Energy Use and Greenhouse Gas Inventory Ipswich, Massachusetts

Commission on Energy Use
and Climate Protection
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1. Introduction

This document is the Greenhouse Gas (GHG) Inventory for Ipswich, MA, prepared by the Commission on Energy Use and Climate Protection (CEUCP) – a group of town officials and citizens convened by the Selectmen in October 2006. Members of the CEUCP are listed in Appendix 1.

The residents, businesses and industries, and municipal government of Ipswich use energy to heat, cool, and light buildings; to power modern household and manufacturing devices; to transport people and products; and to conduct a variety of other activities. As has happened throughout America, the consumption of energy has increased significantly over the years, and the increase has come with costs that can be measured in many ways – financial, environmental, social and otherwise. These costs can adversely affect municipal and state budgets, personal finances, national security, and the sustainability of the earth's ecosystems.

The earth's climate has changed throughout geological history because of a number of natural factors affecting the radiation balance of the planet, such as changes in the earth's orbit, the output of the sun, and volcanic activity. These natural changes in the earth's climate have resulted in past ice ages and periods of warming that have taken place over tens of thousands of years. However, the rate of warming observed over the past 50 years is unprecedented in at least the previous 1,300 years.[1]

The Intergovernmental Panel on Climate Change (IPCC) warns that recent human-induced ("anthropogenic") increases in atmospheric concentrations of GHGs are expected to cause more rapid changes in the earth's climate than have been experienced previously.[2] The buildup of GHGs, primarily carbon dioxide (CO_2), traps heat in the atmosphere and causes the planet's average temperature to increase. This increase in GHGs in the atmosphere is a result of burning coal, oil and natural gas ("fossil fuels"), deforestation, as well as various agricultural activities.

The global atmospheric concentration of CO_2 has increased from about 280 parts per million (ppm) during preindustrial times to 385 ppm in 2009.[3] This increase of over 37% far exceeds the natural range during the last 650,000 years (180-300 ppm) as determined from ice cores.[4] Additional background information on climate change and global warming is provided in the Appendix.

In the Fourth Assessment Report (AR4) of the IPCC, published in 2007, the Contribution of Working Group I issued the following conclusions: *Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.*[5] In addition to CO_2, some other identified GHGs include methane from animal feedlots, landfills, etc., nitrous oxides and hydrofluorocarbons.

The AR4 Report projected increased average global temperatures of 2-4°C and sea level rises between 0.25 and 0.5 meters by 2100, but these estimates did not account for the most recent rates of melting of the Greenland and

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[1] Climate Change 2007: The Physical Science Basis Summary for Policymakers Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
[2] Ibid
[3] US Climate Science Program. Thresholds of Climate Change in Ecosystems Final Report, Synthesis and Assessment Product 4.2 (2009)
[4] Climate Change 2007: The Physical Science Basis Summary for Policymakers Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
[5] Ibid

Antarctic ice sheets.[6] When current rates of ice sheet melting are included in the analysis, the projections of sea level rise will likely reach or exceed 1.0 meter by 2100.[7]

Climate change has also become a recognized driver of ecosystem change. Today, there is worldwide concern over ecological thresholds in danger of being crossed. At the threshold point, relatively small changes in external conditions can cause rapid changes in the ecosystem, to the point where the ecosystem in question is not likely to return to its previous state. Changes in animal migrations, plant budding, the distribution and abundance of plants and animals, ocean chemistry, and increases in such disturbances as coastal storms, floods and wild fires are all examples of ecosystem-scale responses to increased GHG concentrations and a warming biosphere. Instabilities in a system can cause changes to spread in a domino-like fashion. Potentially irreversible, these changes could cause huge impacts on human society.[8] The effects of climate change will be particularly significant for coastal communities, like Ipswich.

This CEUCP report on Ipswich energy use and GHG emissions provides the foundation for local people to take action by reducing energy use and addressing climate protection. The Town and the CEUCP recognize that these actions are urgent, because the current rate of energy consumption is contributing to emissions that cause global climate change.

Concerned about the relationship between GHG emissions and climate change, the Ipswich Board of Selectmen passed a resolution in November 2006 which joined Ipswich with the International Council for Local Environmental Initiatives (ICLEI) and specifically the Cities for Climate Protection (CCP) program. (The text of the Selectmen's resolution is provided in Appendix 1.) Membership in ICLEI affords local governments a cost-effective way to build internal expertise for measuring and tracking GHG emissions.

The CCP has established a five-milestone planning process for member cities and local governments to follow. As part of the first milestone, members are guided to use local data on energy consumption and waste generation to calculate GHG emissions in a base year and a forecast year. The resulting GHG inventory, also referred to as a "carbon footprint," can have many uses.[9] It can serve as a means of illustrating the sources of and trends in emissions; as a tool for developing strategies for emissions reductions; and ultimately as a way of tracking progress toward meeting emission reduction goals and measuring the effectiveness of mitigation programs. (See Section 7.1 for a description of milestones 2 through 5.)

Publication of this report – the GHG emissions inventory for Ipswich – completes the first milestone in the CCP process. The base year is 2000. In subsequent steps of the process, the Town will select an emissions reduction target and then develop and implement specific strategies to lower GHG emissions below the base year. When completed, the Climate Action Plan will serve as the basis for ongoing efforts to reduce emissions in Ipswich.

To reiterate, the compilation of this inventory was driven by concern over climate change. The report is intended to quantify the carbon footprint of day-to-day activities in Ipswich, which are known to negatively impact climate and raise sea levels, threatening fragile, coastal ecosystems in particular and the planet in general. The report helps document the extent of Ipswich's GHG contributions and will hopefully influence the Town, its residents and its businesses to begin considering climate impacts as a factor in routine decision making.

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[6] Ibid
[7] Synthesis Report from Climate Change 2009, www.climatecongress.ku.dk
[8] US Climate Change Science Program www.climatescience.gov
[9] ICLEI Draft Local Government Operation Protocol (6/19/08) for GHG Inventories.

2. Key Findings

In the base year of the inventory report (2000), total Ipswich **GHG (CO_2) emissions** equaled 87,400 metric tons (mt)[10] (Table 2-1). This represents the approximate "**carbon footprint"** of Ipswich in 2000 and is the primary benchmark by which future emission reduction goals will be measured. Over time, GHG emissions generated in Ipswich have been increasing, reaching roughly 110,600 mt in 2005.

While the relative proportion of energy sources has shifted somewhat (e.g., less home heating fuel is used during mild winters, such as happened in 2000), energy use and emissions have been rising overall (Table 2-1, Figure 2-1). The CEUCP considered several historic data points between 1990 and 2005, and has summarized the results of key time periods below. The source analysis of Ipswich's GHG emissions indicates:

- Total emissions are increasing and will continue to do so in the absence of reduction measures.
- Electricity use is the greatest single source of emissions, and its relative importance is projected to increase in the future.
- Space heating fuels (heating oil and natural gas) are also major contributors of GHGs and, combined, constitute the greatest source of emissions.
- Emissions from the use of space heating fuels in homes and businesses are generally increasing, but annual emissions are dependent upon average winter temperatures (e.g., heating demands were below average in 1995 and 2000).

	1990	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Electricity	30,200	31,300	32,800	40,100	*48,300*	*52,700*	*57,500*
Heating Oil	28,400	26,500	24,000	32,600	*28,600*	*28,600*	*27,900*
Natural Gas	17,600	18,900	17,500	24,600	*27,800*	*29,500*	*30,100*
Gasoline/Diesel	12,800	11,700	10,600	10,500	*10,400*	*10,300*	*10,300*
Solid Waste	3,400	2,500	2,500	2,800	*2,800*	*2,900*	*3,100*
Total	**92,400**	**90,900**	**87,400**	**110,600**	***117,900***	***124,000***	***128,900***

Table 2-1 Estimated and projected GHG emissions (mt CO_2) by source

Note: Differences in annual totals reported for source and sector emissions are due to rounding errors.

[10] 1 metric ton = 2,205 pounds

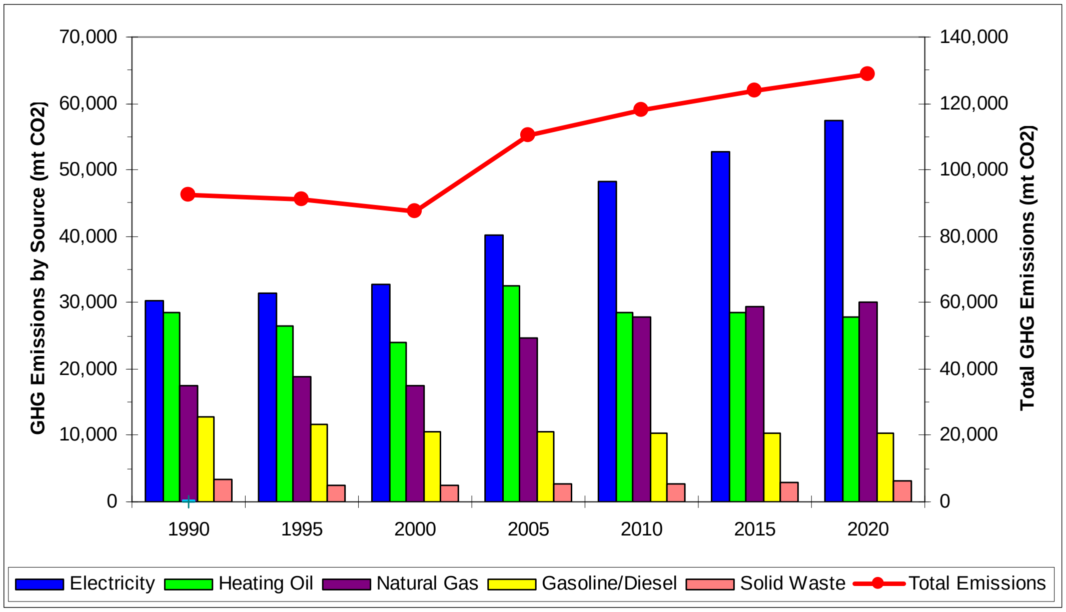

Figure 2-1 Estimated and projected GHG emissions (mt CO_2) by source

The CEUCP also analyzed the carbon footprint of each Town sector (i.e., residential, industrial/commercial, and municipal) (Table 2-2 and Figure 2-2). The sector analysis of Ipswich's GHG emissions indicates:

- The residential sector is the greatest contributor of GHG emissions.
- The industrial/commercial sector shows the fastest growth in terms of the emissions rate.
- Emissions from the residential and industrial/commercial sectors are growing at rates that far exceed the rate of population growth, new job creation, and built space (Table 2-3).

	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential	59,900	58,500	55,300	69,000	*69,700*	*72,400*	*74,000*
Indust./Comm.	29,000	28,900	28,400	37,600	*43,500*	*46,900*	*49,600*
Municipal	3,600	3,500	3,600	4,100	*4,600*	*4,800*	*5,100*
Total	**92,500**	**90,900**	**87,300**	**110,700**	***117,800***	***124,100***	***128,700***

Table 2-2 Estimated and projected GHG emissions (mt CO_2) by sector

Note: Differences in annual totals reported for source and sector emissions are due to rounding errors.

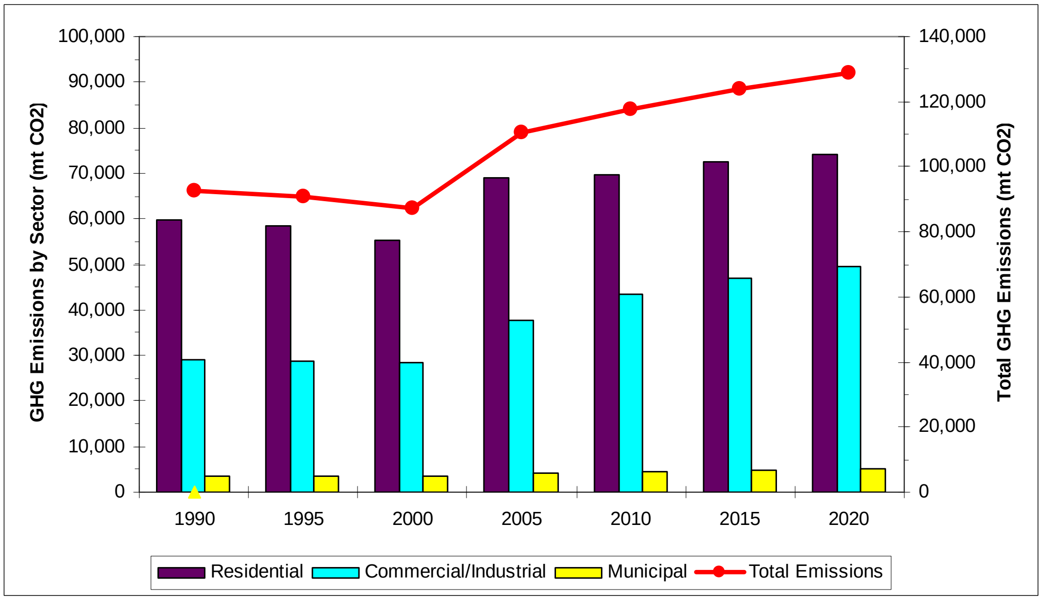

Figure 2-2 Estimated and projected GHG emissions (mt CO_2) by sector

Ipswich	1990	1995	2000	2005
Population[11]	12,791	12,524 (-2%)	13,435 (+7%)	13,483 (+<1%)
Jobs[12]	3,082	3,748 (22%)	3,927 (+5%)	4,144 (+6%)
Built Space (1,000 Sq Ft)	10,779	11,477 (+6%)	12,476 (+9%)	13,567 (+9%)
GHG Emissions (mt CO_2)	92,500	90,900 (-2%)	87,300 (-4%)	110,700 (+27%)

Table 2-3 Growth rate comparisons in Ipswich

Note: The values in parentheses indicate per cent change from prior period.

Regarding the GHG emission projections for 2010, 2015 and 2020, the CEUCP relied on forecast data published by the United States Department of Energy's Energy Information Administration (DOE/EIA), the Massachusetts Municipal Wholesale Electric Company (MMWEC), and the Massachusetts Area Planning Council (MAPC). The CEUCP felt it was important to include the forecast scenario, because it suggests an undesirable future for Ipswich in the absence of new mitigation measures. To reiterate, the carbon footprint in 2000 is the baseline inventory, and any energy use and emission increases above this base means that the Town is increasing its climate impact.

While emissions are most certainly rising, readers should also note that any attempt to precisely project future emissions is subject to uncertainty. In the short term (less than 5 years), the key factors that can influence net changes in energy use include unanticipated fluctuations in retail fuel prices, shifts in the competitive relationship

[11] Annual Town Census
[12] Ibid

between natural gas, heating oil and coal in the energy markets, and abnormal winter or summer temperatures. Additional factors include technology developments, new government policies, and changes in economic activity.[13]

The CEUCP also reviewed Ipswich per capita emissions over time. Between 2000 and 2005, the population remained relatively steady, yet there was about a 27% increase in per capita emissions (Figure 2-3).

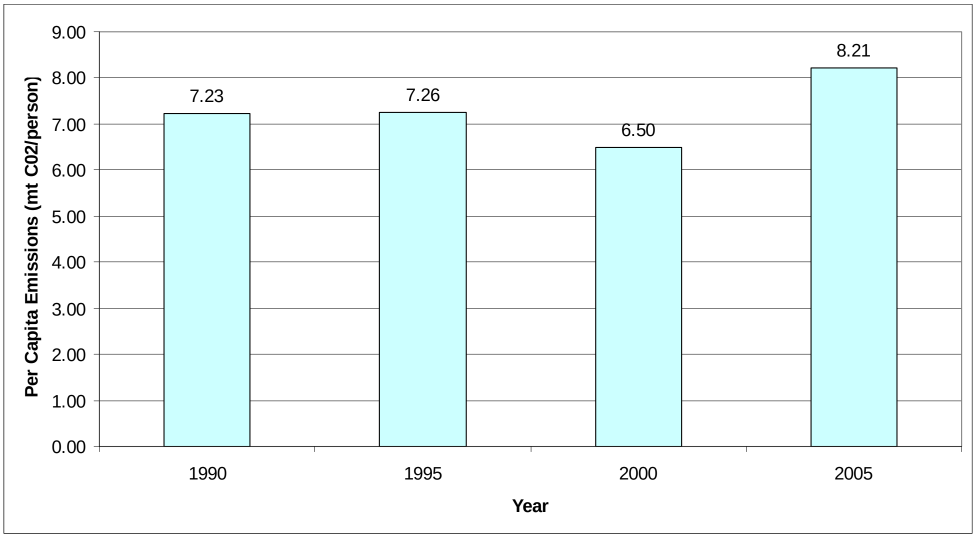

Figure 2-3 Total per capita GHG emissions (mt CO_2)

The data suggest that per capita emissions in Ipswich are lower than per capita emissions measured for Massachusetts and the Northeast. While this appears to present a favorable view of energy use by the Ipswich population, the CEUCP cautions against making a direct comparison across different regions. In all likelihood, methodologies chosen by the CEUCP differed from methodologies chosen elsewhere. For example, this analysis does not account for any of the activities that occur outside of the town's boundaries. Although we recognize that many people from Ipswich also use energy to commute to Boston, travel by plane, or purchase goods that were shipped from overseas, these activities were beyond the CEUCP's scope, because they occurred outside of town. In other words, the per capita emissions measured for this report are understated, because the scope of the report was intentionally limited to activities occurring within town boundaries. Analyses of per capita energy use in Massachusetts and New England result in higher numbers, because a greater variety of activities, across broader geographies, are considered.

[13] US Department of State - Fourth Climate Action Report to the UN Framework Convention on Climate Change (US CAR). http://www.state.gov/g/oes/rls/rpts/car/

3. General Methodology Overview and Important Terms

The Ipswich GHG inventory tallies the GHG emissions from local activities that emit greenhouse gases directly, namely burning fossil fuels. The ICLEI method recommends that a GHG inventory focus on these types of activities, which are called Scope 1 (direct) emissions,[14] in part because they are under the operating control of town government, town businesses or local residents. The Ipswich inventory also accounts for Scope 2 (indirect) emissions related to electricity, because even though most of the electricity used in Ipswich is generated by facilities far away, consumption of electricity is directly controlled by people in Town. The methodology used for this inventory does not, however, include any other Scope 2 sources, such as energy embedded in consumer goods from outside the community. Nor does it consider the potential for capture and storage of carbon by living plants (biomass sequestration).

Energy use was summarized by source (electricity, heating oil, natural gas, gasoline/diesel, and solid waste), as well as by sector (residential, industrial/commercial, and municipal). The residential sector refers to the Ipswich population and households. The industrial and commercial sector refers to other operations in town.[15] The industrial and commercial sectors were combined for the purposes of this inventory, because they were indistinguishable when analyzing fuel sources other than electricity. The municipal sector covers all Town operations, including the Town Hall, schools (if data was available), police and fire departments, harbormaster, library, cemeteries and parks, waste water treatment plant, and street lights.

The CEUCP compiled energy use data for Ipswich using a base year of 2000; looked further back in history to estimate energy use in 1990 and 1995; and then collected more recent data to measure energy use in 2005. Looking ahead, the CEUCP considered energy use forecasts published by public agencies and, in some cases, adjusted those projections in light of known variables (Ipswich population, square footage of built space, etc.). Specific methodologies for collecting and forecasting data are discussed in the subsequent chapters, and actual calculations are provided in the appendix. In all cases, the numbers are rounded.

Using the data on energy use, the CEUCP calculated GHG emissions. To be consistent with global GHG inventories, this report presents metric tons (mt) of CO_2 emissions. CO_2 is the most significant GHG of the various gases tracked under worldwide inventory and climate protection programs. In Ipswich, CO_2 represents the majority of all GHG gases emitted by human activities, and the heat trapping potential of one metric ton of CO_2 is the basic unit of measurement of our GHG emissions.

Inventories that count other GHG emissions adjust the GHGs for their specific warming potential as measured in CO_2 equivalents (CO_2e). For example, scientists have found that methane holds more than 20 times more heat than carbon dioxide.[16] Thus, communities with active landfills or other bio-gas producing decomposition processes typically include the CO_2e of methane emissions in their inventory.[17] Methane is not a significant factor in Ipswich, however, because the local landfill closed more than 25 years ago and very little methane is now produced. Waste at the site has already decomposed. Although methane gas is likely released in small amounts from farms in Ipswich (e.g., agriculture and animal husbandry), this inventory did not quantify these sources.

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[14] Based on a protocol procedure developed by the World Business Council for Sustainable Development and the World Resources Institute (WBCSD/WRI)

[15] general manufacturing plants, warehouses, research and development facilities, sand and gravel operations, retail businesses, inns and motels, commercial condominiums and offices, religious and fraternal organizations, banks, and mixed commercial/residential buildings

[16] http://www.epa.gov/methane

[17] Each mt of methane = 23 mt CO_2e, for a CO_2e value of 23.

GHG emissions for the town as a whole are based on calendar years. Emissions from the municipal sector are presented on a fiscal year basis, from July 1 through June 30. In order for annual data to be captured across timeframes with the same January (an important factor when discussing heating fuels), the fiscal year-end preceded the calendar year-end for each timeframe.

When reviewing the trends in fuel consumption for space heating, weather is an important consideration. The variation in average temperature produces different energy demands for different years. This energy requirement is usually expressed in heating-degree-days (HDD), a quantitative index of the demand for heating fuel based on daily temperature observations. HDD is a measure of how cold it is compared to a base temperature of 65° F. For example, if the average temperature of a given day is 40° F, there would be 25 HDD for that day (i.e. 65 - 40 = 25). The sum of the daily HDD in a calendar year represents the annual HDD for a specific area. For the purposes of this report, HDD was considered as an important variable and records of HDD per year (using July to June timeframes) were obtained from the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC).[18] The CEUCP used the HDD figures from NCDC as a factor when comparing heating fuel consumption across years, which was essential because in the time period reviewed, winter temperatures ranged from 14% below the average to 12% above.[19]

Population and employment trends published in the annual Town census were also considered, as presented in the Appendix. Population growth is one of the primary factors influencing residential demand. In order to estimate how the population might change over time, the CEUCP reviewed census projections published by the Metropolitan Area Planning Council (MAPC)[20] – which have since proven to be underestimates; the Ipswich Tax Assessor's records, and residential building permits. Considering all of this information, the CEUCP estimated population in 2010, 2015, and 2020, by assuming that population will continue to grow at a rate of 1% per year.

4. Results by Source

Energy use has changed over time for a variety of reasons, including the weather (warm winters affect home heating), infrastructure (e.g., expanding natural gas distribution systems), and consumer demand (e.g., people are using more appliances powered by electricity). The historical trends and future projections associated with each energy source are discussed in detail in the subsequent sections.

As a backdrop for understanding subsequent sections of the inventory report, the CEUCP created a snapshot of GHG emissions by source in the most recent year measured, 2005 (Figure 4-1). This snapshot best represents the Town's current portfolio of emission sources. Electricity is the largest single emitter (36% of total emissions in 2005). However, it is also sensible to view heating oil and natural gas in combination, because they are used for the same purpose – space heating. When considered together, heating fuels accounted for more than 50% of all GHG emissions in Ipswich for 2005.

According to the Department of Energy's Energy Information Administration, GHG emissions from transportation account for approximately one-third of the total emissions in the US.[21] Yet, Figure 4-1 illustrates that emissions

[18] http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html
[19] Ibid
[20] http://www.mapc.org
[21] http://tonto.eia.doe.gov/energy_in_brief/greenhouse_gas.cfm

from the use of gasoline and diesel in Ipswich vehicles accounted for only about 9% of all local emissions for 2005. However, it should be noted that the calculations used for estimating vehicular emissions included only vehicles driven in Ipswich by people who live or work here. This inventory did not attempt to quantify Ipswich residents' emissions from driving outside of town, or from traveling by other means, such as commuter rail or airplane. (As discussed in greater detail in the vehicular fuels section of this report, the CEUCP relied on models developed by the MAPC's Central Transportation Planning Staff (CTPS),[22] which estimated that in 2000 about 26% of all vehicular traffic in Ipswich was attributed to Ipswich residents and businesses.)

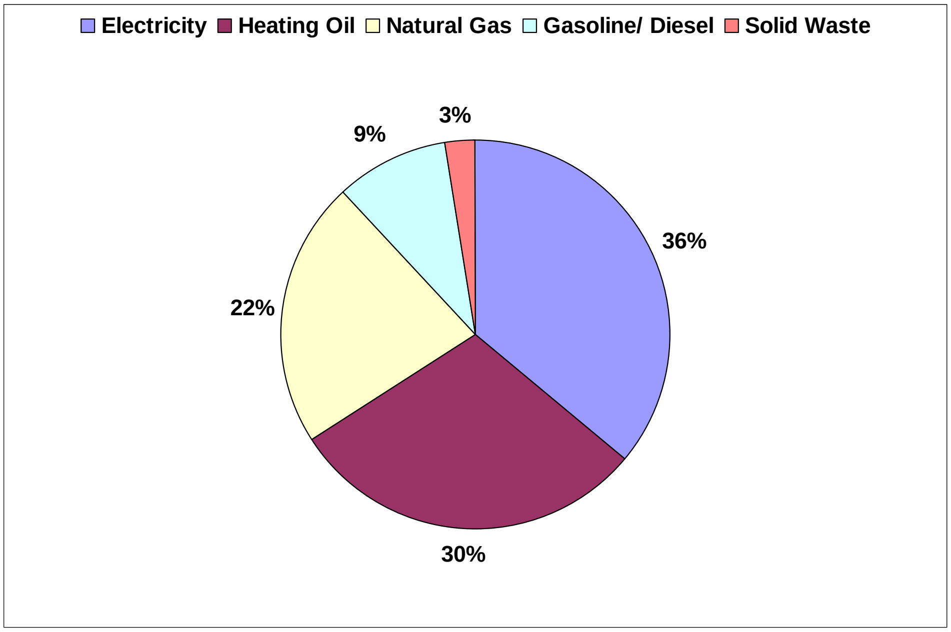

Figure 4-1 Proportional GHG emissions by source for 2005

4.1 Electricity

4.1.1 Introduction

The Ipswich Municipal Light Department (IMLD) is the public utility providing electricity to Ipswich residents and businesses. It was created in 1905, after which Ipswich built an engine generator station to supply Ipswich with electricity. A modern version of that station is still owned and operated by the Town, but the operating cost is prohibitive except under summer peak-demand conditions. As a member of the Massachusetts Municipal Wholesale Electric Company (MMWEC), Ipswich buys much of its electricity in coordination with other municipalities. At the time of this writing, the IMLD has power contracts with two base power nuclear plants, intermediate load MMWEC power plants, New York Power Authority hydroelectric plants (Niagara Falls), and Quebec hydropower. The IMLD is also pursuing wind energy projects in Ipswich and the Berkshires, as well as a landfill gas to energy project in Rhode Island. If these initiatives are completed on time and as planned, up to 40% of the Town's electricity could be generated from renewable sources by 2011[23].

[22] http://www.bostonmpo.org/bostonmpo/1_about_us/2_ctps/ctps.html
[23] Tim Henry, IMLD, personal communication

4.1.2 Methodology

Data for this inventory report was obtained from IMLD records and from future year MMWEC power projections developed specifically for Ipswich.[24] The CEUCP relied on projections from the MMWEC to forecast Town-wide usage in 2010, 2015, and 2020. Since the forecast numbers were gross figures for the town overall, the CEUCP apportioned them across the residential, industrial/commercial, and municipal sectors according to the usage ratio evident in 2005. These projections do not account for the possible increased use of renewable energy. Instead, they are based on increases in consumer demand, and the emissions factor is held constant at 2005 levels. Throughout this report, future projections illustrate emissions growth in the absence of any new mitigation efforts implemented by the Town.

Electricity use data can be translated into GHG emissions if information is known about how much CO_2 is emitted per kilowatt-hour (KWh) by the generating stations. While national or regional CO_2 emission factors are generally used for GHG inventories, more refined calculations are possible in Ipswich – the actual power plant contracts, energy purchase records, and emissions data are readily available. By looking at the particular mix of electricity supply contracts in Ipswich, the CEUCP was able to determine emission factors by generation source.

On an encouraging note, in 2005 the Ipswich GHG emission rate (830 pounds of CO_2 per MWh) was lower than the average electricity emission rate in the United States and Massachusetts (Table 4-1). The relatively favorable local emissions rate arises from having a higher mix of power produced by nuclear, hydroelectric and gas when compared to the United States and Massachusetts grid averages. Details about the origin and supply of electricity in Ipswich are listed in the Appendix. This information is relevant because the portfolio of sources – ranging from fossil fuels to nuclear reactors to renewable energy sources – has changed over time (and will continue to do so). As has apparently been done in the past, the Town should continue to evaluate future energy purchases with careful consideration of the emissions rates of power suppliers.

	Annual Net Generation (MWh)	Annual GHG emission rate (lb/MWh)
United States 2005[25]	4,056,441,933	1,329
MA 2005[26]	47,494,728	1,263
Ipswich 2005	106,388	830
Ipswich 2000	92,578	780
Ipswich 1995*	78,462	830
Ipswich 1990	75,634	880

Table 4-1 Comparative electricity generation and emission rates (lbs of CO_2/MWh)

*1995 data has been estimated by averaging data known for 1990 and 2000.

[24] Massachusetts Municipal Wholesale Electric Company
[25] http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html, eGRID2007Version1.1Year2005SummaryTables
[26] Ibid

4.1.3 Overall Findings

In the base year 2000, electricity consumption in Ipswich was approximately 92,600 megawatt-hours (MWh) (Table 4-2) and caused the generation of 32,800 mt CO_2, nearly 38% of the overall calculated carbon footprint for Ipswich that year (Table 4-3, Table 2-1).

Sector	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential	37,998.4	41,158.3	46,529.8	50,977.4	*61,514.5*	*67,088.6*	*73,168.2*
Indust/Comm	33,134.8	32,841.4	40,730.9	50,104.3	*60,460.9*	*65,939.6*	*71,915.0*
Municipal	4,501.1	4,462.5	5,317.7	5,306.7	*6,403.6*	*6,983.9*	*7,616.7*
Total	**75,634.3**	**78,462.2**	**92,578.4**	**106,388.4**	***128,379.0***	***140,012.1***	***152,699.9***

Table 4-2 Historic and projected electricity use (MWh)

Sector	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential	15,200	16,400	16,500	19,200	*23,200*	*25,300*	*27,500*
Indust/Comm	13,200	13,100	14,400	18,900	*22,800*	*24,800*	*27,100*
Municipal	1,800	1,800	1,900	2,000	*2,400*	*2,600*	*2,900*
Total	**30,200**	**31,300**	**32,800**	**40,100**	***48,400***	***52,700***	***57,500***

Table 4-3 Estimated and projected GHG emissions (mt CO_2) from electricity use

Electricity consumption has increased at a much faster rate than population, Ipswich-based jobs, and new construction (Tables 2-3, 4-2). Specifically, electricity use increased 18% between 1995 and 2000 and an additional 15% between 2000 and 2005.

Using the electricity consumption figures (Table 4-2) and the known emission factors generated by the Town's power suppliers (Table 4-1), an inventory of electricity-related GHG emissions was calculated (Table 4-3). The data shows that as town-wide demand for electricity has grown, so has the electricity-related carbon footprint.

Total power demand in 2010, 2015, and 2020 was forecasted using consumption projections devised by MMWEC specifically for Ipswich. The MMWEC data pertained to the Town as a whole, so the CEUCP apportioned the total in keeping with the ratio of electricity used by each sector in 2005. In making its emissions forecasts, the CEUCP also held constant the 2005 annual emission rate of 830 lb CO_2/MWh (which assumes the most recent portfolio of electricity suppliers will not change). Again, the emission forecasts suggest GHG emissions will grow in the absence of new mitigation efforts (Table 4-3, Figure 4-2).

The CEUCP also considered emissions from electricity use by sector (Figure 4-2). The residential sector has historically been the greatest user of electricity and hence the greatest contributor to GHG emissions, relative to the other sectors. However, consumption by industrial/commercial customers has been increasing since 1990, to the point where in 2005 the industrial/commercial sector used nearly as much power as the residential sector. Growth in the industrial/commercial sector during this time is primarily attributed to two large industrial facilities (New England Biolabs and EBSCO Publishing) that were opened during the late 1990s and early 2000s. The municipal sector is the smallest sector, yet it too experienced significant growth in electricity use and emissions as a result of square footage expansions at the Schools and Town Hall.

