not replacing. For more information, visit http://www.energysavers.gov/your_home/windows_doors_skylights/index.cfm/mytopic=13500

Sources

- http://www.edf.org/article.cfm?contentID=3998
- http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=WI

Seal Air Leaks and Insulate Your Home

CO_2 Saved Annually: 2000 pounds

Money Saved Annually: $125

Initial Cost: $100 – $1200

Effort Required: Moderate

Why

Air leaks can account for as much as 40% of heat loss in the winter. By sealing and insulating your home, you can reduce the amount of energy required to heat your home by up to 20%, which in turn will save you money on your heating bill and reduce the amount of CO_2 produced from heat production.

How

Air leaks in your home are easy enough to identify by finding the drafts caused by air entering your home. Most air leaks can be sealed using caulking on the inside of your home, or weather stripping on the outside. If you attic is accessible, consider applying insulation. For more information on sealing and insulating, consider reading the Do-it-yourself sealing and insulating guide provided by Energy Star: http://www.energystar.gov/index.cfm?c=diy.diy_index

Tips

- Check around windows and doors for easy to find air leaks.
- Don't worry about all of the small air leaks. Your greatest savings will come from sealing the larger holes.
- Check the above-ground area where the basement/foundation meets the house for significant leaks.

Sources

- http://www.edf.org/article.cfm?contentID=3998
- http://www.energystar.gov/index.cfm?c=diy.diy_index

Turn Down the Heating Thermostat

CO_2 Saved Annually: 350 pounds per 2 degrees Fahrenheit

Money Saved Annually: $20 per 2 degrees Fahrenheit

Initial Cost: Free

Effort Required: None

Why

Turning down your thermostat while you are home, and even more so while you are away or asleep, is an easy way to see quick savings in your heating bills.

How

Try turning down your thermostat to a comfortable temperature of 65-68 degrees while you are awake, and 55-58 degrees while you are asleep or at work.

Tips

- A little chilly? Try wearing a sweater or adding an extra blanket to your bed rather than turning up the thermostat.
- Consider investing in a programmable thermostat to establish a heating schedule (initial cost = $30-$100).
- Try reducing the thermostat temperature by 1 degree at a time, and trying that for a week to get accustomed to the cooler temperature.

Sources

- http://www.edf.org/article.cfm?contentID=3998
- Gershon, D. (2006). *Low carbon diet.* Woodstock, NY: Empowerment Institute.

Tune Up your Furnace

CO_2 Saved Annually: 350 pounds

Money Saved Annually: $20

Initial Cost: $0 – $100

Effort Required: Medium

Why

Much like your car, your furnace needs a tune-up in order to continue to run efficiently. The less efficient your furnace is running, the greater amount of fuel it requires to heat your home. Tune ups can increase your furnace efficiency by as much as 15%.

How

Contact a service professional to perform tune-ups on your furnace every couple years. You can perform annual maintenance on your furnace yourself, such as replacing the filter, replacing the blower belt, and cleaning the motor. Altering a combustible system is strongly recommended against.

Tips

- For more ways to maintain your furnace yourself, visit http://www.state.mn.us/portal/mn/jsp/content.do?subchannel=-536895037&programid=536917251&sc2=-536895038&id=-536893808&agency=Energy.
- If you want to replace your old furnace, you can get up to 30% tax credit for Energy Star models. Go to http://energystar.custhelp.com/cgi-bin/energystar.cfg/php/enduser/std_adp.php?p_faqid=5786 for more details.

Sources

- http://www.edf.org/article.cfm?contentID=3998
- http://www.doityourself.com/stry/furnacetuneup

Turn Down your Water Heater

CO_2 Saved Annually: 200 pounds

Money Saved Annually: $10

Initial Cost: Free

Effort Required: Medium

Why

Heating the water in your house up to the standard 140 degrees uses extra energy, while water temperatures of over 120 degrees are too hot for average use anyway. By turning the thermostat on the water heater down, you will be reducing the amount of energy used to keep your water hot. For every 10 degrees you turn down your water heater, you can save between 3% and 5% off of your energy bill.

How

Consult your water heater's handbook to learn how to properly turn down the thermostat. Locate the thermostat, and turn the temperature down to 120 degrees. On thermostats without numbers, 120 is usually between Low and Medium.

