Greenhouse Gas Emissions Inventory for the Town of Nantucket

Prepared for The Town of Nantucket

Prepared by Sustainable Nantucket

Sustainable Nantucket
Think local, work together, grow smart.

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Table of Contents

Appendices

Acknowledgements

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Introduction

In March of 2007, Nantucket's Board of Selectmen unanimously voted in favor of joining the Cities for Climate Protection Campaign (CCP), a program of the International Council of Local Environmental Initiatives (ICLEI). The Board of Selectmen accepted Sustainable Nantucket's offer to assist with the process of completing the five milestones, acting as a facilitator/researcher for the project, in collaboration with the Energy Study Committee, as town liaison and advisory group.

This report will summarize the greenhouse gas emissions of the Town of Nantucket (year 2007). There are two reasons for completing an inventory of anthropogenic (caused by humans) greenhouse gas emissions: first, to identify the sources of our emissions and second, to begin the process of reducing them. Once we have identified the sources of our greenhouse gas emissions, Nantucket will be better equipped to strategically and cost-effectively reduce said emissions. This is the first step in the Town of Nantucket's efforts to address global warming at the local level, and the first of five milestones in the ICLEI CCP program.

Town of Nantucket's Goals and Objectives

Overall Goal:

To reduce emissions of gases and air pollutants that contribute to the lowering of air quality, to address global climate change, leading to an increase in quality of life and operational, and cost efficiency of municipal systems.

Specific Objectives:

1. Raise awareness of climate change and the sources of greenhouse gases.*
2. Implement strategies to increase energy efficiency in order to reduce Nantucket's greenhouse gas emissions and our contribution to the global climate change crisis.
3. To develop initiatives within our municipal government to reduce emissions of greenhouse gases while simultaneously increasing the cost efficiency of our operations.

*For a detailed explanation of greenhouse gas emissions, please see Appendix A

ICLEI and Cities for Climate Protection Campaign

ICLEI - Local Governments for Sustainability is an international membership association of local governments dedicated to the prevention and solution of global environmental problems through local initiatives. Over 1000 municipalities, from around the world, and more than 500 in the U.S., 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.

Milestones of the Cities for Climate Protection Campaign

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.

As of March 15th, 2009, the Town of Nantucket has completed Milestone One and Two of the Cities for Climate Protection Campaign and will be developing an action plan in the coming months. Sustainable Nantucket staff and volunteers will work with the Energy Study Committee, with Town departments and agencies, and with community members to help formulate this plan.

Emissions Inventory Methods and Data Sources

The baseline year for the Nantucket greenhouse gas inventory was 2007. 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 on this island. The community emissions data includes that from within

the Town's borders such as vehicle tail pipes and heating broilers. The inventory required data and technical information to be collected from a wide range of sources including:

- Local Utilities: National Grid, Harbor Fuel, Sun Island Fuel, Waste Options
- Transportation surveys provided by the Nantucket Planning & Economic Development Commission
- Steamship Authority, Hy-line ferry, commercial airlines, and the Nantucket Memorial Airport

Community data gathered and entered into the software are general figures and not expected to be, nor can they be, completely accurate. Quantifying the consumption and emissions of the community over a period of time using the same methodology can be beneficial in that progress in the community can be recorded and monitored. The associated costs were generated from the internal records of the energy providers, such as the utility companies.

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

- Local Utilities: National Grid, Yates Gas, Harbor Fuel, Waste Options;
- Town of Nantucket Offices and Departments
- Public Schools
- Nantucket Cottage Hospital
- Police Department
- Fire Department

The data gathered will be expressed in eCO2 emissions, which consist of emissions associated with carbon dioxide, nitrous oxide, and methane. eCO2 is a measure that describes how much warming a given type and amount of a greenhouse gas may cause, using the functionally equivalent amount of carbon dioxide as a reference. For example, methane is 21 times more potent of a greenhouse gas than carbon dioxide on a molecule by molecule basis. Therefore, 1 ton of methane has an equivalent CO2 value of 21 tons.

The data 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. BTUs are a unit of energy that allows comparisons across various types of energy. Every different energy source (such as natural gas, electricity, diesel, gasoline, etc.) has a natural amount of energy embedded within it. British Thermal Units standardize the amount

of energy embodied in these different fuels comparisons can be made amongst their energy content. For example, when we determine the energy content in electricity (in BTUs) and in natural gas (in BTUs), we can compare and sum these figures. The energy costs associated with each category were taken from the energy providers' bills kept on record at the appropriate Town department.

