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**Executive Summary**

Scientific evidence strongly suggests that the buildup of greenhouse gases in the atmosphere from anthropogenic sources is raising the earth’s temperature and changing the earth's climate - both have many potentially serious consequences. In Massachusetts the average temperature has increased by 2% over the past century and precipitation levels have risen by up to 20% in many regions of the Commonwealth. This trend is expected to continue through the this century with an expected four degrees Fahrenheit increase in winter and spring temperatures and 5 degree F in the summer and fall. Sea levels in Boston have risen 11 inches in the last century and this trend is expected to accelerate. More frequent heavy storm events are expected to bring an increase in rain and snowfall. Changes in weather patterns will affect our water resources including increased flooding in spring, water scarcity in summer and greater threats to water quality. Natural habitats and resources such as forest, fisheries, and agricultural lands will face increased stresses.

The greenhouse gas emissions inventory report will summarize the anthropogenic greenhouse gas emissions for the town of Falmouth (year 2000 for the community analysis and fiscal year 2001 for municipal analysis). It is the first step in the Town of Falmouth’s efforts to address global warming at the local level. In April of 2002, Falmouth chose to join Cities for Climate Protection Campaign, a program of the International Council of Local Environmental Initiatives (ICLEI). The inventory is the first of five milestones in the program. The purpose of completing an inventory of anthropogenic greenhouse gas emissions is twofold: first, to better understand the sources of emissions and second, to initiate the process of reducing them. By first knowing the sources of greenhouse gas emissions, Falmouth will be better equipped to strategically and cost-effectively reduce emissions.

**Inventory Results**

The greenhouse gas (GHG) inventory measured emissions based in two separate studies. The first was a measure of all emissions from the Falmouth residential and commercial community. The second level of the inventory investigated the emissions from municipal government operations. The emission levels of greenhouse gases are expressed in equivalent carbon dioxide (eCO$_2$) levels.

In 2000, the community's greenhouse gas emissions totaled 630,910 tons of eCO$_2$ (Figure 1). Transportation energy use accounted for 39% and residential household energy use accounted for 31% of the communities’ emissions. The other large contribution came from the commercial, which provides 28% of the town's emissions. Energy for transportation (gasoline alone) was the largest overall source of eCO$_2$. Electricity and natural gas produced large quantities of eCO$_2$ after gasoline (176,259 tons and 125,877 tons eCO$_2$ respectively).

![Community eCO2 Emissions by sector](image)

*Figure 1*
In FY 2001 the Town of Falmouth generated 12,370 tons of eCO\textsubscript{2}, 60\% of which came from building energy use (Figure 2). ECO\textsubscript{2} emitted by the 7 public schools accounted for over 76\% of the total eCO\textsubscript{2} in this sector. The municipal water/sewage, vehicle fleet, and streetlights/traffic lights accounted for 19\%, 14\%, and 6\% respectively, of the remaining emissions. The total cost of energy for municipal operations was $1,903,211.

![Municipal eCO\textsubscript{2} by Sector](image)

**The Next Steps**

The next step for the Town of Falmouth is to set a target and draft a Climate Protection Action Plan. The Action Plan is a proposal for how the Town can take a leadership role in the community towards reducing energy use and greenhouse gas emissions in Falmouth. This document will be written with the input of multiple departments within Town Hall, Energy Committee, and community members.

The municipal operations currently account for just fewer than 2\% of the community's total eCO\textsubscript{2} emissions. Measures taken to increase energy efficiency within Town operations will have a measurable impact of these emissions and a clear cost savings benefit. At the same time, the Town can also promote community wide programs to reduce energy consumption and emissions. Behavior modification is an example of an action that can be taken today. The Falmouth Public Schools saved over 110,000 dollars in a behavior modification program in the year 2001. Technology also provides many opportunities to increase electrical, heating, and transportation efficiency. Policies can shift energy sources towards cleaner burning fuels and renewable energy. Finally, other types of behavior changes such as vehicle use, material purchasing and waste disposal will also be needed to reach the Town's emission reduction goal.

Behavior modification is a prime example of a cost effective solution to reduce greenhouse gas emissions that potentially requires no initial investment. Education and outreach are also low cost, or no cost methods to conserve energy. These are actions that Falmouth can take immediately. The next step for Falmouth is to seek other opportunities that are cost-effective, efficient, and reduce emissions. Many solutions like retrofitting buildings, changing lighting, heating, and changing vehicle purchasing policies easily fit this description without making any sort of lifestyle changes or sacrifices. There is great potential for Falmouth to reduce emissions, cut energy costs and be a leader on this initiative.
Climate Change

Scientific evidence strongly suggests that the buildup of greenhouse gases in the atmosphere from anthropogenic sources is raising the earth's temperature and changing the earth's climate - both have many potentially serious consequences. The atmosphere of Earth is a delicate balance of gases that maintain our climate. Carbon dioxide (CO$_2$), methane (CH$_4$), and other greenhouse gases (GHGs) are necessary to maintain our climatic conditions, but human growth, technology and transportation dependence, energy consumption, waste generation, and other anthropogenic actions have begun to disrupt this balance. Similar to a greenhouse, CO$_2$ and other GHGs let sunshine through, but prevent the heat from the earth to escape (see figure 1). When these gases build up, and the balance is upset, too much heat is trapped, and we have too much global warming, which leads to climate change.

The two major contributors to global warming and climate change are CO$_2$ and CH$_4$, which are produced from the combustion of fossil fuels (coal, oil, gas) in vehicles, industrial boilers, generation of waste, and other human activities. Concentration of GHGs, especially CO$_2$, has increased substantially since the beginning of the industrial revolution.