Tips

- Try turning the thermostat down gradually in order to find a comfortable temperature for you and your family.
- Turning down your hot water heater to 120 degrees can also reduce the amount of mineral buildup and corrosion, which can lengthen the life of your water heater.
- If your dishwasher does not have a water heater booster, you may want to keep your thermostat around 130 degrees.

Sources

- http://www.edf.org/article.cfm?contentID=3998
- http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13090

Wrap your Hot Water Heater

CO_2 Saved Annually: 250 pounds

Money Saved Annually: $15

Initial Cost: $10 – $20

Effort Required: Low

Why

Heat from hot water stored in your water heater tank can be lost through the sides of your tank. A simple water heater blanket wrap can reduce standby heat loss by up to 45%. This reduction of heat loss can save you 4-9% in water heating costs.

How

To wrap your hot water heater, simply purchase a precut blanket wrap and follow the instructions provided. Make sure to leave the thermostat access panel uncovered.

Tips

- If wrapping a gas-powered water heater, it is recommended that you contact a professional.
- Try also installing insulation underneath the water heater to prevent heat escaping into the floor. This can further improve energy savings.

Sources

- http://www.edf.org/article.cfm?contentID=3998
- http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13070

Insulate your Heating Ducts

CO_2 Saved Annually: 300 – 500 pounds

Money Saved Annually: $200 – $600

Initial Cost: $20 – $50

Effort Required: High

Why

Heat loss from heat ducts can account for 15-30% of heat production. By insulating the heating ducts, you can greatly reduce the amount of heat loss from your ducts. Well insulated heating ducts can increase the efficiency of your furnace by 20%.

How

To look for leaks in the ducts, turn on the heat and observe the joints. Seal any joints with mastic or metallic tape; do not use duct tape to seal leaks. Seal any places where the ducts penetrate the floor with sealing foam. Insulate your heating ducts with insulation with at least a value of R-6.

Tips

- For more information on insulating your heating ducts, go to http://www.energystar.gov/ia/partners/publications/pubdocs/DIY_Guide_May_2008.pdf

Sources

- http://www.builditsolar.com/References/Half/ProjectsConservation.htm
- http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11500

Water Reduction Strategies

1. Turn the Water off when you Brush your Teeth
2. Buy an Energy Efficient Clothes Washer
3. Go to the Car Wash Instead of Washing your Car Yourself
4. Hand Wash your Dishes
5. Reduce your Shower Time
6. Replace your Shower Head with a Low Flow Fixture
7. Take a Shower Instead of a Bath

Turn the Water off when you Brush your Teeth

CO_2 Saved Annually: 5 pounds

Money Saved Annually: $23

Initial Cost: Free

Effort Required: None

Why

The average household sink flows at about 2 gallons per minute. By turning off the faucet while you brush your teeth you can save up to 8 gallons a day.

How

Only turn the water on to wet your toothbrush, and then turn it off.

Tips

- Use the same strategy when washing your hands, face, and shaving.
- Keep a glass of water next to the sink to rinse your mouth with.

Sources

- http://www.epa.gov/watersense/water_efficiency/what_you_can_do.html#full

Buy an Energy Efficient Clothes Washer

CO_2 Saved Annually: 3 pounds

Money Saved Annually: $11

Initial Cost: $550 – $2000

Effort Required: Medium

Why

Typical electric clothes washers generate 2.5 lbs of CO_2 and 41 gallons of water per cycle. An energy efficient clothes washer may cost you more money than a regular washer up front but will save you money in utility bills. These machines save on both water and energy usage; on average about 1lb of CO_2 is saved with an energy efficient washer along with 13 gallons of water.

How

Purchase an energy efficient clothes washer from your local appliance store. Most stores will deliver and set up the machine for you.

Tips

- Wash your clothes in cold water; a hot water wash with warm rinse can cost 5 to 10 times more than a cold water wash and rinse.
- A front loading washer uses less water than a top loading washer because it doesn't need to fill the whole tub and reduces the amount of water used in each load by about 50%.
- Instead of doing small loads of laundry frequently, wait until the load is bigger, reducing the amount of loads and water used.

Sources

- *Low Carbon Diet*
- http://www.aceee.org/Consumerguide/laundry.htm
- http://www.epa.gov/watersense/water_efficiency/what_you_can_do.html#full

Go to the Car Wash Instead of Washing your Car Yourself

CO_2 Saved Annually: 9 pounds

Money Saved Annually: $45

Initial Cost: $8 – $30

Effort Required: Low

Why

A car wash typically uses about 32 gallons of water per vehicle, but it is estimated that washing your car yourself can use up to 500 gallons of water.