4. U.S. Census Bureau. http://quickfacts.census.gov/qfd/states/25/25019.html
5. Data Source: US DOE Energy Information Administration
http://www.eia.doe.gov/oiaf/aeo/supplement/supref.html

Community Emissions Findings

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (MMBtu)
Residential			
Nantucket, Massachusetts			
All Residential			
Electricity	34,227	9.7	310,580
Light Fuel Oil	38,179	10.8	461,859
Propane	33,767	9.6	466,524
Subtotal All Residential	106,174	30.1	1,238,963
Subtotal Residential	106,174	30.1	1,238,963
Commercial			
Nantucket, Massachusetts			
sm. commerical/ industrial			
Electricity	9,027	2.6	81,911
Subtotal sm. commerical/ industrial	9,027	2.6	81,911
Subtotal Commercial	9,027	2.6	81,911
Industrial			
Nantucket, Massachusetts			
lg. commerical/industrial			
Electricity	9,027	2.6	81,911
Subtotal lg. commerical/industrial	9,027	2.6	81,911
Subtotal Industrial	9,027	2.6	81,911
Transportation			
Nantucket, Massachusetts			
Ferries			
Diesel	20,322	5.8	234,327
Subtotal Ferries	20,322	5.8	234,327

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (MMBtu)	
Private and Commercial Jets/Planes				
Gasoline	2,674	0.8	31,401	
Diesel	13,773	3.9	158,618	
Subtotal Private and Commercial Jets/Planes	16,447	4.7	190,019	
Road Vehicles				
Gasoline	149,454	42.3	1,748,452	
Diesel	31,667	9.0	364,841	
Subtotal Road Vehicles	181,121	51.3	2,113,293	
Subtotal Transportation	217,890	61.7	2,537,639	
Waste				
Nantucket, Massachusetts				
Waste Options				*Disposal Method - Managed Landfill*
Paper Products	4,319	1.2		
Food Waste	8,062	2.3		
Plant Debris	-493	-0.1		
Wood/Textiles	-864	-0.2		
Subtotal Waste Options	11,025	3.1		
Subtotal Waste	11,025	3.1		
Total	353,142	100.0	3,940,425	

Municipal Emissions Findings

	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (MMBtu)	Cost ($)
Buildings				
Nantucket, Massachusetts				
Schools				
Electricity	709	11.3	6,429	315,245
Light Fuel Oil	1,176	18.7	14,221	235,912
Subtotal Schools	1,884	30.0	20,651	551,157
Town Accounts				
Electricity	516	8.2	4,678	252,643
Light Fuel Oil	1,318	21.0	15,943	429,016
Subtotal Town Accounts	1,833	29.2	20,621	681,659
Subtotal Buildings	3,718	59.2	41,272	1,232,816

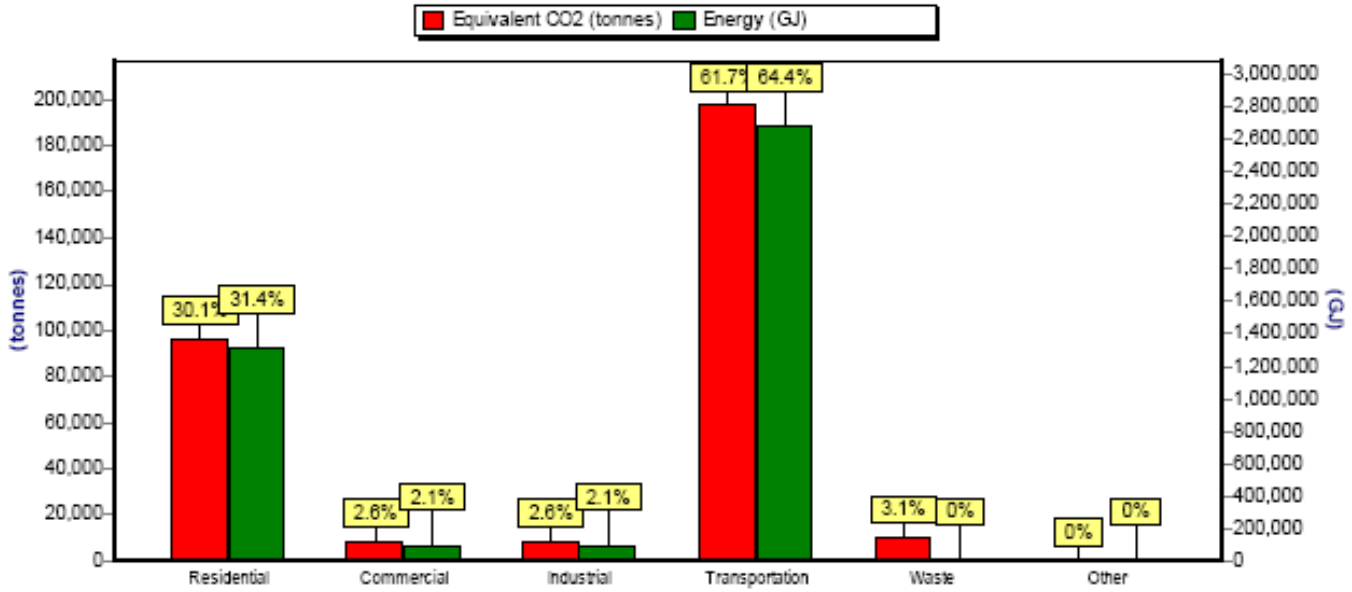
	Equiv CO_2 (tons)	Equiv CO_2 (%)	Energy (MMBtu)	Cost ($)
Vehicle Fleet				
Nantucket, Massachusetts				
Town Fleet				
Gasoline	499	8.0	5,847	212,480
Diesel	100	1.6	1,149	43,520
Subtotal Town Fleet	599	9.5	6,996	256,000
Subtotal Vehicle Fleet	599	9.5	6,996	256,000
Employee Commute				
Nantucket, Massachusetts				
Town Employees				
Gasoline	15	0.2	176	
Diesel	0	0.0	0	
Subtotal Town Employees	15	0.2	176	
Subtotal Employee Commute	15	0.2	176	
Streetlights				
Nantucket, Massachusetts				
Untitled				
Electricity	102	1.6	924	73,848
Subtotal Untitled	102	1.6	924	73,848
Subtotal Streetlights	102	1.6	924	73,848
Water/Sewage				
Nantucket, Massachusetts				
Town of Nantucket				
Electricity	1,773	28.3	16,088	1,330,894
Light Fuel Oil	69	1.1	835	20,081
Subtotal Town of Nantucket	1,842	29.4	16,923	1,350,975
Subtotal Water/Sewage	1,842	29.4	16,923	1,350,975
Total	6,275	100.0	66,290	2,913,639