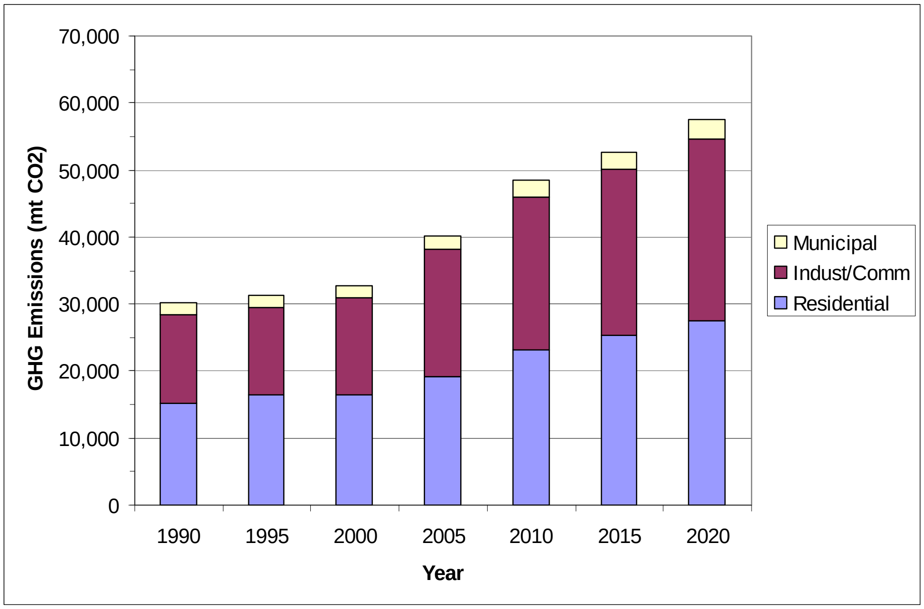

Figure 4-2 Historic and projected GHG emissions from electricity use (mt CO_2)

4.1.4 Residential Sector

In 2000, the GHG inventory base year, residential electricity use totaled 46,529.8 MWh (Table 4-2), which resulted in 16,500 mt CO_2 (Table 4-3). Residential electricity use in Ipswich has increased steadily since 1990. IMLD records show that residential demand was more than 20% greater in 2000 than in 1990. In the five years between 2000 and 2005, demand increased an additional 10%. Projections made using MMWEC forecasts suggest even greater increases in residential electricity use in the years to come.

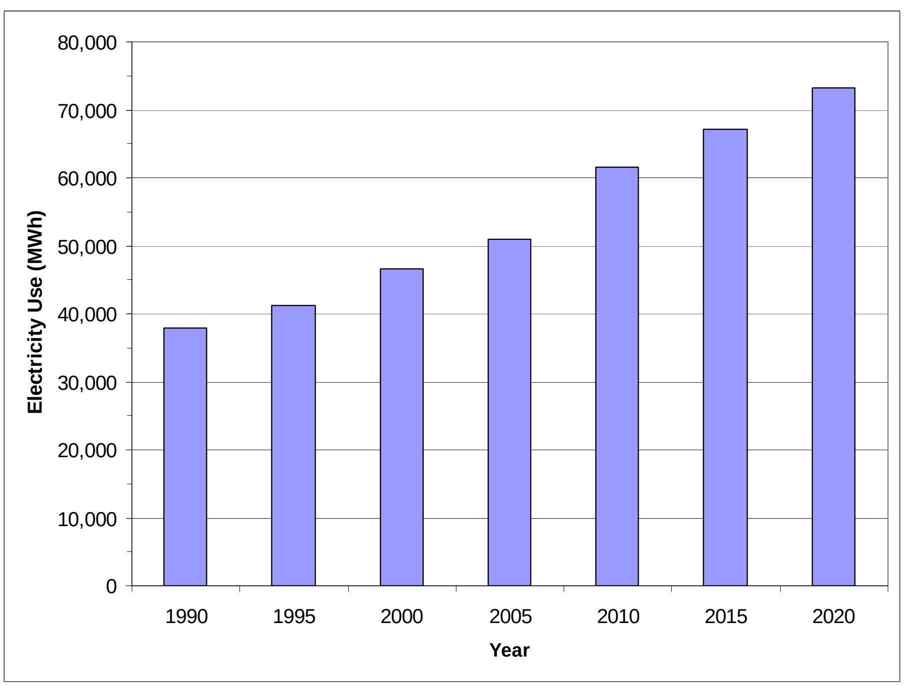

Figure 4-3 Historic and projected residential electricity use (MWh)

Residential electricity use per household was also calculated (Figure 4-4). For this purpose, per household use was determined by dividing total residential consumption by the number of IMLD residential customers (as reported by IMLD). In 1990, the typical Ipswich residence used about 7,450 KWh. By 2000, the household use increased roughly 13%, to about 8,400 KWh. By 2005, an additional 3% increase occurred, raising the average household usage to about 8,700 KWh per year. These data indicate that compared to prior periods, Ipswich residents are now using greater amounts of electricity per household. As a comparison, in 2005 the average New England household used approximately 7,478 KWh, or about 14% less than Ipswich households.[27]

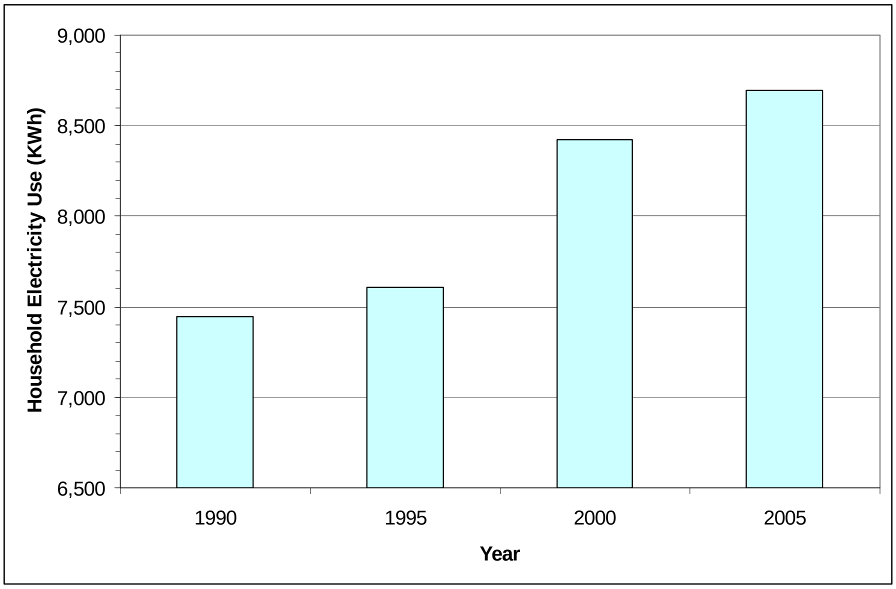

Figure 4-4 Residential electricity consumption per household (KWh)

4.1.5 Industrial/Commercial Sector

The industrial and commercial sectors were combined in all sources for the purposes of this inventory report, because they could not be distinguished from one another when analyzing fuel sources other than electricity. However, IMLD records do allow for separate analysis. The data shows that industrial businesses in Ipswich consume more electricity than commercial businesses. In 2000, for example, industry accounted for 77% of industrial/commercial electricity use, while commercial accounted for about 23%.

On the industrial side, modest growth in electricity demand occurred between 1990 and 2000, followed by rapid growth between 2000 and 2005. The increase in demand is primarily attributed to the opening of two large companies, New England Biolabs and EBSCO Publishing. On the commercial side, electricity consumption more than doubled between 1990 and 2000, but then leveled off and even declined slightly between 2000 and 2005.

When considered in combination, the industrial and commercial sectors account for significant increases in electricity demand since 1990 (Figure 4-5). This sector expanded rapidly between 1995 and 2005, at a pace that even exceeded growth on the residential side. In 2000, the base year of the GHG inventory, the industrial/commercial sector used 40,730.9 MWh of electricity (Table 4-2, Fig. 4-5) and produced 14,400 mt CO_2 (Table 4-3).

[27] 2005 Residential Energy Consumption Survey. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

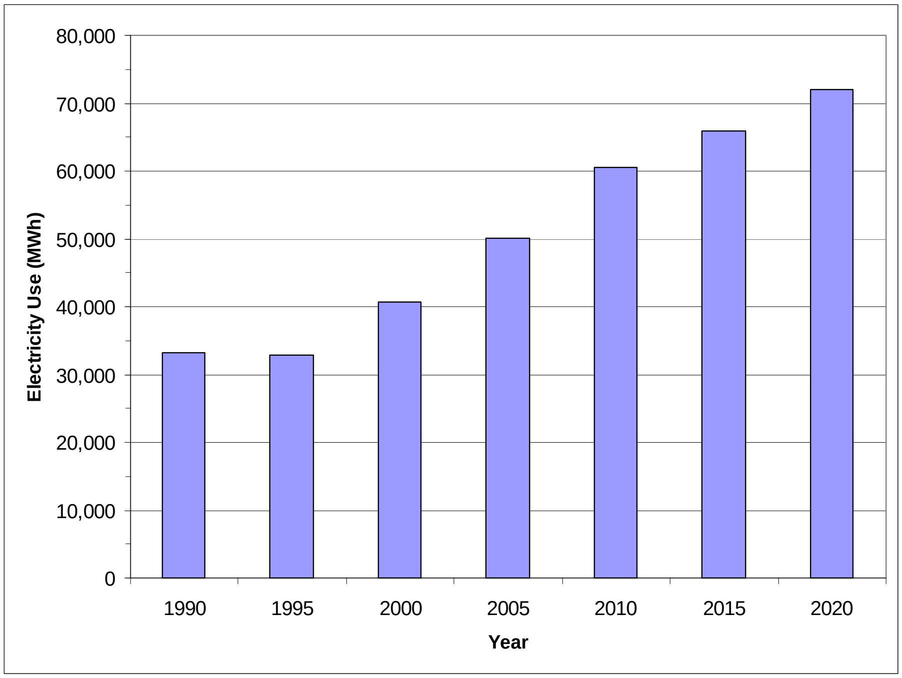

Figure 4-5 Historic and projected industrial/commercial electricity use (MWh)

Again, the projections for 2010 and 2020 are based on the overall demand forecasts put forth by MMWEC for Ipswich, 47% of which were apportioned to the industrial/commercial sector based on known sector ratios from the year 2005 (Table 4-2, Figure 4-5).

The CEUCP also reviewed industrial/commercial electricity consumption per square foot of business space (Figure 4-6). Like the other trends, energy use per square foot has increased over the fifteen year time period.

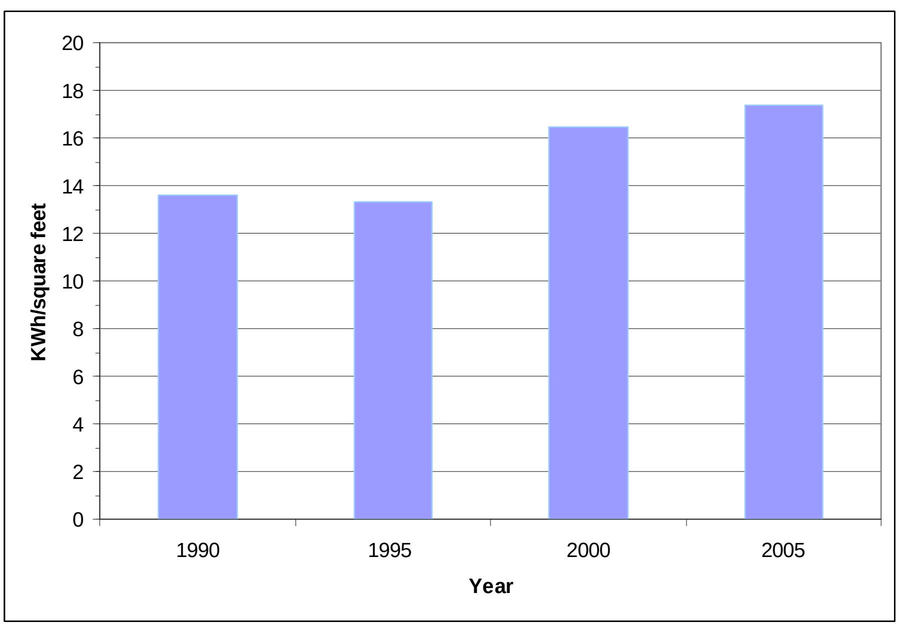

Figure 4-6 Historic industrial/commercial electricity use (KWh) per square foot of business space

4.1.6 Municipal Sector

Data on actual, overall electricity consumption in the municipal sector was obtained from the IMLD. The Department's data was categorized rather generally as "municipal operations" and "streetlights." To obtain more detailed information about the municipal operations, the CEUCP extracted historic usage data from Excel spreadsheets typically prepared by the Town Manager during the budget process. These spreadsheets presented actual figures for prior periods for each department reporting to the Town Manager. Consumption data was also obtained from the schools, though figures for periods prior to 2001 were not available. However, power consumption by the schools was captured in the composite municipal information provided by IMLD (Table 4-4).

In 2000, the base year of the inventory report, the municipal sector consumed 5,317.7 MWh, or about 6% of the Town's electricity (Table 4-2). This energy use resulted in emissions of 1,900 mt CO_2 (Table 4-3). Historic municipal electricity consumption is shown in some detail in Table 4-4.

	1990	1995	2000	2005
Streetlights**	1,092.0	1,092.0	1,092.0	843.5
Wastewater Plant+	873.0	930.0	986.4	1,158.2
Water Distribution+	270.0	546.0	419.1	466.3
Water Treatment+	450.0	356.1	303.2	375.9
Police+	147.0	157.3	171.9	174.3
Town Hall+	107.9	121.6	131.6	291.0
Library+	50.7	63.2	134.2	112.2
Fire Department+	58.1	59.2	76.8	69.1
Cemeteries/ Parks+	12.9	16.6	10.9	14.8
Equipment Maint.+	*	14.1	4.8	14.1
Animal Control+	*	13.6	18.3	22.2
Council on Aging+	*	10.8	10.9	*
Transfer Station+	*	9.5	3.6	2.8
Highway Dept.+	*	3.8	*	*
Harbormaster+	*	*	*	*
Shellfish+	*	*	1.8	1.1
Doyon School++	*	*	*	364.7
Winthrop School++	*	*	*	275.8
Middle/High School++	*	*	*	1,846.1
Total Municipal**	**4,501.1**	**4,462.5**	**5,317.7**	**5,306.7**

Table 4-4 Municipal electricity consumption (MWh) by department

*No data available.
** Data source is Ipswich Municipal Light Department
+ Data source is Town Manager's budget spreadsheet with actual figures for prior periods
++ Data source is School Department

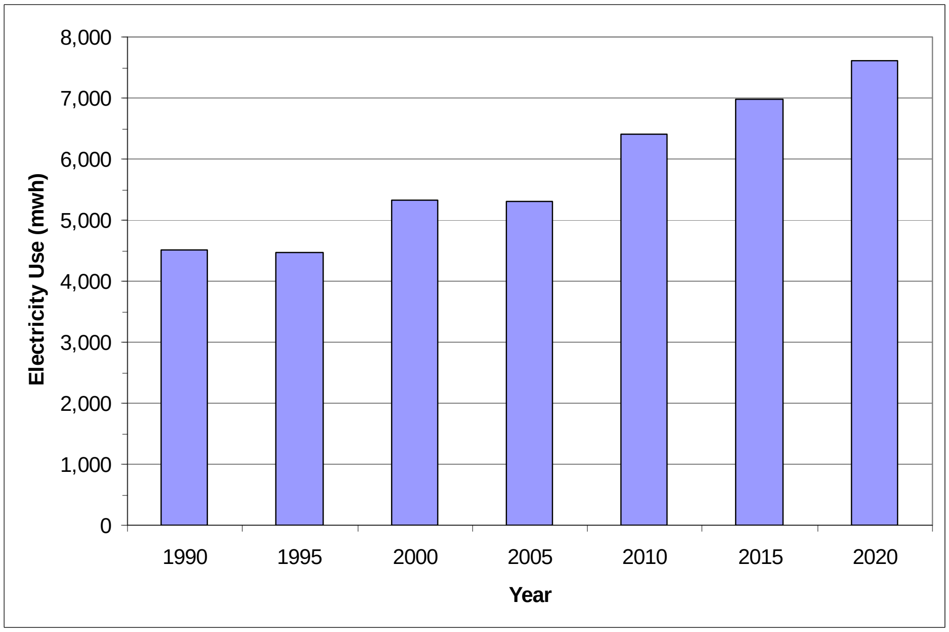

Figure 4-7 Historic and projected municipal electricity use (MWh)

Between 1990 and 2000, electricity consumed in the municipal sector grew more than 18% (Table 4-4, Figure 4-7). This sizeable increase is attributed to the overall growth in the square footage of town-owned facilities. For example, all of the schools increased in size. The Doyon Elementary and Winthrop Elementary schools constructed additions in the early 1990s, and the High School/Middle School facilities nearly doubled when a new campus was built in the late 1990s and 2000. In 2001, the functions of the old Town Hall, the Memorial Building, and the Council on Aging consolidated into the former Middle School, nearly doubling the floor area of those functions.

Between 2000 and 2005, municipal electricity use remained relatively stable and even declined slightly as percentage of overall Town use (from 6% to 5%) (Table 4-2, Figure 4-2). During this time, significant efforts were made to improve energy efficiency, particularly with regard to streetlights and indoor lighting.

The projection for 2010, 2015, and 2020 was determined by using data from MMWEC. MMWEC forecasted future power demand for Ipswich, and the CEUCP apportioned the overall figure across each sector of Town (residential, industrial/commercial, and municipal) based on the sector ratios evident in 2005. The projection illustrates a future consumption scenario in which municipal functions continue to require 6% of the Town's power.

4.2 Heating Oil

4.2.1 Introduction

This section assesses the consumption of heating oil and corresponding GHG emissions in Ipswich. Data from the Ipswich Assessor's Office show that in 2005, approximately 3,257 residential homes, or about 70% of the households in Ipswich, were heated with oil.[28] Heating oil was also used for domestic water heating purposes, as well, although some homes using oil for heating may have heated water with electricity, natural gas, or propane.[29] Heating oil use in commercial and industrial buildings was much less prevalent than in residential buildings, comprising less than 10% of the total heating oil consumption in Ipswich.

4.2.2 Methodology

Actual heating oil consumption records were difficult to obtain because, unlike electricity and natural gas distribution systems, residential heating oil is purchased from more than two dozen, private oil delivery services throughout the area. The CEUCP contacted many of the companies that distribute heating oil in Ipswich, but was unable to obtain information that could be used to quantify the amount of heating oil consumed in Ipswich for the specific inventory years.

Estimates of heating oil consumption for the residential sector were generated using data from the US Department of Energy's Energy Information Administration (EIA) and the Town of Ipswich Assessor's Office. Consumption estimates were made by adapting formulas developed for the EIA's Residential Energy Consumption Survey (RECS), which accounts for such factors as annual heating degree days (HDD) and space heating intensity. These formulas are sensitive to annual weather conditions by region and typical improvements in insulation and heating system efficiency. The formulas also included square footage of heated space for homes in Ipswich using heating oil, which was obtained from the Town of Ipswich Assessor's databases.

For commercial and industrial heating oil consumption, data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS)[30] and the Manufacturing Energy Consumption Survey[31] were used to generate relationships between Energy Intensity Factors developed by CBECS and the annual HDD in Ipswich. In addition, square footage of heated space for commercial and industrial buildings was used to estimate heating oil consumption for each survey year. Municipal heating oil consumption data were obtained directly though the Town of Ipswich. To estimate the projected heating oil consumption for the residential and industrial/commercial sectors in 2010, 2015, and 2020, the EIA's 2008 Annual Energy Outlook report estimates for New England were used[32]. A detailed description of the methodology for the heating oil estimates can be found in the Appendix.

4.2.3 Overall Findings

The estimated heating oil consumption in Ipswich has remained relatively consistent in the 15-year time frame reported in this inventory, ranging from a low in 2000 of 2,364,900 gallons to a high of 3,213,900 gallons in 2005 (Table 4-5). The estimated and projected GHG emissions from heating oil are provided in Table 4-6 and Figure 4-8. Residential heating oil use is by far the largest sector, accounting for over 90% of all consumption and emissions from heating oil in Ipswich. As discussed in other sections of the report, consumption of fuels for space heating is

[28] Town of Ipswich Assessor
[29] Jim Sperber, Ipswich Building Inspector, personal communication
[30] http://www.eia.doe.gov/emeu/cbecs/contents.html
[31] http://www.eia.doe.gov/emeu/mecs/contents.html
[32] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

highly dependent upon the weather. Colder winters result in greater space heating demands (i.e., increased HDD) and, hence, higher consumption of heating oil. The lowest consumption year (2000) also had the smallest HDD (5,754) and the two highest consumption years (1990 and 2005) had the greatest HDD (6,317 and 6,522, respectively).

Other factors that may have influenced the amount of heating oil consumed in Ipswich include price. Average retail prices (excluding taxes) of heating oil in Massachusetts remained at or below $1 per gallon between 1992 and 1999; average price jumped from $0.84 per gallon in 1999 to $1.27 per gallon in 2000, and has climbed steadily since then in Massachusetts.[33] In 2005, the average New England heating oil price was $2.00 per gallon.[34] The sudden spike above historic heating oil prices at the beginning of the 2000/2001 winter, combined with relatively mild temperatures during most of the heating season, may have contributed to the decline in consumption in 2000. Another factor that may have influenced heating oil consumption in Ipswich is an increased number of homes that have been converted to natural gas heating. Increased growth in new residential construction and more typical winter temperatures since 2000 may be responsible for the increased consumption of heating oil in Ipswich in 2005.

Sector	**1990**	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential	2,570.7	2,402.5	2,156.1	2,936.3	*2,563.4*	*2,575.1*	*2,507.6*
Indust/Comm	205.2	181.7	188.9	256.4	*230.7*	*223.0*	*217.9*
Municipal	23.3	23.0	19.9	21.2	*18.8*	*18.5*	*18.0*
Total	**2,799.2**	**2,607.2**	**2,364.9**	**3,213.9**	***2,812.9***	***2,816.6***	***2,743.5***

Table 4-5 Estimated and projected heating oil consumption (thousands of gallons)

Sector	**1990**	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential	26,100	24,400	21,900	29,800	*26,000*	*26,100*	*25,500*
Indust/Comm	2,100	1,800	1,900	2,600	*2,300*	*2,300*	*2,200*
Municipal	200	200	200	200	*200*	*200*	*200*
Total	**28,400**	**26,400**	**24,000**	**32,600**	***28,500***	***28,600***	***27,900***

Table 4-6 Estimated and projected GHG emissions (mt CO_2) from heating oil consumption

[33] Table 9.8a. No. 2 Distillate Prices to Residences: Northeastern States. November 2008 Monthly Energy Review. http://www.eia.doe.gov/emeu/mer/petro.html
[34] Ibid

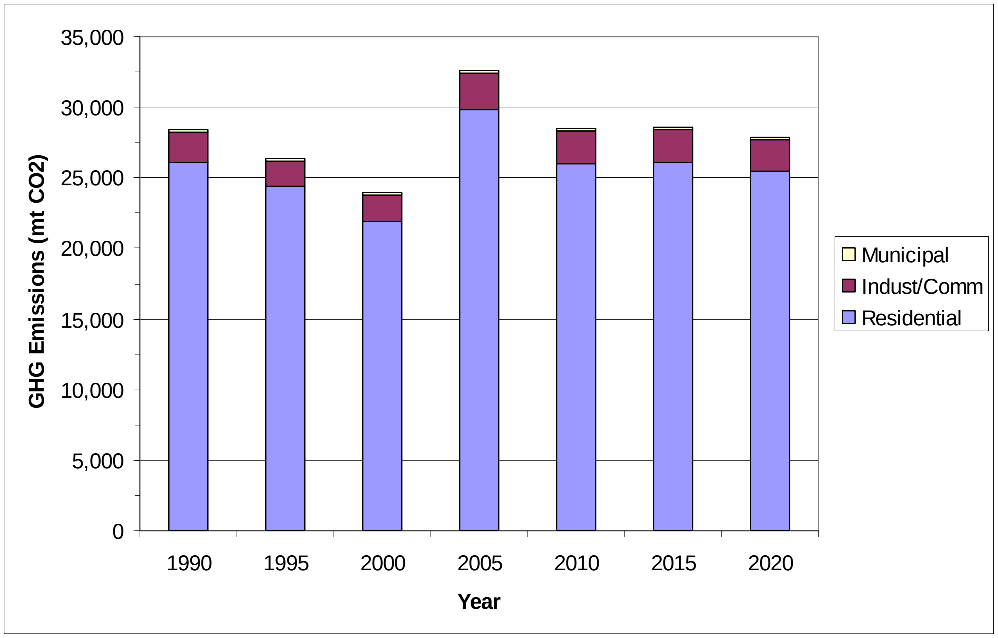

Figure 4-8 Historic and projected GHG emissions (mt CO_2) from heating oil consumption

4.2.4 Residential Sector

In the 15-year period between 1990 and 2005, there has been a steady increase in the total square footage of residential buildings using heating oil for space heat. The total area of residential buildings heated with heating oil increased by approximately 18% from 5.2 million square feet in 1990 to 6.1 million square feet in 2005, while the consumption of heating oil has increased by about 14% from about 2,571,000 gallons to 2,936,000 gallons (Table 4-5; Figure 4-9). However, the heating oil consumption between 1990 and 1997 increased by less than 2%; in contrast, the annual consumption between 2000 and 2005 increased by about 36%, even though the rate of increase in residential square footage was similar to previous years (Figure 4-9). As discussed above, much of this increase in consumption may be attributed to the higher HDD in 2005 (6,522) compared to 2000 (5,754) (Figure 4-10).

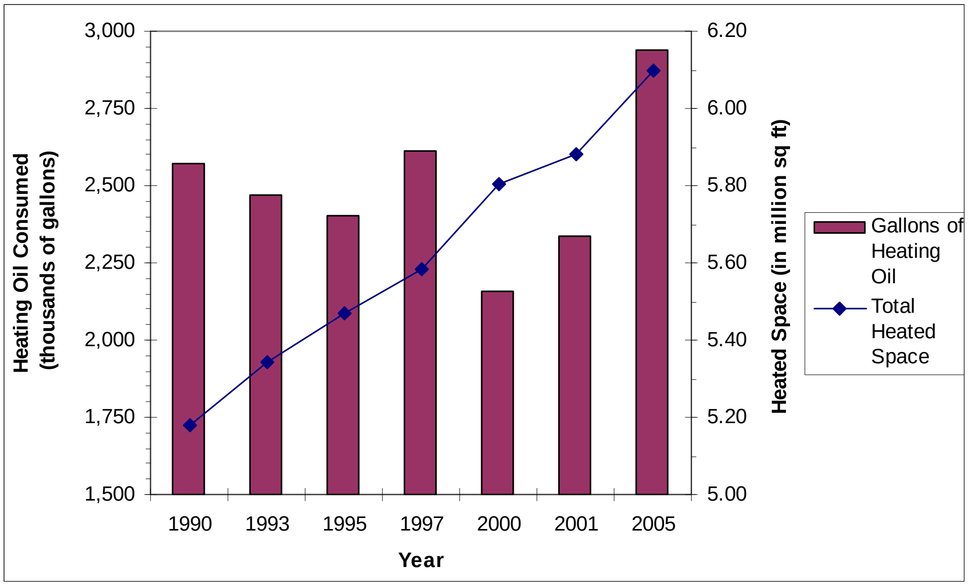

Figure 4-9 Residential heating oil consumption and square footage of heated space

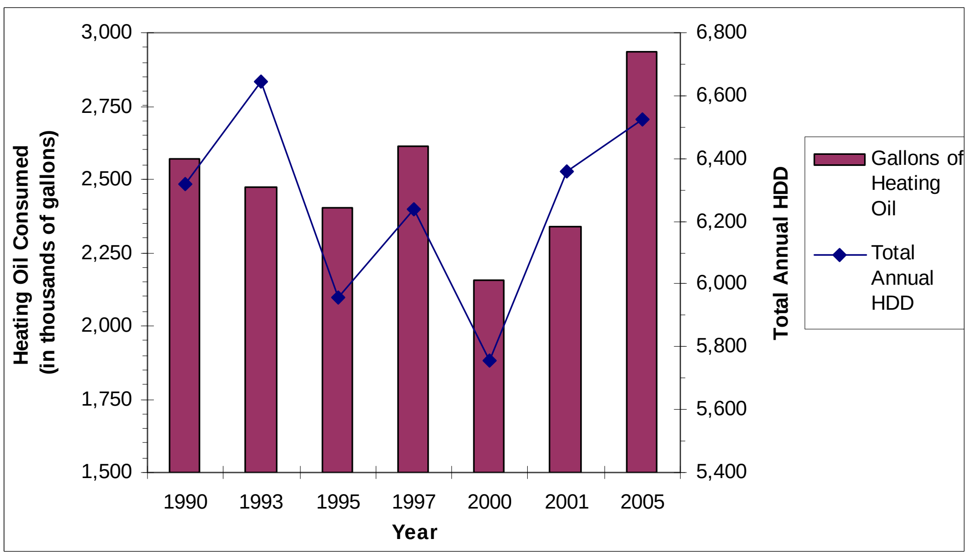

Figure 4-10 Residential heating oil consumption for Ipswich and annual HDD for Massachusetts

The EIA's 2008 Annual Energy Outlook (AEO) report estimates for New England heating oil consumption were used to generate a projection for 2010, 2015, and 2020.[35] Relative to the 2005 residential consumption, the EIA's projection for 2010, 2015, and 2020 reflects a decreased residential heating oil consumption of about 13%, 12%, and 15%, respectively. According to the AEO report, this projected reduction in future residential heating oil consumption is attributed to energy efficiency improvements of new and existing homes, increased heating oil prices, slower growth in the housing stock, and revised HDD trends over the past decade compared to 30-year trends (i.e., predicted warmer winters).[36] In addition, the trend of conversion from heating oil to natural gas in

[35] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov
[36] Ibid

Ipswich homes will likely continue, further reducing the consumption of heating oil in the future. The historic and projected residential heating oil for Ipswich is depicted in Figure 4-11. As seen in this figure, the 2020 projection for heating oil consumption is expected to be equivalent to the average consumption between 1990 and 2005.

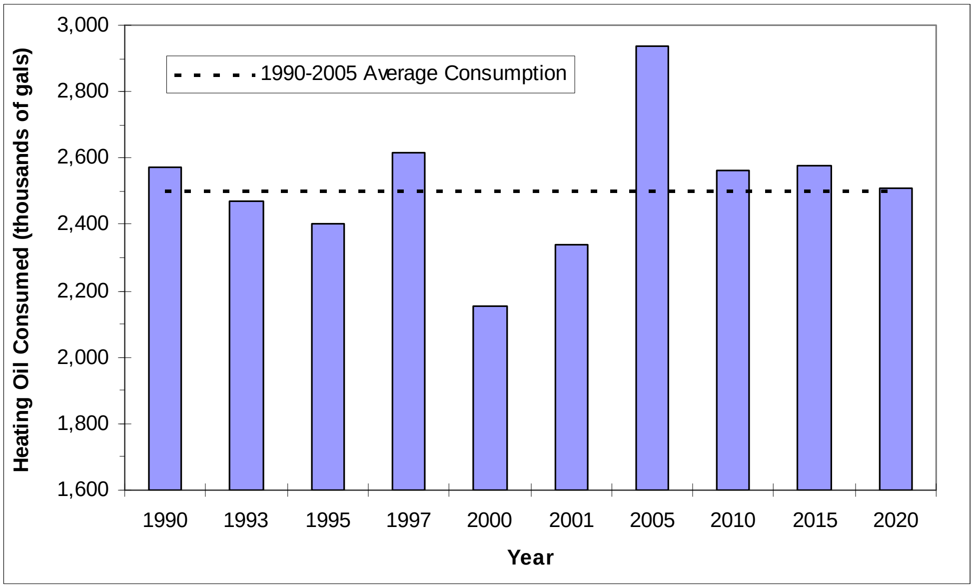

Figure 4-11 Historic and projected residential heating oil consumption

Based upon the estimated heating oil consumption for Ipswich, households in Ipswich consume more heating oil than the average New England households for which DOE/EIA Residential Energy Consumption Survey data exist (Figure 4-12). For example, in 2005 the average New England household consumed 855 gallons of heating oil for space and water heating, compared to an estimated 929 gallons per household in Ipswich. Some of this difference may be explained by the size of the average Ipswich home heated with oil. The average size of Ipswich single-family homes using heating oil in 2005 was 2,039 square feet,[37] compared to 1,910 square feet for all New England homes heated with oil.[38]

[37] Town of Ipswich Assessor

[38] 2005 Residential Energy Consumption Survey. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

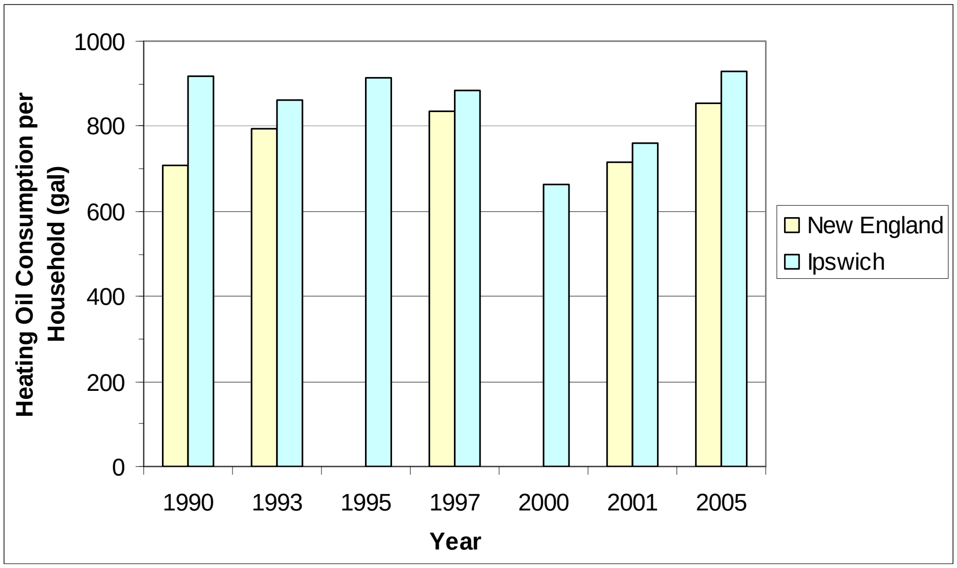

Figure 4-12 Heating oil consumption per household in Ipswich and New England

4.2.5 Industrial/Commercial Sector

This section assesses the commercial and industrial consumption of heating oil in Ipswich. Commercial and industrial uses of heating oil are believed to be relatively small compared to residential uses. Most commercial and industrial businesses in Ipswich use natural gas as the primary type of space and water heating fuel.[39] Accurate estimates for commercial and industrial heating oil consumption were difficult to obtain because, as with the residential sector, heating oil for commercial and industrial buildings are purchased from multiple, private oil delivery services throughout the area.