Figure 1: The Greenhouse Effect

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1 Other GHGs include methane (CH$_4$), nitrous oxides (NO$_x$), and hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF$_6$)
**Impacts**

The scientific findings that the earth is warming are no longer controversial. The Intergovernmental Panel on Climate Change (IPCC) estimates that global temperatures will rise and concluded “most of the warming observed over the last 50 years is attributable to human activity.”² The U.S. Environmental Protection Agency, NASA, and the National Oceanic and Atmospheric Administration all agree that the climate is changing as a result of human activities.

In Massachusetts the average temperature has increased by 2% over the past century and precipitation levels have risen by up to 20% in many regions of the Commonwealth. This trend is expected to continue through the next century with an expected four degrees F increase in winter and the spring and 5 degree F in the summer and fall. Increased heat waves will elevate heat-related deaths particularly in urban areas such as Boston. Ground level ozone level will rise, reducing air quality in the Boston area. The Massachusetts human population will likely face a combination of elevated populations of disease carrying insects such as mosquito and ticks, with growing range of infectious diseases usually found in tropic areas, such as encephalitis and malaria.³

Sea levels in Boston have risen 11 inches in the last century and this trend is expected to accelerate. More frequent heavy storm events are expected to bring an increase in rain and snowfall. Changes in weather patterns will affect our water resources including increased flooding in spring, water scarcity in summer and greater threats to water quality. Natural habitats and resources such as forest, fisheries, and agricultural lands will face increased stresses.

Global climate change is an issue that needs to be addressed at every level of government and society. International treaties are in negotiation, federal and state studies have been conducted, and local governments have begun taking actions. The objective of Local Agenda 21 of the Kyoto Protocol asks municipal governments to work on local emission reduction plans. Energy consumption and waste disposal policies can often be most effective at the local government level and action can be taken most quickly. It is the hope of this campaign that the collective efforts of many communities can have a significant impact on this global problem.

Most of the U. S. is expected to warm. Scientists are unable to determine exact effects of each area, but there will be an increased frequency and severity of extreme weather events. Some possible examples are intense rainstorms or warmer winters. The impacts of climate change are global. They will adversely affect everyone whether you are living on a small island on the South Pacific, a village in Africa, or a town in New England.

In the New England area, climate change is expected to:

- Increase temperatures
- Worsen regional air quality-If the climate becomes hotter and wetter, and automobile and power plant emissions remain the same or increase, regional air quality and acid rain problems will become worse in the future.
- Risks to human health will increase due to Lyme disease-carrying tick populations and other disease vectors in the region.
- Impact the regional economy, especially on the human health sector, moderate on tourism, and least severe on the natural resources sector due to the resiliency of the forest industry to projected changes.

The possible effects of climate change on Cape Cod and the islands⁴:

- Beaches and waterfront property vulnerable to sea-level rise and storm surges, along with loss of wetlands and marshes
- Fresh water supplies are vulnerable to increased salinity
- Already documented marked increase in tick-borne Lyme disease, due to lack of prolonged deep-freezes

² IPCC  [www.ipcc.ch/](http://www.ipcc.ch/)
³ New England Regional Climate Variability and Change Assessment,  [www.necci.sr.unh.edu](http://www.necci.sr.unh.edu)
⁴ “Our changing climate, our changing Cape”, Mary Walsh, Cape Cod Times, April 16, 2000.
**The Town of Falmouth’s Goals and Objectives**

**Overall Goal:**
To reduce emissions of gases and air pollutants that contribute to global climate change and local air quality degradation, leading to an increase in quality of life and operational efficiency of local systems.

**Specific Objectives:**
1. Raise general public awareness of climate change and the sources of greenhouse gases.
2. Implement public programs to increase energy and transportation efficiency in order to reduce Falmouth’s greenhouse gas emissions contributions to the global problem of climate change.
3. To develop initiatives within the municipal government to reduce emissions of greenhouse gas emissions while simultaneously increasing operational cost efficiency of local government.

**ICLEI and Cities for Climate Protection Campaign**

The International Council for Local Environmental Initiatives (ICLEI) is an association of municipal governments dedicated to the prevention and solution of global environmental problems through local initiatives. Over 300 municipalities from around the world belong to this association. ICLEI was launched in 1990 as the international environmental agency for local governments under the sponsorship of the United Nations Environment Program, the International Union of Local Authorities (IULA), and the Center for Innovative Diplomacy. ICLEI’s mission is to build and support a worldwide movement of local governments to achieve tangible improvements in global environmental conditions through the cumulative impact of local actions.

In 1993, ICLEI began the Cities for Climate Protection Campaign (CCP) to assist local governments that have committed to addressing the issue surrounding increased greenhouse gas emissions and the pressing threat of global climate change. As such, the CCP is a global campaign to slow earth's warming trend and to improve local air quality and urban livability. The CCP enlists cities to prepare and enact plans to reduce energy consumption and associated greenhouse gas emissions. The campaign presently includes more than 175 municipalities that account for nearly 5% of global greenhouse gas emissions. The CCP's target is to recruit cities that together account for 10% of global anthropogenic emissions. The CCP operates a variety of technical assistance projects that focus on innovative approaches to implementing energy-efficiency measures in municipal and commercial buildings, reducing greenhouse gas emissions through land-use planning, and developing strategies to reduce emissions in the transportation sector.