Inventory Results

The greenhouse gas (GHG) inventory measured emissions based on two separate studies. The first was a measure of all emissions from the Nantucket residential and commercial community. (Fig. 1) The second level of the inventory investigated the emissions from municipal operations. (Fig. 2)

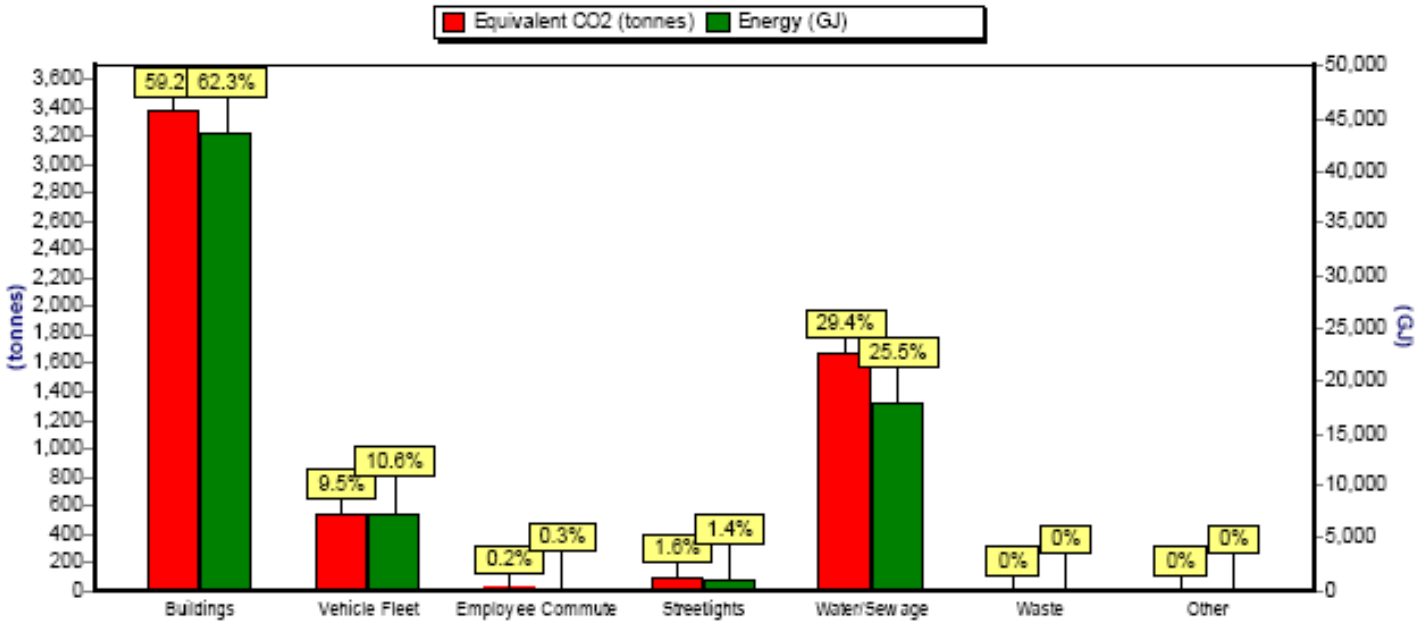
In 2007, the community of Nantucket's greenhouse gas emissions totaled 353,142 tons of eCO2. Transportation energy use accounted for 64.4% and residential household energy use accounted for 31.4% of the communities' emissions. Gasoline used for transportation was the largest overall source of eCO2. Light fuel oil and electricity produced large quantities of eCO2 after gasoline (38,179 tons and 34,227 tons eCO2 respectively).