How

Drive your car to the local car wash.

Tips

- Waxing your car can preserve the finish as well as repelling dangerous contaminants, meaning you won't have to wash it as often.
- Make going to the car wash part of your weekly/monthly routine; get in the habit of stopping by on your way home from work.

Sources

- http://www.aboutmyplanet.com/environment/reduce-water-money/

Hand Wash your Dishes

CO_2 Saved Annually: 5 pounds

Money Saved Annually: $25

Initial Cost: Free

Effort Required: Medium

Why

Each dishwasher cycle produces about 2 lbs of CO_2. Inefficiently hand washing dishes can use up to 15 gallons of water per wash. Efficiently hand washing dishes can save on both electrical and water bills.

How

Fill two tubs; one with soap for washing and another with just water for rinsing. Dry your dishes with a cloth after or put them in a drying rack.

Tips

- Use clean recycled water collected from waiting for your shower to heat to fill the tubs.
- Cold water cleans just as well as hot water does, and doesn't use as much energy to heat.
- Put on music to make dish washing more fun.
- An assembly line will help get it done quicker. Have one person scraping the food off, one person washing the dishes, one person drying the dishes, and one person putting them away.

Sources

- *Low Carbon Diet*
- http://housekeeping.about.com/od/dishes/a/dishwashfun5.htm

Reduce your Shower Time

CO_2 Saved Annually: 3 pounds per minute reduced

Money Saved Annually: $12 per minute reduced

Initial Cost: Free

Effort Required: Medium

Why

Reducing your shower time saves water and saves you money.

How

Try reducing your shower time a little more each day to make the transition easier.

Tips

- Put a timer in your bathroom and set it a few second shorter each day.
- Wash your hair in the sink.
- While waiting for the water to get hot, collect the water and reuse it for other things (watering plants, washing dishes …).

Sources

- http://www.epa.gov
- http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13050

Replace your Shower Head with a Low Flow Fixture

CO_2 Saved Annually: 5 pounds

Money Saved Annually: $22

Initial Cost: $10 – $20

Effort Required: Low

Why

Replacing your shower head saves water which in turn saves you money. Using a low flow fixture gives a water savings of 25%-60%. Although the fixture itself will cost money at first, you will very quickly see that and more in savings on your water bill.

How

Purchase a low flow fixture at your local appliance store. Take off the existing shower head and install the new one. If you cannot do this on your own, ask an appliance store employee for advice.

Tips

- Pick a shower head with a flow rate less than 2.5 gpm for maximum efficiency.
- If you're in a humid climate, buy a laminar-flow low flow shower head because it won't create as much steam.

Sources

- http://www.epa.gov
- http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13050

Take a Shower Instead of a Bath

CO_2 Saved Annually: 35 pounds

Money Saved Annually: $171

Initial Cost: Free

Effort Required: Low

Why

An average bath uses 70 gallons of water, but a 5 minute shower only uses between 10 and 25 gallons.

How

Instead of taking a bath, take a shower.

Tips

- If you need to take a bath, put the stopper in immediately and adjust the temperature as you fill the tub.

Sources

- http://www.epa.gov/watersense/water_efficiency/what_you_can_do.html#full

Transportation Reduction Strategies

1. Avoid Flying when Possible
2. Purchase a Fuel Efficient Vehicle
3. Keep your Car well Maintained
4. Drive at a Fuel Efficient Speed
5. Reduce Vehicle Miles Driven
6. Take Public Transportation
7. Turn off your Vehicle while Idling

Avoid Flying when Possible

CO_2 Saved Annually: 1 – 4 pounds per air mile

Money Saved Annually: Varies

Initial Cost: None

Effort Required: Medium

Why

By flying you produce twice as much carbon emissions than you would if you drove. This impact is even greater if you consider how much carbon you could have saved by taking a train or bus.

How

Drive, take a train, or take a bus, there are dozens of ways to get around the country that don't require flight. These other methods may even save you money compared to flying, although they may take longer.

Tips

- Do a quick search online for alternate transportation options to different locations around the country.
- If you can't avoid flying try to pack lightly. The added weight increases the fuel consumption of the plane and increases carbon emissions.