The Cities for Climate Protection Campaign involves a five-milestone process to achieve greenhouse gas emissions reductions. The five milestones are as follows:

- **Milestone One:** Conduct a baseline emissions inventory for the entire community and municipal operations. From the baseline data, emissions growth or decline is forecasted assuming no actions are taken to address greenhouse gas emissions. The primary emission sources examined in the Milestone One Inventory are:
  - **Energy Use** - Energy for residential, commercial, and municipal facilities
  - **Transportation** - Emissions from personal & commercial vehicles
  - **Solid Waste** - Methane and CO₂ contribution of waste disposal operations

- **Milestone Two:** Set an emissions reduction target. Many local and international targets have been set at twenty percent of the base year emissions level and use their projection year as the target year for obtaining these emissions reductions.
Milestone Three: Develop a local action plan or a collection of initiatives to reach the target reductions. These initiatives will include finding efficiency and technological improvements available to the municipality.

Milestone Four: Implement actions. This milestone involves municipal government to formally adopt emission reduction initiatives. Further, various municipal departments may be called upon to coordinate and implement the adopted initiatives.

Milestone Five: Monitor emission reductions. Monitoring and verification of progress on the implementation of actions to reduce emissions is an ongoing step that begins once measures are implemented. ICLEI's software tool assists in the quantification of emissions reductions and allows for convenient reporting of results.

At the present, the Town of Falmouth has completed milestone one and will begin in the coming months to set a target and develop an action plan.

Emissions Inventory and Forecast Methods

The baseline year for the Falmouth greenhouse gas inventory was 2000 for community and fiscal year 2001 for municipal. These were the earliest years for which reliable data could be generated. The year 2015 was chosen to project future emissions forecasts and emissions reduction targets. This however is only a temporary target year for forecasting purposes and will be changed to the actual target year, which will be determined in the coming months as the Local Action Plan is being drafted. This document will be written with the input of multiple departments within Town Hall, Energy Committee, and community members.

The emission inventory and forecast, as well as most of the reduction measures, are separated into two distinct areas. The first is a community wide assessment of all energy and waste related activities that occur within the Town of Falmouth. The emissions data includes that from within the Town's borders such as vehicle tail pipes and heating broilers, as well as upstream emissions from activities within Town including electricity generation and waste disposal. The second section of the inventory is an evaluation of emissions coming from municipal operations. This includes building energy use, vehicle fleet emissions, Town generated solid waste, and other energy use such as outdoor/street lighting and water works operations.

A separate Town government-based inventory is conducted because the Town ultimately has greater control over its own emissions than private activities in the community. The Town can contribute directly to emission reductions through its own practices while setting an example for responsible energy and fuel use for residents and institutions within the community. The CCP program allows the Town to do just that, by showing emissions reduced and cost saved. Government operations that are not directly controlled by Town government as well as energy use by contractors working for the Falmouth are not included in this inventory.

The inventory required data and technical information to be collected from a wide range of sources including:

- Local Utilities: NSTAR, KEYSPAN, AmeriGas, Loud Fuel Company;
- Town of Falmouth Offices: Accounting Department, Department of Public Works, Assessor's Office, Libraries, Public Schools, Police Department, Recreation Department, Fire and Rescue Department, Senior Center, Shellfish Constable;
- State Agencies and Offices: Department of Environmental Protection, Division of Energy Resources;
- Federal Agencies: Environmental Protection Agency, Department of Transportation, Bureau of the Census, Department of Energy;
- Non-Profit Organizations: Cape & Islands Self-Reliance

A list of contacts for the offices providing direct data for this inventory can be found in Appendix A.
Each GHG differs in its ability to absorb heat in the atmosphere. Hydrofluorocarbons (HFCs) and PFCs (perfluorocarbons) are the most heat-absorbent. Methane traps over 21 times more heat per molecule than CO₂, and nitrous oxide absorbs 270 times more heat per molecule than CO₂. This analysis will focus on the two prominent gases: CO₂ and methane. The data gathered will be expressed in equivalent carbon dioxide (eCO₂) emissions.

The data gathered was entered into specialized software designed by ICLEI and Torrie Smith Associates. The CCP software calculates eCO₂ from energy use and other inputs and also translates all energy units into British Thermal Units (BTU's) for comparison between energy sources. For the Corporate (Municipal) inventory, operational costs were included in the data and inventory reports.

**Community Emissions Inventory Methods and Data Sources**

Community data gathered and entered into the software are all quite general figures and not expected to be, nor can they be, completely accurate. Many sectors are calculated based on average annual consumption and the actual numbers vary. Though most averages used in this module are figures that experts in the field produce, some averages are national and may not represent the Town of Falmouth. That being said, quantifying the consumption and emissions over a period of time using the same solid methodology can be beneficial in that progress in the community can be recorded and monitored.

**Residential Homes**

To measure residential emissions contributions within Falmouth, the consumption of electricity and heating fuels by customers was calculated. Kevin Galligan in the Cape Light Compact provided all community electricity data. Michael Manning of KEYSPAN ENERGY provided the number of natural gas customers. He also provided average annual usage of natural gas per household (100 million BTUs per calendar year), which was multiplied by the number of residential customers to calculate the total consumption of natural gas by the residential sector. *The number of natural gas customers for year 2002 is used in the inventory as data for the 2000 was unavailable.* The numbers of customers for other fuels (Light oil, LPG, and fuel wood) was taken from the U.S. Census 2000 data⁶. Again, these numbers were multiplied by the average annual usage of the fuel.