Fig. 1 – Community Emissions Inventory Results



In 2007 the Town of Nantucket generated 6,275 tons of eCO2, 59.2% of which came from building energy use (Figure 2). ECO2 emitted by the public schools accounted for 1,884 tons, or 30 % of this total, and ECO2 emitted by other town buildings was equal to 1771 tons, or 29% The municipal water/sewage, vehicle fleet, and streetlights/traffic lights accounted for 29.35%, 9.5%, and 1.6% respectively, of the remaining emissions. In 2007, the Town of Nantucket spent a total of $2,913,639 on energy.

Fig. 2 – Municipal Emissions Inventory Results



Forecasting

Between April 1, 2000 and July 1st, 2007, Nantucket's population expanded by 10.5%. [4] With the 2008 economic recession in mind, we are projecting Nantucket's population growth rate between 2008 and 2020 at 50% of the rate of the previous 7 years, or 5.3%. Based on this growth rate and utilizing the Energy Use Growth Forecast Tool provided by the U.S. Department of Energy's *Energy Information Association* (EIA),[5] our total energy use as a community could grow by 6.42%. Correspondingly, if unchecked, our community's carbon emissions would rise from 353,142 tons of eC02 in 2007 to 375,813 tons of eC02 by 2020.

Targets for reduction

The 2nd Milestone of the ICLEI Cities for Climate Protection Campaign is to set targets for reduction of greenhouse gas emissions. We recommend that Nantucket's initial target be to reduce our emissions by **10% below 2000 levels by 2020**. This would mean reducing our overall GHG emissions from 380,302 tons of eC02 emissions in 2007, to 294,392 tons by 2020.[6], an overall reduction of 86,000 tons from 2007 levels, and a reduction of 110,325 tons from our projected total carbon emissions in 2020, if no steps were taken.

While the state of Massachusetts set targets in the 2004 Massachusetts Climate Protection Action Plan, which aim for the reduction of greenhouse gas emissions in Massachusetts by at least 10% below 1990 levels by 2020, we believe Nantucket should set it's own tough, yet realistic targets for reduction that take into account our high rate of population expansion -- 36.8% from 1990 to 2000, in comparison to the state's expansion of 5.2% in that time frame, and 10.5% from 2000 to 2007 in comparison to the statewide average of 1.6%.[7,]

For longer-term targets, we suggest reducing emission to 25% below 2000 levels by 2030, 55% by 2040, and 75-80% by 2050. This timeline for reduction would put us roughly in line, in terms of per capita emissions reduction, with the state of Massachusetts long-term targets of a 75 – 80% reduction from 1990 levels, by the target date recommended by the Union of Concerned Scientists, which is 2050.[8]

[6] According to the Energy Use Forecast Tool provided by the U.S. Department of Energy's *Energy Information Association* (EIA)

[7] U.S. Census Bureau, State and County Quick Facts (http://quickfacts.census.gov/qfd/states/25/25019.html)

[8] At a population expansion rate in Massachusetts as a whole of 6.8% between 1990 and 2007

Conclusion & Next Steps

The municipality of the Town of Nantucket spent close to 3 million dollars on energy in 2007. Measures taken to increase energy efficiency within Town operations will have a measurable impact on these emissions and a clear cost savings benefit. The Town can also promote and legislate incentives to encourage community-wide programs to reduce energy consumption and emissions. Technology also provides many opportunities to increase electrical, heating, and transportation efficiency. Policies can shift energy sources towards cleaner burning fuels and renewable energy.

Behavior changes such as reducing vehicle use, material purchasing, and waste disposal can also be instituted to reach the Town's emission reduction goal. Education and outreach

are low cost methods to conserve energy. These are actions that Nantucket can take immediately. We can 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. There is great potential for Nantucket to reduce emissions and cut energy costs.

The next step for the Town of Nantucket, once the target emissions level has been selected, is to draft a Climate Protection Action Plan. The Action Plan is a proposal for how the Town can take a proactive role towards reducing energy use and greenhouse gas emissions on Nantucket. Sustainable Nantucket will continue to act as a volunteer to help to facilitate the writing of this document with the input of the Town's Energy Study Committee, multiple town departments and agencies, and community members.

Appendix A[1]

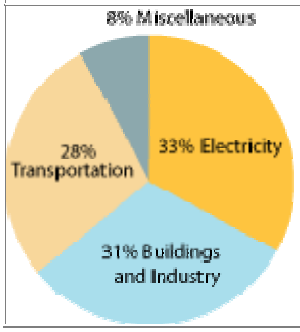
What Are Greenhouse Gas Emissions (GHGs)?