For the purposes of this assessment, commercial buildings include retail businesses, inns and motels, commercial condominiums and offices, religious and fraternal organizations, banks, and mixed commercial/residential buildings. Commercial buildings in Ipswich are primarily dominated by small businesses. According to the 2005 Ipswich Assessor's Office data, there were 102 commercial buildings in Ipswich using heating oil as the primary source for space heating and hot water with an average size of 5,097 square feet. Nine commercial buildings were between 10,000 and 20,000 square feet, and only one was larger than 20,000 square feet (i.e., 138,751 square feet).[40]

The types of industrial facilities using heating oil include general manufacturing, industrial warehouse, research and development facilities, and sand and gravel operations. As of 2006, industrial facilities in Ipswich using heating oil consisted of 10 buildings, with an average size of 25,968 square feet; however, only one industrial building was larger than 26,000 square feet (109,138 square feet). The remaining nine buildings averaged 16,426 square feet in size.[41]

[39] Town of Ipswich Assessor
[40] Ibid
[41] Ibid

As with residential buildings, heating oil consumption for commercial and industrial buildings is influenced by the weather during the heating season. Therefore, the influence of weather should be factored into comparisons of heating oil consumption between years.[42] Although some commercial and industrial businesses may use heating oil for processes other than space and domestic water heating, such uses were not included in this analysis because the data were not available.

For these consumption estimates we used the relationships between the Energy Intensity Factors developed by the EIA's Commercial Building Energy Consumption Survey (CBECS)[43], and the total annual heating degree days (HDD) for New England. According to these estimates, the total square footage of commercial and industrial buildings using heating oil increased by about 136,000 square feet (21%) between 1990 and 2005, or an average of about 9,000 square feet per year. Heating oil consumption during this time has increased approximately 25%. The largest growth occurred in 2003 after the construction of one, 109,138 square-foot industrial building, in addition to a 14,197 square-foot combined commercial/residential building in 2001 (Figure 4-13).

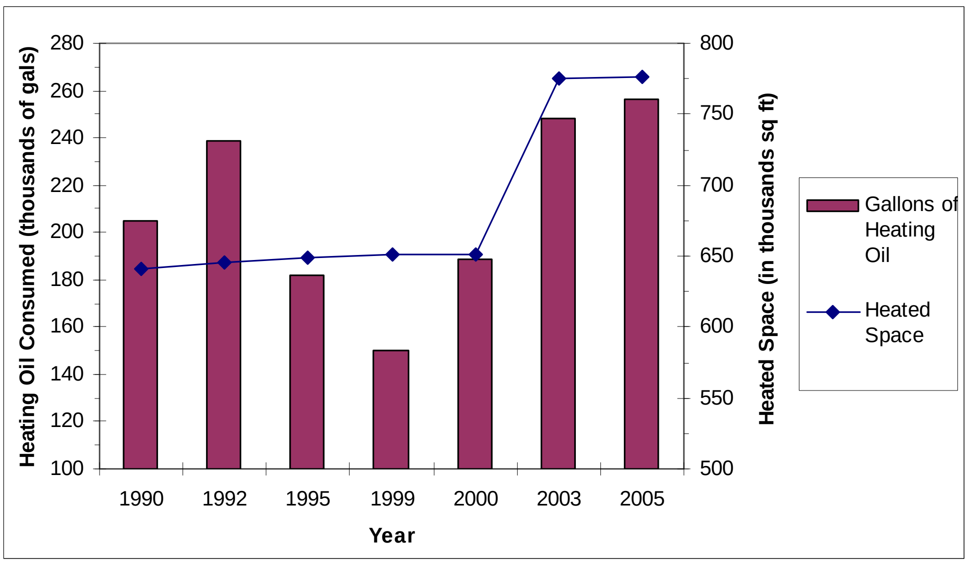

Figure 4-13 Industrial/commercial heating oil consumption and square footage of heated space

Much of the variability in annual heating oil consumption can be attributed to weather. The lowest consumption in heating oil (1999) had the smallest annual HDD (Figure 4-14). Improvements in energy efficiency (e.g., insulation value and more efficient heating systems) in commercial and industrial buildings have likely moderated increases in heating oil consumption.

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[42] 1993 Residential Energy Consumption Survey. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

[43] http://www.eia.doe.gov/emeu/cbecs/contents.html

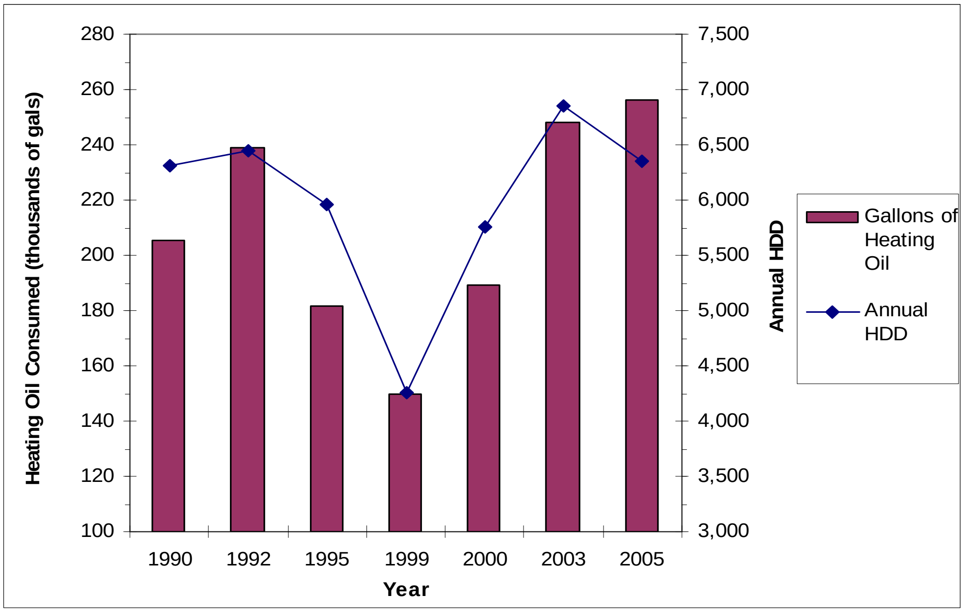

Figure 4-14 Industrial/commercial heating oil consumption in Ipswich and annual HDD in Massachusetts

Factors that may influence future industrial/commercial heating oil consumption in Ipswich are 1) energy efficiency improvements in buildings; 2) higher heating oil prices; and 3) slower growth in commercial square footage; 4) a reduction in commercial and industrial buildings using heating oil; and 5) slower growth in energy-intensive industries. The EIA's 2008 Annual Energy Outlook (AEO) report estimates for New England were used to generate a projection for 2010, 2015, and 2020.[44] To project the combined commercial and industrial heating oil consumption for future years, we used the average of the commercial and industrial AEO projection trends (i.e., 2010 = -10%; 2015 = -13%; 2020 = -15%). Relative to the 2005 consumption in New England, the combined commercial and industrial sector heating oil consumption is projected to decrease by about 10%, 13%, and 15% in 2010, 2015, and 2020, respectively. The projected heating oil consumption for the industrial/commercial sector in Ipswich is estimated to be approximately 218,000 gallons in 2020, which is slightly higher than the average consumption between 1990 and 2005 (Figure 4-15).

[44] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

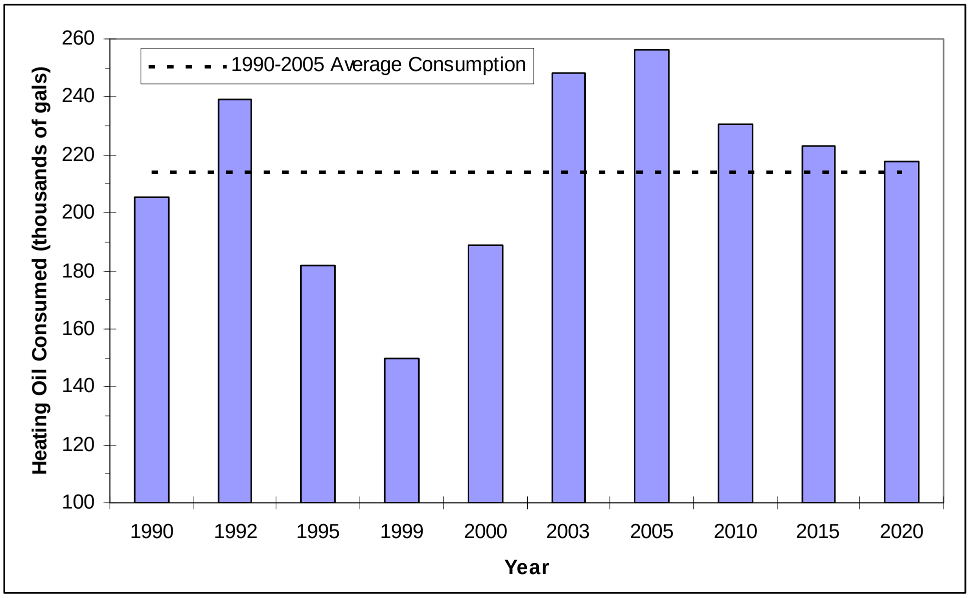

Figure 4-15 Historic and projected industrial/commercial heating oil consumption

4.2.6 Municipal Sector

The Town uses oil to heat many of its buildings. Heating oil consumption at the wastewater and water treatment plants accounted for almost 60% of the total for municipal activities in 1990, and the relative amounts in subsequent years have remained relatively constant. However, heating oil consumption for both the cemeteries and parks and fire departments has decreased (Table 4-7). Doyon Elementary school is the only public school facility that used heating oil during the years of this inventory. The CEUCP was not able to obtain heating oil consumption data prior to 2006 for this school, but usage data obtained for 2006-2008 indicates the Doyon Elementary facility consumed a significant proportion of municipal heating oil. From 2006-2008 the average annual heating oil consumption at this facility was 23,000 gallons, which is slightly greater than all other municipal departments combined for 2005. Since heating oil use at the Doyon School is not included here, heating oil consumption reported for the municipal sector may be underestimated by about one-half.

	1990	1995	2000	2005
Wastewater Plant	9,300	7,700	9,100	10,400
Fire Department	4,600	4,700	3,100	3,500
Cemeteries & Parks	3,600	4,300	700	1,400
Water Treatment Plant	4,100	4,200	5,400	4,100
Library	1,800	2,100	1,600	1,800
Schools	*	*	*	*
Total	**23,400**	**23,000**	**19,900**	**21,200**

Table 4-7 Municipal heating oil consumption (gallons)

*Data not available

The projected municipal heating oil consumption for 2010, 2015, and 2020 was estimated using the average percent change for the projected years from 2005 for the residential and industrial/commercial sectors (-11.5%, -12.5%, and -15.0%, respectively). The 2010, 2015, and 2020 municipal heating oil consumption is projected to decline to 18,800, 18,500, and 18,800 gallons, respectively (Figure 4-16).

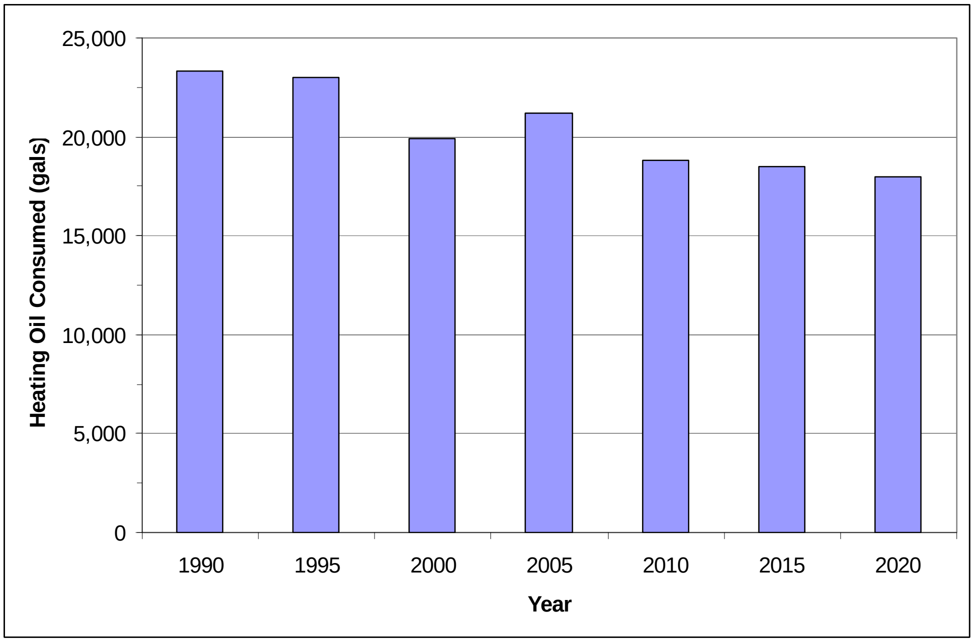

Figure 4-16 Historic and projected municipal heating oil consumption

4.3 Natural Gas

4.3.1 Introduction

This section assesses the consumption of natural gas and corresponding GHG emissions in Ipswich. Natural gas is used for space heating and water heating purposes in residential, industrial/commercial, and municipal buildings. In addition, industrial facilities may use natural gas for non-heating purposes, such as manufacturing processes; however, no attempts were made to estimate specific non-heating applications. According to the Ipswich Assessor's Office, approximately 30% of all residential buildings were heated with natural gas in 2005.[45] Natural gas in the primary fuel used in industrial/commercial facilities for both heating and non-heating purposes.

4.3.2 Methodology

Estimates of historic residential natural gas consumption were obtained using data from the U.S. Census Bureau, the Department of Energy's Energy Information Administration's Residential Energy Consumption Surveys (EIA/RECS), and the Town of Ipswich Assessor. Consumption estimates were made by adapting formulas developed for the RECS, which accounts for such factors as annual heating degree days (HDD) and space heating intensity. These formulas are sensitive to annual weather conditions by region and typical improvements in insulation and

[45] Town of Ipswich Assessor

heating system efficiency. The formulas also included square footage of heated space for homes in Ipswich using natural gas, which was obtained from the Town of Ipswich Assessor's databases.

For the years 2003-2005, the CEUCP was able to calibrate and verify its consumption estimates using actual consumption data from the single natural gas provider for Ipswich, KeySpan Gas. According to data provided by KeySpan Gas, actual consumption for Ipswich residences in 2005 was about 1% higher than our estimates (based on the EIA/RECS data) for that year. However, the KeySpan Gas data also included non-heat (i.e., cooking and water heating) consumption. Although our initial natural gas consumption estimates included water heating use, they did not include cooking use. It is likely that the 1% discrepancy between the CEUCP estimates and the KeySpan consumption data for 2005 can be attributed to this cooking-related consumption. Because the methodology of consumption estimates for years prior to 2003 was similar, the CEUCP has confidence that its estimates are accurate. For residential natural gas consumption in Ipswich for 2003-2005, the CEUCP used the actual consumption reported by KeySpan Gas.

The use of propane as a fuel for space and water heating and other uses, such as cooking, were not estimated in this GHG inventory. According to the Town of Ipswich Assessor's 2006 database, only three residential buildings and one commercial building reportedly used propane for space heating (uses other than space heating were not identified in the Assessor's database). Although more residential and commercial buildings in Ipswich use propane than are listed in the Assessor's database, data on the actual propane consumption in Ipswich was difficult to obtain. Similar to heating oil, propane is supplied by more than one independent provider.

For commercial and industrial natural gas consumption, data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS)[46] and the Manufacturing Energy Consumption Survey (MECS)[47] were used to generate relationships between Energy Intensity Factors developed by CBECS and the annual HDD in Ipswich. In addition, square footage of heated space for commercial and industrial buildings was used to estimate natural gas consumption for each survey year. For industrial/commercial natural gas consumption in Ipswich for 2003-2005, the CEUCP used the actual consumption reported by KeySpan Gas. Comparing the actual combined commercial and industrial natural gas consumption data from KeySpan Gas with CEUCP estimates (based on the CBECS/MECS data) suggests we had underestimated consumption for 2003, 2004, and 2005 by about 43%, 51%, and 56%, respectively. However, the KeySpan Gas data included both heat and non-heat natural gas use for the commercial and industrial sectors, and CEUCP estimates did not include non-heat consumption. The data from KeySpan Gas indicates the consumption of natural gas attributed to non-heating purposes in 2003, 2004, and 2005 comprised approximately 33%, 28%, and 61%, respectively, of all commercial and industrial natural gas consumption in Ipswich. To account for the non-heating applications of natural gas in the industrial/commercial sector, the CEUCP increased its estimates for earlier years (i.e., 1990, 1992, 1995, 1999, and 2000) by a factor of 2.

Municipal natural gas consumption data were obtained directly through the Town of Ipswich. However, consumption data were not available for Ipswich public schools prior to 2001. Therefore, estimates of the school consumption for 1990, 1995, and 2000 were made by calculating relationships between actual consumption in years 2001-2005 and the HDD for each of those years. The estimates were then multiplied by the HDD recorded for 1990, 1995, and 2000. Since there was a strong relationship between actual natural gas consumption for the schools and the HDD for those years, the CEUCP believes its estimates are accurate.

[46] http://www.eia.doe.gov/emeu/cbecs/contents.html
[47] http://www.eia.doe.gov/emeu/mecs/contents.html

To estimate the projected natural gas consumption for the residential and industrial/commercial sectors in 2010, 2015, and 2020, the EIA's 2008 Annual Energy Outlook report estimates for New England were used.[48] A detailed description of the methodology for the natural gas estimates can be found in the Appendix.

4.3.3 Overall Findings

The residential and Industrial/commercial sectors consume most of the natural gas in Ipswich, with the latter consuming more than one-half of the total. Between 1990 and 2000, the consumption of natural gas in Ipswich ranged between 320.7 and 322.7 million cubic feet (cf) (Table 4-8). Steady growth in the residential sector and a substantial increase in the industrial/commercial sector in 2005 have contributed to increasing the annual rate of natural gas consumption in Ipswich. Natural gas consumption increased by 41% between 2000 and 2005. The EIA's projection of natural gas consumption for New England suggests that GHG emissions from natural gas consumption in Ipswich will continue to increase, particularly for the industrial/commercial sector (Table 4-9; Figure 4-17).

Sector	**1990**	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential	139.221	148.383	150.243	199.207	*209.964*	*216.936*	*216.936*
Indust/Comm	166.166	181.558	154.284	231.046	*274.945*	*300.360*	*309.602*
Municipal	17.347	16.334	16.173	21.121	*23.550*	*23.761*	*24.289*
Total	**322.734**	**346.275**	**320.700**	**451.374**	***508.459***	***541.057***	***550.827***

Table 4-8 Estimated and projected natural gas consumption (million cubic feet)

Sector	**1990**	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential	7,600	8,100	8,200	10,900	*11,500*	*11,800*	*11,800*
Indust/Comm	9,100	9,900	8,400	12,600	*15,000*	*16,400*	*16,900*
Municipal	900	900	900	1,200	1,300	1,300	1,300
Total	**17,600**	**18,900**	**17,500**	**24,700**	***27,800***	***29,500***	***30,000***

Table 4-9 Estimated and projected GHG emissions (mt CO_2) from natural gas

[48] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

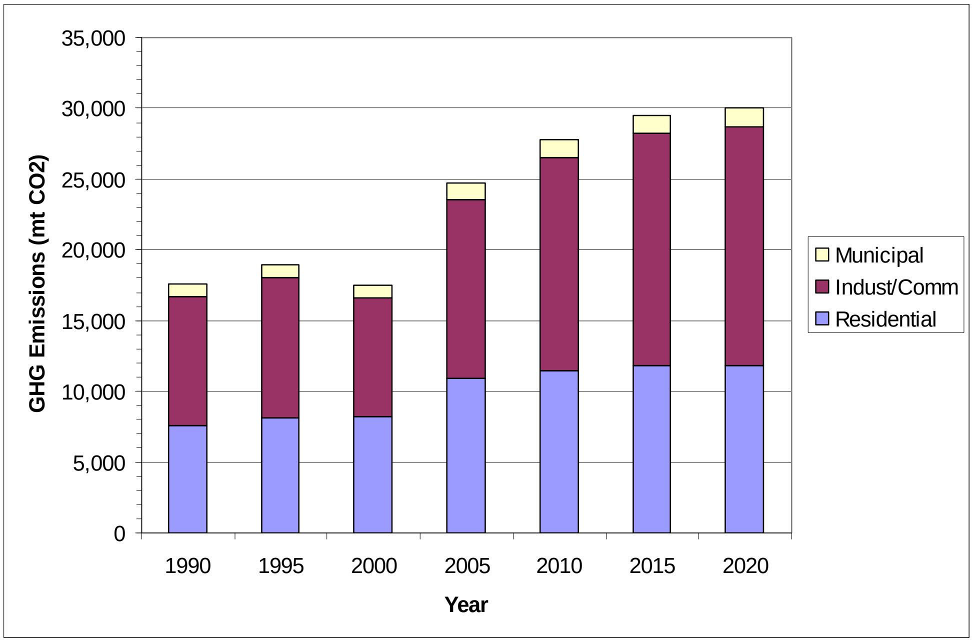

Figure 4-17. Historic and projected GHG emissions from natural gas consumption

4.3.4 Residential Sector

The increase in natural gas consumption correlates closely with an increase in the square footage of residential homes heated with natural gas during this period. Between 1990 and 2005, the square footage of homes heated with natural gas increased by about 70%, and the estimated natural gas consumption increased by about 43% (Figure 4-18).

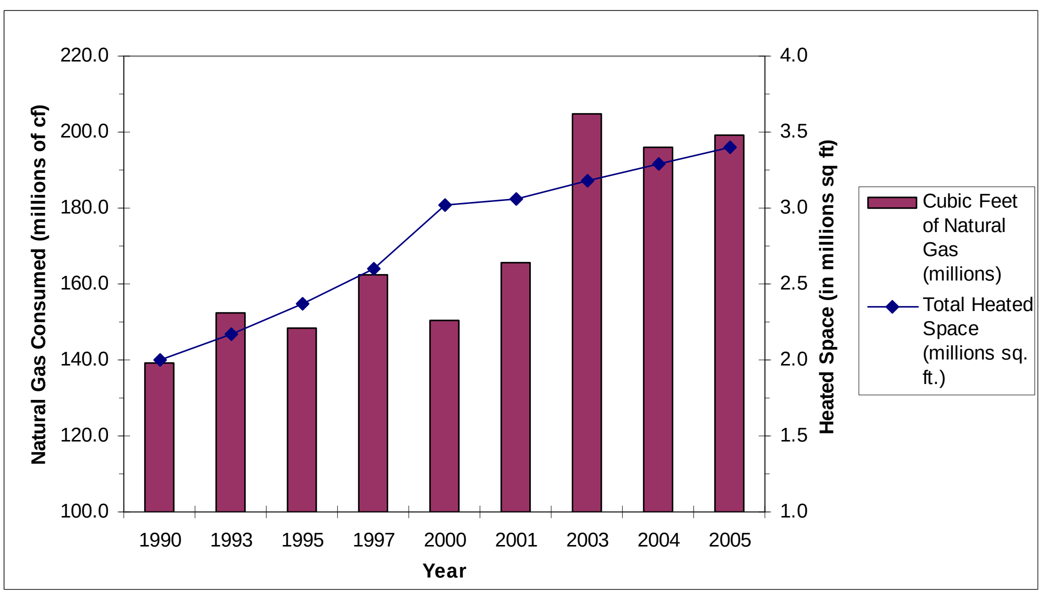

Figure 4-18 Residential natural gas consumption and square footage of heated space

As discussed previously, consumption of fuels for space heating can be dependent upon the weather. Colder winters result in greater space heating demands (i.e., increased HDD) and, hence, higher consumption of space-heating fuels. However, for residential natural gas consumption in Ipswich, it appears that the increased square footage of heated space and households using natural gas as the primary heating source was at least as important as weather in driving greater natural gas consumption. Figure 4-19 below depicts the relationship between estimated natural gas consumption in Ipswich and HDD for Massachusetts.

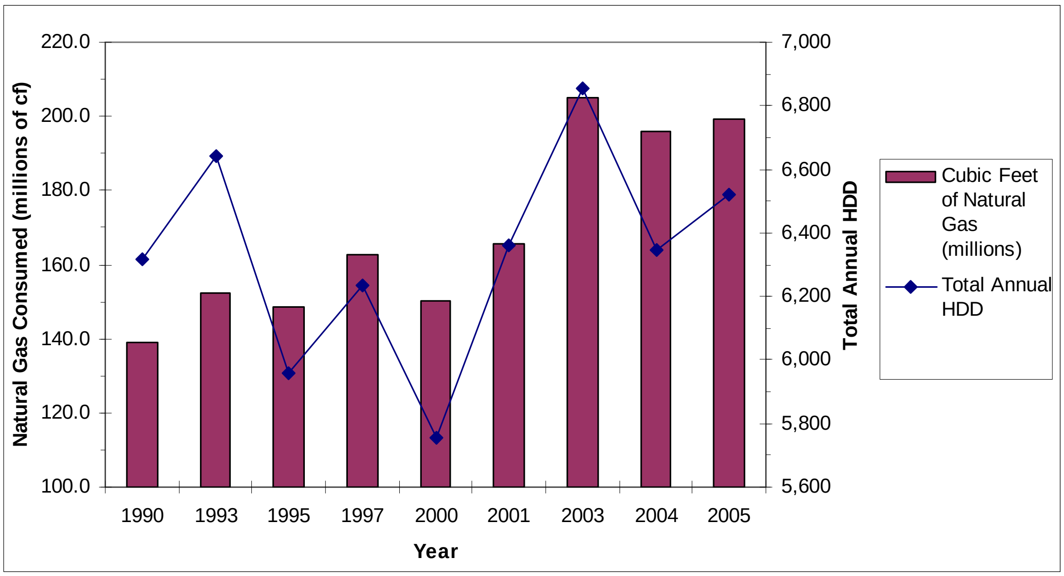

Figure 4-19 Estimated residential natural gas consumption for Ipswich and annual HDD for Massachusetts

The EIA's 2008 Annual Energy Outlook (AEO) report estimates for New England were used to generate a projection for 2010, 2015, and 2020.[49] Relative to the 2005 residential consumption, the EIA's projection for 2010, 2015, and 2020 reflect an increase in residential natural gas consumption of about 5.4%, 8.9%, and 8.9%, respectively.[50] Compared to the previous 15-year growth of 43%, these projections suggest a more modest increase in residential natural gas consumption. Factors influencing the residential natural gas projections include increased energy efficiency improvements of new and existing homes, higher natural gas prices, slower growth in the housing stock, growth in the proportion of homes heated with natural gas, and warmer winters. Warmer temperatures during the heating season over the past 10 years have reduced heating demands and this trend is expected to continue into the future.[51] In addition, projected higher natural gas prices are expected to induce energy conservation behaviors and efficiency investments by homeowners. The historic and projected residential natural gas consumption for Ipswich is depicted in Figure 4-20.

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[49] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov
[50] Ibid
[51] Ibid

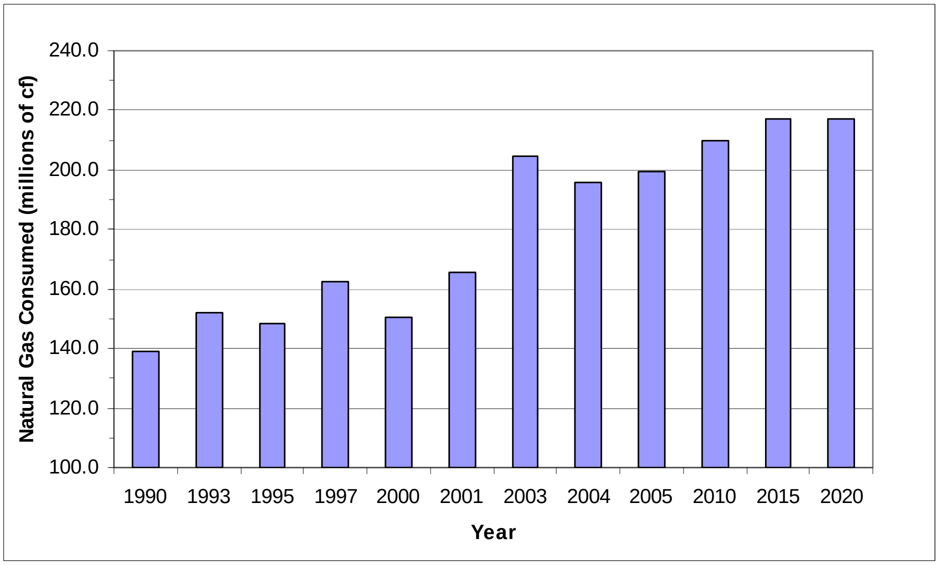


Figure 4-20 Historic and projected residential natural gas consumption

Based upon the estimated natural gas consumption for Ipswich, households in Ipswich consume more natural gas than the average New England households for which DOE/EIA Residential Energy Consumption Survey data exist (Figure 4-21). For example, in 2005 the average New England household consumed 88,000 cf of natural gas for space and water heating, compared to an estimated 119,000 cubic feet per household in Ipswich. Some of this difference may be explained by the size of the average Ipswich home heated with natural gas. The average size of all Ipswich homes heated with natural gas in 2005 was 2,031 square feet[52], compared to an average of 1,620 square feet for all New England homes heated with natural gas.[53]

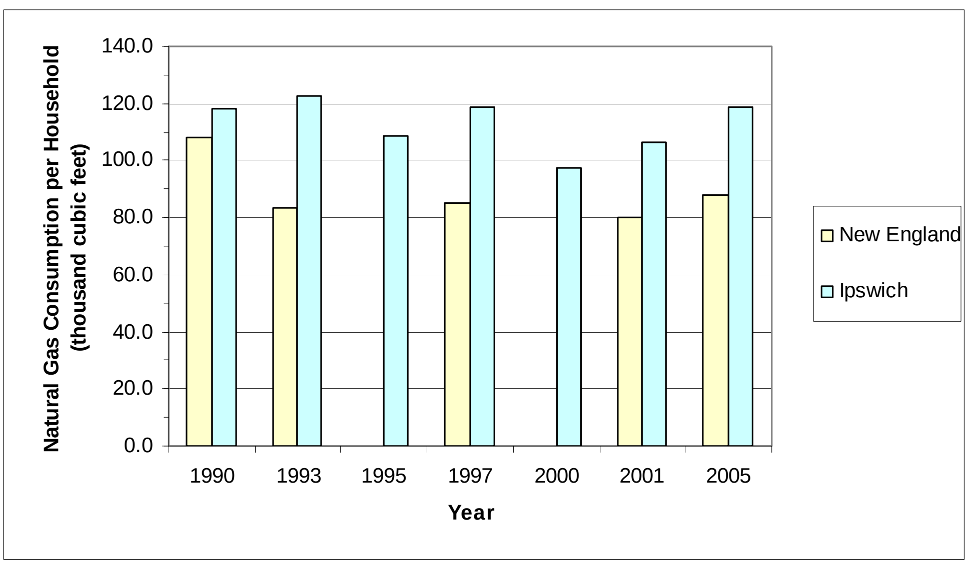


Figure 4-21 Natural gas consumption per household in Ipswich and New England

[52] Town of Ipswich Assessor

[53] 2005 Residential Energy Consumption Survey. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov

4.3.5 Industrial/Commercial Sector

Most businesses and industries in Ipswich use natural gas as the primary fuel for space and water heating. Although the total square footage of commercial and industrial buildings is less than half the total square footage of residential buildings, the industrial/commercial sector consumes more than 50% of the total natural gas used in Ipswich.