Sources

- http://www.fueleconomy.gov/
- http://www.stewartmarion.com/carbon-footprint/html/carbon-footprint-plane.html#casestudy

Purchase a Fuel Efficient Vehicle

CO_2 Saved Annually: Varies

Money Saved Annually: Varies

Initial Cost: $10,000 – $100,000

Effort Required: High

Why

Newer vehicles and especially hybrid and electric vehicles have vastly improved gas mileage compared to older models. Even cars that use diesel fuel have superior gas mileage and also produce less carbon emissions per gallon.

How

Head out to a car dealership and purchase a vehicle with the highest fuel efficiency you can find. Think about going for a hybrid or electric car as they have far superior gas mileage to a normal vehicle. Many newer electric vehicles don't use gasoline at all for the first 40 miles or so traveled after a charge and this can greatly reduce your carbon footprint.

Tips

- With increasing gasoline costs this could also save you money in the long run, especially if you were planning to buy a new vehicle anyway.
- Check manufacturer's websites for specific fuel economy values for each vehicle.

Sources

- http://www.eia.doe.gov/
- http://www.fueleconomy.gov/

Keep your Car well Maintained

CO_2 Saved Annually: 500 – 1500 pounds

Money Saved Annually: $30 – $150

Initial Cost: Varies

Effort Required: High

Why

A car needs to be well maintained to operate at its highest efficiency. By keeping your car well maintained you can improve fuel efficiency by as much as 10% and if something was seriously wrong with your car it could improve by as much as 40%.

How

Have your car inspected, keep your tire pressure at recommended levels, and use the recommended grade of motor oil in your vehicle. You can expect to improve your fuel efficiency from 2% – 4% from each of these precautionary measures.

Tips

- Despite common belief, replacing a dirty air filter will not improve fuel efficiency; it will however improve your acceleration.
- Check your cars manual for the suggested tire pressure and grade of motor oil.

Sources

- http://www.fueleconomy.gov/Feg/maintain.shtml

Drive at a Fuel Efficient Speed

CO_2 Saved Annually: Varies

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Low

Why

Highway driving may increase fuel economy in most vehicles; however driving too fast can vastly reduce your car's miles per gallon.

How

55 miles per hour is considered to be the speed where fuel economy starts to diminish. Every 10 miles per hour you drive faster than that can reduce your car's miles per gallon by as much as 15%. Try to keep your speed at or around 55 when driving on highways and stick to the speed limit at all times.

Tips

- Try avoiding highways where you know drivers tend to travel faster than the posted limits.
- Check your speedometer occasionally and try to get in the habit of driving a little slower.

Sources

- http://blogs.consumerreports.org/cars/2009/09/tested-speed-vs-fuel-economy.html

Reduce Vehicle Miles Driven

CO_2 Saved Annually: 1 – 2 pounds per mile

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Medium

Why

Carbon is emitted into the atmosphere with every mile you drive. By reducing the amount of miles you drive overall you can easily reduce your carbon emissions and save money while doing so.

How

Carpool, consolidate trips to the store, go to stores near each other, and try to stop at places on your way home from work. There are hundreds of ways to reduce how many miles you drive. Choose the methods easiest for you and your family and enjoy the money you save on fuel.

Tips

- Try public transportation if you live near the T or Commuter Rail.
- See if anyone at your work comes from the same area and try to arrange a carpool each day. Taking turns carpooling is an easy way to save money and the planet.
- Walk short distances and try riding a bike to nearby stores.

Sources

- http://www.eia.doe.gov/
- http://www.fueleconomy.gov/

Take Public Transportation

CO_2 Saved Annually: 1 – 2 pounds for every mile you travel

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Medium

Why

Public transportation always runs, whether you take it or not. Because of this the carbon emissions emitted from the T and Commuter Rail are always happening. By taking public transportation you avoid emitting carbon from driving, carpooling, or even flying.

How

Ride the T, take the Commuter Rail, or even take the bus around town when you can. Think of public transportation as a giant carpool that can save you money and carbon.

Tips

- Buying weekly or monthly passes can save you money and can be shared among your family for further savings.
- Google Maps allows you to route directions using public transportation. Simply click Maps – Get Directions – and then select By Public Transit from the dropdown menu.