Emissions are gases and particles released into the air as byproducts of a natural or man-made process. One of these processes is the burning of fuels to create electricity and other forms of energy. The emissions from burning fossil fuels contribute significantly to global warming and poor air quality.

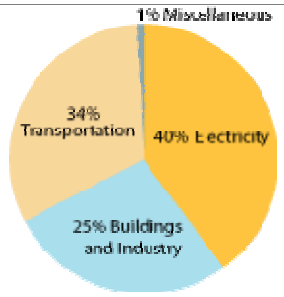
Types of Emissions

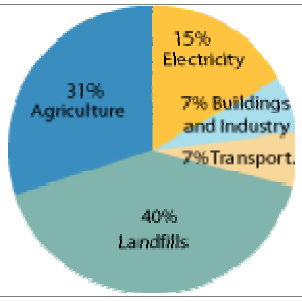
A small set of emissions are responsible for the majority of human impacts on climate change and health. These gases and particulates come from a variety of sources and can be categorized as greenhouse gas emissions (that affect climate change) and air quality emissions. Clean energy typically produces no emissions, which is one of its most significant benefits.

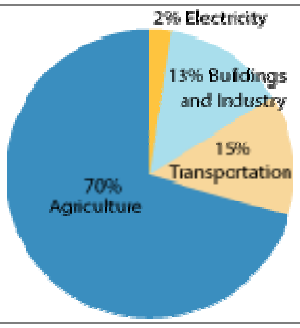
Worldwide emission levels from human activity have increased significantly over the past 200 years as industrial activity, electricity infrastructure, and transportation have developed. As greater understanding of the impacts of these emissions has increased, regulation and new development practices have been implemented to reduce the rate of emissions in many countries. However, high levels of these emissions are still being produced each year.

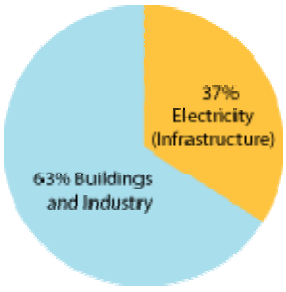
Greenhouse Gas Emissions: Sources of All Emissions	
	Greenhouse gas emissions come from four main sources: the burning of fossil fuels to make electricity; industrial, commercial and residential burning of fossil fuels for heat and the use of other emission-producing processes; the burning of fossil fuels to power transportation; and the emissions produced through agriculture and miscellaneous activities.

The primary emissions and their sources are as follows:

1. Carbon Dioxide	Sources
Carbon dioxide is one of the most common gases in the atmosphere and is regulated through the natural carbon cycle, where carbon dioxide is emitted into the air through animal and plant respiration and reabsorbed by vegetation and water. This cycle is upset by the emission of additional carbon dioxide from human activity. Because natural cycles cannot absorb these additional emissions, a large portion of carbon dioxide remains in the atmosphere. The primary human source of carbon dioxide is the burning of fossil fuels for electricity, heat, and transportation.	

2. Methane	Sources
Methane is another naturally occurring gas. The primary natural source of methane is the decay of plants. Like carbon dioxide, the amount of methane in the atmosphere has increased significantly due to human activity and exacerbates climate change. Human activities that produce methane include fossil fuel production, decay in landfills, and the digestive processes of farm animals.	

3. Nitrous Oxide	Sources
The primary natural sources (contributing 70% of the total) of nitrous oxide in the atmosphere are the bacterial breakdown of nitrogen in soils and in the earth's oceans. Human activities that increase nitrous oxide levels in the atmosphere, and as a result, contribute to climate change, include fossil fuel burning, use of nitrogen-based fertilizers in farming, animal manure and agricultural land management, sewage treatment, and emissions from industrial processes such as nitric acid production.	

4. Halocarbons and Sulfur Hexafluoride	Sources
Halocarbons are frequently introduced into the atmosphere via man-made processes. Their most common use is in refrigeration and air conditioning technologies but they are also used heavily in the electrical system manufacturing. When released into the atmosphere as gases, some halocarbons can significantly disrupt global climate patterns. No discussion about sulfur hexafluroide	

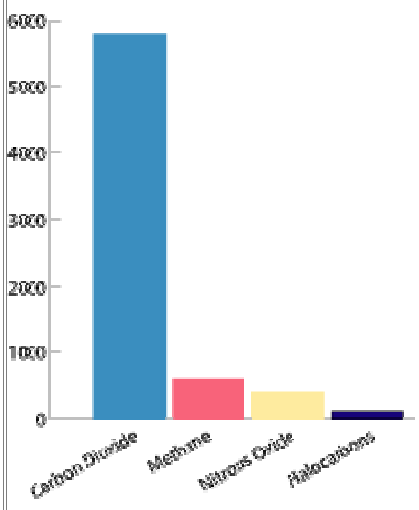
5. Emissions with Indirect Impact

Other gases like carbon monoxide, nitrogen oxides, and volatile organic compounds (VOCs) impact climate change indirectly and have more direct effects on health when they are released into the lower atmosphere.