Oil company representatives, Mr. Nelson of Nelson Oil Co. and Bob at Hall Oil Co. estimate that an "Average" house--one of "pretty good efficiency" with a furnace or boiler no more than 10 years old, 1600 square feet, will consume about 800 gallons light fuel annually. Beth at Self-Reliance also confirmed the average figure of 800 gallons. The estimate on number of cords, 8 cords (per year) comes from Karol Silva at Silva Firewood in Bourne, (508) 759-3903. She says she heats her home exclusively with wood. Sales representatives at AmeriGas (800) 323-9699 say that a typical home uses about 700 gallons to provide heat and hot water annually. Total usage was calculated by multiplying the annual usage numbers by the respective number of customers, according to the Census data.

Sales reps. caution that these figures are just estimates since there are wide fluctuations in fuel consumption based on lifestyle, efficiency of building envelope and heating equipment and size of home. Some homes, for example, have heated pools making them extraordinary consumers of fuel. (1,200 gallons of LPG just for heating a pool.)

**Commercial and Industrial Operations**

The process for calculating emissions for commercial and industrial establishments was the same to that of residential housing (Though the software has these in separate sectors, figures gathered were combined). The data provided by Kevin and Michael included commercial and industrial operations. However, no data on other

⁶ [http://censtats.census.gov/data/MA/0602500123105.pdf](http://censtats.census.gov/data/MA/0602500123105.pdf)
fuels were found, therefore the eCO$_2$ emissions in this report have underestimated the total energy consumption and eCO$_2$ emissions by the commercial and industrial sector.

**Transportation Methods**
The VMT Calculator in the Software was used to calculate the eCO$_2$ emissions by the transportation sector. This is done by first, entering the length of road for the 3 road types: Collectors and local roads, limited access highway, and major arterial roads. The booklet *Road Directory of Falmouth 2001*, provided by the DPW Engineering Department, categorized the roadway in the community into: private roads, abandoned streets, town accepted streets, and state highways within town. The sum of private roads and abandoned streets were entered into the software as the length of collectors and local roads, town accepted streets as limited access highway, and state highways within town as major arterial roads. Future researchers can arrange these categories differently if he/she sees fit. The directory lists each specific road and its length.

Then, Average daily traffic (ADT) needs to be entered into the software. This data is available by The Cape Cod Commission\(^7\). The Commission has been conducting traffic counts in over 100 locations throughout the Town of Falmouth since 1984. For the purposes of this analysis, the counts conducted in the years 2000 and 2001 were used as samples. The size of the sample is arbitrary but it is recommended to take the year for which the inventory is taken, and one year before and after. Counts were then sorted into the 3 categories (Collectors and local roads, limited access highway, and major arterial roads). *The count was not conducted on any of the collectors and local roads; 0 is entered into the ADT for this category. Therefore, VMT figure may be an underestimated figure.*

The average of each category was then taken. When duplicate counts (counts conducted on the same site) were conducted, the average of the duplicate counts was taken. The vehicle miles traveled calculator in the software calculates the eCO$_2$ using the number of total mileage of road types and the average ADTs. The national average data for vehicle fuel efficiency provided by the software was used to calculate fuel use.

**Solid Waste Disposal**
All solid waste generated by the community of Falmouth is collected by a contractor and sent to the Otis Transfer Station. It is then sent to SEMASS, a waste-to-energy facility, in Rochester, MA by rail. The Director of DPW, Bill Owen, provided total tonnage of waste generated by the Town. Because there is no place in the software analysis module to enter in waste that is incinerated at an incineration facility or a waste-to-energy facility, the eCO$_2$ is manually calculated and entered into the “Other” sector in the software. The EPA has developed coefficients for GHG emissions from incinerators that should now be used if local government incinerates all or a portion of its waste\(^8\). This is done in the following way.

1. Total tonnage is multiplied by .11 metric ton carbon equivalent (MTCE)/ton
2. Multiply the product by 4.042 to convert from MTCE to eCO$_2$\(^9\)

**Forecasting**
Forecasting is done only in the community analysis to show how much GHG emissions are likely to grow and from which sectors this growth is likely to occur. These figures are nebulous at best. All projections were made based on the population projections produced by Massachusetts Institute for Social and Economic Research\(^10\). The projection figures in the website only go up to 2010, so the figure entered into the software was extrapolated from the percentage on the website. According to the site, the population projection growth from year 2000 to 2010 was $[100(34,726/31,047 – 1)]$, or 11.85\%. This is calculated by first dividing the projected population of 2010 by the population of 2000. Then subtract 1 and multiply by 100 to get the percentage figure. This is the projected growth for 10 years. Since the (temporary) forecast year is 2015, 1.5 was multiplied to 11.85\%,

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\(^7\) [http://www.gocapecod.org/counts/home.htm](http://www.gocapecod.org/counts/home.htm)

\(^8\) [http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf](http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf) chapter 6

\(^9\) All emissions data on the EPA website are in MTCE (metric tons carbon equivalent). This can be converted to eCO$_2$ simply by multiplying 4.042

\(^10\) [http://www1.miser.umass.edu/datacenter/projections/color/Falmouth.pdf](http://www1.miser.umass.edu/datacenter/projections/color/Falmouth.pdf)
giving 17.77%. This figure was used as the projection figure for all components of the community forecast module. Therefore, the forecast is assuming that every source of energy will increase by the same rate. Needless to say, more precise figures must be entered to calculate a more realistic forecast projection. Appendix A includes some figures and tips that were not used for this inventory.