Sources

- http://www.eia.doe.gov/
- http://www.fueleconomy.gov/

Turn off your Vehicle while Idling

CO_2 Saved Annually: 150 – 400 pounds

Money Saved Annually: $20 – $50

Initial Cost: Free

Effort Required: Medium

Why

Cars waste gas even when they aren't moving. This includes while stopped at lights, while waiting in parking lots, while standing at the drive-thru, and while idling in the driveway. Today's cars use fuel injectors to start the engine, so the amount of fuel required to start the car is negligible compared to the amount wasted from idling.

How

A general rule is that if you will be idling for more than 10 seconds it is a good idea to turn off the car instead. If you can manage to cut back on 10 minutes of idling each day, you can save as much as ten gallons of fuel over the course of a year.

Tips

- Some newer cars, such as the Toyota Prius, automatically cut power to the engine while idling.
- Restarting a six-cylinder engine uses the same amount of gas as idling a car for six just seconds.

Sources

- http://www.slate.com/id/2192187/

Miscellaneous Reduction Strategies

1. Buy Locally Grown Food
2. Cancel Unnecessary Paper Subscriptions
3. Compost
4. Eat Greener
5. Recycle
6. Reduce Bottled Water Consumption
7. Use Reusable Grocery Bags When Shopping

Buy Locally Grown Food

CO_2 Saved Annually: Varies

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Low

Why

To bring food to grocery stores, food is shipped 1,500 miles on average. Transportation of all of this food creates a lot of CO_2. Production and packaging of bulk food also produces a lot of CO_2 as well. Locally grown food does not have to be shipped, processed, or packaged in factories.

How

Visit farmers' markets or farm stands to buy locally grown food. You can also take part in Newton's Community Sponsored Agriculture (CSA) to receive locally grown food for 20 weeks of the year.

Tips

- Visit http://newtoncommunityfarm.org/produce for more information about locally grown foods, farm stands, and CSA's.

Sources

- http://newtoncommunityfarm.org/produce/csa/
- http://www.sustainabletable.org/issues/whybuylocal/

Cancel Unnecessary Paper Subscriptions

CO_2 Saved Annually: 25 pounds per monthly magazine

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Low

Why

Production of magazines, newspapers, catalogs, and junk mail create a large amount of CO_2. Not only are trees consumed, ink must be produced, the magazine needs to be printed and manufactured, and the magazine also needs to be shipped across the country.

How

Contact the provider of your magazine or newspaper to cancel your subscription. Almost every magazine, catalog, and newspaper is available online.

Tips

- Most providers also offer a discount for online subscriptions. Newspapers are also typically free online, as are catalogs.
- To reduce your junk mail, try visiting http://www.directmail.com/directory/mail_preference/ to be put on the Do Not Mail list.

Sources

- http://www.directmail.com/directory/mail_preference/

Compost

CO_2 Saved Annually: 8 pounds per gallon of waste composted

Money Saved Annually: None

Initial Cost: Free

Effort Required: Low

Why

Incineration of waste produces a large amount of CO_2. Composting organic materials cuts down on the amount of garbage that needs to be incinerated.

How

Create a compost bin outside to compost your organic materials. You can compost things like fruits, vegetables, paper, and other organic waste.

Tips

- For a more comprehensive list of what you can and cannot compost, check out: http://compostinstructions.com/what-you-can-and-cannot-compost/
- Composting can also improve the quality of your soil. Composted organic waste is full of nutrients.

Sources

- http://compostinstructions.com/

Eat Greener

CO_2 Saved Annually: Varies

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Low

Why

The production of beef and pork produce significantly greater amounts of CO_2 than chicken or vegetables.

How

Replace beef or pork dishes with vegetarian or chicken dishes.

Tips

- Try starting by replacing two or three meals a week with chicken vegetarian meals.
- For every pound of beef you replace with vegetables, you save over 35 pounds of CO_2.

Sources

- http://geosci.uchicago.edu/~gidon/papers/nutri/nutriEI.pdf

Recycle

CO_2 Saved Annually: 8 pounds per gallon of garbage recycled

Money Saved Annually: None

Initial Cost: Free

Effort Required: Low

Why

About 80% of America's waste is recyclable. Recycling materials reduces the amount of raw materials required to produce new products.