Current Emission Levels and Sources

Emissions of greenhouse gases from human activity in the United States in 2001 totaled 6,936 gigatons (billion tons). In the same year, the natural cycles that regulate these gases were able to absorb 838 gigatons. This left 6,098 extra gigatons to remain in the air. This unsustainable amount of emissions represented a slight increase over previous years, and emissions are estimated to have increased even more in recent years. The U.S. produces more greenhouse gas emissions per person than any other country.

U.S. Greenhouse Gas Emissions (gigatons carbon dioxide equivalent)



U.S. emissions in 2001 for each of the greenhouse gases are tabulated in this chart. Carbon dioxide is the highest emitted greenhouse gas from human activities.

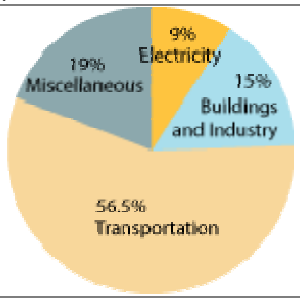
The amounts in this chart are measured in gigatons of emissions per year. Their relative environmental impact is accounted for in these numbers through a measurement known as "Carbon dioxide equivalent".

Greenhouse gas emission levels and sources in Massachusetts are comparable to those nationwide.

Air Quality Emissions

In the U.S. , emissions that impact air quality come from a variety of sources.

Air Quality Emissions: Sources of All Emissions	

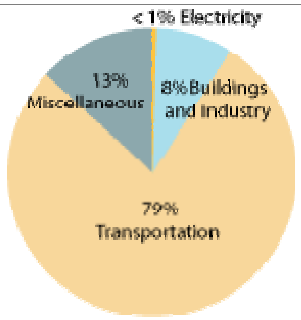
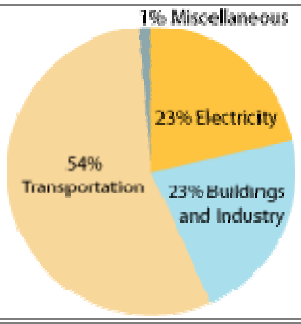


For each gas, the sources responsible for emissions vary greatly as different activities emit different levels of each gas. Electricity production plays the most significant role in nitrogen oxide and sulfur dioxide emissions. Transportation plays the most significant role for a number of emissions.

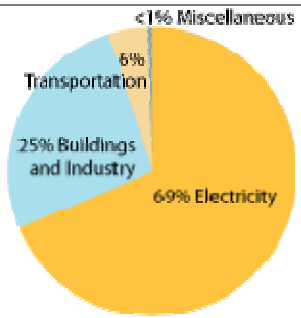
The primary air quality emissions and their sources are as follows:

1. Ozone

Ozone is a unique emission because it is not directly produced by human sources. Instead, it is created as a result of chemical reactions between human-produced emissions and other gases in the atmosphere. Ozone is also unique because it is considered beneficial in some places and detrimental in others. When ozone is in the earth's upper atmosphere it is considered good because it protects the earth from the sun's radiation. But when ozone is created in the lower atmosphere, it creates smog which can cause respiratory problems and damage to plant and animal life. In the lower atmosphere, ozone is typically created when volatile organic compounds (VOCs) or nitrogen oxides react with other atmospheric gases.

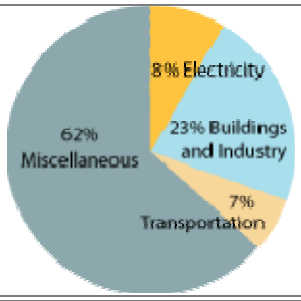
2. Carbon Monoxide	**Sources**
This gas is created when the carbon in fossil fuels is not entirely burned during combustion. The majority of carbon monoxide emissions come from the use of fossil fuels in transportation. Lesser quantities come from electricity production and natural events like forest fires. When released into the air, carbon monoxide can exacerbate heart disease and damage the human nervous system. Vehicles are the primary source and as a result, emission testing was started in the US in x year	
3. Nitrogen Oxides	**Sources**
Nitrogen oxides come almost exclusively from the burning of fossil fuels for transportation, electricity, and building and industrial use. Their impacts on air quality include creation of acid rain, ozone in the lower atmosphere, and direct respiratory problems.	
4. Sulfur Dioxide	**Sources**

Sulfur dioxide is created by burning fossil fuels with trace amounts of sulfur, like coal and oil. Smaller amounts can be created during industrial metal processing. The major source of sulfur dioxide is the use of fossil fuels in electricity production. Lesser sources include other energy production and transportation. Sulfur dioxide contributes to respiratory problems and the creation of acid rain.