Commercial buildings that use natural gas include retail businesses, inns and motels, restaurants and bars, professional and general offices, commercial condominiums, commercial storage facilities, automobile sales, service and repair centers, daycare facilities, a golf club, gas stations, religious and fraternal organizations, banks, research and development facilities, and mixed commercial/residential buildings. Commercial buildings in Ipswich are primarily used by small businesses. According to the 2005 Ipswich Assessor's Office data, there were 133 commercial buildings in Ipswich using natural gas as the primary source of space heating and hot water with an average size of 7,792 square feet. Eleven of those commercial buildings were between 10,000 and 20,000 square feet, and fourteen were larger than 20,000 square feet.[54]

The types of industrial facilities using natural gas include general manufacturing, industrial warehouse, research and development facilities, and sand and gravel operations. Industrial facilities in Ipswich using natural gas for space and water heating consisted of 57 buildings, with an average size of 18,896 square feet in 2006. Two industrial building were larger than 100,000 square feet.[55]

The total natural gas consumption for commercial and industrial buildings has increased by nearly 65 million cf (i.e., 39%) between 1990 and 2005 (Figure 4-22). The total square footage of commercial and industrial buildings heated with natural gas has increased by about 315,000 square feet, or 18%, between 1990 and 2005. The construction of the 208,000-square-foot New England Biolabs research facility in 2005 contributed to about two-thirds of the increase in floor area for the industrial/commercial sector during this period.

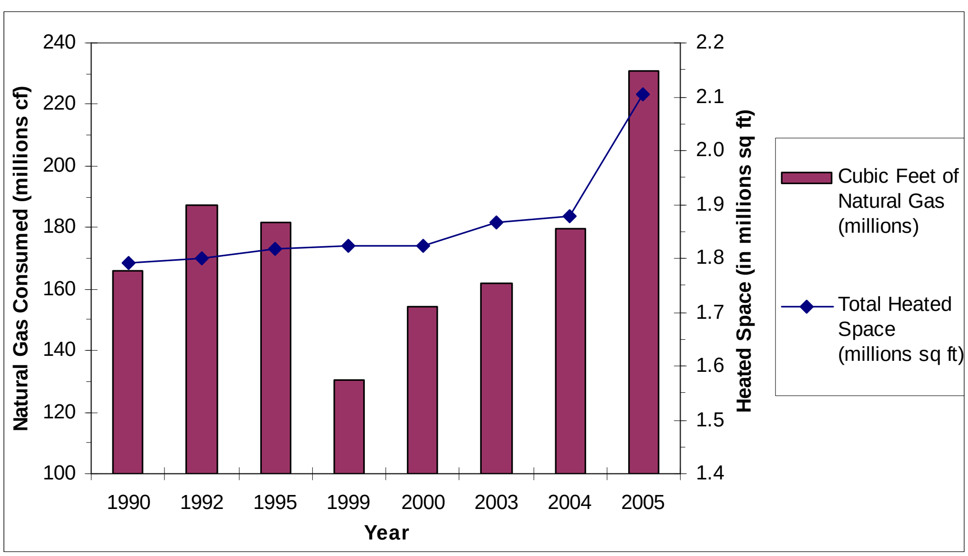


Figure 4-22 Industrial/commercial natural gas consumption and square footage of heated space

[54] Town of Ipswich Assessor
[55] Ibid

As with residential buildings, natural gas consumption for commercial and industrial buildings is influenced by the weather during the heating season. However, unlike the residential sector, commercial and industrial facilities also use natural gas for non-space heating applications. According to data provided by KeySpan Gas, the consumption of natural gas attributed to non-heating purposes in 2003, 2004, and 2005 comprised approximately 33%, 28%, and 61%, respectively, of all commercial and industrial natural gas consumption in Ipswich. Consequently, weather is less of an influence in natural gas consumption in the industrial/commercial sectors than in the residential sector. Figure 4-23 illustrates the relationship between natural gas consumption in the industrial/commercial sector and HDD.

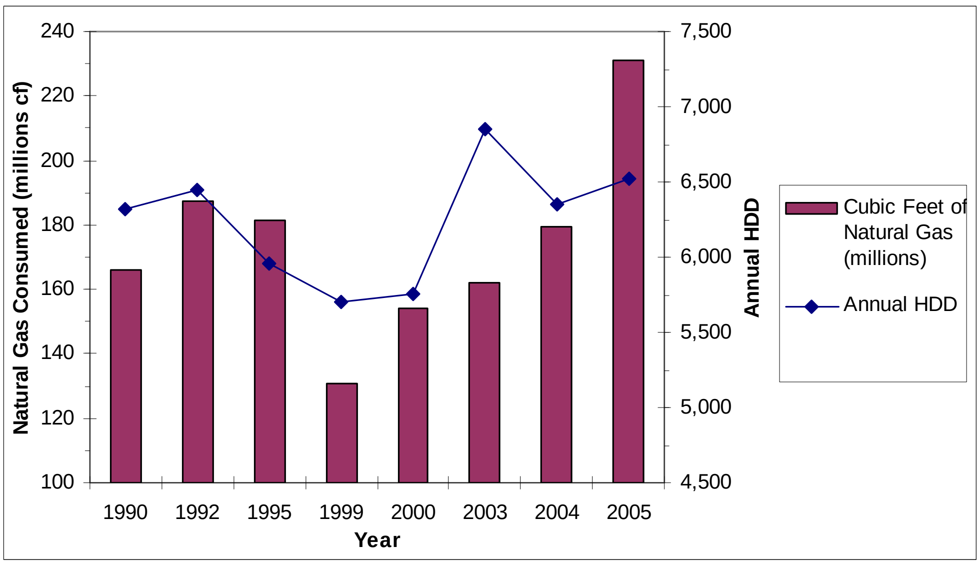


Figure 4-23 Industrial/commercial natural gas consumption for Ipswich and annual HDD for Massachusetts

The EIA's 2008 Annual Energy Outlook (AEO) report estimates for New England were used to generate a projection for 2010, 2015, and 2020.[56] To project the combined commercial and industrial natural gas consumption, we averaged the commercial and industrial AEO projection trends. The average of the commercial and industrial consumption suggests an increase of about 19%, 30%, and 34% for 2010, 2015, and 2020, respectively (Figure 4-24).

Factors that may influence the commercial and industrial natural gas consumption in Ipswich are energy efficiency improvements in buildings, higher natural gas prices, lower economic growth, slower growth in commercial square footage, and slower growth in energy-intensive industries.[57] As with residential buildings, improved heating equipment efficiency and more stringent building codes that require more insulation, better windows, and more efficient building design are expected to reduce consumption of natural gas in commercial and industrial buildings. However, industrial consumption may not be as dependent upon weather as residential and commercial buildings due to the nature of these facilities. For example, industrial buildings are often not heated or are heated to lower

[56] Annual Energy Outlook 2008. Dept. of Energy, Energy Information Administration. http://www.eia.doe.gov
[57] Ibid

temperatures than residential or commercial buildings. In addition, non-space heating uses of natural gas for industrial processes will not necessarily be dependent upon weather conditions.

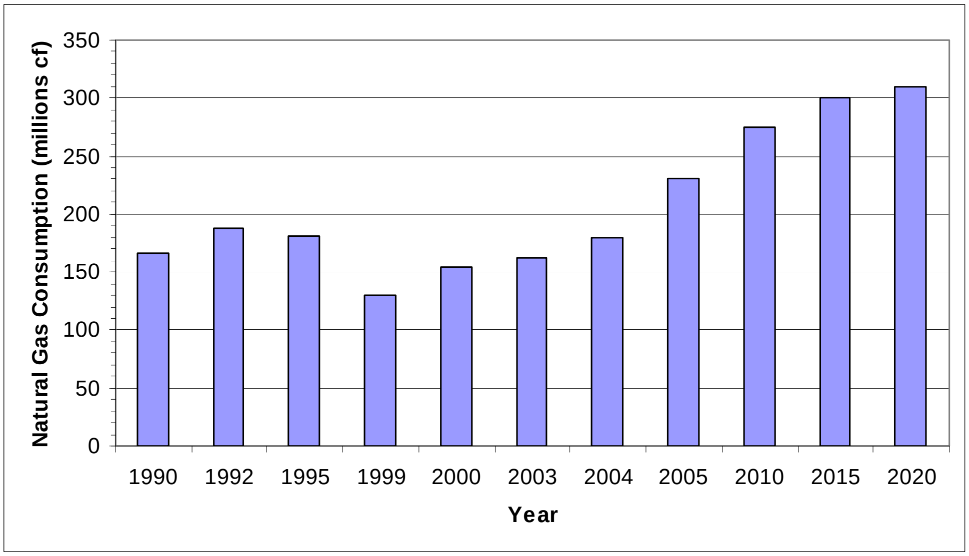


Figure 4-24 Historic and projected industrial/commercial natural gas consumption

4.3.6 Municipal Sector

The Public School facilities at Winthrop Elementary and the Middle-High schools are the primary natural gas users for the municipal sector. However, 2005 was the only inventory year for which actual natural gas consumption data for the schools was available (consumption for the schools prior to 2001 was not available to the CEUCP). Therefore, consumption for 1990, 1995, and 2000 were estimated based on HDD for those years (refer to section 4.3.2 for a detailed explanation of the methodology). With the move to the former middle school on Green Street in 2001, the Town Hall's annual gas consumption rose by more than 2 million cf. The public Library changed to natural gas in the late 1990s and, following its renovation and expansion, gas use increased about 50% (Table 4-10). Historic and projected natural gas consumption from the municipal sector is depicted in Figure 4-25.

	1990	1995	2000	2005
Town Hall	1,022.3	917.3	713.6	2,860.7
Quint Fire Barn	14.5	*	220.0	264.2
Equipment Maint.	260.2	296.3	251.4	440.1
Water Treatment	70.1	74.3	56.4	82.6
Library	+	+	288.9	427.4
Council on Aging	*	*	80.7	*
Wastewater	30.0	*	34.0	67.0
Schools	15,949.7**	15,045.8**	14,528.2**	16,979.1
Total	**1,397.1**	**1,287.9**	**1,645.0**	**4,142.0**

Table 4-10 Municipal natural gas consumption (in thousand cubic feet)

*No data available
**Estimated
+Not applicable for these years

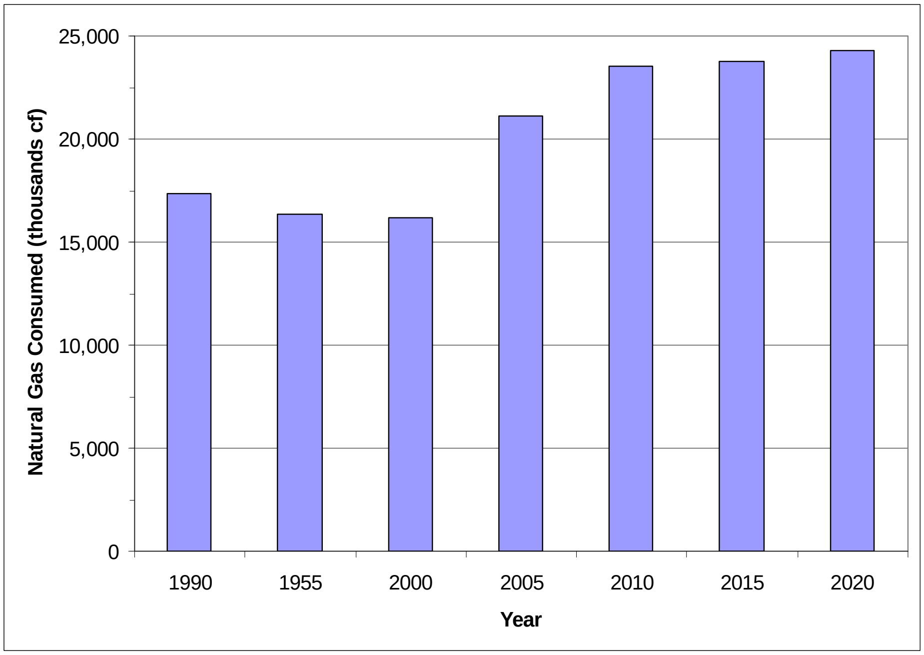


Figure 4-25 Historic and projected municipal natural gas consumption

4.4 Vehicular Fuels: Gasoline and Diesel

4.4.1 Introduction

This section estimates the GHG emissions caused by gasoline and diesel vehicles driven within Ipswich. In general, transportation is a major source of GHG emissions in the United States, comprising approximately one-third of all emissions.[58] GHG emissions from transportation are affected by the fuel efficiency of vehicles, the price of fuel, and driving habits. Changes in these factors can play a substantial role in determining the GHG emissions from the transportation sector and could alter the assumptions used to project vehicular fuel use in the future. For example, during the course of preparing this inventory, the price of gasoline and diesel fuel broke historic records for a series of months in 2008 and caused changes in consumer behaviors around conservation and efficiency.

4.4.2 Methodology

To calculate vehicle-related emissions on a town-wide basis, the CEUCP used information provided by the Metropolitan Area Planning Commission's Central Transportation Planning Staff (CTPS).[59] This blend of Motor Vehicle Registry information and data on Vehicle Miles Traveled (VMT) in Ipswich included the number of vehicles by category (motorcycles, automobiles, light trucks and sport utility vehicles [SUVs], heavy trucks) as well as VMT by vehicle category on each type of road (highway, secondary, local). Because pollutant emissions also vary by engine speed and vehicle type, the U.S. Environmental Protection Agency has developed methods for calculating emissions based on all of the aforementioned considerations. The CTPS data was based on 1990 and 2000

[58] http://tonto.eia.doe.gov/energy_in_brief/greenhouse_gas.cfm
[59] http://www.bostonmpo.org/bostonmpo/1_about_us/2_ctps/ctps.html

information; their modeling projection was for the year 2025.[60] All other years presented in this inventory were interpolated by the CEUCP.

Based on modeling of the road types in Ipswich, the average speed of a vehicle in Ipswich is estimated to be 32.2 miles per hour with light passenger cars representing about 46% of all vehicles and another 40% being gasoline powered SUVs and light trucks. Passenger cars (<6,000 lb vehicles) are estimated to have an average fuel economy of 23.8 miles per gallon which, considering the average speed, yields emissions of 3.7 mt CO_2 for every 10,000 miles traveled. The SUV/truck category is estimated to have a fuel economy of approximately 18.2 miles per gallon, which results in emissions of 5.1 mt CO_2 per 10,000 miles traveled.

The VMT estimates developed by CTPS were classified in various ways, such as by whether the vehicles were driven by residents or non-residents, whether the trips originated or finished inside or outside Ipswich, or whether the drivers were simply passing through town. In order to calculate vehicular emissions for this inventory, the CEUCP used only the VMT data derived from vehicle trips within Ipswich, by people living or working in town. Gasoline-fueled cars and light trucks were considered to belong to residents, and heavy-duty trucks powered by gasoline and all diesel-fueled vehicles were considered to be part of commercial/industrial operations. (Note: People who neither live nor work in Ipswich likely generate two to three times more vehicular traffic through town than local residents and employees.)

In addition to relying on data from CTPS, the CEUCP used town records to determine vehicle fuel use in the municipal sector (i.e., annual town budget records for gasoline and diesel fuel purchases). Estimates for GHG emissions from the municipal sector were calculated using emission factors for gasoline and diesel fuel combustion. Projections for municipal vehicle fuel consumption in 2010, 2015, and 2020 assumed improvements in fleet fuel economy, a conversion from gasoline to diesel fuel vehicles will continue at approximately 1% per year, and an increased rate of fuel use at approximately 1% per year. Because VMT from municipal vehicles are included in the CTPS analysis, the municipal GHG emissions (estimated from fuel purchases) were deducted from the residential and industrial/commercial GHG emissions. The residential and industrial/commercial GHG emissions were reduced according to the relative proportion of gasoline- and diesel-related emissions from the municipal sector for each year. In addition, local trends in vehicle ownership in Ipswich (extracted from vehicle registration records at the Assessor's Office) were considered.

4.4.3 Overall Findings

The CTPS data indicated that vehicles traveled more than 71.6 million miles on Ipswich roads in 1990 and 74.7 million miles in 2000 (Table 4-11). In 1990, the CTPS data suggests that 33% (23.6 million miles) of that travel originated in Ipswich, whereas in 2000 only about 26% (19.4 million miles) originated here. By 2020, CTPS estimates that total VMT in Ipswich will increase to 82.1 million miles, an increase of 10% over 2000 values (Table 4-11). However, CTPS projects that most of these miles will be driven by people originating from outside of town; only about 23% (18.9 million miles) of this travel is expected to originate in Ipswich. Thus, while vehicle miles traveled on town roads are forecast to increase, the CTPS projects the number of miles driven by Ipswich-based drivers will decline (Table 4-12).

[60] MOBILE4.1 Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume 1: General Guidance for Stationary Sources EPA-450/4-91-016, May 1991

	1990	2000	2020
Total Vehicle Miles Travelled (VMT)	71,567.1	74,757.5	82,124.8

Table 4-11 Estimated and projected VMT (in thousand miles) for all vehicles traveling through Ipswich[61]

	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential	20,643.7	18,816.8	16,989.8	16,870.0	*16,750.2*	16,630.4	*16,510.6*
Indust/Comm	2,973.4	2,710.3	2,447.1	2,429.9	*2,412.6*	*2,395.4*	*2,378.1*
Total	**23,617.1**	**21,527.0**	**19,436.9**	**19,299.9**	***19,162.8***	***19,025.8***	***18,888.7***

Table 4-12 Estimated and projected VMT (in thousand miles) for Ipswich-based vehicles

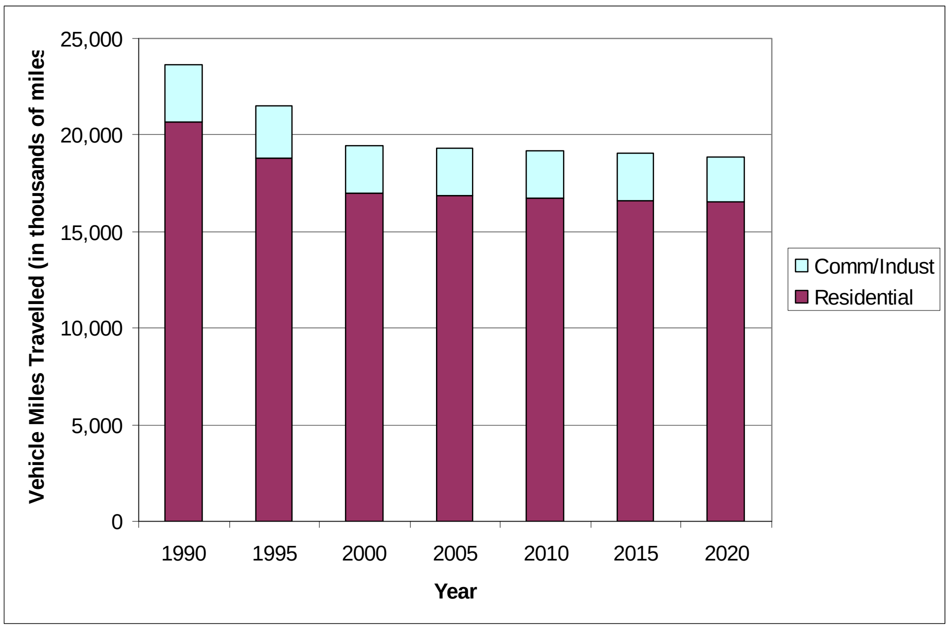


Figure 4-26 Estimated and projected VMT for Ipswich-based vehicles

The miles driven for residential and industrial/commercial Ipswich-based vehicles are depicted in Figure 4-26. The figure also illustrates the decreasing trend in Ipswich-based vehicles miles as estimated and projected by the CTPS. The CTPS data presented a bit of a dilemma for the CEUCP, which also considered changes in the number of vehicles registered in Ipswich. Vehicle registrations have increased considerably over time, especially between 1995 and 2000 (16%)[62] (Table 4-13). This data could lead one to expect corresponding increases in VMT and emissions from Ipswich-based vehicles.

	1990	1995	2000	2005
Vehicle Registrations	12,821	13,805 (+8%)	15,943 (+16%)	16,543 (+4%)

Table 4-13 Number of Ipswich-registered vehicles

[61] http://www.mapc.org

[62] Town of Ipswich Assessor

However, upon further inquiry, the CEUCP learned that the CTPS model is also calibrated on actual vehicle counts – a factor which CTPS has shown is not directly correlated to VMT.[63] While there has been an increase in vehicles registered in Ipswich, many of them may have limited purposes and use. For example, rather than all being primary vehicles, some may be extra vehicles in the same household. Individual drivers are more likely than in the past to own two or more vehicles – such as a truck for towing a boat or a convertible or motorcycle for sunny days. Additionally, teenagers tend to own vehicles at a higher rate than in the past, but drive them relatively short distances, primarily between school and home. Thus, though there are more vehicles registered in town, the actual road use of some of these vehicles may be less than first supposed.

The vehicle-related carbon emissions for the residential, industrial/commercial, and municipal sectors are shown in Table 4-14 and Figure 4-27. Ipswich residential vehicles contribute more GHG emissions than industrial/ commercial and municipal vehicles. CTPS data indicates that local VMT was 87% residential and 13% industrial/commercial in 2000, the base year of the GHG inventory. The same ratio was evident in the CTPS modeling projections for 2025. As reflected in the CTPS VMT data, the vehicular GHG emissions from Ipswich-based vehicles for both residential and industrial/commercial sectors have declined and this trend will likely continue in the future. Based upon records of fuel consumption for municipally-owned vehicles obtained from the Town, the overall GHG emissions from municipal vehicles have not changed considerably from 1990 to 2005. They are expected to remain about the same in the future. According to these estimates, the municipal sector vehicles contributed approximately 7% of all Ipswich-based vehicular emissions in the base year 2000.

	1990	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential	8,400	7,700	6,800	7,000	*6,800*	*6,900*	*6,800*
Indust/Comm	3,800	3,400	3,100	2,800	*2,800*	*2,700*	*2,700*
Municipal	700	600	700	700	*700*	*700*	*800*
Total	**12,900**	**11,700**	**10,600**	**10,500**	***10,400***	***10,300***	***10,300***

Table 4-14 Estimated and projected Ipswich GHG emissions (mt CO_2) from vehicles

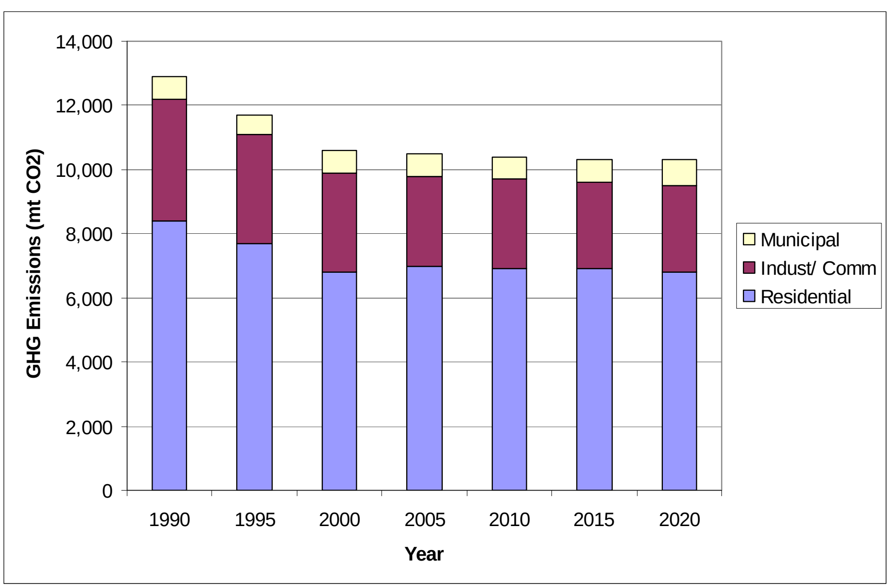


Figure 4-27 Historic and projected GHG emissions for Ipswich-based vehicles

[63] Personal correspondence with Nand Sharma of CTPS, Spring 2009

4.4.4 Residential Sector

On a percentage basis, the contribution of Ipswich residents to total annual VMT has declined over time. In 1990, Ipswich residents were responsible for 33% of the total annual vehicle miles traveled in town. This percentage dropped to 26% in 2000 and is projected to decline to 23% in 2020, according to CTPS.

For this inventory, it has been assumed that all light-duty gasoline VMT is residential. The vehicle categories that are included in residential VMT are light-duty gasoline cars, light-duty gasoline trucks (of which there are two categories in the CTPS model), and motorcycles. The VMT for each category of residential vehicles are listed in Table 4-15 and depicted in Figure 4-28.

	1990	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Lt. Duty Gas Car	10,946.5	9,977.8	9,009.0	8,945.5	*8,882.0*	*8,818.4*	*8,754.9*
Lt. Duty Gas Truck	7,169.7	6,559.8	5,922.9	5,881.2	*5,839.4*	*5,797.6*	*5,755.9*
Lt. Duty Gas Truck 2	2,398.9	2,186.6	1,974.3	1,960.4	*1,946.5*	*1,932.5*	*1,918.6*
Motorcycle	101.6	92.6	83.6	83.0	*82.4*	*81.8*	*81.2*
Total	**20,643.7**	**18,816.8**	**16,989.8**	**16,870.1**	***16,750.3***	***16,630.3***	***16,510.6***

Table 4-15 Estimated and projected VMT (in thousand miles) for Ipswich-based residential vehicles

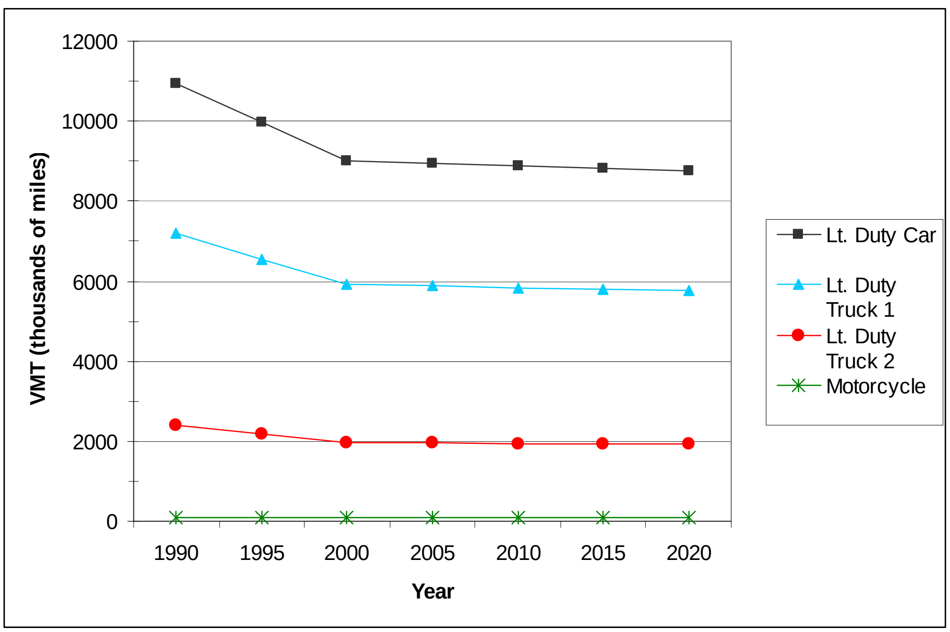


Figure 4-28 Historic and projected VMT for residential vehicles based in Ipswich

4.4.5 Industrial/Commercial Sector

This inventory assumes that all the VMT from heavy-duty gasoline trucks and heavy- and light-duty diesel vehicles, as measured by CTPS, operate as part of Ipswich's commercial and industrial sector. The diesel vehicle transportation in Ipswich is approximately 9% of all locally-based travel and about 72% of all industrial/commercial sector travel. Table 4-16 and Figure 4-29 show the VMT for all categories of industrial/commercial vehicles.

	1990	1995	2000	2005	*2010*	*2015*	*2020*
Hvy. Duty Gas Truck	819.5	747.0	674.5	669.7	*665.0*	*660.2*	*655.4*
Lt. Duty Diesel Truck	16.5	15.1	13.6	13.5	*13.4*	*13.3*	*13.2*
Hvy. Duty Diesel Truck	2,137.4	1,948.2	1,759.0	1,746.6	*1,734.2*	*1,721.8*	*1,709.4*
Total	**2,973.4**	**2,710.3**	**2,447.1**	**2,429.9**	***2,412.6***	***2,395.3***	***2,378.0***

Table 4-16 Estimated and projected VMT (in thousand miles) for Ipswich-based industrial/commercial vehicles

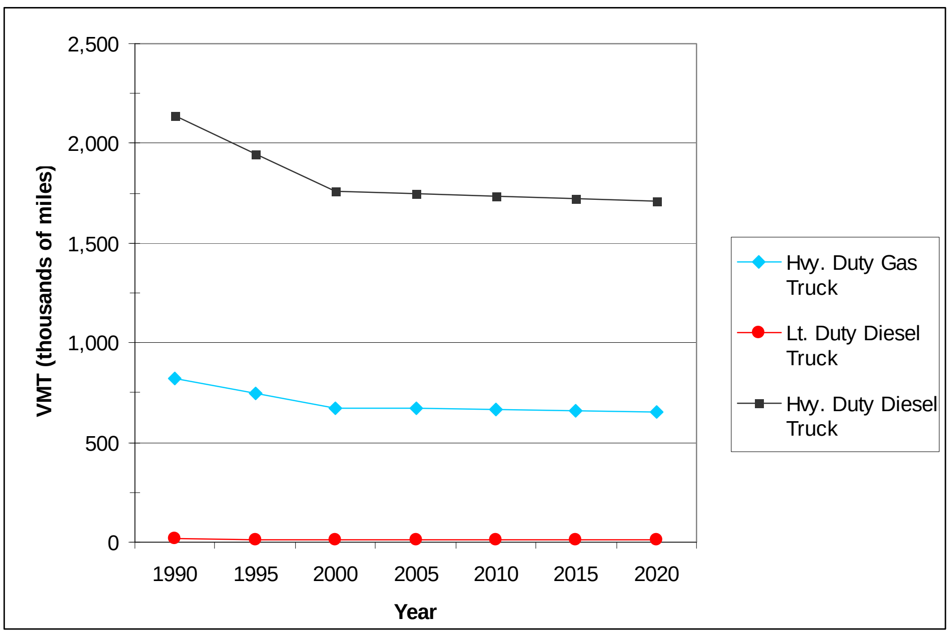


Figure 4-29 Historic and projected VMT for industrial/commercial vehicles based in Ipswich

4.4.6 Municipal Sector

The Town maintains records of gasoline and diesel fuel consumption of municipal vehicles and equipment. Consequently, the CEUCP was able to use this data and standard conversion formulas to estimate GHG emissions (Table 4-14).[64] The historic and projected fuel consumption for gasoline and diesel municipal vehicles is presented in Table 4-17 and Figure 4-30.

	1990	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Gasoline	65,549	53,408	58,194	38,526	*38,602*	*38,634*	*38,619*
Diesel	8,961	9,932	13,782	34,819	*36,595*	*38,462*	*40,424*
Total	**74,510**	**63,340**	**71,976**	**73,345**	***75,197***	***77,096***	***79,043***

Table 4-17 Estimated and projected fuel consumption (gallons) for municipal vehicles

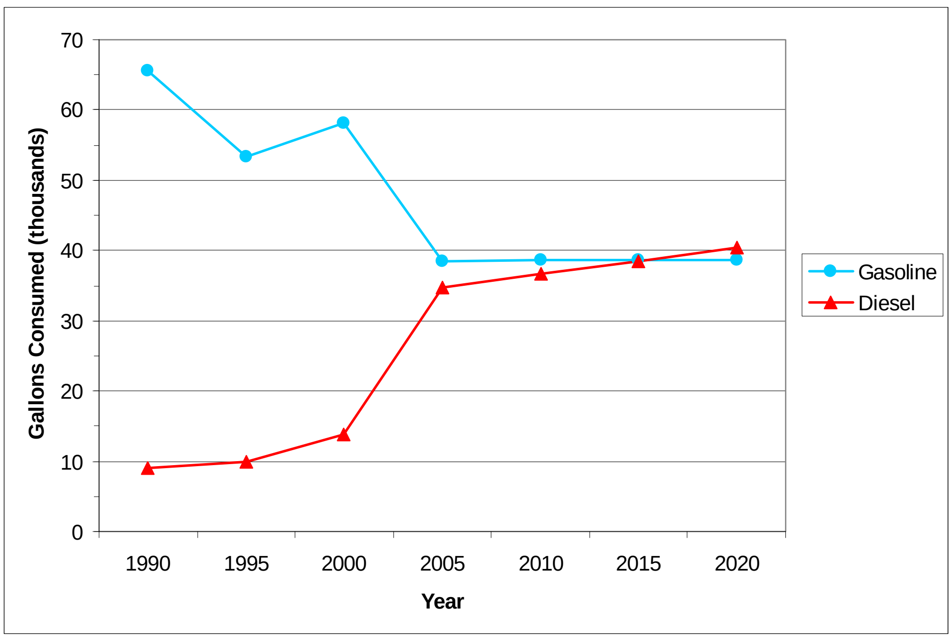


Figure 4-30 Historic and projected fuel consumption for municipal vehicles

Gasoline vehicles contributed the largest share of municipal vehicular fuel use from 1990-2000 (88% of total consumption). However, the consumption of gasoline in the municipal fleet has declined while the consumption of diesel fuel has increased substantially. The proportion of these fuels was approximately equal in 2005 and is projected to remain so until about 2015. Diesel consumption is expected to slightly exceed gasoline by 2020. Overall, the vehicular fuel consumption for the municipal sector is expected to remain relatively constant in the future.