Municipal Emissions Inventory Methods and Data Sources

Summary
The Municipal GHG Inventory was conducted using fiscal year data for 2001 rather than the calendar year. Most of the data needed for the Municipal GHG Emissions inventory was not available within Town Hall or the departments. Departments do not necessarily keep track of energy bills and almost all departments do not keep track of consumption. This made the task of data collection difficult and time consuming. Because the Town has no record of energy of any sort, it was necessary to go through bills in the accounting office, write down account numbers of buildings and facilities for each department, and send the list of numbers to the utilities for the account histories for each account. Utilities will fax or send this free of charge. With a complete list of account numbers, the updating of data in the future should not take as long as the first inventory.

Buildings
With the exception of schools and the Water and Sewer Division of DPW, all data for buildings was collected by: creating a list of accounts for energy sources, and having the local utilities send or fax the account histories for each building or facility. For electricity, however, the NSTAR website allows customers to view account information after entering in account number and the phone number for the account. (Appendix B includes the list of account numbers, phone numbers (only needed for NSTAR), and addresses for electricity, natural gas, propane, and heating oil consumption) Therefore it is possible to update information while waiting on the other account histories to arrive, as utilities take some time (from a day to 2 weeks) to send/fax information. Unfortunately, many of the electric accounts have no phone numbers assigned. Those account histories must be sent/faxed from NSTAR. Falmouth Public Schools have joined a behavior modification program to reduce energy consumption and have been keeping track of their energy use. Marc Dupuis, the business administrator for the schools provided consumption and cost data for the schools.

Vehicle Fleet
DPW director, Bill Owen keeps excellent records on the consumption and cost of the municipal fleet. All fuel is purchased in the DPW yard with the exception of vehicles owned by the Harbormaster/Waterways Commission. They purchase their fuel from Texaco for their vehicles and some boats. A detailed record of this was not available at the department. The total cost of the Commission’s fuel use was tracked down in the accounting department, but again, consumption records are not available, and Texaco did not release this information. For this inventory, the Commission’s fuel use was extrapolated using a month’s ratio of gasoline and diesel fuel. An accurate inventory can be obtained only by going through each bill either at the Harbormaster’s office, or at Accounting, in Town Hall. Administrative Assistant Barbara Ford provided a list of all vehicles in the municipal fleet in FY 2001.

Street Lights
There are over 2500 streetlights and other outdoor lights in the Town of Falmouth. Streetlights have one account number, and data for this is available by having NSTAR send the account history. There are 3 types of bulbs that are used for street lighting: incandescent, mercury, and sodium. Within each type are different wattages and lumens. There are 34 traffic lights, each with account numbers also. The list of traffic light accounts is included in Appendix B. Outdoor lights for some buildings were separated from the buildings account and the data collector included these in the streetlights sector because some outdoor lights had their own accounts. This can be added on to their respective buildings in the future. Lighting outside schools is assumed to be included in the school building energy use. There are also many lights for the harbor, which are also included in this sector. Some of these lights are purely for lighting, but some are also used for powering boats. Therefore, not all the energy in this part of the inventory goes to lighting, and some outdoor lighting has been included as part of some buildings (for schools).
Solid Waste
The same contractor collects the dumpsters for municipal buildings as well as buildings outside municipal operations. The trash is delivered to the Otis Transfer Station, and then sent on to SEMASS where it is incinerated. Though tonnage of the entire community of waste is available, there is no record of how much waste is generated by the municipal buildings. The figure in this inventory is based on general data on the average amount of waste produced per municipal employee, according to a study conducted by the California Integrated Waste Management Board. They estimate .59 tons/employee/year for government, which is pre-recycling so the diversion rate, or rate not sent to recycling, for the Town of Falmouth must be applied. The Cape Cod Commission provided this rate on their website on Solid Waste Statistics. Cape Cod Commission Planner/Solid Waste Specialist Greg Smith compiled this waste data. The figure in this inventory is based on general data on the average amount of waste produced per municipal employee, according to a study conducted by the California Integrated Waste Management Board.11 They estimate .59 tons/employee/year for government, which is pre-recycling so the diversion rate, or rate not sent to recycling, for the Town of Falmouth must be applied. The Cape Cod Commission provided this rate on their website on Solid Waste Statistics.12 Cape Cod Commission Planner/Solid Waste Specialist Greg Smith compiled this waste data.13 The calculation for the municipal solid waste was done as follows:

1. Gather total employee figures.14
2. Multiply .59 tons/employee/year for total tonnage of waste generated
3. Multiply product by diversion rate (.6 in year 2000) for waste taken to Otis
4. Multiply .11 metric ton carbon equivalent (MTCE)/ton for amount of carbon released
5. Convert from MTCE to eCO₂ by multiplying 4.042

Water and Sewer
Long Pond, Fresh Pond, and Coonamessett Pond supply a third of Falmouth’s water (2.1 Million Gallons per Day) with the remaining water coming from Long Pond (capable of producing up to 8 MGD). All sources are treated with Potassium Hydroxide to stabilize the pH as well as Chlorine for disinfection. Data for these wells and other water and sewer data were gathered in the same manner the data for buildings were collected. However, the account numbers and bills were available in the Utilities Division office in Town Hall.