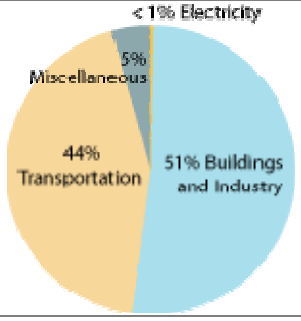
5. Particulates	**Sources**

Particulates include dust, dirt, soot, smoke and other miniscule solids released into the air. Particulates can be composed of many different chemicals. Their human sources vary but come largely from construction activities like road building. Particulates can also form when emissions from fossil fuels react with sunlight and water vapor to create solid particles in the air. Particulates can affect heart and respiratory health.



6. Volatile Organic Compounds	**Sources**

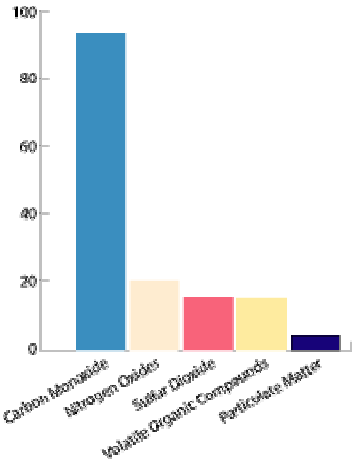
VOCs are found in a wide variety of consumer products from paints, solvents, and adhesives to carpeting, deodorants, and cleaning fluids. When released into the air, they react with other chemicals to create ozone in the lower atmosphere. They can also have direct air quality impacts inside buildings when off-gased by indoor paints, carpeting, and adhesives.



7. Other Emissions Other gases can also impact air quality. The production of these gases is heavily regulated and the gases are currently emitted in much smaller quantities than the emissions listed above.

Current Emission Levels and Sources Levels of emissions that affect air quality vary greatly by country and region. In the United States, the rate of emissions has actually decreased per year, both overall and per person. In some developing countries, as industry, electricity and transportation have developed, air quality has become a greater problem than before. In all nations, significant amounts of emissions are still being released.

U.S. Air Quality Emissions (in million tons)	



In 2003, 147.7 million tons of emissions impacting air quality were released in the U.S. These amounts are measured in million tons of emissions per year. (eCO2? CO@ equiv?) need to quote sources

Air quality emission levels and sources in Massachusetts are comparable in proportion to those nationwide.

How Clean Energy Can Help

Combating climate change and improving air quality requires a significant reduction in emissions. One of the defining features of clean energy technologies is that they either produce no emissions or produce far fewer emissions than fossil fuels.

Technologies that use solar energy, wind, hydropower, wave, or tidal energy do not have to burn any fuel to create power, and therefore produce zero emissions. Advanced clean energy technologies like advanced biomass gasification and fuel cells do burn fuel and produce some emissions, but because they are efficient they produce fewer emissions than fossil-fuel-burning technologies.

[1] Source: Massachusetts Technology Collaborative (http://www.masstech.org/cleanenergy/important/envemissions.htm)

Appendix B: Climate Change & Impacts

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 by introducing more of these substances that can be balanced or taken up by the earth's oceans and plants.

Similar to a greenhouse, CO_2 and other GHGs[1] let sunshine through, but prevent the heat from the earth from escaping (see figure 1).