[64] MOBILE4.1 Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume 1: General Guidance for Stationary Sources EPA-450/4-91-016, May 1991

4.5 Solid Waste

4.5.1 Introduction

Until 1978, solid waste generated in Ipswich was disposed of in a sanitary landfill located on town-owned land at the end of Town Farm Road. The landfill was officially closed in accordance with State regulatory procedures in 1982. Since 1978, municipal solid waste has been processed at municipal waste combustion facilities including RESCO in Saugus and Mass Refusetec, Inc. in North Andover. While these facilities are regulated and monitored in terms of particulate matter and other criteria air pollutants, there are no technologies that are commercially available that remove GHGs from the emissions generated at these types of waste combustion facilities.

Solid waste generated by residents and businesses in Ipswich is collected in the following manner:

1. **Residential Curbside Pick-up -** Solid waste and recycling materials generated by single-family residences are picked up at curbside. The weekly limit for solid waste has varied. There has been no limit on quantities set out for recycling, though the range of acceptable plastics has increased.
2. **Municipal Buildings and Schools –** Solid waste and recycling materials generated at town government facilities and schools are picked up under the same contract as residences.
3. **Multifamily Buildings** - Apartment buildings with more than three units and the Ipswich Country Club arrange for their own trash pickup.
4. **Industrial/Commercial Businesses and Institutions -** Businesses are eligible for curbside pick-up, but they must be able to adhere to the same requirements as residences.
5. **Transfer Station** – The Transfer Station at the end of Town Farm Road is open on Wednesdays and Saturdays and accepts yard waste only. Prior to April 30, 2003, the transfer station was open five days a week and also accepted trash, metals, recyclables, white goods, televisions and cathode-ray tubes, and car batteries as well as tires.

Local action aimed at increasing recycling rates in Ipswich has been both voluntary and in direct response to regulatory action at the state level. Municipal recycling was not available in Ipswich prior to 1991. By 1995 the recycling rate – a proportion of the tonnage of recycled waste and solid waste – was 35%. Between 1995 and 2005, the rate has fluctuated. The highest rate, achieved in 2000, was 47%. Recycling is an important consideration, because it helps mitigate the need for solid waste incineration. The more robust a community's recycling program, the less demand there is for solid waste disposal.

4.5.2 Methodology

Solid waste disposal and recycling tonnage data was obtained from a variety of sources including the Ipswich Recycling Committee, solid waste disposal and recycling reports for Massachusetts, Town of Ipswich Annual Reports, and the Ipswich Department of Public Works.

The detailed data about solid waste disposal contracted by the Town did not differentiate between residential waste and municipal waste, so these sectors are combined in this part of the inventory. Furthermore, no specific information was available for solid waste generated by commercial and industrial businesses in Town, or multifamily buildings, because these entities are responsible for their own waste removal. However, estimates were made based on regional trends. For the purpose of this inventory, the CEUCP estimated industrial/commercial solid waste in Ipswich as equaling 30% of the total amount for the Town.

Forecast data was determined by calculating the average per capita solid waste tonnage between 2000 and 2006, holding the average rate constant, and multiplying it by the population. Based upon historic population trends in Ipswich from 1980 to 2006[65], a 1% annual increase in population was assumed between 2005 and 2020.

The incineration of waste containing fossil fuel derived materials, such as plastics, generally increase emission coefficients, whereas "biogenic" wastes, such as food scraps, paper, and wood do not. The average emission coefficient for plastic is 5,771 pounds of carbon dioxide per short ton.[66] Therefore, calculations of GHGs from solid waste incineration should take into account the relative proportions of fossil fuel derived materials in the waste stream. Because data on the composition of Ipswich's waste stream were not available, the CEUCP used a default emission coefficient for solid waste incineration developed by the Energy Information Administration (EIA) for use in the United States and based on earlier research by the US Environmental Protection Agency. Their estimate assumes an average national waste stream of 16 percent plastics and total emissions of 929 pounds of CO_2 per short ton of municipal solid waste.[67] The CEUCP used these figures for its calculations, and though Ipswich recycling rates were considered, they did not directly factor into the equations.

4.5.3 Overall Findings

Disposal of solid waste in Ipswich declined nearly 28% between 1990 and 2000, before beginning to rise again in the years leading up to 2005 (Table 4-18). This trend may be related to the rapid population growth between 2000 and 2005 and to the Town's recycling campaigns, which have varied in intensity over time.

Sector	**1990**	**1995**	**2000**	**2005**	***2010***	***2015***	***2020***
Residential/Municipal	6,330	4,630	4,570	5,190	*5,110*	*5,370*	*5,630*
Industrial/Commercial	1,900	1,400	1,370	1,560	*1,530*	*1,610*	*1,690*
Total	8,230	6,020	5,940	6,750	*6,640*	*6,980*	*7,320*
Per capita solid waste*	0.50	0.37	0.34	0.39	*0.36*	*0.36*	*0.36*

Table 4-18 Estimated and projected solid waste (tons) for all sectors

*Per capita estimates are based on the annual residential/municipal solid waste tonnage and population

Although these estimates indicate an increasing trend in solid waste disposal since 2000, the CEUCP notes that Ipswich has recently implemented regulations intended to reduce solid waste such as mandatory bag limits, "pay and you throw" policies, and co-mingled (i.e., no separation of paper, plastics, and metal) recycling. These regulations should further reduce solid waste entering the waste stream, thereby reducing the GHG emissions from incineration. Consequently, the CEUCP's estimates for future GHG emissions from waste incineration may be overestimated, yet also serve to illustrate a future emissions scenario in the absence of new mitigation measures.

[65] Annual Town Census
[66] Voluntary Reporting Of Greenhouse Gases (1605(B)) Program, Office Of Policy And International Affairs US Dept. of Energy, Jan. 2007 (http://www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf)
[67] Voluntary Reporting Of Greenhouse Gases (1605(B)) Program, Office Of Policy And International Affairs US Dept. of Energy, Jan. 2007 (http://www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf)

The historic and projected GHG emissions from solid waste incineration are provided in Table 4-19 and Figure 4-31.

Sector	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential/Municipal	2,640	1,930	1,900	2,160	*2,130*	*2,240*	*2,350*
Industrial/Commercial	790	580	570	650	*640*	*670*	*700*
Total	3,430	2,510	2,470	2,810	*2,770*	*2,910*	*3,050*

Table 4-19 Estimated and projected GHG emissions (mt CO_2) from solid waste for all sectors

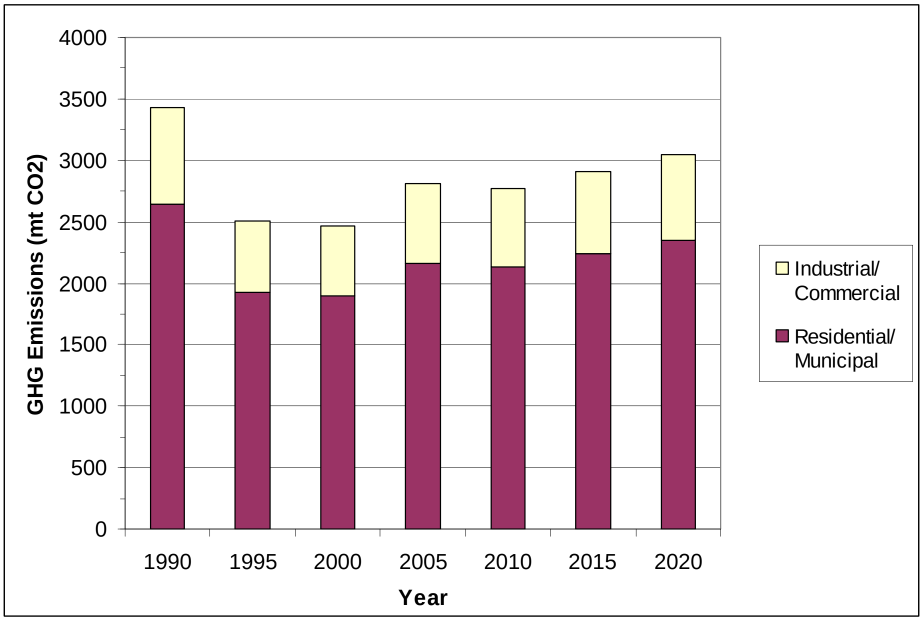


Figure 4-31 Historic and projected GHG emissions (mt CO_2) from solid waste

5. Results by Sector

The total emissions of GHGs from the residential sector represent the largest component of GHG emissions for Ipswich (Table 5-1, Figure 5-1). In 2000, the base year of the inventory, 63% of the town's carbon footprint was attributed to the residential sector, 33% to the industrial/commercial sector, and 4% to the municipal sector. Despite modest increases in the number of new buildings and increased emissions from electricity, estimated emissions from all sectors decreased in 1995 and 2000 (primarily as a result of warmer winters and reduced space heating demands). However, emissions increased substantially in all sectors in 2005. Under the "business-as-usual" scenario, GHG emissions are projected to increase in the future. The greatest proportional increase in emissions is expected to occur in the industrial/commercial sector.

	1990	1995	2000	2005	*2010*	*2015*	*2020*
Residential	59,900	58,500	55,300	69,000	*69,800*	*72,400*	*74,000*
Indust./Comm.	29,000	28,900	28,400	37,600	*43,500*	*46,900*	*49,600*
Municipal	3,600	3,500	3,600	4,100	*4,600*	*4,800*	*5,100*
Total	**92,500**	**90,900**	**87,300**	**110,700**	***117,800***	***124,100***	***128,700***

Table 5-1 Historic and projected GHG emissions (mt CO_2) by sector in Ipswich

As discussed in other sections of the report, consumption of space heating fuels and hence, emissions of GHGs, is highly dependent upon the weather. Because space heating (combined heating oil and natural gas) is proportionally the largest contributor of GHG emissions for the residential sector, winter weather is a major contributing factor in annual emission rates for this sector. The two lowest emission years (1995 and 2000) in this inventory occurred in the years with the smallest HDD (5,959 and 5,754, respectively) and the highest estimated emission years (1990 and 2005) had the greatest HDD (6,317 and 6,522, respectively). This relationship, which is a particularly strong factor in the residential sector, is illustrated in Figure 5-1. Similarly, future annual emissions in Ipswich will be influenced by weather, particularly winter temperatures.

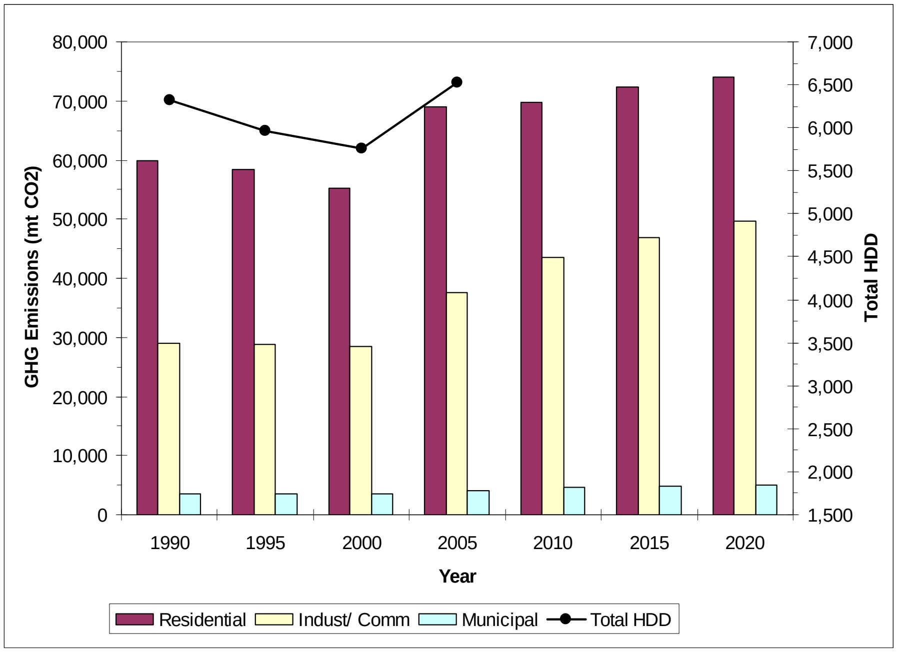


Figure 5-1 Historic and projected GHG emissions (mt CO_2) by sector and annual HDD in Massachusetts

5.1 Residential Sector

The residential sector generates more GHG emissions relative to the other sectors (Figure 5-1). Figure 5-2 shows that in 2005, most of these emissions came from space heating (59% from combined heating oil and natural gas consumption). Heating oil is the greatest single source of residential emissions (43%), followed by electricity (28%).

Transportation-related emissions comprised about 10% of the residential carbon footprint. This figure is relatively low compared to national averages (GHG emissions from transportation account for about one-third of the total emissions in the United States[68]) because it considers only a portion of transportation activity – it is restricted to emissions from vehicles driven by Ipswich residents and employees traveling within Town. Though many residents work outside of Ipswich – commuting long distances by car, commuter rail, or even airplane – the substantial GHG emissions that arise from activities undertaken by Ipswich residents outside the Town borders are beyond the scope of this report.

[68] http://tonto.eia.doe.gov/energy_in_brief/greenhouse_gas.cfm

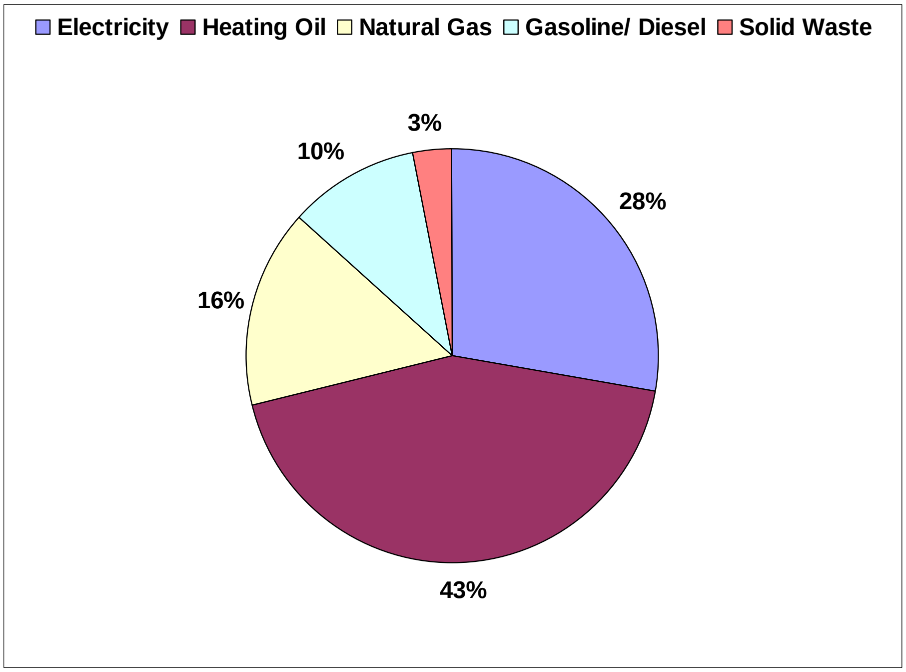


Figure 5-2 Proportional GHG emission sources for the residential sector in 2005

(Note: The proportion of solid waste-related emissions shown above is not entirely from residences – the data also includes solid waste emissions that are attributable to the municipal operations.)

As noted elsewhere in this report, emissions from space heating are highly dependent upon winter temperatures. The variation in emissions from heating oil use is evident between 1990 and 2005. However, the emissions from heating oil use is projected to decline somewhat in the future, as a result of energy efficiency improvements in homes, increased heating oil prices, and expected warmer winters. On the other hand, emissions from electricity consumption have increased consistently since 1990 and are projected to continue this trend into the next decade. By 2020, GHG emissions attributed to electricity are expected to exceed that of heating oil emissions (Figure 5-3).

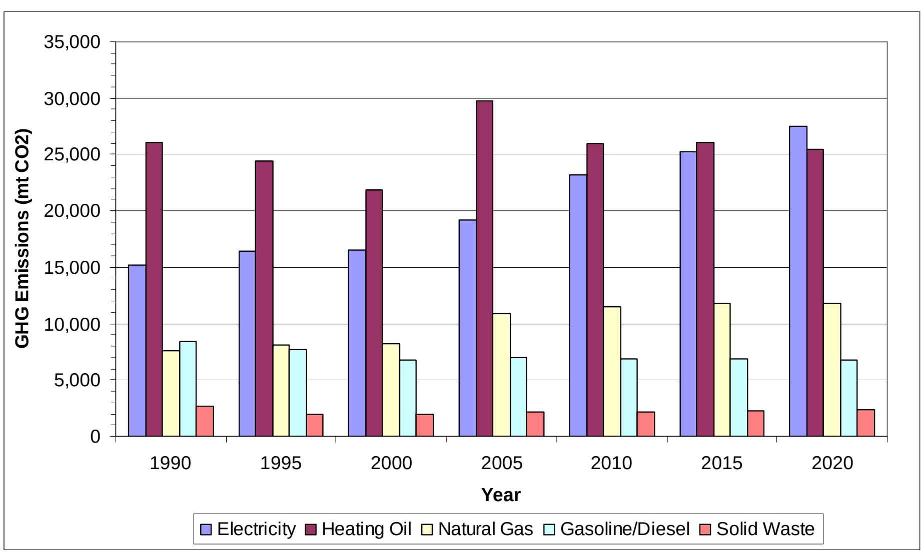


Figure 5-3 Historic and projected GHG emissions for all sources in the residential sector

5.2 Industrial/Commercial Sector

The emissions profile of the industrial/commercial sector differs greatly from that of the residential sector. Whereas the residential sector generates most of its emissions from heating oil (Figure 5-2), the industrial/commercial sector uses very little heating oil. Rather, most emissions result from electricity (49%) and natural gas (34%), as depicted in Figure 5-4.

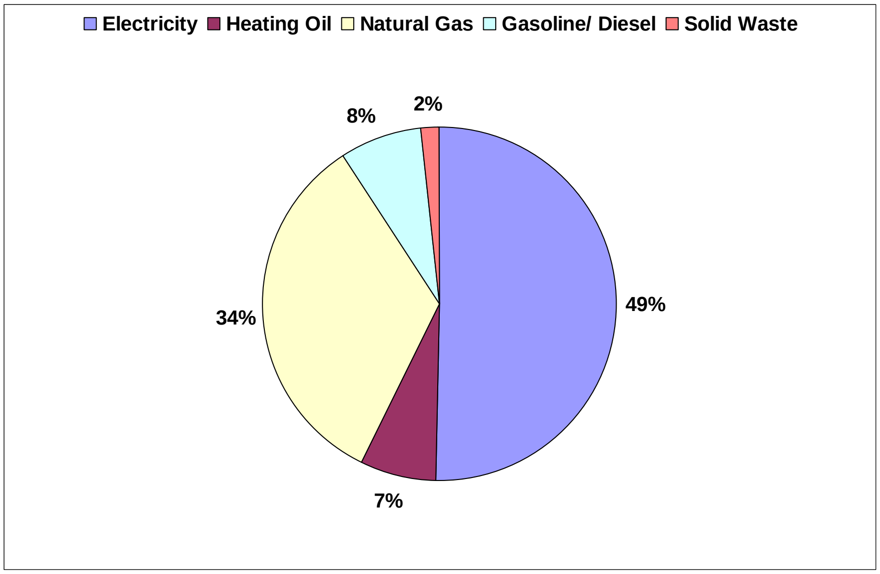


Figure 5-4 Proportional GHG emission sources for the industrial/commercial sector in 2005

As depicted in Figure 5-5, GHG emissions from electricity use have been increasing in the industrial/commercial sector since 1995 and will continue to increase relatively unabated over the next decade. A similar trend is expected for natural gas, although at a lower annual emissions rate.

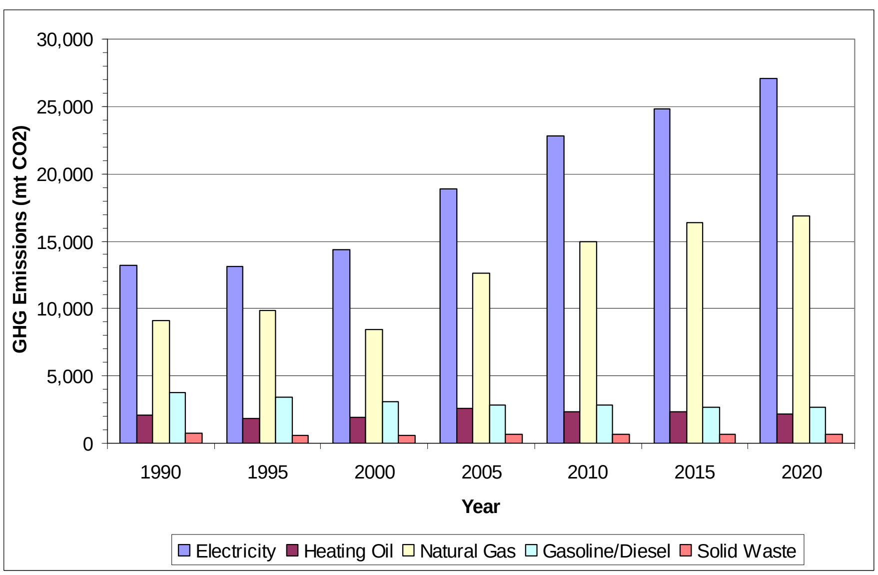


Figure 5-5 Historic and projected GHG emissions for all sources in the industrial/commercial sector

5.3 Municipal Sector

For the municipal sector in 2005, electricity was the greatest source of GHG emissions (50%), followed by natural gas (28%) and vehicular fuels (17%). Combined, heating oil and natural gas contribute 33% of the total emissions (Figure 5-6). Emissions from solid waste are not included in this sector analysis, because municipal solid waste pickup is included in residential disposal; separate data on municipal tonnage were not available. However, the municipal sector's GHG contributions from solid waste are believed to be a relatively minor component of the emissions profile.

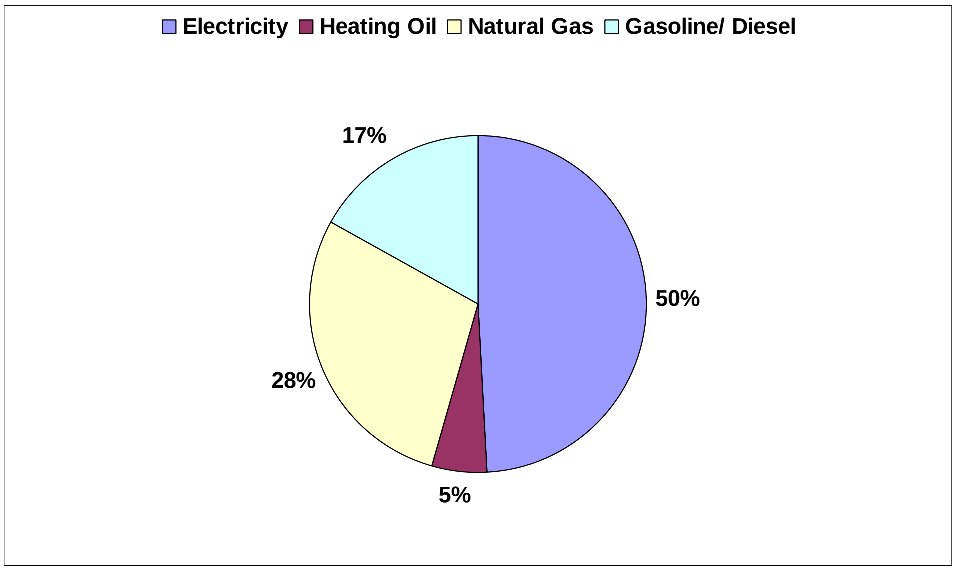


Figure 5-6 Proportional GHG emission sources for the municipal sector in 2005

Figure 5-7 depicts the historic and projected relative importance of GHG emissions from electricity in the municipal sector, primarily relating to the heavy electrical demands of the wastewater treatment plant, water filtration plant, and streetlights. According to the MMWEC projections, demand for power will continue to grow in Ipswich, and a portion of that growth is likely to arise from the municipal sector. The projection assumes a "business as usual" scenario and no new conservation efforts. The projection may be overstated, however. It seems unlikely that new municipal space will be developed – recent expansions to the schools, Town Hall and Library, for example, are anticipated to meet the Town's needs for years to come. Furthermore, some town-owned buildings and streetlights have been retrofitted with more efficient electrical fixtures since 2005. On the whole, most sources of emissions for the municipal sector are expected to remain relatively stable.

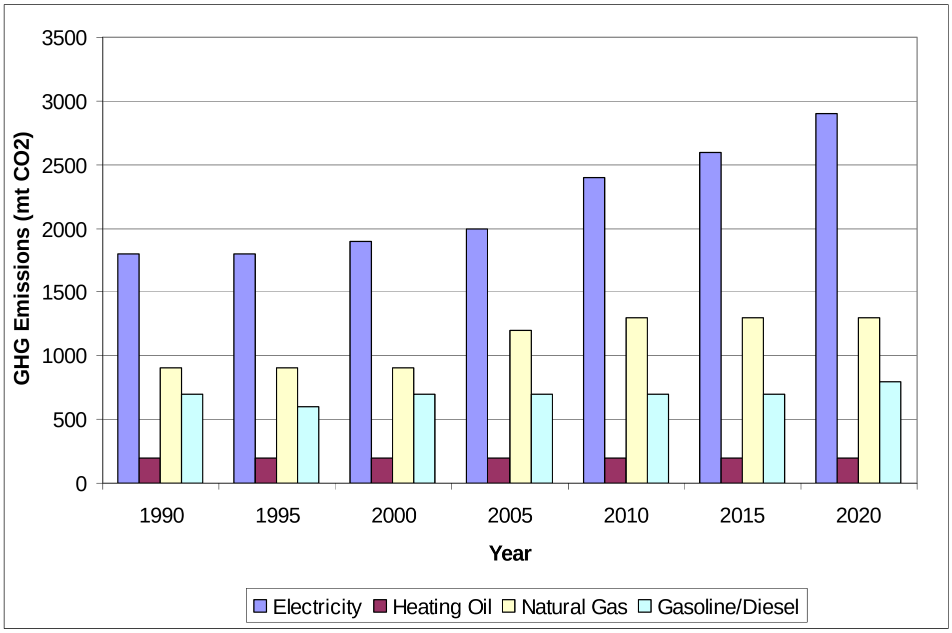


Figure 5-7 Historic and projected GHG emissions for all sources in the municipal sector

6. Data Comments and Recommendations

Detailed methodologies behind the calculations for this inventory are explained in the appendices of this report. In situations where direct consumption data were not available and estimates were necessary (e.g., residential and industrial/commercial heating oil, natural gas prior to 2003), efforts were made to double check the results against other data sources or alternative calculation methods. Similarly, efforts were made to study regional and national trends and to ensure that the CEUCP's findings were consistent with those published by other entities.

The CEUCP believes this inventory takes into account most of the relevant information about energy and emissions in Ipswich that is currently available. Some of the data reported actual, historic consumption. For example, records of electricity demand were provided by the Ipswich Municipal Light Department. Natural gas information for 2003 and subsequent years was provided by the local gas utility, Keyspan. Whenever available, municipal consumption data were obtained through departmental budgets and reports. However, in some cases, direct fuel use data could not be obtained and had to be estimated using models based on square footage, population, and heating degree days. For example, natural gas consumption for years prior to 2003 was estimated using regional surveys by the US Department of Energy's Energy Information Administration (EIA). Calculations for heating oil use were some of the most challenging due to the lack of direct fuel consumption information. These estimates were based on realistic and generally accepted methodologies developed by the EIA. Calculations of vehicle emissions for 1990, 2000, and 2020 relied on vehicle-mile estimates that had been modeled and monitored by the Metropolitan Area Planning Council and its Central Transportation Planning Section (CTPS). All other years were interpolated from these CTPS modeled data. Overall, data collection and analysis were often arduous processes, and dependent on many diverse and disparate sources.

Although the CEUCP believes that all large and readily identifiable sources of GHGs have been included in this inventory, several unreported sources are believed to exist within the Town of Ipswich. These sources contribute to our emissions profile, but are minor energy users compared to residential buildings, commerce and industry, Town operations, and vehicles. It is not our intention to discount the smaller sources of GHG emissions, but our emphasis is most appropriately placed on the leading emissions sources – those that have the greatest potential for reduction, and hence, wide-scale community benefit. Although these sources are probably not major contributors of GHGs, efforts should be made in subsequent inventories to quantify and include them to the extent practical. Some currently unreported sources are:

- Agriculture and husbandry (horse, crop, and livestock farms)
- U.S. Postal Service operations
- Recreational and commercial boats, off-road vehicles (e.g., ATV)
- Non-vehicular engines (e.g., gas lawn mowers, leaf and snow blowers)
- Residential brush burning
- Wood heat (e.g., fireplaces, wood stoves)
- Industrial processes (e.g., bituminous road construction, concrete manufacturing)
- Commuter rail service through Ipswich

Additionally, subsequent GHG inventories would be improved by obtaining fuel consumption data directly from suppliers. By improving the current methodology (e.g., utilizing real data in place of estimates) the Town would position itself well for monitoring GHG emissions. Such monitoring should occur at regular intervals to assess the impact of implementing a Climate Action Plan. For example, local heating oil suppliers could be expected to provide aggregate sales data for Ipswich residents to the Town on an annual basis. Because heating oil is the primary heating fuel in more than 60% of Ipswich homes and has been identified as the largest contributor of GHG emissions for the residential sector, accurate data on heating oil consumption will be critical for measuring town-wide efforts at reducing GHG emissions.

Although the GHG emissions from the municipal sector is small compared to the residential and commercial sectors, having readily available and accurate consumption data for all municipal departments would facilitate future GHG inventories and measurement of the Town's efforts toward achieving GHG reduction targets. Most importantly, data on fuel use in the Ipswich Schools will be essential, because the Schools are the largest single consumer of electricity and space heating in the municipal sector. In addition, the Town Assessor's database could be improved by updating information on the types of heating systems and domestic hot water systems used in residential and commercial buildings.

Because the residential sector contributes the largest share of GHG emissions in Ipswich, programs could be put in place to collect more robust data on home heating and vehicular fuel consumption. For example, stand-alone surveys or surveys included in the annual Town census would be a means of collecting data about residential energy use. The Assessor could implement surveys too, in order to periodically update the Town's records of heating systems and fuel sources used in buildings throughout Town.

Industrial and commercial businesses in Ipswich generally manage their own solid waste hauling. Consequently, actual data on solid waste incineration from the industrial/commercial sector was unavailable for this inventory. Although the CEUCP estimated the industrial/commercial solid waste to be 30% of the total for the Town, actual tonnage data from waste haulers would improve the accuracy of future inventories. These data could be made available to the Town by waste haulers as part of their local license requirements.

Regarding residential, commercial and industrial vehicular emissions, subsequent GHG inventories could consider actual gasoline and diesel sales information for Ipswich, as published by the Massachusetts Department of Environmental Protection (MA DEP). The MA DEP prepares the statewide emissions inventory required under the federal Clean Air Act,[69] using fuel sales data collected at the county level. In addition, the methods for measuring transportation emissions caused by Ipswich residences and businesses could be re-considered as part of the next inventory. While this inventory considered emissions by Ipswich residents and employees driving within Town boundaries, future inventories could take a wider view of transportation emissions, including those generated by Ipswich residents and employees using the commuter rail, commercial aircraft, and roadways beyond town limits.