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11 http://www.ciwmb.ca.gov/wastechar/wastegenrates/wginstit.htm
13 Greg Smith, 508-362-3828
14 The personnel department in Town Hall can give numbers of employees in municipal operations other than schools. School personnel department (508-548-0151) can give numbers for the school employees.
**Community Emissions Findings**

**Introduction**
In 2000, the community's GHG emissions totaled 630,910 tons of eCO₂ (Figure 1). Transportation energy use accounted for 39% and residential household energy use accounted for 31% of the communities’ emissions. The other large contribution came from the commercial, which release 28% of the town's emissions. Bear in mind that the figures gathered/calculated for the community are general figures. (Many of the data are calculated using average figures; natural gas data is for the year 2002; and transportation figures are based on incomplete traffic counts).

![Pie chart showing distribution of GHG emissions by sector](image)

**Total GHG Emissions**
According to the US Census, the Town of Falmouth had a population of 32,660 in 2000, and in 2015, using the methodology described in the forecasting section of this inventory, will grow to 38,539. Falmouth’s per capita eCO₂ emissions equaled 19.3 tons of eCO₂ per person when the Census population is used\(^{15}\). Population figures can be adjusted to account for seasonal residents in Falmouth. However, comparing emissions at the local level is inappropriate because of the many factors that change the outcome of the figure such as methodology of the inventory, coefficients of electricity, weather, and population fluctuations. That being said, Falmouth’s emissions are near average (Figure 2), compared to other municipalities of similar size that have conducted similar GHGs emissions inventories in the region.

<table>
<thead>
<tr>
<th>Community</th>
<th>Population</th>
<th>eCO₂ (tons)</th>
<th>Emissions per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watertown, MA</td>
<td>33,284</td>
<td>695,675</td>
<td>20.9</td>
</tr>
<tr>
<td>Falmouth, MA</td>
<td>32,660</td>
<td>630,910</td>
<td>19.3</td>
</tr>
<tr>
<td>Saratoga Springs, NY</td>
<td>26,186</td>
<td>470,135</td>
<td>18</td>
</tr>
<tr>
<td>Northampton, MA</td>
<td>28,978</td>
<td>395,335</td>
<td>13.6</td>
</tr>
<tr>
<td>Gloucester, MA</td>
<td>29,456</td>
<td>360,693</td>
<td>12.2</td>
</tr>
<tr>
<td>Burlington, VT</td>
<td>39,127</td>
<td>438,931</td>
<td>11.2</td>
</tr>
<tr>
<td>Amherst, MA</td>
<td>34,874</td>
<td>380,904</td>
<td>10.9</td>
</tr>
</tbody>
</table>

**Figure 2: Inventories of other North Eastern cities/towns**

\(^{15}\) Because only population growth figures are used in forecasting, there is almost no change in the per capita eCO₂ emissions for 2015.
Emissions by Source
Energy for transportation (gasoline alone) was the largest overall source of eCO₂ (Figure 3) in 2000. Electricity and natural gas produced large quantities of eCO₂ after gasoline (176,259 tons and 125,877 tons eCO₂ respectively). Although waste is incinerated in a waste-to-energy facility, it could not be quantified in the software, hence, zero for energy generated.

<table>
<thead>
<tr>
<th></th>
<th>Equiv CO₂ (tons)</th>
<th>Equiv CO₂ (%)</th>
<th>Energy (million BTUs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>224028</td>
<td>35.5</td>
<td>2581511</td>
</tr>
<tr>
<td>Electricity</td>
<td>176259</td>
<td>27.9</td>
<td>842656</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>125877</td>
<td>20</td>
<td>2039500</td>
</tr>
<tr>
<td>Light Fuel Oil</td>
<td>63751</td>
<td>10.1</td>
<td>772182</td>
</tr>
<tr>
<td>Diesel</td>
<td>20038</td>
<td>3.2</td>
<td>229803</td>
</tr>
<tr>
<td>Waste</td>
<td>12215</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>LPG</td>
<td>4347</td>
<td>0.7</td>
<td>59877</td>
</tr>
<tr>
<td>CNG</td>
<td>3910</td>
<td>0.6</td>
<td>63358</td>
</tr>
<tr>
<td>Fuelwood (Air Dry)</td>
<td>485</td>
<td>0.1</td>
<td>63163</td>
</tr>
<tr>
<td>Total</td>
<td>630910</td>
<td>100</td>
<td>6652050</td>
</tr>
</tbody>
</table>

Figure 3: Emissions by source

Forecasting
The figures used in the projections are all based on the population growth rate, which is not sufficient to accurately forecast GHG emissions. However, this is an important step in determining target reductions. More specific projections will be necessary to complete this portion of the inventory. Figure 4 shows the breakdown of emissions if all consumption growth rates were the same as the projected population growth rate (17.7%).

Figure 4

eCO₂ Emissions Forecast in tons

A complete report of the community findings is in Appendix C.
**Municipal Emissions Findings**

**Introduction**
The municipal operations of the Town of Falmouth generated 12,370 tons of eCO$_2$ in the 2001 fiscal year. This represents approximately 1.96% of the community’s net eCO$_2$ emissions. Buildings account for about 60% of the municipal government’s operations. Figure 5 provides a detailed breakdown of the percentage each sector contributes to municipal emissions and some other key figures. From figure 5, municipal buildings account for 60% of all eCO$_2$ emissions generated from municipal operations or 7,292 tons of eCO$_2$ with water/sewage accounting for 19% or 2,386 tons of eCO$_2$ and the vehicle fleet accounting for 14% or 1,791 tons of eCO$_2$. A detailed breakdown of all municipal properties is included in Appendix D.