How

Simply place all of your paper products and recyclable containers into your green recycling cart. Take note of what not to include in your recycling cart on the Newton website here: http://www.ci.newton.ma.us/DPW/recycling/ittakestwo/singlestream.html.

Tips

- Keep a small recycling bin in the house to help separate the garbage and recycling.
- Return plastic shopping bags to grocery stores to recycle them.

Sources

- http://www.ecocycle.org/tidbits/
- http://www.ci.newton.ma.us/DPW/recycling/ittakestwo/singlestream.html
- http://www.greenprogress.com/carbon_footprint_calculator.php

Reduce Bottled Water Consumption

CO_2 Saved Annually: 35 pounds per 30 pack of bottled water

Money Saved Annually: Varies

Initial Cost: Free

Effort Required: Low

Why

Production of bottled water uses a very large amount of resources. To produce and fill an average bottle of water, around 1.2 pounds of CO_2 are produced, a quarter of a gallon of fuel is used, and for every gallon of water bottled, almost seven gallons are used.

How

Reduce or eliminate your consumption of bottled water. Utilize a reusable water bottle, such as a Nalgene, to drink tap water instead of bottled water.

Tips

- If you must use a disposable water bottle, refill it and use it more than once.
- Tap water actually has stricter requirements by the EPA than bottled water does by the FDA.

Sources

- http://www.treehugger.com/files/2007/02/pablo_calculate.php
- http://www.ehso.com/ehshome/DrWater/drinkingwater.php#TABLE1

Use Reusable Grocery Bags When Shopping

CO_2 Saved Annually: Varies

Money Saved Annually: None

Initial Cost: $1 per bag

Effort Required: Low

Why

Both paper and plastic grocery bags require materials and energy to produce. Recycling grocery bags still uses energy and materials. By using reusable bags, you reduce the amount of grocery bags that need to be manufactured, which in turn reduces the amount of materials and energy consumed.

How

Simply purchase reusable grocery bags at your local grocery store and bring them with you every time you go to the store.

Tips

- Keep the bags in your car so that you will not forget them at home when you shop.
- Some stores, such as Stop & Shop, offer reduction to your bill for bringing reusable bags.

Sources

- http://www.greenprogress.com/carbon_footprint_calculator.php
- http://www.reusablebags.com/facts.php?id=7

Appendix J – Summative Team Assessment

While working together as a team for the past fourteen weeks, our group has learned successful methods to improve our effectiveness as a team, as well as identified areas in which to improve. We have identified guidelines to follow to work successfully as a team. These guidelines include being respectful of each other's work and offering constructive criticism. After receiving feedback on drafts, we went through the drafts together as a team and offered our own feedback expanding on the comments provided by the advisors.

We regularly have group discussions to talk about our progress as a team, as well as any new ideas that each of us may have. We assess these ideas and determine ways to move forward as a group. For example, Justin suggested a method to keep us on track on a daily basis. At the end of each workday, we meet together and discuss what needs to be completed the following day. This idea originally started as having a goal for the next day, however, the group expanded the idea to consist of an agenda for each workday. The agenda consists of tasks for each member as well as the entire group.

By responding to the conflicts within our group, we have become a stronger team. Our process in resolving conflict is to identify the problem, assess possible viewpoints, determine a solution, and take the appropriate action. For example, when creating a survey to gather information about motivational tools, Colleen wanted to create an email-based survey, which included all of the questions directly in the email. Bryan, however, insisted that we use an online service such as Survey Monkey. After assessing the pros and cons of each option, we determined that Survey Monkey was a more beneficial method for providing surveys. We then acted on this solution by creating a web survey using Survey Monkey.

Our team communicates well when faced with challenges, and seeks assistance from the advisors, as well as each other, when necessary. At the beginning of the term, we faced the challenge of redefining our project goals. Faced with many options, we met as a group and then with the advisors to discuss the best possible course of action to take. We then refocused our efforts on establishing a new set of background information and methodology for the project. We created a revised work schedule to reflect these changes and to help us stay on track with our limited timeframe.

We have also identified ways in which to improve our own teamwork in the future. For example, we will be sure to work to define clear project goals from the very beginning. Throughout the term, as the report was written, we redefined our goals many times. This change can be viewed through the different changes in definition throughout the paper. We will make sure when changing any project goals that we are all on the same page. After fourteen weeks of collaboration, we have improved ourselves and our team and will use what we have learned in our future endeavors.