7. Next Steps

7.1 Toward a Climate Action Plan

This inventory of Ipswich GHG emissions accomplishes the first milestone of the Cities for Climate Protection (CCP) program. The next milestones are:

- **Milestone 2 - Adopt an emissions reduction target for the forecast year.**
  The town establishes an emissions reduction target for the town. The target both fosters political will and creates a framework to guide the planning and implementation of measures.

- **Milestone 3 - Develop a local Climate Action Plan.**
  Through a multi-stakeholder process, the town develops a local Climate Action Plan that describes the policies and measures that the local government will take to reduce GHG emissions and achieve its emissions reduction target. Most plans include a timeline, a description of financing mechanisms, and an assignment of responsibility to departments and staff. In addition to direct GHG reduction measures, most plans also incorporate public awareness and education efforts.

- **Milestone 4 - Implement policies and measures.**
  The town implements the policies and measures contained in their local Climate Action Plan. Typical policies and measures implemented by CCP participants include energy efficiency improvements to municipal buildings and water treatment facilities, streetlight retrofits, public transit improvements, installation of renewable power applications, and methane recovery from waste management.

- **Milestone 5 - Monitor and verify results.**
  Monitoring and verifying progress on the implementation of measures to reduce or avoid GHG emissions is an ongoing process. Monitoring begins once measures are implemented and continues for the life of the measures, providing important feedback that can be used to improve the measures over time.

[69] http://www.epa.gov/air/caa/

7.2 Context for Setting Targets

To avoid the most damaging impacts from climate change, various international, national, and state GHG emissions reduction targets have been established to reduce the total concentrations of carbon dioxide in the atmosphere (e.g., Kyoto Protocol, Regional Greenhouse Gas Initiative [RGGI], Massachusetts Climate Protection Plan). Targets for reductions in GHG emissions typically include both a timeline and a volume goal. This analysis has assumed a target year of 2020. Setting the target for a reduction in the volume of GHG emissions will be the next step in Ipswich's Climate Action Plan. The following table shows possible targets and the level of GHG emission reductions necessary to meet each target.

2020 Target	Total Annual Emissions (mt CO_2)	Total Reduction (mt CO_2) to Meet Target (from 2010)	Annual Emissions Percent Reduction/Yr (from 2010)
Business as Usual	128,900	None	None
Meet 1990 Levels	92,400	25,500	2.41%
Meet 2000 Levels	87,400	30,500	2.95%
Kyoto Protocols (7% < 1990)	85,900	32,000	3.12%
MA Climate Protection Plan (10% < 1990)	83,200	34,700	3.43%

Table 7-1 Potential 2020 GHG reduction targets for Ipswich

Table 7-1 includes the annual reductions that would be needed to achieve each of these potential GHG reduction targets. The selection of any of these reduction targets will require significant political will and cooperation from the Town government, residents and businesses. The most effective strategies will be those that lower current emissions, while also avoiding *all* additional GHG emissions resulting from a growing population and expanding local economy. Clearly, reductions in both total emissions and *per capita* emissions will be required if a goal is to be met.

Figure 7-1 shows historic and projected GHG emissions and several potential reduction targets.

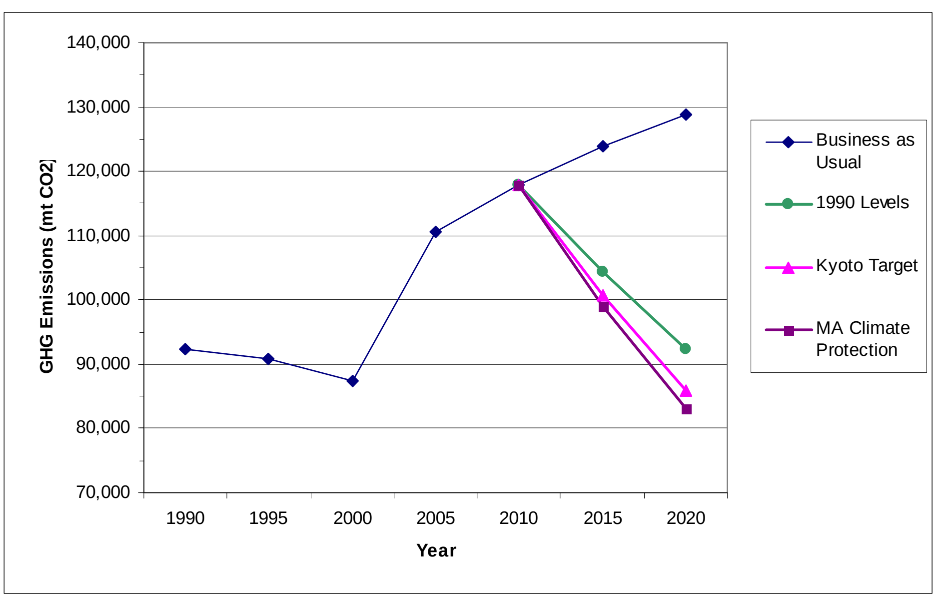


Figure 7-1 Historic and projected GHG emissions and potential reduction targets for Ipswich

For comparison, the appendix provides a summary of other climate action plans, the dates of the plans, and the reduction targets.

To be effective, the mitigation strategies adopted in Ipswich should address the greatest causes of GHG emissions, as well as the causes that will be most responsive to action plans, such as those over which the Town has greatest control. For example, the Town has significant control over the municipal government through policies and budgets. The Town may have much less control over the types of vehicles residents purchase and drive. In addition, the Town may consider creating new incentives to increase energy efficiency and conservation in residences and businesses.

The emission choices we make today can make a difference for our quality of life and the character of our region. Reducing dependence upon fossil fuel energy sources can reduce the economic instability associated with increasingly volatile world energy prices. Although we can't avoid all the consequences of global warming, committing ourselves to action today will help ensure more favorable environmental, economic, and social conditions for our children and grandchildren.

Appendix 1: Commission on Energy and Climate Protection

CEUCP History and Membership

The Commission on Energy Use and Climate Protection was established by the Ipswich Board of Selectmen in October 2006. The Commission includes a broad range of representatives of town government, schools, local businesses, and citizens. Town government representatives on the Commission include: the Town Manager, the Director of Public Utilities, the Director of Public Works, and one member each of the Board of Selectmen and Planning Board. Most members of the Commission participated in gathering data, analyzing trends, writing sections or reviewing this report.

The following individuals are (or were) members of the Commission during the preparation of this report:

- Don Bowen, Civil Engineer
- Laura Dietz, Board Member of Cuvilly Arts and Earth Center
- Robert Gravino, Director of Public Works
- Tim Henry, Director of Public Utilities
- Dan Jarmolowicz, Ipswich High School Senior
- Mike Johnson, Marine Biologist
- Emily Levin, Ipswich Planning Board
- Robert Markel, Town Manager
- Heidi Paek, Writer
- Edward Rauscher, Board of Selectmen
- Ken Savoie, Architect
- Harvey Schwartz, Attorney
- Marc Simon, General Contractor
- Sarah Simon, Environmental Compliance Manager
- Web Bingham, Corporate Real Estate Advisor

Other individuals who contributed information for the preparation of this report are: Jim Sperber (Director, Building Department), Frank Ragonese (Chief Assessor), Pam Carakatsane (Town Clerk), Glenn Gibbs (Director, Planning and Community Development), Kate Day (Assistant Planner), George Howe (former Town Manager), Richard Korb (Superintendent of Schools), Carl Lemiesz (Operations Manager, Ipswich Municipal Light Department), Mark E. Cousins (Business Manager, Ipswich Municipal Light Department), Ed Dick (Realtor), Jane Spellman (Director Of Purchasing), Kevin Merz (Treasurer) and Scott Peterson (Central Transportation Planning Staff).

Resolution by the Ipswich Board of Selectmen, November 6, 2006

The Ipswich Board of Selectmen voted to approve the following resolution on November 6, 2006, thereby officially joining cities throughout the world in a program of the International Council for Local Environmental Initiatives (ICLEI) known as Cities for Climate Protection (CCP):

WHEREAS, scientific consensus has developed that Carbon CO_2 and other greenhouse gases released into the atmosphere have a profound effect on the Earth's climate; and

WHEREAS, in 2006 the U.S. National Climatic Data Center confirmed clear evidence of human influences on climate due to changes in greenhouse gases; and

WHEREAS, the U.S. Conference of Mayors endorsed the 2005 U.S. Mayors' Climate Protection Agreement initiated by Seattle Mayor Nickels and signed by 238 mayors in the United States as of June 2006; and

WHEREAS, in 2003 the American Geophysical Union adopted a Statement noting that human activities are increasingly altering the Earth's climate and that natural influences cannot explain the rapid increase in near-surface temperatures observed during the second half of the 20th century; and,

WHEREAS, in 2001, at the request of the Administration, the National Academy of Sciences (NAS) reviewed and declared global warming a real problem caused in part by the actions of humankind; and,

WHEREAS, 162 countries including the United States pledged under the United Nations Framework Convention on Climate Change to reduce their greenhouse gas emissions; and

WHEREAS, energy consumption, specifically the burning of fossil fuels, accounts for more than 80% of U.S. greenhouse gas emissions; and

WHEREAS, local government actions taken to reduce greenhouse gas emissions and increase energy efficiency provide multiple local benefits by decreasing air pollution, creating jobs, reducing energy expenditures, and saving money for the local government, its businesses, and its residents; and,

WHEREAS, the Cities for Climate Protection Campaign sponsored by ICLEI – Local Governments for Sustainability has invited Ipswich to join ICLEI and become a partner in the Cities for Climate Protection Campaign;

NOW THEREFORE, BE IT RESOLVED, that Ipswich, Massachusetts will join ICLEI as a Full Member and participate in the Cities for Climate Protection Campaign and, as a participant, pledges to take a leadership role in promoting public awareness about the causes and impacts of climate change.

BE IT FURTHER RESOLVED that Ipswich, Massachusetts will undertake the Cities for Climate Protection Campaign's five milestones to reduce both greenhouse gas and air pollution emissions throughout the community, and specifically:

- *Conduct a greenhouse gas emissions inventory and forecast to determine the source and quantity of greenhouse gas emissions in the jurisdiction;*
- *Establish a greenhouse gas emissions reduction target;*
- *Develop an action plan with both existing and future actions which when implemented will meet the local greenhouse gas reduction target;*
- *Implement the action plan; and*

- *Monitor and report progress; and*

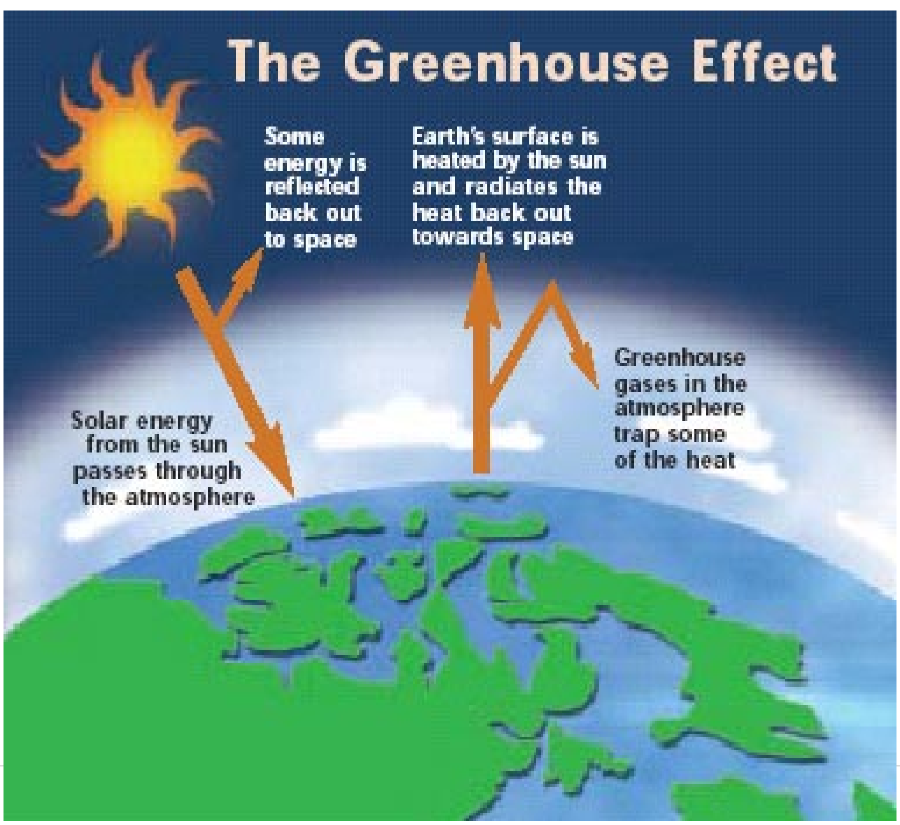
BE IT FINALLY RESOLVED that Ipswich, Massachusetts requests assistance from ICLEI's Cities for Climate Protection Campaign as it progresses through the milestones.

Appendix 2: Greenhouse Gases

About Greenhouse Gases and Global Warming

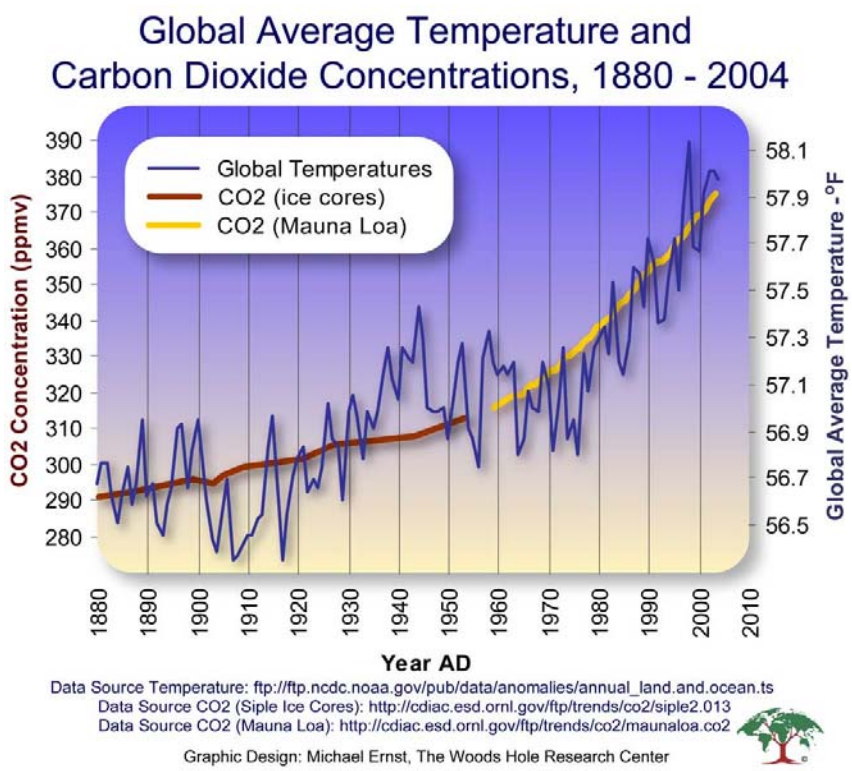
The "greenhouse effect" refers to the natural phenomenon that keeps the Earth in a temperature range that allows life to flourish. The sun's energy warms the Earth's surface and its atmosphere. As this energy radiates back toward space as heat, a portion is absorbed by a delicate balance of heat-trapping gases in the atmosphere – most importantly carbon dioxide – which creates an insulating layer. With the temperature control of the greenhouse effect, the Earth has an average surface temperature of 59°F (15°C). Without it, the average temperature would be so low that the Earth would be frozen and could not sustain life.

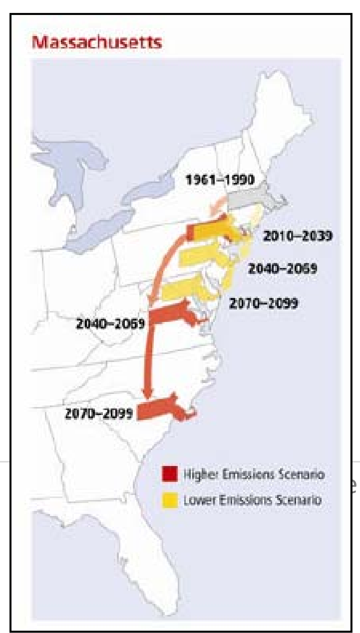
Currently, the delicate balance of the greenhouse effect is shifting out of equilibrium. The Earth's temperature is rising as a result of an increase in heat-trapping gases in the atmosphere. The result, called "global warming," is most visible in the Arctic, where rising temperatures and melting ice are dramatically changing the region's unique landscapes and wildlife, as well as people's lives and livelihoods. Across the globe, other effects of global warming include extreme weather patterns, shifting ranges of plants and animals, and the earlier onset of spring.



Scientists have concluded that human activities contribute to global warming by adding large amounts of heat-trapping gases to the atmosphere. Our fossil fuel use is the main source of these gases. Every time we drive a car, use electricity from coal-fired power plants, or heat our homes with oil or natural gas, we release carbon dioxide and other heat-trapping gases into the air. To complicate matters, the Earth's primary filter system – forests – are being cleared in vast areas over much of the world to accommodate modern forms of land use.

The Intergovernmental Panel on Climate Change (IPCC)[70] – established in 1988 by the World Meteorological Organization[71] and the United Nations Environment Programme[72] in recognition of the problem of global warming – has reviewed all the published and peer-reviewed scientific information produced to assess what is known about the global climate, why and how it changes, what it will mean for people and the environment, and what can be done about it. The IPCC is comprised of more than 1,250 authors and 2,500 scientific reviewers from more than 130 countries. These scientists published comprehensive assessments in 1990, 1996, 2001, 2007, and 2009, and presented their findings to world leaders.





The IPCC asserts with "high confidence" that heat trapped by greenhouse gases changes the climate system, causing altered weather patterns that can bring unusually intense precipitation or dry spells and more severe storms. The matter is urgent. With continued warming, we can expect more extreme heat

[70] www.ipcc.ch
[71] www.wmo.ch
[72] www.unep.org

and drought, less snow cover, rising sea levels, and higher-intensity storms. At risk are our coastal properties and resources, the livability of our cities in summer, the availability of fresh water, and the productivity of our farms, forests, and fisheries.

In November 2006, the Northeast Climate Impacts Assessment (NECIA), a collaboration between the Union of Concerned Scientists and a team of independent experts, published its forecast of how global warming will impact the Northeast United States. NECIA used state-of-the-art tools to assess the impact of global warming in our region under two different scenarios: a higher emissions path with continued rapid growth in global warming pollution, and a lower emissions path with greatly reduced heat trapping emissions.

The NECIA scientists predicted that summer in Massachusetts will feel like the typical summer in South Carolina by the end of the century unless we take action to reduce heat-trapping emissions today. The migration in temperature was calculated using average daily summer temperature (the average of daytime highs and nighttime lows) combined with relative humidity, and averaged over June, July, and August. While both pathways show an acceleration of the warming already under way, higher and lower emissions lead to starkly different climate futures.

The most recent findings show that the atmospheric concentration of carbon dioxide has increased by 35 percent since pre-industrial levels (from 280 ppm in 1750 to 379 ppm in 2005). The current level far exceeds the natural range over the last 650,000 years as determined from ice cores. These emissions will remain in our atmosphere for decades or even centuries, causing more heat to be trapped near the Earth and allowing less to escape back into space.

International and U.S. Action on Greenhouse Gas Emissions

Governments and businesses around the world are increasingly engaged in efforts to monitor and reduce GHGs. The Kyoto Protocol, an international treaty regulating greenhouse gas emissions, became effective in November 2004. Carbon dioxide equivalents (metric tons) are the standard of measure for GHG emissions. Industrialized countries that are part of the Kyoto Protocol (Tier 1) agreed to reduce greenhouse gas emissions to levels 5% less than baseline emissions (from the year 1990) by the year 2012 as Phase I. Procedures for calculating baseline GHG inventories and mechanisms for measuring greenhouse gas reductions were developed and agreed to at many Conferences of the Parties (COP). The most recent meeting took place in Bali, Indonesia, in December 2008, and began to plan for the period after 2012, Phase II.

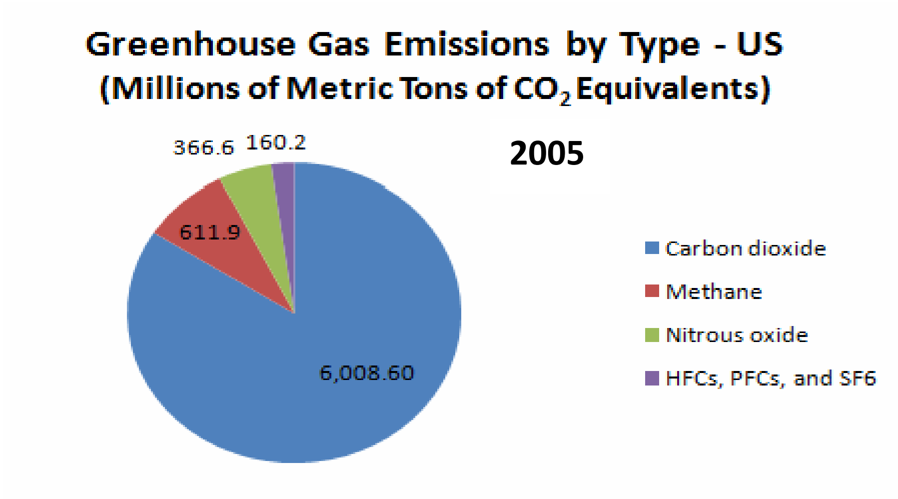
While the United States signed the original United Nations Framework Convention on Climate Change (UNFCCC, 1992), it did not ratify the Kyoto Protocol for fear of hampering our economy while developing countries like China (Tier III countries) continued to grow and increase GHG emissions. However, our commitment under the UNFCCC to produce and maintain a GHG inventory was confirmed by our Energy Policy Act of 1992 (section 1605(a)). The baseline US CO_2e inventory shows that the United States emitted 5,017.5 million MT CO_2e in 1990.[73]

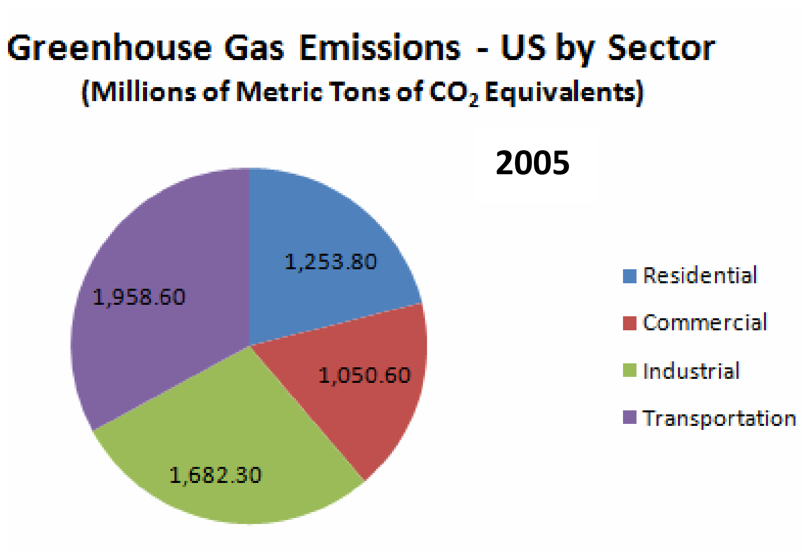
The most recent national GHG inventory, Emissions of Greenhouse Gases in the United States 2006, was published by the Energy Information Administration in November 2007[74] and indicates that the US emitted 7,184 million mt

[73] *Emissions of Greenhouse Gases in the United States 1987-1992* http://www.eia.doe.gov/oiaf/1605/archive/87-92rpt/chap2.html#Emission_Trends
[74] *Emissions of Greenhouse Gases in the United States,* Report # DOE/EIA-0573 (2006), November 28, 2007. http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html

CO_2e, of which 5,934.4 mt were CO_2 emissions, more than 85% of the total.[75] The chart on the next page summarizes the primary constituents of GHGs for the United States in 2005.

GHG inventories are conducted by many states and municipalities in the United States on a voluntary basis, and state and local plans have been developed to achieve GHG reduction targets. In 2001, the New England Governors and Eastern Canadian Premiers (NEG/ECP) developed a Climate Change Action Plan requiring emission reductions of 10% below 1990 levels by 2020[76]. The study predicted that GHG emissions levels could rise 30% between 2000 and 2030 if no reduction activities were undertaken.





[75] http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html
[76] http://www.cleanair-coolplanet.org/information/pdf/2001_Climate_Action_Plan.pdf

Some of the findings of the 2006 national US inventory are that the US GHG emissions were 17% higher than the 1990 emissions level, but they have increased more slowly than average annual growth in population (1.2%); primary energy consumption (1.1%); and gross domestic product (3.0%). Transportation sector increases of 24% from 1990-2003 far outweighed the average increase of other sectors, which was only 9.3%.[77]

The Massachusetts Climate Protection Plan (CPP) was completed in 2004, requiring a return to 1990 levels by 2010, with a further 10% reduction to meet the NEG/ECP target by 2020.[78] In 2005, The US Mayors Climate Protection Plan made a commitment to reduce GHG emissions 7% below 1990 levels by 2012. And California's 2006 Climate Change Law sets a goal of returning to 1990 GHG emission levels by 2020, which represents a 25% reduction.

[77] U.S. Energy Information Administration, Annual Energy Outlook 2005 with Projections to 2025, Table A2. U.S. Department of Energy, Energy Information Administration, Washington, DC.

[78] Mass DEP climate protection programs at: http://www.mass.gov/dep/air/climate/index.htm

Sample Greenhouse Gas Reduction Targets

Source	Greenhouse Gas Reduction Target	Plan Date
Kyoto Protocol[79]	By 2008-2012, Annex 1 (i.e. industrialized) countries have to reduce their GHG emissions by around 5% below their 1990 levels.	1997
U.S. Mayors Climate Protection Agreement	7% below 1990 levels by 2012	2005
Regional Greenhouse Gas Initiative80	Stabilize emissions of carbon dioxide (CO2) from electricity generation by 2015 and then decrease emissions 10% by 2019 through a "cap-and-trade" program.	2003
New England Governors and Eastern Canadian Premiers Climate Change Action Plan	Reduction to 1990 emission levels by 2010 and to 10% below 1990 emissions by 2020.	2001
Massachusetts Climate Protection Plan	SHORT-TERM Reduce GHG emissions to 1990 levels by the year 2010. MEDIUM-TERM Reduce GHG emissions 10% below 1990 levels by the year 2020. LONG-TERM Reduce GHG emissions sufficiently to eliminate any dangerous threat to the climate.	2004
Cambridge, Massachusetts Climate Protection Plan	Reduction of GHG emissions by 20 percent below 1990 levels (target date not identified).	2002
Somerville, Massachusetts	Reduce to 1990 levels by the year 2010, and further reduce emissions to 10% below 1990 levels by the year 2015.	2003
Medford, Massachusetts	Municipal Emissions of 20% below 1998 levels by the year 2010. The Community Emissions Reduction target has been set at 10% below 1998 levels by 2010.	2001
California Climate Change Law (AB 32)	Reduction to 1990 levels by 2020 (25% reduction)	2006

[79] The Kyoto Protocol covers more than 160 countries globally and over 55% of global greenhouse gas (GHG) emissions. Governments are separated into two general categories: developed countries, referred to as Annex 1 countries (who have accepted GHG emission reduction obligations); and developing countries, referred to as Non-Annex 1 countries (that have no GHG emission reduction obligations). Any Annex 1 country that fails to meet its Kyoto target will be penalized by having its reduction targets increased by 30% in the next period.

[80] Under this program, allowances—equal to one short ton of CO_2—would be distributed among the states and could then either be sold on a secondary market within the region or "banked" to sell at a later date.

Appendix 3: GHG Inventory Data (Not in Main Report)

- Conversion Factors
- Historic and Forecasted Electricity Use (IMLD and MMWEC)
- Comparative Electricity Generation and Emission Rates (U.S. EPA)
- School Department Energy Use (Ipswich Public Schools)
- Heating Degree Days, Massachusetts (NOAA, NCDC)
- Heated Area (Square Feet) of Ipswich Residences and Businesses (Town Assessor)
- Vehicle Miles Traveled in Essex County and Ipswich (MA DEP)
- Vehicle Miles Traveled by Vehicle Type (CTPS)
- Ipswich Municipal Fleet (Town Reports)
- Solid Waste Emissions Calculations

Conversion Factors

	kg CO_2		lb CO_2		Energy Value		/mmbtu		lb CO2	
Natural Gas	0.0546	/scf	0.120	/ mcf	1029	btu/scf	971.82	scf	116.98	/mmbtu
heating oil	10.154	/gallon	22.39	/gallon	138,690	btu/gallon	7.21	gal	161.44	/mmbtu
Propane	5.74	/gallon	12.66	lb/gal						/mmbtu
Motor Gasoline	8.81	/gallon	19.43	/gallon	124,238	btu/gallon	8.05	gal	156.36	/mmbtu
					5.218	MMBtu / Barrel				/mmbtu
										/mmbtu
Table 13.1 U.S. Default CO2 Emission Factors										
Diesel Fuel #1 and 2		10.15	/gallon	*for Transport Fuels p. 74*						
Ethanol		5.56	/gallon							/mmbtu
Combined Solid Waste			919	/ton MSW					92	/mmbtu
Mixed Plastics Only			5771	/ton plastic						
Wood and wast	1443.67	/ton								
Waste Tires	3159.49	/ton				2.205	lb/kg			
			Other units							
		(Electricity	3412.1	Btu/kW			293.07	kw	243.31	/mmbtu
		Heating Oil	5.825	MMBtu / Barrel						
		Propane	70.88	kg CO2/ mmbtu						
		Gasoline	19.33	kg C/ Mmbtu						
		Solid Waste	2885.5	kg CO2/mt MSW						

Historic and Forecasted Electricity Use (IMLD and MMWEC)

NUMBERS OF RESIDENTIAL ELECTRICITY CUSTOMERS (IMLD)

1990	5,102
1995	5,408
2000	5,523
2005	5,863

EMISSIONS FACTORS

	mt CO2 by Sector						
	Residential	Indus / Comm*	Municipal	Ipswich Total			
1990	15165	13224	1796	**30,190**	880	lb CO2/MW 1990	
1995	16426	13107	1781	**31,310**			
2000	16472	14419	1882	**32,770**	781	lb CO2/MW 2000	
2005	19194	18865	1998	**40,060**	830	lb CO2/MW (2006)	
2010	*23161*	*22765*	*2411*	***48,340***			
2015	*25260*	*24827*	*2630*	***52,720***			
2020	*27549*	*27077*	*2868*	***57,490***			
	kWh x EF / 1000 kw / 2205 lb/mt				886	lb CO2/MW (2007)	

IPSWICH ELECTRICITY USE (KWH) PROVIDED BY IPSWICH MUNICIPAL LIGHT DEPARTMENT

	1985	1986	1987	1988	1989	1990
Residential	31,932,288	33,716,732	35,118,929	57,236,097	38,371,141	37,998,377
Commercial	2,699,435	3,088,647	3,470,157	3,853,885	3,886,006	4,047,350
Industrial	20,546,564	21,024,565	22,489,596	25,488,740	29,589,880	28,911,627
Municipal	2,911,415	3,011,023	3,280,666	3,307,620	3,194,593	3,409,095
Street light	1,092,000	1,092,000	1,092,000	1,092,000	1,092,000	1,092,000
Outdoor Light	175,848	175,848	175,848	175,848	175,848	175,848
Total:	59,357,550	62,108,815	65,627,196	91,154,190	76,309,468	75,634,297

	1991	1992	1993	1994	1995	1996
Residential	37,404,791	39,037,247	40,083,179	39,585,781	41,158,258	40,902,335
Commercial	3,915,887	4,015,449	4,093,599	4,476,764	4,066,446	5,343,463
Industrial	30,293,585	30,736,045	33,304,358	34,876,756	28,599,133	28,807,489
Municipal	3,440,173	3,305,634	3,407,947	3,490,442	3,370,528	3,326,692
Street light	1,092,000	1,092,000	1,092,000	1,092,000	1,092,000	1,092,000
Outdoor Light	175,848	175,848	175,848	175,848	175,848	175,848
Total:	76,322,284	78,362,223	82,156,931	83,697,591	78,462,213	79,647,827

	1997	1998	1999	2000	2001	2002
Residential	40,220,278	40,210,891	42,643,191	46,529,828	47,532,470	46,617,207
Commercial	5,992,159	6,496,983	7,153,850	9,120,544	7,044,530	5,725,821
Industrial	30,478,249	28,597,981	27,647,374	31,419,872	29,051,491	32,099,596
Municipal	3,371,767	3,434,337	3,567,319	4,170,074	5,078,392	5,182,531
Street light	1,092,000	1,092,000	1,092,000	1,147,636	667,632	667,632
Outdoor Light	175,848	175,848	175,848	190,502	175,848	175,848
Total:	81,330,301	80,008,040	82,279,582	92,578,456	89,550,363	90,468,635