![Municipal eCO2 by Sector](image)

**Emissions by Sector**
Unlike the community analysis above, the energy source responsible for the greatest percentage of emissions within the municipal analysis is electricity use. Electricity accounts for over half (60%) the emissions generated by the municipal government in Falmouth. Natural gas (23%) and gasoline (9%) are the next largest contributors. Figure 6 contains this information.

![Municipal eCO2 Emissions by Source](image)
Highest GHGs Emitting Buildings
As mentioned previously, the Town’s buildings are the largest contributors to eCO\(_2\) within the municipal inventory. Collectively, buildings contributed to 7,292 tons of eCO\(_2\) released into the atmosphere during the 2001 fiscal year. According to figure 7, it is apparent that Falmouth High Schools is the largest contributors of GHG emissions of all municipal buildings producing about 2,340 tons of eCO\(_2\). All schools are in the top 10 GHGs emitting buildings. Falmouth Public Schools totaled at 5,583 tons of the total 7,293 tons of eCO\(_2\) by buildings in FY 2001.

![Figure 7](image)

Water and Sewage
The second highest GHGs emitting sector in FY 2001 was the water and sewage, which includes all facilities in the Utilities Division of DPW. The sector emitted a total of 2,386 tons of eCO\(_2\). By far, the largest emitting facility in the division is the Long Pond Water Plant (Figure 8). The figure shows the 11 of the 16 facilities. Water facilities (Water plants) appear to consume more than the wastewater facilities (WWT facilities and pump stations).

![Figure 8](image)
Municipal Fleet
The Town’s vehicle fleet produced a total of 1,791 tons of eCO₂ in the 2001 fiscal year\textsuperscript{16}. Of all the municipal departments, the vehicles operated by the DPW were responsible for producing the most eCO₂. The Police Department produced 525 tons of eCO₂. Figure 9 shows a fuel usage by vehicles for each department. All fuel purchased for the Town is premium fuel. The Police Department needs “premium” for “good performance”.

<table>
<thead>
<tr>
<th></th>
<th>gasoline (gallons)</th>
<th>diesel (gallons)</th>
<th>eCO₂ (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total DPW</td>
<td>20832.2</td>
<td>53148.8</td>
<td>794</td>
</tr>
<tr>
<td>Police</td>
<td>48141.6</td>
<td>0</td>
<td>525</td>
</tr>
<tr>
<td>Fire Department</td>
<td>10260.3</td>
<td>8960.7</td>
<td>207</td>
</tr>
<tr>
<td>total HM/WW</td>
<td>7993.81</td>
<td>816.16</td>
<td>96</td>
</tr>
<tr>
<td>School</td>
<td>5223.4</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td>Dept. of N. R.</td>
<td>4870.3</td>
<td>0</td>
<td>53</td>
</tr>
<tr>
<td>Council of Aging</td>
<td>2741.5</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Beach Committee</td>
<td>48.5</td>
<td>1207.4</td>
<td>13</td>
</tr>
<tr>
<td>Shellfish Warden</td>
<td>1086.1</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Rec. Committee</td>
<td>299.4</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 9

Streetlights
The streetlights sector is the 4\textsuperscript{th} highest GHG emitter in the Town of Falmouth with approximately 721 tons of eCO₂. Many of the traffic lights have been switched to LEDs this past year. Harbor lights and parking lot lights are also included in this sector. Many of the accounts for the sector have no consumption the majority of the year and a large bill for one, or a few months.

Waste
Waste figures are based on an average figure provided by a study. However, the figure is small and so rather than calculating a more accurate figure, the Town must ensure that the three R’s are a common practice.

\textsuperscript{16} Though the vehicle inventory provided by the Administrator’s Assistant gives the figure 175 for the total number of Falmouth owned fleet, some vehicles in the Harbormaster/Waterways Department include boats, which are not in the inventory. These boats, and sometimes Harbormaster vehicles, purchase gasoline from Texaco using a credit card.
**Measures**

Listed below is a collection of current actions and options for consideration to reduce GHG emissions in Falmouth. Current initiatives or capital improvement plans are included to measure efforts already underway to conserve energy or reduce waste. This list also recognizes programs with other goals or priorities other than energy savings or waste reduction but have GHG reduction benefits. Some existing measures have the potential for extensions that would increase the programs effectiveness at reducing emissions.

**Community Programs**

- Home Energy Conservation/Efficiency Program
- Climate change outreach and Education
- Block purchasing of green energy
- Designated bike lanes and bike routes
- Lobby for increased federal CAFÉ standards
- Increase bike facilities
- Town sponsored transit service
- Methane energy recovery at landfill
- Sustainable Business Awards

**Municipal Operations**

- Energy efficient office equipment procurement
- Municipal buildings energy efficiency standards and goals
- Purchase of Clean/Green Energy
- Solar hot water and/or PV on public buildings
- Downsize municipal fleet vehicles
- LED traffic lights
- Alternative fuel vehicle replacement of Town fleet
- Tele-commuting option for employees
- Improving lighting efficiency
- Improving heating and cooling efficiency
- Window upgrades
- Energy education in schools

Many of the Municipal buildings have conducted energy audits, specifically looking at lighting, and improved efficiency in that area. These are all entered into the software but the data is incomplete as the inventory was only conducted for FY 2001. Even though these audits are free of charge, not all buildings have conducted them. Also, the audits to date are only for lighting and not for heating/cooling or for ventilation. These can also be conducted free of charge and can potentially reduce significant amount of GHG emissions and reap major savings for the town.

The Recreation Center and the Falmouth High School will use renewable energy for their buildings (Solar for the Recreation Center and Solar, fuel cell, and geothermal for the High School).