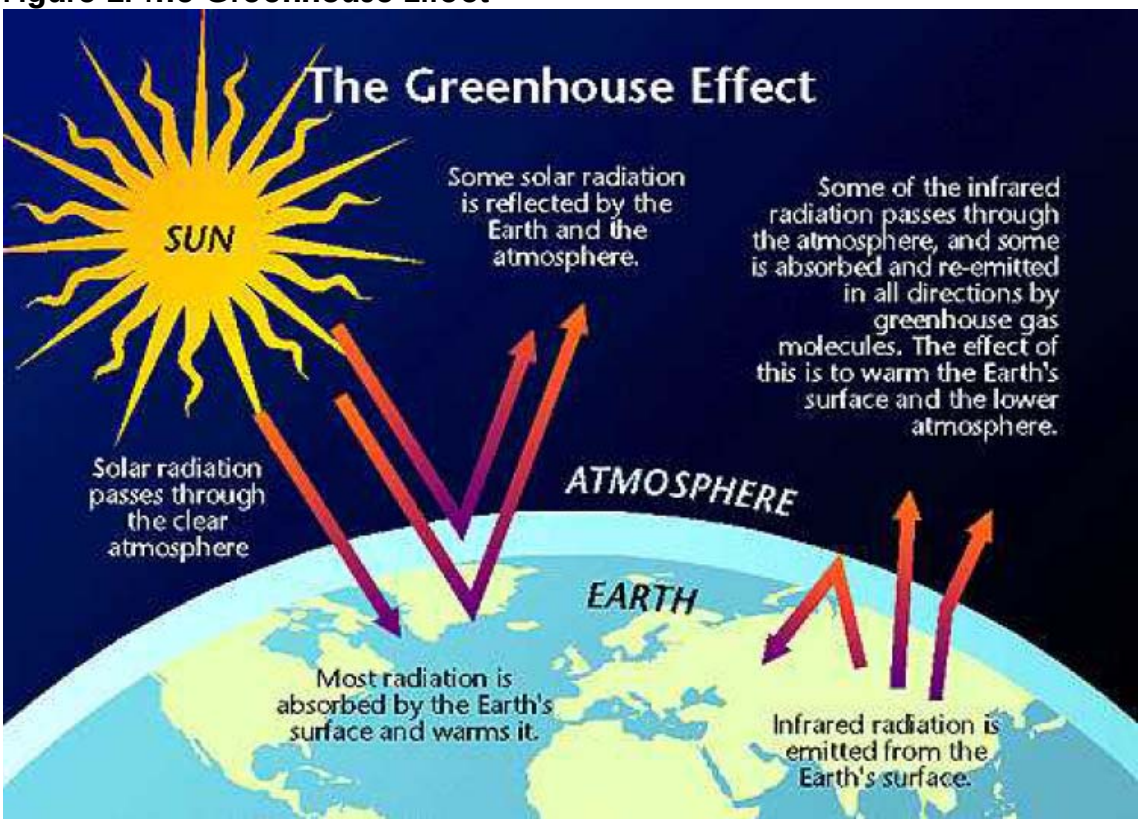
The two major contributors to global warming and climate change are CO_2 and CH_4, which are produced from the combustion of fossil fuels (coal, oil, gas) in vehicles, industrial boilers, generation of waste, and other human activities. Concentration of GHGs, especially CO_2, has increased substantially since the beginning of the industrial revolution. "The global

carbon cycle is made up of large carbon flows and reservoirs. Billions of tons of carbon in the form of CO_2 are absorbed by oceans and living biomass (i.e., sinks) and are emitted to the atmosphere annually through natural processes (i.e., sources). When in equilibrium, carbon fluxes among these various reservoirs are roughly balanced. Since the Industrial Revolution (i.e., about 1750), global atmospheric concentrations of CO_2 have risen about 36 percent, principally due to the combustion of fossil fuels" [1]

[1] Intergovernmental Panel on Climate Change (IPCC) 2007 Report

Over the last two hundred and fifty years, the concentration of CH_4 in the atmosphere increased by 148 percent (IPCC 2007).

Figure 1: The Greenhouse Effect*



* Source: US Environmental Protection Agency (EPA) website: www.epa.gov

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 at a faster rate that is normally seen with changes in earth's orbit and concluded "most of the warming observed over the last 50 years is attributable to human activity." 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 past 100 years sea surface temperatures (SST) have gone up one degree Fahrenheit in New England (Union of Concerned Scientists -2006 report). 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 4 ° F increase in winter and the spring and 5° F in the summer and fall.[1]

Other anticipated effects include the potential for more heat waves which can elevate heat-related deaths, particularly in urban areas such as Boston. Ground level ozone level could rise, reducing air quality in the Boston area. The Massachusetts population will likely face a combination of elevated populations of disease-carrying insects such as mosquito and ticks, with the potential for the introduction of infectious diseases more normally found in tropic areas, such as encephalitis and malaria. 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 exacerbated threats to water quality. Natural habitats and resources such as forests, fisheries, and agricultural lands will face increased stresses. [1]

In the New England area, according to climate change is expected to:[1]

- 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 impacts of climate change are global. They will adversely affect everyone on the planet. Energy consumption, and waste disposal policies can often be most effective at the local government level and that is where action can be taken most quickly. It is our hope that the collective efforts of many communities can have a significant impact on this global problem.

1, New England Regional Climate Variability & Change Assessment (www.necci.sr.unh.edu)

The possible effects of climate change on Nantucket: [2]

- Beaches and waterfront property are vulnerable to sea-level rise and storm surges, which will be exacerbated with an accompanying loss of wetlands and marshes. Storm events that correspond with astronomically high tides will lead to increase "overtopping" and more flooding of low-lying buildings and streets. Erosion along Nantucket's shoreline will also increase.
- Our sole source aquifer is vulnerable to increased salinity

- As water temperatures rise, our scallop industry will be affected. A five-degree increase in water temperatures will severely stress their systems.
- Fish are very temperature dependent and the warmer waters also help support more bacteria and lower oxygen levels
- Warmer waters off the Northeast coast could drive cod, haddock, American plaice and other cold-water species further north or further offshore to colder waters

Nantucket Harbor and Sconset with a 1 meter sea level rise superimposed on the current topography[3]

2. *Climate Change and Its Effect on Nantucket:* October 24th, 2008 presentation by Dr. Sarah D. Oktay, Managing Director, UMass Boston Nantucket Field Station.

3 http://www.civilsocietyinstitute.org/capecod/