	2003	2004	2005	2006
Residential	48,689,791	48,461,887	50,977,398	49,884,232
Commercial	6,176,403	5,706,651	8,386,922	4,667,685
Industrial	31,871,795	37,673,236	41,535,233	45,782,845
Municipal	5,320,384	5,173,925	4,463,231	5,168,501
Street light	667,632	897,328	843,480	843,480
Outdoor Light	175,848	224,332	182,170	182,170
Total:	92,901,853	98,137,359	106,388,434	106,528,913

Forecast Electricity Data Provided by MMWEC

MMWEC

MASSACHUSETTS MUNICIPAL WHOLESALE ELECTRIC COMPANY

Ipswich Long Range Energy and Peak Load Forecast

	Total Energy Required (MWh)
2007	121,271
2008	123,697
2009	126,171
2010	128,379
2011	130,625
2012	132,912
2013	135,237
2014	137,604
2015	140,012
2016	142,463
2017	144,955
2018	147,492
2019	150,074
2020	152,700

Peak Load	
Summer (MW)	Winter (MW)
28.0	22.0
28.6	22.4
29.1	22.9
29.6	23.3
30.2	23.7
30.7	24.1
31.2	24.5
31.8	24.9
32.3	25.4
32.9	25.8
33.5	26.3
34.1	26.7
34.7	27.2
35.3	27.7

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MJL
05/2007

Comparative Electricity Generation and Emission Rates (U.S. EPA)

Year 2005 State Emissions and Emission Rates

State	Nitrogen oxides (NO_x) Emissions (tons)	Nitrogen oxides (NO_x) Output emission rate (lb/MWh)	Nitrogen oxides (NO_x) Ozone season emissions (tons)	Nitrogen oxides (NO_x) Ozone season output emission rate (lb/MWh)	Sulfur dioxide (SO_2) Emissions (tons)	Sulfur dioxide (SO_2) Output emission rate (lb/MWh)	Carbon dioxide (CO_2) Emissions (tons)	Carbon dioxide (CO_2) Output emission rate (lb/MWh)	Methane (CH_4) Emissions (lbs)	Methane (CH_4) Output emission rate (lb/GWh)	Nitrous oxide (N_2O) Emissions (lbs)	Nitrous oxide (N_2O) Output emission rate (lb/GWh)
AK	10,908.68	3.3174	4,473.51	3.4100	3,551.84	1.0801	3,583,598.7	1,089.79	162,166.8	24.66	39,690.3	6.04
AL	138,269.28	2.0138	47,105.68	1.5258	466,164.70	6.7892	92,043,923.1	1,340.53	3,447,073.9	25.10	3,169,994.4	23.08
AR	38,011.21	1.5906	16,918.57	1.4968	71,132.21	2.9766	29,375,197.8	1,229.23	1,528,239.0	31.98	1,065,991.2	22.30
AZ	81,977.08	1.6159	36,631.70	1.5345	53,238.17	1.0494	58,778,193.0	1,158.58	1,576,157.9	15.53	1,616,641.9	15.93
CA	22,302.45	0.2231	10,460.26	0.2211	13,576.65	0.1358	53,985,904.8	540.06	6,117,976.5	30.60	899,178.9	4.50
CO	72,523.23	2.9224	31,180.47	2.9113	62,897.66	2.5346	47,420,655.1	1,910.88	1,165,299.6	23.48	1,452,396.6	29.26
CT	10,086.99	0.6013	4,293.69	0.5862	9,165.89	0.5464	13,485,688.6	803.92	2,274,325.3	67.79	457,295.8	13.63
DC	412.95	3.6538	364.40	3.4464	914.34	8.0900	274,901.1	2,432.30	23,728.7	104.97	4,745.7	21.00
DE	13,546.31	3.3297	6,143.41	3.1073	32,534.86	7.9972	8,209,955.0	2,018.04	296,927.1	36.49	215,766.6	26.52
FL	232,374.96	2.1140	111,431.69	2.1066	427,367.29	3.8879	147,356,227.6	1,340.54	10,052,442.6	45.73	3,886,101.1	17.68
GA	118,496.71	1.7347	38,039.96	1.1683	646,010.65	9.4572	95,805,693.5	1,402.54	3,007,898.5	22.02	3,269,108.9	23.93
HI	22,355.13	3.8802	10,042.06	4.0215	24,009.52	4.1673	9,973,066.3	1,731.01	1,905,878.4	165.40	345,203.5	29.96
IA	75,754.12	3.4444	32,979.97	3.3393	137,912.79	6.2706	41,947,003.5	1,907.24	984,511.8	22.38	1,390,794.3	31.62
ID	757.77	0.1400	310.67	0.1091	949.00	0.1753	723,800.4	133.73	207,424.6	19.16	37,193.7	3.44
IL	133,020.84	1.3702	36,776.61	0.8605	350,703.25	3.6126	109,310,141.6	1,126.00	2,552,683.7	13.15	3,591,868.2	18.50
IN	214,229.26	3.2885	57,740.17	2.0258	876,661.47	13.4570	136,006,998.2	2,087.75	3,197,209.9	24.54	4,529,353.0	34.76
KS	89,973.17	3.9236	41,595.24	4.0563	136,521.99	5.9535	43,453,084.3	1,894.92	1,066,380.4	23.25	1,435,914.1	31.31
KY	167,571.04	3.4260	37,558.49	1.7481	503,807.18	10.3004	100,632,256.5	2,057.45	2,360,641.2	24.13	3,415,398.9	34.91
LA	75,548.05	1.6303	34,533.52	1.6445	114,467.12	2.4701	54,472,600.4	1,175.49	2,358,929.2	25.45	1,243,498.4	13.42
MA	26,342.18	1.1093	9,904.96	0.9788	83,686.32	3.5240	29,990,704.0	1,262.91	3,249,178.6	68.41	818,561.7	17.23
MD	64,802.53	2.4622	21,144.97	1.8401	287,866.63	10.9375	35,590,672.9	1,352.27	1,820,454.0	34.58	1,196,458.5	22.73
ME	9,024.74	1.0270	3,187.89	0.8969	10,734.92	1.2216	6,499,973.0	739.65	4,024,971.4	229.01	571,043.6	32.49
MI	126,584.90	2.0812	49,344.62	1.8298	390,490.65	6.4202	81,961,230.9	1,347.55	3,606,301.5	29.65	2,877,490.0	23.65
MN	88,480.38	3.3448	36,404.38	3.2585	105,570.95	3.9909	42,183,866.1	1,594.67	2,048,507.3	38.72	1,507,279.7	28.49
MO	128,506.86	2.8288	45,188.35	2.2706	295,031.83	6.4944	83,903,379.0	1,846.93	1,935,821.3	21.31	2,790,190.8	30.71
MS	44,190.09	1.9607	23,209.19	2.0488	77,262.10	3.4281	27,626,151.8	1,225.77	1,194,115.4	26.49	785,181.7	17.42
MT	40,795.63	2.9204	17,023.30	2.6724	21,771.26	1.5585	22,239,943.1	1,592.05	551,190.5	19.73	759,879.5	27.20
NC	115,726.42	1.7841	30,807.83	1.0613	510,453.44	7.8692	79,459,971.8	1,224.97	2,571,438.6	19.82	2,765,521.0	21.32
ND	77,082.25	4.8278	31,582.75	4.7365	138,894.30	8.6992	37,124,155.8	2,325.16	801,563.0	25.10	1,192,829.3	37.35
NE	54,116.87	3.4398	21,949.35	3.2538	74,209.47	4.7169	25,265,169.3	1,605.90	584,468.8	18.58	839,872.9	26.69
NH	11,493.84	0.9416	3,614.40	0.6653	55,228.58	4.5243	9,622,652.3	788.28	1,489,325.3	61.00	366,366.3	15.01
NJ	29,863.52	0.9855	10,678.02	0.7658	58,199.36	1.9205	21,775,912.9	718.57	1,831,535.3	30.22	653,702.4	10.79
NM	76,309.72	4.3437	33,169.92	4.2931	30,669.27	1.7458	34,009,625.1	1,935.90	817,809.9	23.28	1,072,523.1	30.53
NV	45,933.21	2.2450	20,228.28	2.2128	53,553.12	2.6174	29,479,348.3	1,440.79	819,356.5	20.02	730,423.8	17.85
NY	65,647.39	0.8867	29,366.38	0.8842	181,615.48	2.4531	61,325,138.0	828.33	5,472,744.6	36.96	1,540,840.6	10.41
OH	260,352.29	3.3173	53,428.45	1.5639	1,116,299.97	14.2233	139,060,670.8	1,771.84	3,294,991.9	20.99	4,693,870.1	29.90
OK	87,234.01	2.4823	41,141.98	2.3163	108,741.39	3.0944	54,918,161.6	1,562.76	1,522,726.5	21.67	1,436,581.1	20.44
OR	11,003.14	0.4444	4,792.80	0.5116	12,932.42	0.5223	9,939,648.9	401.45	840,128.9	16.97	237,791.9	4.80
PA	184,311.23	1.6909	50,735.83	1.0600	997,192.45	9.1482	135,654,583.9	1,244.50	5,541,258.4	25.42	4,564,949.7	20.94
RI	644.39	0.2129	311.35	0.2089	165.92	0.0548	2,919,853.8	964.72	116,308.2	19.21	11,957.8	1.98
SC	55,594.47	1.0846	17,930.98	0.8004	226,159.35	4.4122	45,817,122.1	893.86	1,529,849.3	14.92	1,555,340.6	15.17
SD	14,800.40	4.5395	5,348.46	3.6268	11,460.63	3.5151	3,851,980.4	1,181.45	91,052.9	13.96	124,118.7	19.03
TN	103,412.56	2.1318	22,468.09	1.0633	268,048.54	5.5257	61,076,912.7	1,259.07	1,592,464.6	16.41	2,103,950.4	21.69
TX	196,031.29	0.9870	86,302.46	0.9044	597,420.87	3.0079	269,204,654.5	1,355.41	7,843,575.9	19.75	6,099,389.7	15.35
UT	70,779.96	3.7098	31,263.89	3.7409	37,007.65	1.9397	40,122,566.9	2,102.97	921,222.2	24.14	1,342,781.2	35.19
VA	70,496.04	1.7890	21,874.59	1.2729	227,114.45	5.7635	47,130,905.6	1,196.05	3,230,331.6	40.99	1,676,006.1	21.27
VT	581.37	0.2034	266.69	0.2220	48.48	0.0170	13,297.8	4.65	506,578.9	88.61	67,621.1	11.83
WA	21,600.13	0.4236	8,332.14	0.3878	4,525.15	0.0887	16,882,589.7	331.11	1,672,301.6	16.40	616,155.6	6.04
WI	74,369.76	2.4052	31,798.10	2.3253	189,960.37	6.1436	53,186,665.6	1,720.13	1,578,126.8	25.52	1,748,801.6	28.28
WV	162,304.81	3.4680	28,802.00	1.4143	472,124.15	10.0881	90,236,388.9	1,928.12	2,049,347.8	21.89	3,062,605.3	32.72
WY	91,392.93	4.0113	37,458.62	3.8958	90,280.78	3.9625	51,296,417.0	2,251.46	1,170,313.5	25.68	1,696,751.6	37.24
U.S.	**3,827,828.62**	**1.8366**	**1,387,841.07**	**1.5162**	**10,666,306.79**	**6.2688**	**2,696,209,203.8**	**1,329.35**	**110,605,268.4**	**27.27**	**83,672,872.8**	**20.60**

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Year 2005 State Resource Mix

State	Nameplate capacity (MW)	Net Generation (MWh)	Generation resource mix (percent) Coal	Oil	Gas	Other fossil	Biomass	Hydro	Nuclear	Wind	Solar	Geo-thermal	Other unknown/ purchased fuel
AK	2,009.5	6,576,653.1	9.4749	11.5578	56.6188	0.0000	0.0799	22.2597	0.0000	0.0090	0.0000	0.0000	0.0000
AL	33,206.2	137,325,018.7	56.8508	0.1453	10.0961	0.0869	2.3450	7.3873	23.0797	0.0000	0.0000	0.0000	0.0090
AR	14,609.1	47,794,506.6	48.2004	0.4324	12.5703	0.0320	3.6295	6.4928	28.6426	0.0000	0.0000	0.0000	0.0000
AZ	28,727.3	101,465,934.9	39.5633	0.0426	28.4758	0.0000	0.0595	6.4107	25.4346	0.0000	0.0134	0.0000	0.0000
CA	66,022.8	199,924,749.7	0.9833	1.2886	46.7057	1.1304	2.9082	19.8833	18.0843	2.1305	0.2685	6.5138	0.1035
CO	12,454.8	49,632,185.6	71.6675	0.0343	24.0594	0.0000	0.0692	2.6056	0.0000	1.5640	0.0000	0.0000	0.0000
CT	8,695.9	33,549,743.9	11.9121	9.4071	26.4242	2.3010	2.1191	1.4204	46.3852	0.0000	0.0000	0.0000	0.0309
DC	868.0	226,042.0	0.0000	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DE	3,517.5	8,136,567.1	59.3979	14.9501	19.5508	6.1013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FL	62,446.5	219,845,864.3	28.4303	16.9257	38.0526	0.6249	1.9701	0.1211	13.0814	0.0000	0.0000	0.0000	0.7941
GA	39,737.9	136,617,442.0	63.8539	0.7365	7.1539	0.0375	2.3397	2.7963	23.0822	0.0000	0.0000	0.0000	0.0000
HI	2,592.7	11,522,803.2	14.1567	78.7692	0.0000	1.6454	2.6132	0.8348	0.0000	0.0576	0.0000	1.9231	0.0000
IA	12,869.5	43,987,078.7	77.4852	0.3399	5.6396	0.0283	0.2637	2.1814	10.3174	3.7446	0.0000	0.0000	0.0000
ID	3,441.4	10,824,979.6	0.8793	0.0000	14.3203	0.0000	5.3306	78.9112	0.0000	0.0000	0.0000	0.0000	0.5586
IL	48,313.8	194,157,100.8	47.5204	0.1679	3.6622	0.1229	0.3526	0.0665	48.0348	0.0727	0.0000	0.0000	0.0000
IN	30,085.7	130,290,362.9	94.2483	0.2029	2.7603	2.0747	0.0510	0.3364	0.0000	0.0000	0.0000	0.0000	0.3264
KS	12,007.5	45,862,689.7	75.1825	2.1508	2.4801	0.0000	0.0000	0.0247	19.2334	0.9285	0.0000	0.0000	0.0000
KY	22,703.9	97,822,418.3	91.0662	3.7626	1.6950	0.0174	0.4318	3.0271	0.0000	0.0000	0.0000	0.0000	0.0000
LA	29,797.0	92,680,362.2	24.8924	3.7612	47.2937	3.0399	2.8873	0.8750	16.9144	0.0000	0.0000	0.0000	0.3360
MA	15,549.2	47,494,728.0	25.3366	14.9838	42.6922	1.7478	2.5277	1.1843	11.5277	0.0000	0.0000	0.0000	0.0000
MD	13,375.7	52,638,599.3	55.6890	7.2524	3.5936	1.2514	1.0446	3.2365	27.9324	0.0000	0.0000	0.0000	0.0000
ME	4,440.0	17,575,739.2	1.8341	8.6192	42.5971	1.7437	21.9299	23.2760	0.0000	0.0000	0.0000	0.0000	0.0000
MI	33,052.7	121,645,244.3	57.8285	0.7381	11.2060	0.8296	2.0856	0.2882	27.0225	0.0015	0.0000	0.0000	0.0000
MN	13,222.8	52,906,084.8	62.1160	1.4806	5.1446	0.5644	1.8917	1.4643	24.2604	2.9911	0.0000	0.0000	0.0869
MO	22,048.1	90,857,129.2	85.2296	0.1854	4.2889	0.0768	0.0102	1.3706	8.8387	0.0000	0.0000	0.0000	0.0000
MS	17,176.7	45,075,692.9	36.9066	3.1866	34.0245	0.0430	3.4793	0.0000	22.3576	0.0000	0.0000	0.0000	0.0025
MT	5,245.8	27,938,776.3	63.7943	1.4818	0.1291	0.0458	0.2335	34.3156	0.0000	0.0000	0.0000	0.0000	0.0000
NC	29,011.9	129,733,725.3	60.4706	0.3739	2.4122	0.0572	1.4159	4.2726	30.8183	0.0000	0.0000	0.0000	0.1793
ND	5,070.8	31,932,614.6	94.7582	0.1071	0.0285	0.1829	0.0313	4.2020	0.0000	0.6900	0.0000	0.0000	0.0000
NE	7,494.6	31,465,429.7	66.1620	0.0992	2.5535	0.0000	0.1355	2.7696	27.9731	0.3070	0.0000	0.0000	0.0000
NH	4,540.1	24,414,429.8	16.6827	5.5588	27.7899	0.2574	3.8400	7.1405	38.7307	0.0000	0.0000	0.0000	0.0000
NJ	20,854.5	60,608,679.6	19.1018	1.7996	25.0872	0.9535	1.3778	0.0000	51.5799	0.0000	0.0000	0.0000	0.1001
NM	7,066.8	35,135,640.6	85.2332	0.1050	11.9173	0.0000	0.0132	0.4696	0.0000	2.2616	0.0000	0.0000	0.0000
NV	9,841.9	40,921,212.2	44.9260	0.1088	47.4446	0.2748	0.0000	4.1601	0.0000	0.0000	0.0000	3.0857	0.0000
NY	42,824.3	148,069,580.2	13.7535	16.2274	22.4641	0.6988	1.2371	16.8852	28.6643	0.0696	0.0000	0.0000	0.0000
OH	36,796.1	156,967,960.4	87.1937	0.8859	1.7164	0.1907	0.2458	0.3286	9.4304	0.0085	0.0000	0.0000	0.0000
OK	21,796.6	70,283,511.1	51.7183	0.1001	43.0045	0.0268	0.4115	3.5236	0.0000	1.2062	0.0000	0.0000	0.0090
OR	12,766.9	49,519,311.3	7.0007	0.1197	27.0387	0.0879	1.7727	62.4975	0.0000	1.4828	0.0000	0.0000	0.0000
PA	49,296.0	218,007,339.4	55.4403	2.2741	4.9592	0.5835	0.9138	0.6949	34.9940	0.1304	0.0000	0.0000	0.0099
RI	1,996.2	6,053,293.4	0.0000	0.9220	98.9667	0.0000	0.0000	0.1112	0.0000	0.0000	0.0000	0.0000	0.0000
SC	25,142.2	102,514,661.4	38.7035	0.6563	5.2798	0.0906	1.7389	1.6968	51.8341	0.0000	0.0000	0.0000	0.0000
SD	3,027.0	6,520,768.5	45.9508	0.3187	4.1551	0.0003	0.0000	47.1504	0.0000	2.4246	0.0000	0.0000	0.0000
TN	22,688.1	97,019,349.1	60.9995	0.2376	0.5484	0.0000	0.5745	8.9792	28.6573	0.0034	0.0000	0.0000	0.0000
TX	108,093.4	397,230,222.1	37.3481	0.5724	49.2611	1.3029	0.2762	0.3355	9.6248	1.0667	0.0000	0.0000	0.2123
UT	6,856.3	38,158,077.2	94.2668	0.1072	3.0858	0.0000	0.0000	2.0558	0.0000	0.0000	0.0000	0.4843	0.0000
VA	24,321.6	78,811,115.8	44.9138	5.3757	10.4345	0.6539	3.1170	0.0806	35.4245	0.0000	0.0000	0.0000	0.0000
VT	1,086.5	5,716,751.9	0.0000	0.1780	0.0392	0.0000	7.1805	21.1800	71.2213	0.2009	0.0000	0.0000	0.0000
WA	27,646.9	101,975,586.7	10.3026	0.1001	8.4150	0.3704	1.5561	70.6843	8.0826	0.4888	0.0000	0.0000	0.0000
WI	16,934.7	61,840,344.8	67.3493	1.1367	10.4811	0.1203	1.8919	2.7541	16.0429	0.1496	0.0000	0.0000	0.0743
WV	17,343.0	93,600,525.1	97.6556	0.2388	0.2917	0.1021	0.0008	1.5465	0.0000	0.1644	0.0000	0.0000	0.0000
WY	7,031.4	45,567,305.6	95.1245	0.0928	0.7132	0.5785	0.0000	1.7740	0.0000	1.5741	0.0000	0.0000	0.1429
U.S.	**1,067,746.8**	**4,058,441,833.0**	**49.8064**	**3.0307**	**18.7669**	**0.6021**	**1.3028**	**6.4888**	**19.2776**	**0.4390**	**0.0138**	**0.3622**	**0.1010**

School Department Energy Use (Ipswich Public Schools)

Fuel and Utilities Usage, Cost & Averages Last Updated: 07/28/08 JLH

Location and FY	Fuel Units Used (CCF)	Cost of Fuel	Electric KWH Used	Cost of Elec.	Water/Sewer Used	Cost of Water/Sewer
DOYON		OIL				
2001	0	$24,665	319,760	$32,840	60,500	$1,712
2002	0	$14,342	351,280	$35,087	48,100	$1,517
2003	0	$31,705	379,912	$38,487	52,000	$2,198
2004	0	$32,569	375,520	$40,720	62,880	$2,207
2005	0	$40,842	364,720	$41,531	61,145	$2,227
2006	23,000	$42,120	362,960	$57,795	61,847	$2,560
2007	23,598	$43,435	316,560	$41,880	81,685	$3,401
2008	22,333	$60,739	303,920	$40,262	81,463	$3,695
3 YR AVERAGE	*22,977*	*$48,765*	*327,813*	*$46,646*	*74,998*	*$3,219*
WINTHROP		GAS				
2001	25,450	$27,446	241,280	$24,712	135,400	$4,376
2002	24,370	$19,074	269,760	$26,904	144,400	$4,999
2003	27,730	$29,003	273,120	$27,835	138,800	$5,523
2004	23,830	$26,900	273,920	$29,709	65,900	$4,750
2005	25,071	$29,192	275,840	$31,865	73,100	$6,200
2006	24,226	$38,884	268,960	$43,194	75,600	$6,379
2007	39,735	$63,827	276,480	$36,526	79,600	$7,072
2008	30,338	$43,456	244,721	$32,433	68,800	$6,374
3 YR AVERAGE	*31,433*	*$48,722*	*263,387*	*$37,384*	*74,667*	*$6,608*
MIDDLE-HIGH		GAS				
2001	134,180	$136,693	1,644,000	$172,025	168,600	$5,541
2002	106,700	$78,503	1,691,720	$172,482	209,600	$7,259
2003	153,450	$157,250	1,925,520	$195,932	205,200	$8,142
2004	129,230	$142,650	1,823,040	$198,000	106,247	$8,054
2005	144,720	$166,165	1,846,080	$208,135	117,864	$9,228
2006	144,939	$238,555	1,962,880	$310,777	120,036	$10,635
2007	116,486	$192,286	1,736,480	$231,844	122,486	$10,881
2008	113,190	$162,660	1,790,560	$237,237	125,369	$11,547
3 YR AVERAGE	*124,872*	*$197,834*	*1,829,973*	*$259,953*	*122,630*	*$11,021*

Handwritten notes: Doyon 2001–2005: "Gallons Un-Available"; Doyon 2006–2008: "Gallons of Oil"

CCF = 1 hundred cubic feet Natural Gas

thus Middle/High for 2001 = 13,418 thousand cf

Z:\Business Office\1UTILITIES FY09\Fuel-Utilities Averages FY082/4/2009

Heating Degree Days, Massachusetts (NOAA, NCDC)

Monthly HDD for Massachusetts (July - June)

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total HDD
89-90	8	18	125	418	741	1472	977	945	843	573	155	42	6317
90-91	5	12	143	315	631	871	1191	908	804	481	155	42	5558
91-92	7	12	167	379	683	1017	1154	998	991	649	321	69	6447
92-93	19	28	129	514	766	1041	1126	1193	1001	562	218	46	6643
93-94	0	5	117	490	699	1046	1424	1162	925	497	304	17	6686
94-95	0	21	141	411	576	921	998	1083	842	612	314	40	5959
95-96	0	11	147	318	786	1167	1201	1063	989	561	294	36	6573
96-97	4	11	112	447	818	871	1172	873	923	623	340	43	6237
97-98	1	16	115	467	775	1000	1013	851	801	517	181	65	5802
98-99	1	5	72	391	696	863	1139	926	847	520	233	13	5706
99-00	0	11	52	444	559	933	1236	935	714	568	258	44	5754
00-01	14	25	120	412	701	1169	1193	991	962	547	208	17	6359
01-02	15	0	81	353	580	849	969	886	831	468	296	65	5393
02-03	0	1	54	473	749	1085	1372	1157	917	652	330	66	6856
03-04	0	0	82	477	650	996	1444	1011	863	537	216	70	6346
04-05	9	11	94	441	701	1038	1265	1012	1017	498	416	20	6522
05-06	0	0	50	376	653	1090	972	1002	895	495	274	32	5839
06-07	0	14	126	436	550	829	1066	1168	935	637	205	46	6012
07-08	1	6	74	271	766	1115	1107	994	931	507	319	22	6113
08-09													
												Avg	6164

Monthly HDD for Massachusetts (Jan. – Dec.)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total HDD
1990	977	945	843	573	155	42	5	12	143	315	631	871	5512
1991	1191	908	804	481	155	42	7	12	167	379	683	1017	5846
1992	1154	998	991	649	321	69	19	28	129	514	766	1041	6679
1993	1126	1193	1001	562	218	46	0	5	117	490	699	1046	6503
1994	1424	1162	925	497	304	17	0	21	141	411	576	921	6399
1995	998	1083	842	612	314	40	0	11	147	318	786	1167	6318
1996	1201	1063	989	561	294	36	4	11	112	447	818	871	6407
1997	1172	873	923	623	340	43	0	1	41	272	640	825	5753
1998	750	662	598	265	51	1	0	0	5	246	524	700	3802
1999	903	755	716	319	85	1	0	11	52	444	559	993	4838
2000	1236	935	714	568	258	44	14	25	120	412	701	1169	6196
2001	1193	991	962	547	208	17	15	0	81	353	580	849	5796
2002	969	886	831	468	296	65	0	1	54	473	749	1085	5877
2003	1372	1157	917	652	330	66	0	0	82	477	650	996	6699
2004	1444	1011	863	537	216	70	9	11	94	441	701	1038	6435
2005	1265	1012	1017	498	416	20	0	0	50	376	653	1090	6397
2006	972	1002	895	495	274	32	0	14	126	436	550	829	5625
2007	1066	1168	935	637	205	46	1	6	74	271	766	1115	6290
2008	1107	994	931	507	319	22							3880
												Avg.	5965

Heated Area (Square Feet) of Ipswich Residences and Businesses (Assessor)

Residential Fuel Oil			
(Percent change from 1990)			
Year	Number of Buildings	Number of Residential Households	Total Space Heated (square feet)
1990	2,510	2,799	5,180,204
2000	2,753 (+9.7)	3,119 (+11.4)	5,805,794 (+12.1)
2005	2,821 (+12.4)	3,257 (+16.4)	6,097,302 (+17.7)

Residential Natural Gas			
(Percent change from 1990)			
Year	Number of Buildings	Number of Residential Households	Total Space Heated (square feet)
1990	926	1,250	2,001,528
2000	1,244 (+34.3)	1,546 (+23.7)	3,016,803 (+50.7)
2005	1,368 (+47.7)	1,674 (+33.9)	3,400,052 (+69.9)

Commercial/Industrial Oil		
(Percent change from 1990)		
Year	Number of Buildings	Total Space Heated (square feet)
1990	116	641,098
2000	119 (+2.6)	651,545 (+1.6)
2005	122 (+5.2)	776,832 (+21.2)

Commercial/Industrial Natural Gas		
(Percent change from 1990)		
Year	Number of Buildings	Total Space Heated (square feet)
1990	168	1,672,890
2000	174 (+3.6)	1,714,008 (+2.5)
2005	187 (+11.3)	1,992,902 (+19.1)

Vehicle Miles Traveled in Essex County and Ipswich (MAPC)

Massachusetts

	Gasoline used (gallons)	Travel (daily VMT)	Essex County: (daily VMT)
1990	2,404,777,794	123,200,000	11,446,665
1999	2,738,289,000	141,346,000	15,790,000
2002	2,851,292,000	145,838,290	16,381,760
2006	2,821,777,481	147,562,083	16,511,904

DAILY VEHICLE MILES TRAVELLED (DVMT)

1990 Daily VMT: State: 123,200,000 miles Essex County: 11,446,665 miles
1999 Daily VMT: State: 141,346,000 miles Essex County: 15,790,000 miles
2002 Daily VMT: State: 145,838,290 miles Essex County: 16,381,760 miles
2006 Daily VMT: State: 147,562,083 miles Essex County: 16,511,904 miles

Vehicle Miles Traveled by Vehicle Type (MAPC)

	Passenger/Residential				
VMT DATA	Gasoline Vehicles				
	Light Duty (LD) Vehicle Car	LD Truck >6000 lb	Other LD Truck	motorcycle	Total
1990	10,946,541	7,196,731	2,398,910	101,554	20,643,736
1995	9,977,785	6,559,829	2,186,610	92,567	18,816,789
2000	9,009,028	5,922,926	1,974,309	83,579	16,989,842
2005	8,945,499	5,881,159	1,960,387	82,990	16,870,034
2010	8,881,970	5,839,393	1,946,465	82,400	16,750,227
2015	8,818,440	5,797,626	1,932,542	81,811	16,630,419
2020	8,754,911	5,755,859	1,918,620	81,221	16,510,611
	2005 =VMT ((2020-2000)/4) + 200		2010 = VMT((2020-2000)/4 + 2005		
	1995 =VMT ((2000-1990/2) + 199(		2015 =VMT((2020-2000)/4 + 2010		

	Commercial/Industrial		100.0%	
	Gasoline	Diesel Fuel Vehicles		Total
	Heavy Duty (HD) truck	LD Diesel Truck	HD Diesel Truck	VMT
1990	819,515	16,532	2,137,351	2,973,398
1995	746,989	15,069	1,948,198	2,710,255
2000	674,462	13,606	1,759,044	2,447,112
2005	669,706	13,510	1,746,640	2,429,856
2010	664,950	13,414	1,734,236	2,412,600
2015	660,194	13,318	1,721,831	2,395,343
2020	655,438	13,222	1,709,427	2,378,087
	2005 =VMT ((2020-2000)/4) + 200		2010 =VMT((2020-2000)/4 + 2005	
	1995 =VMT ((2000-1990/2) + 199(		2015 =VMT((2020-2000)/4 + 2010	

Ipswich Municipal Fleet (Town Reports)

	1990	2000	2006
Bus	5		6
Car	9	7	12
Fire	5	6	6
Heavy Equipment	7	10	10
Pickup Truck	18	18	22
SUV		3	4
Truck	19	18	17
Van	4	3	7
Total Vehicles	67	65	84

Solid Waste Emissions Calculations

Solid Waste GHG Estimates (MT CO2) (MJ's			
Year	Residential	Commercial	Total
1990	2,640	790	**3,430**
1995	1,930	580	**2,510**
2000	1,900	570	**2,470**
2005	2,160	650	**2,810**
2010	*2,130*	*640*	***2,770***
2015	*2,240*	*670*	***2,910***
2020	*2,350*	*700*	***3,050***

MJ's alternative method to calculate solid waste projections, based on a 1% pop. increase per year:				Note: Ave. per capita waste 2000-		*Assumes Comm/Indust solid waste=30% of	
Year	Residential solid waste (tons)	Ipswich population	per capita waste (tons)	Comm/Indust solid waste (30%)	Ipswich solid waste (tons)		
1990	6327.00	12791	0.495	1898.10	8225.10		
1995	4631.00	12524	0.370	1389.30	6020.30		
2000	4566.00	13435	0.340	1369.80	5935.80		
2005	5191.00	13483	0.385	1557.30	6748.30		
2010	5110.68	14157	0.361	1533.20	6643.88		
2015	5366.27	14865	0.361	1609.88	6976.14		
2020	5634.49	15608	0.361	1690.35	7324.83		

Appendix 4: Municipal Information

- Growth Trends: Population
- Growth Trends: Employment
- Growth Trends: Construction
- School Department Efforts to Save Energy

Growth Trends: Population

The table below presents population estimates of the U.S. Census along with projections of the Metropolitan Area Planning Council (MAPC) for 2010, 2020, and 2030. Conclusively, the population of Ipswich is growing.

Year	Ipswich Population[81]	Population Growth (Previous 10 yrs)
1960	8,544	--
1970	10,750	2,206
1980	11,158	408
1990	11,873	715
2000	12,987	1,114
2010	13,532	545
2020	13,964	432
2030	14,300	336

Population growth in Ipswich has escalated over the three decades spanning 1970 – 2000. Population projections by MAPC indicate that the rate of growth peaked in the '90s. During the present decade MAPC estimates that population growth will be less than ½ of that during the '90s.