The Falmouth Public Schools have joined a behavior modification program in which custodians are specifically trained to work energy efficiently. After the program, these workers can become trainers themselves and conduct in-house workshops for other custodians employed by the Town.

Because there is no Energy Department or an Environment Department, idea sharing, or people sharing in the case of School custodians, must flow smoothly in order to implement these solutions throughout the Municipal.
If energy audits are being conducted, all buildings should be considered, not just the buildings in a particular department. In order to facilitate this process, the Energy Committee is advised to create a green network within the Town.

Appendix A: Contacts and Forecasting

**Community Data Contacts**

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kevin Galligan</td>
<td>Cape Light Compact</td>
<td><a href="mailto:kfg@cape.com">kfg@cape.com</a></td>
</tr>
<tr>
<td>Michael Manning</td>
<td>Keyspan Energy</td>
<td><a href="mailto:mmanning@keyspanenergy.com">mmanning@keyspanenergy.com</a></td>
</tr>
<tr>
<td>Mr. Nelson</td>
<td>Nelson Oil Company</td>
<td>(508)775-1190</td>
</tr>
<tr>
<td>Beth</td>
<td>Self Reliance</td>
<td>(508)457-7679</td>
</tr>
<tr>
<td>Karol Silva</td>
<td>Silva Firewood</td>
<td>(508)759-3903</td>
</tr>
<tr>
<td>William Owen</td>
<td>DPW Director</td>
<td>(508)548-7611</td>
</tr>
</tbody>
</table>

**Municipal Data Contacts**

<table>
<thead>
<tr>
<th>Company</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSTAR Electric</td>
<td>1-800-592-2000</td>
</tr>
<tr>
<td>KeySpan</td>
<td>1-800-548-8000</td>
</tr>
<tr>
<td>AmeriGas</td>
<td>1-800-323-9699</td>
</tr>
<tr>
<td>Loud Fuel Company</td>
<td>1-800-525-0888</td>
</tr>
</tbody>
</table>

**Department Contacts**

<table>
<thead>
<tr>
<th>Department</th>
<th>Name</th>
<th>Email</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>Mary Alwardt</td>
<td>malwardt</td>
<td>x392</td>
</tr>
<tr>
<td></td>
<td>Melissa Abrams</td>
<td>mabrams</td>
<td>x391</td>
</tr>
<tr>
<td>Beach Department</td>
<td>Don Hoffer</td>
<td></td>
<td>508-548-8623</td>
</tr>
<tr>
<td>Building Facilities Department</td>
<td>Shardell Newton</td>
<td>snewton</td>
<td>x456</td>
</tr>
<tr>
<td>Department of Natural Resources</td>
<td>Tom</td>
<td></td>
<td>508-457-2536</td>
</tr>
<tr>
<td>Department of Public Works</td>
<td>Bill Owen</td>
<td>wowens</td>
<td>x423</td>
</tr>
<tr>
<td></td>
<td>George Calise</td>
<td>falengr</td>
<td>x430</td>
</tr>
<tr>
<td>Fire and Rescue Department</td>
<td>Jill Bishop</td>
<td>jbishop</td>
<td>508-457-2500</td>
</tr>
<tr>
<td>Harbormaster/Waterways Dept.</td>
<td>Jane Morton</td>
<td>jmorton</td>
<td>508-457-2550</td>
</tr>
<tr>
<td>Police Department</td>
<td>Melinda Rebelo</td>
<td>mrebelo</td>
<td>508-457-2526</td>
</tr>
<tr>
<td>Public Library</td>
<td>Janet</td>
<td></td>
<td>508-457-2555</td>
</tr>
<tr>
<td>Public School</td>
<td>Marc Dupuis</td>
<td><a href="mailto:mdupuis@40falmouth.k12.ma.us">mdupuis@40falmouth.k12.ma.us</a></td>
<td>508-548-0151</td>
</tr>
<tr>
<td>Recreation Center</td>
<td>Helen Kennedy</td>
<td>hkennedy</td>
<td>508-457-2567</td>
</tr>
<tr>
<td>Senior Center</td>
<td>John Magnani</td>
<td>jvmag</td>
<td>508-540-0196</td>
</tr>
<tr>
<td>Shellfish Constable</td>
<td>Paul Montague</td>
<td>montague</td>
<td>x334</td>
</tr>
<tr>
<td>Water &amp; Sewer Department</td>
<td>Ray Jack</td>
<td>rjack</td>
<td>x342</td>
</tr>
</tbody>
</table>

Town Hall Phone Number: 508-548-7611
On Forecasting
In this inventory, forecasting is based only on population figures because of incomplete figures collected. However, using national averages, more reliable forecasting can be made be possible (The first link was found during the writing of this report).

◊ The AEO 2000 projections found in the “Annual Energy Outlook 2000” published by the Energy Information Administration is available at www.eia.doe.gov/oiaf/aeo/forecast.html. This website provides projection figures for residential, commercial, and industrial sectors for electricity, natural gas, and heating oil.

◊ According to Lev Malakhoff (lmalakhoff@capecodcommission.com) at the Cape Cod Commission, an estimate of 16% total traffic growth has been forecast for period 1997-2025. Historically, traffic has been growing at about 1.5% per year (over the last 10 years).

These figures can be extrapolated to calculate future consumption of energy for a specific year. It is advised to use the target year as forecasting year.
Appendix B: Lists of Accounts
Appendix C: Community Findings
Appendix D: Municipal Findings