However, statistics gathered by the Commission suggest that population in the year 2010 will be higher than that projected by MAPC. The annual Town Census indicates that population grew 549 persons between 2000 and 2006.

[81] Source: US Census through 2000; Projections by MAPC.

Our review of Ipswich Assessor's records and residential building permits supports the conclusion that population in Ipswich is growing faster than predicted by MAPC. The table on the next page presents residential development activity between 2000 and 2006 based on data from the assessor and the building inspector.

	Estimated Dwelling Units Built 2000 - 2006[82]	Dwelling Units Permitted but Not Built
Single Family Dwellings	150[83]	38
Residential Condominiums[84]	89	240
Two Family Dwellings	12	0
Apartment Units	72[85]	48
Total	**323**	**326**

Based on the number of dwelling units built in Ipswich between 2000 and 2006, our conclusion is that the corresponding population growth was 550 - 650 persons[86] - an amount that exceeds the MAPC prediction of 545 new residents between 2000 and 2010.

Growth Trends: Employment

Ipswich has a diverse economic base including farming, shellfishing, light industry, life sciences, information technologies, retail, personal and business services, finance, insurance, and real estate.

In 1990, 3,201 people were employed in Ipswich. Between 1990 and 2006, an additional 1,062 new jobs were created. The majority of new jobs have been added by EBSCO Publishing (approximately 525) and New England Biolabs (approximately 250).

MAPC projected that the number of jobs in Ipswich would grow 0.49% per year between 2000 and 2010 and 0.35% per year between 2010 and 2020.

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[82] Source: Ipswich Assessor's database – adjusted as noted.

[83] Actual count of 181 was reduced to 150 to account for dwellings demolished and subsequently rebuilt.

[84] Includes Turner Hill where all units are sold under condominium form of ownership.

[85] Estimated unit count based on 79,332 square feet of apartment building development and an average estimated unit size of 1,100 square feet.

[86] Using 2.25 persons per single-family dwelling and 1.25 persons per multi-family dwelling unit indicates that 565 people occupy the new units constructed since 2000.

The table below summarizes population and employment in Ipswich through 2020.

	Population	Change	Employment	Change
2000	12,987	--	3,927	--
2006	13,587	600	4,164	237
2010	13,793	206	4,246	82
2020	14,234	441	4,397	151

Growth Trends: Construction

Residential Construction Trends

Since 1970, new construction in Ipswich has added 6.0 million sq. ft. of building area in Ipswich. The construction of 1,374 new single-family homes accounted for 3.5 million sq. ft.; new residential condominiums added 0.6 million sq. ft., new commercial/industrial space resulted in 1.3 million sq. ft. of new space; apartment building construction added 0.3 million sq. ft. of building area; and, new construction in the government/institution sector resulted in an additional 0.3 million sq. ft. of space. The table below presents total new floor area constructed in Ipswich in each of these sectors over the past four decades.

	1970s	1980s	1990s	2000 - 2006	Total
Single Family[87]	736,810	939,169	1,274,225	536,234	**3,486,438**
Condominiums	8,314	344,445	104,520	178,519	**635,798**
Multi-Homes	18,508	25,075	0	8,182	**51,765**
Apartments	133,070	40,348	35,222	110,608	**319,248**
Gov't. /Inst.[88]	164,328	8,751	142,208	2,826	**318,113**
Commercial[89]	69,285	282,689	23,018	18,333	**393,325**
Industrial[90]	102,103	463,779	12,300	306,156	**884,338**
Total	**1,232,418**	**2,104,256**	**1,591,493**	**1,160,858**	**6,089,025**

[87] Net new single family construction (total SF new construction less floor area of dwellings demolished and reconstructed) excluding single-family condominiums.
[88] Old High School floor area (est. at 70,000 SF) netted out.
[89] Excluding buildings without heating or air conditioning.
[90] ibid

Some of the more significant new projects developed in Ipswich in recent years are described below:

- **Turner Hill Estates** – Planned golf course community on a 311-acre site that was formerly the Rice Estate, and more recently, The National Shrine of Our Lady of LaSalette. Sixteen new single-family and eight duplex residences of the 182 planned residences at this new golf course community have been built;
- **Ipswich Country Club** -- 229 new homes have been constructed at this planned golf course community. Construction commenced in 1988. In all, 235 single-family attached and detached residences were permitted along with a 52, 800 square foot main clubhouse; a 3,600 square foot tennis/swim clubhouse; and a private, tertiary sewage treatment plant.
- **76 Apartment Units off High Street** -- Located on the west side of Route 1A (toward Rowley). The 27-unit, 32,700 square foot Phase I garden-style units were completed in 1997 and the 10 building, 49-unit Phase II townhouse apartment complex was built between 2002 and 2004.

The table below lists many of the larger single family subdivisions, condominium and apartment complexes developed and planned over the past 20 years.

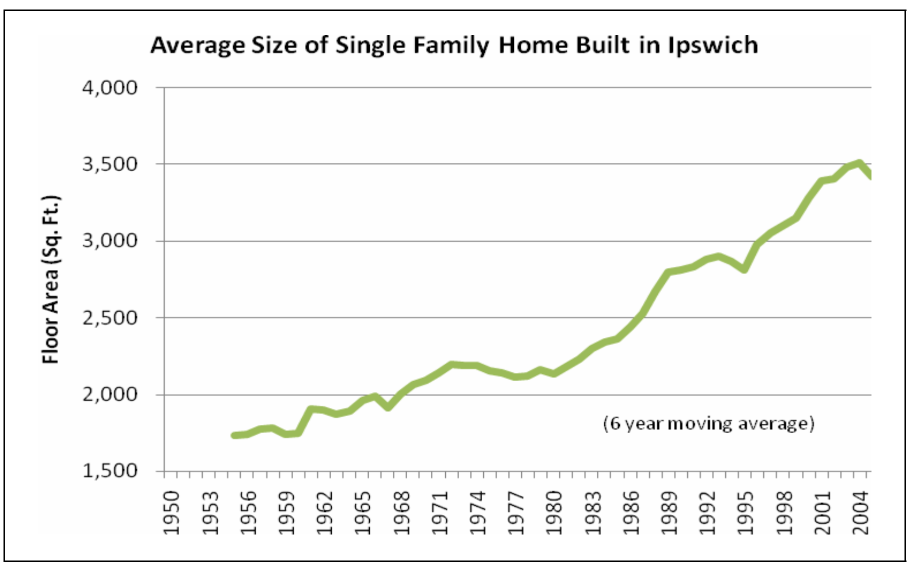
Project	# Units Planned	# Units Built	# Units Remaining	Start	Finish
Single Family Subdivisions					
Appleton Estates	32	32	0	1986	1992
Belle and Fille Streets	21	21	0	1986	1995
Meadowview Estates	30	30	0	1988	1993
Ipswich Country Club	235	229	6	1988	2005
Pond Edge Lane	4	4	0	1991	1993
Jewett Hill	7	7	0	1992	1995
Alderson and Adeline Drives	11	11	0	1993	1998
Oakwood Knoll	16	16	0	1993	2001
Hood Farm	26	26	0	1995	1998
Sand Pebble Dr./Pine Swamp Rd.	17	17	0	1995	2004
Bradley Estates (Hickory Lane)	15	15	0	1998	2001
Pitcairn Way	11	11	0	2001	2003
Partridgeberry Place	22	14	8	2003	2005
Willowdale Circle	8	0	8	Pending	
Mill Road	8	0	8	Pending	
Riverdale Circle/Howard Street	8	0	8	Pending	
Subtotal	**471**	**433**	**38**		
Condominium Developments					
Ipswich Woods	27	27	0	1986	1993
Mayfair Court	12	12	0	1990	1990
Lilac Meadows	16	16	0	1998	1998
Mill Place	21	21	0	2000	2000
Olde Ipswich Village	8	8	0	2002	2002
Turner Hill[91]	182	24	158	2004	--

[91] 16 of 30 single-family homes approved for construction have been completed; a total of 21 have been sold at a starting price of $1.25 million. Four of the 50 to 60 townhouse cottages allowed by permit – for sale starting in the

Project	# Units Planned	# Units Built	# Units Remaining	Start	Finish
Southgate - 6 Essex Road	18	18	0	2005	2006
26 Topsfield Road (Duplexes)	8	6	2	2006	2007
Ipswich River Pt. 40B (82 Tops. Rd.)	40	0	40	2007	--
Green Meadow/Locust Road 40B	40	0	40	2008	--
Subtotal	**372**	**32**	**240**		

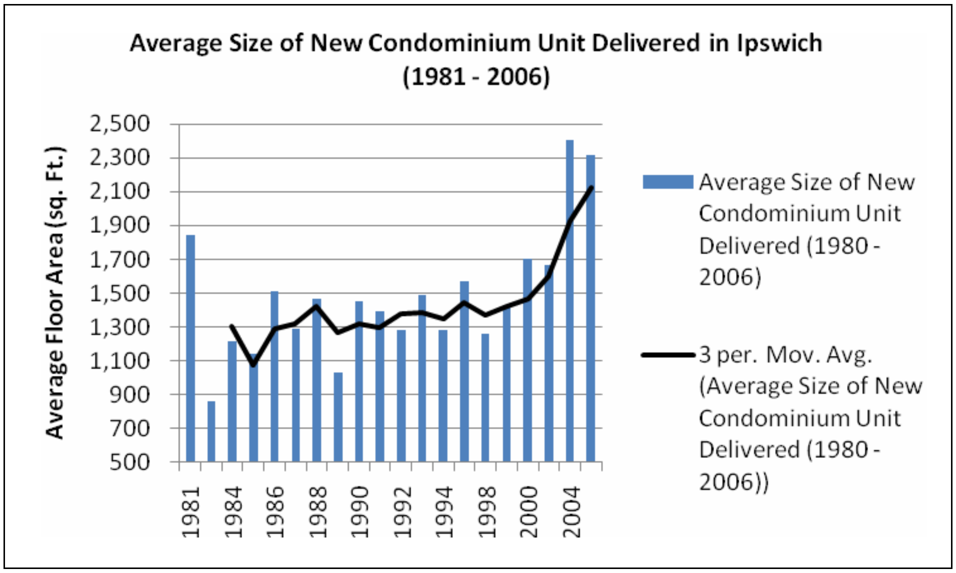
Apartments					
Oak Hill (Sr. Housing)	33	33	0	1989	1989
Cable Gardens (Sr. Housing)	70	70	0	1989	1990
218 - 220 High St.	27	27	0	1997	1997
Rosewood Drive 40B (LeBlanc)	49	49	0	2002	2004
Memorial Hall Housing (Sr. Housing)	7	7	0	2005	2005
Whipple School Annex (Sr. Housing)	10	10	0	2006	2007
43 Avery Street 40B	14	14	0	2006	2007
Powder House Village 40B	48	0	48	--	--
Subtotal	**258**	**210**	**48**		
TOTAL	**1,101**	**775**	**326**		

The average size of a single family house in Ipswich is 2,138 sq. ft. During the '90s, 460 new homes were built in town at an average size of 3,051 sq. ft. Since 2000, 181 houses have been built at an average size of 3,418 sq. ft. (see chart below).



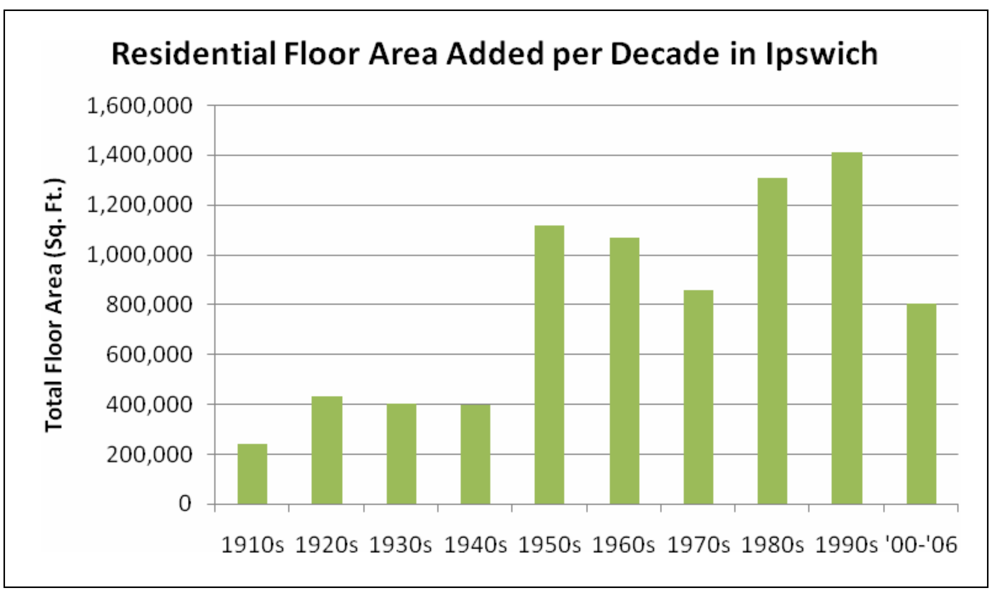
mid-$700,000s (mid-$800,000s for fairway frontage) – have been built. An additional 53 units could be developed on the site following special permit approval under the Great Estate bylaw.

Similarly, condominiums have increased in size (see chart below).



The average condominium unit increased in size from 1,300 sq. ft. during the 80s to 1,375 sq. ft. in the 90s and 2,025 sq. ft. in the 2000s.

Condominium development in town since the year 2000 has been dominated by three projects: Turner Hill (off Topsfield Road), Southgate (at 6 Essex Road), and Mill Place (off Brownville Ave.). The typical unit averages 3,650 sq. ft. at Turner Hill; 2,040 sq. ft. at Southgate; and 1,705 sq. ft. at Mill Place.



Commercial and Industrial Construction Trends

Commercial and Industrial Square Footage Constructed per Decade in Ipswich
(Excluding Buildings w/o Heat and Air Conditioning)

	2000s	1990s	1980s	1970s
Commercial[92]	18,333	23,018	282,689	69,285
Industrial[93]	306,156	12,300	463,779	102,103

In the 1980s approximately 283,000 sq. ft. of new commercial space was constructed in Ipswich. An estimated 35,000 sq. ft. of additional office space was constructed in the downtown area and along High Street. Redevelopment projects were responsible for most of the new space in the downtown area. Clubhouse facilities at the Ipswich Country Club accounted for 53,000 sq. ft. Six new buildings on Route 1 accounted for an additional 96,000 sq. ft. Since 1990, 9 projects resulted in an additional 41,000 sq. ft. of commercial space. Eight of these projects were downtown and along High Street and one was on Route 1. The four projects downtown were all redevelopment projects.

Industrial buildings are concentrated in three areas in Ipswich: 1) Route 1/Old Right Road area; 2) Mitchell Road; and 3) Peabody and Hayward Streets near downtown. Nearly every developable lot in these industrial zones has been developed. The Mitchell Road and Peabody/Hayward Street industrial areas were largely developed in the '80s. Specifically, 16 buildings totaling approximately 225,000 sq. ft. were built on Mitchell Road and 5 buildings totaling 55,000 sq. ft. were built in the Peabody/Hayward Street area. About ½ of the 310,000 sq. ft. developed in the Route 1/Old Right Road zone since 1980 was built in the '80s, the rest has been built in the past 6 years.

In 2000, the 147,000 square foot New England Biolabs project was completed. This project is located on a former Archdiocese property between Route 1A and Fellows Road.

[92] Excludes buildings without heat or air conditioning.
[93] ibid

Government and Institutional Construction Trends

Government and institutional sector facilities in Ipswich occupy 1.15 million sq. ft. of space.

Sector	Floor Area
Town Government[94]	440,851
Not for Profit Organizations[95]	398,424
Public Housing	155,232
Religious Institutions	147,395
Federal Government	9,271
State Government	1,820
Total	**1,152,993**

Since 1990, the growth in the government and institutional sector can be attributed mainly to additions to town government facilities and public schools. Since 1990, the local government/schools facilities portfolio has grown more than 111,000 sq. ft. (see details below).

	Year	Additions	Deletions	Inventory
Municipal Facilities Inventory - 1990	1990			329,416
Doyon School addition	1994	16,962		346,378
Library addition	1998	3,496		341,530
Central Fire (Quint Fire Barn)	1994	2,066		343,596
New High School/Middle School	2000	196,695		540,291
Old High School demolished	2000		-80,000	460,291
Memorial Building sold	2003		-8,344	338,034
Town Hall Annex sold	2005		-6,000	454,291
Old Town Hall sold	2006		-13,440	440,851
Total		**219,301**	**-107,784**	**440,851**

The only significant addition in the government/institution sector was the new 34,000 sq. ft. YMCA facility that opened in 1999.

[94] Includes all municipal facilities and schools

[95] Includes Sisters of Notre Dame (231,500 SF), Trustees of the Reservations facilities (85,000 SF), YMCA (34,256 SF), Caldwell House (21,560 SF), Ipswich Historical Society (16,516 SF).

School Department Efforts to Save Energy

In recent years, the Ipswich schools have undergone some substantial upgrades which both modernize the facilities and make them more energy-efficient.

Winthrop Elementary School

- New Boilers (FY 2004) -- two new high-efficiency boilers were installed. Previously the school relied on one boiler. The new boilers provide redundancy for the school's heating system and are considerably more energy efficient.
- Roof Replacement (FY 2004) -- Winthrop school received a new roof that included replacement of old insulation that had been saturated due to leaks.
- Replacement Light Fixtures and Controls (FY 2006) -- old lamps throughout the school, including fluorescent fixtures with T8 ballasts were replaced with modern florescent lamps with T12 ballasts. Motion sensors were installed in the majority of classrooms.
- FY 2007 -- energy efficiency upgrades at Winthrop school include Phase II roof replacement ($180,000), upgrading of the ventilation system ($10,000), and Phase 1 of a program to replace exterior doors ($110,000).
- FY 2008 -- Replacement of steam traps in the heating system ($10,000) and replacement of the remaining exterior doors ($30,000).

Doyon Elementary School

- Window Replacement (FY 2005) -- approximately 60% of the windows were replaced ($185,000).
- Door Replacement (FY 2005) -- included the replacement of exterior doors (included in window replacement cost above).
- Window Replacement (FY 2006) -- the remaining exterior windows were replaced ($120,000).
- New Light Fixtures/Re-lamping (FY 2006) -- old lamps and fluorescent fixtures to be replaced with modern fixtures and fluorescent bulbs. Motion sensing lighting controls will be installed.
- Roof Replacement - Phase 1 (FY 2007) -- a portion of the school's roof was replaced ($175,000).
- Roof Replacement - Phase II (FY 2008) -- replacement of the remaining sections of old roof ($43,000).

High School/Middle School Projects

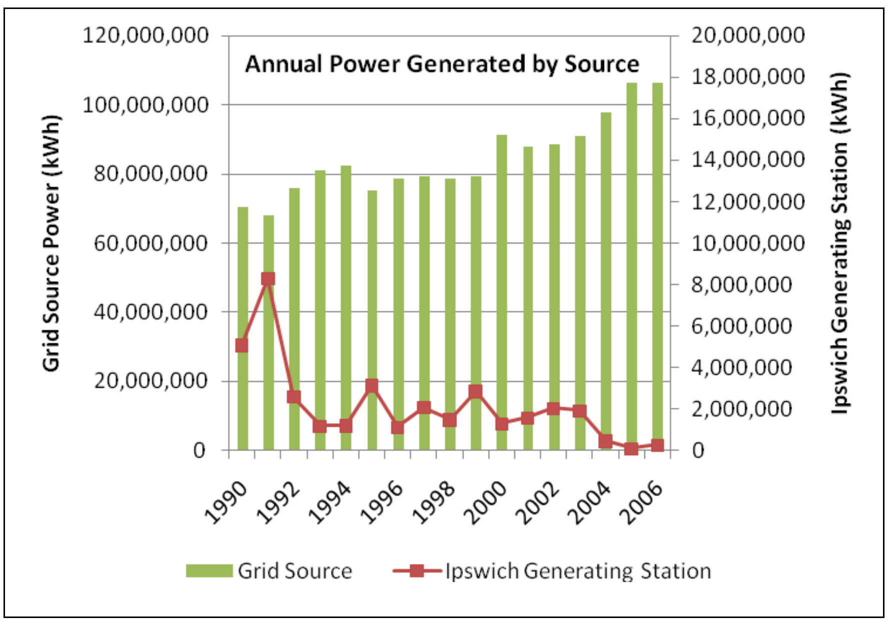
- Installation of an energy management system (EMS) to regulate the heating, cooling, and venting ducts reducing natural gas and electricity use and the replacement of the three-way missing bypass valve associated with the heated water loop ($135,000). Estimated payback period for the new energy management systems is estimated at four years.
- Insulation to areas of the building that were not insulated properly or under-insulated during original construction. These areas were identified in the LCI Consultants infrared scan of the building ($40,000). Estimated payback period for the additional insulation/air ceiling is estimated at 3.7 years.
- Replacement of the multi-vapor lamps in the gymnasiums with lower cost/high efficiency fluorescent fixtures and lamps ($40,000). The payback period is estimated at 5.7 years.

Appendix 5: Electricity

- Sources of Electricity in Ipswich
- Growth in Electricity Demand vs. Population and Employment Trends
- Changes in Peak Period Electricity Use
- Electricity Used for Wastewater Treatment and Water Distribution
- Net Metering in Ipswich
- Renewable Energy Portfolio Standards
- Funding Requirements for Renewable Energy and Energy Efficiency
- Appliance Efficiency Standards
- Municipal Appliance Rebate Program

Sources of Electricity in Ipswich

Ipswich ties into its electricity with its own Electric Department, the Ipswich Municipal Light Department (IMLD). IMLD acquires most of its electricity through its membership in the Massachusetts Municipal Wholesale Electric Company (MMWEC), but the town also has its own peak demand, diesel fuel engine generating station. Built in the early 1900s, the local generating station provides peak power to the New England Power grid (NEPOOL) when it is occasionally called for.



Ipswich acquires the bulk of its electricity from Massachusetts Municipal Wholesale Electric Company (MMWEC). MMWEC has an ownership interest in five major New England power generating stations. The energy from these plants is resold at cost to participating municipal electric companies. MMWEC also purchases power in bulk through bilateral contracts with power suppliers and resells the power at cost to participating utilities.

Much of the power supply available to Ipswich through MMWEC has been generated by natural gas fueled facilities with very little coal. Ipswich is a participant in the following MMWEC power plants:

	Stony Brook Intermediate Unit	Seabrook Station	Millstone Unit No. 3	Proposed Stony Brook Unit
Location	Ludlow, MA	Seabrook, NH	Waterford, CT	Ludlow, MA
On-Line Date	1981	1990	1986	2010
Fuel	No. 2 oil or natural gas	Nuclear – Pressurized Water Reactor	Nuclear - Pressurized Water Reactor	No. 2 oil or natural gas
Principal Owner Operator	MMWEC (90.75%)	FPL Energy Seabrook, LLC (88,2%)	Dominion Nuclear Connecticut, Inc. (93.47%)	MMWEC
Total Capacity	350 MW	1,150 MW	1,150 MW	350 MW
MMWEC Ownership	318 MW (90.75%)	133.3 MW (11.59%)	55.2 MW (4.8%	280 MW (11.59%)
Notes	Additional power produced using a single steam turbine in a combined-cycle process	Owner is seeking to increase capacity by 100 MW and extend license expiration from 2026 to 2050.	Operating license expires in Nov. 2045	Combined cycle

The proposed new unit at MMWEC's Ludlow, MA site will be a combined cycle facility fueled by natural gas with the capability of operating on #2 distillate oil (ultra-low sulfur). The facility will be designed to meet the Lowest Achievable Emission Rate and Best Available Technology Standards (including selective catalytic reduction for nitrogen oxide (NOx) and an oxidation catalyst for carbon monoxide). The facility will utilize wet cooling that is expected to require the use of 1.113 million gallons per day of water.

The project is subject to the review of the Massachusetts Executive Office of Environmental Affairs (EOEA) under the Massachusetts Environmental Policy Act (MEPA). The required Environmental Notification Form was published in the Environmental Monitor on October 10, 2006 (EOEA No. 13889). On November 9, 2006 EOEA issued the scoping requirements of the Environmental Impact Report (EIR). In addition to the EIR, the project will require at least eight additional state and local permits.

The two MMWEC power plants that Ipswich does not participate in are listed in the table below:

	Stony Brook Peaking Unit	Wyman Unit No. 4
Location	Ludlow, MA	Yarmouth, ME
On-Line Date	1982	1978
Fuel	No. 2 oil	No. 2 oil
Principal Owner Operator	MMWEC (100%)	FPL Energy Wyman, LLC (61.8%)
Total Capacity	170 MW	619 MW
MMWEC Ownership	170 MW (100%)	22.7 MW (3.7%)

In addition to its jointly owned resources, MMWEC enters into bulk power purchase contracts to supply additional power to member utilities.

- **All-Requirements -** MMWEC offers an All Requirements Power Supply Program through which program participants pool their electric loads and resources to achieve greater efficiency and economy in New England's wholesale power marketplace. The All-Requirements participants delegate certain decision-making authority to an MMWEC program administrator, who can act on behalf of participants to complete certain transactions.
- **NYPA Contracts -** MMWEC administers contracts and other arrangements covering the purchase and delivery of inexpensive hydroelectric power from the New York Power Authority (NYPA) to Massachusetts municipal utilities. Under an agreement with the Massachusetts Department of Telecommunications & Energy (DTE), the official Massachusetts bargaining agent for NYPA power, MMWEC acts as the agent for DTE in overseeing the Massachusetts allocations of power and energy from federally licensed, NYPA-operated hydroelectric projects in New York.
- **MASSPOWER Contract -** MMWEC is receiving approximately 21 megawatts of power and energy from the MASSPOWER Project through a 20-year contract that runs through 2013. MASSPOWER is a 270-megawatt, gas-fired, combined-cycle plant located in Springfield, Mass., that began operating in 1993. Power and energy from this contract is resold to the six contract participants at MMWEC's cost.
- **Hydro-Quebec Interconnection -** The Hydro-Quebec Interconnection is an approximate 2,000-megawatt, direct-current electric transmission line connecting central New England with the Canadian utility Hydro-Quebec. Construction of the U.S. portion of the interconnection, which stretches from Groton/Ayer, Mass. to the Canadian border in northern Vermont, was a joint effort of many New England utilities, including most Massachusetts municipal utilities. Thirty-two Massachusetts municipal utilities own usage rights over approximately 4 percent of the interconnection, either through MMWEC or independently. MMWEC owns approximately 1 percent of the stock in several of the companies that operate the interconnection on behalf of numerous municipals. MMWEC also manages the ownership interests of all but two of the Massachusetts municipals involved with the project.

While a portion of the electricity that IMLD acquires through MMWEC is renewable energy from Québec Hydro, this facility would not qualify as "new" renewable energy for the State's investor-owned utilities.

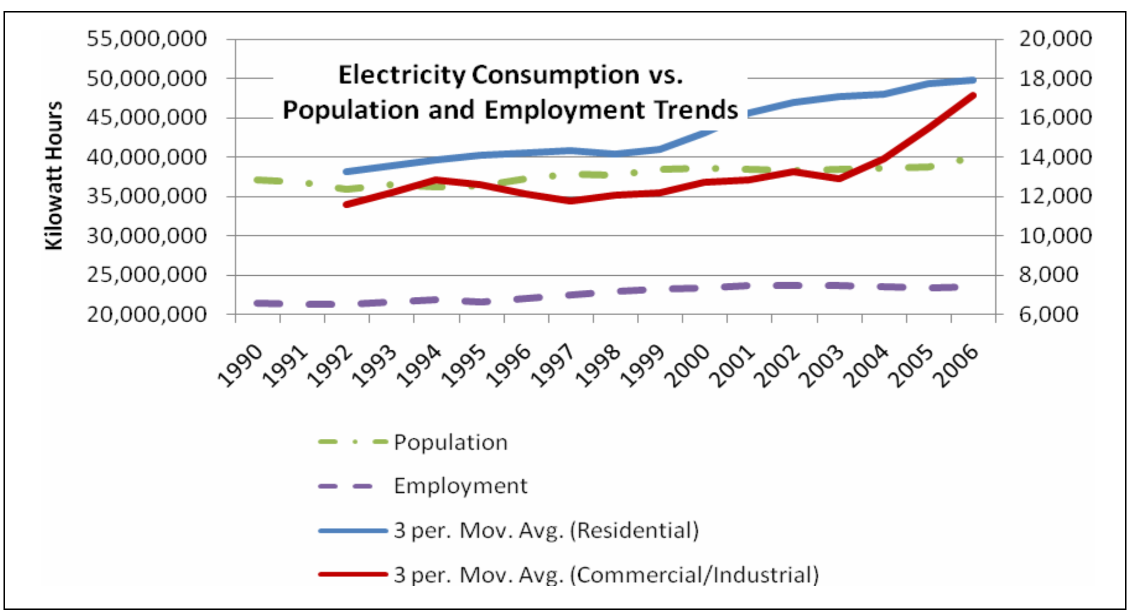
MMWEC has also acquired a new wind energy project planned for the western part of the state and known as Berkshire Wind. The project received approval under the Massachusetts Environmental Policy Act (EOEA 12532). This project, as currently conceived, will include ten, 1.5 MW wind turbines and be located on Brody Mountain in Hancock, Massachusetts. The annual energy output of the project is estimated at 42,700 MWh. Construction on the project commenced in 2006 but was delayed as a result of a lawsuit filed by an adjacent landowner that has requested the relocation of five of the turbines. Pretrial hearings at the Federal District Court commenced in March 2007.

The sources of Ipswich electricity consumed in 2006 is shown below:

Generation Source	Fuel	Percent of KWhs Consumed
Seabrook and Millstone	Nuclear	14%
NYPA + Wind	Hydoelectric and Wind	4%
Masspower	Natural Gas	3%
Stonybrook Intermediate	No. 2 Oil	1%
Power Purchases	Natural Gas	58%
ISO-NE	Mix	20%
	Total	100%

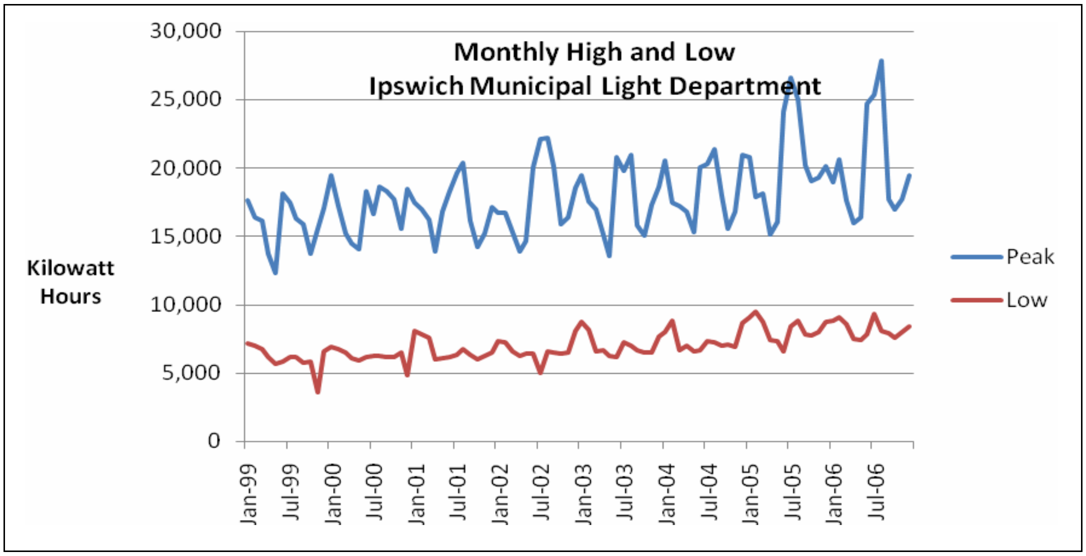
The relatively favorable emissions rate in Ipswich relates to having a higher mix of power produced by nuclear, hydroelectric and gas when compared to the New England and Massachusetts grid average. The portfolio of sources – ranging from fossil fuels to nuclear reactors to renewables – has changed (and will change) over time.

Growth in Electricity Demand vs. Population and Employment Trends



Changes in Peak Period Electricity Use

Growth in electricity consumption in Ipswich during peak periods outpaced the growth in overall electricity consumption between 1999 and 2006.



Electricity Used for Wastewater Treatment and Water Distribution

The town's wastewater collection and treatment facilities include the wastewater treatment plant located on Fowler's Lane, and three pumping stations including Town Wharf, Campbell Ave., and Lappen's. The table below presents electricity consumption at these three facilities:

System Element	Kilowatt Hours	Percent
Wastewater Treatment Plant	812,544	72%
Town Wharf Pump Station	290,494	26%
Other Pump Stations	21,229	2%
Total	**1,124,337**	**100%**

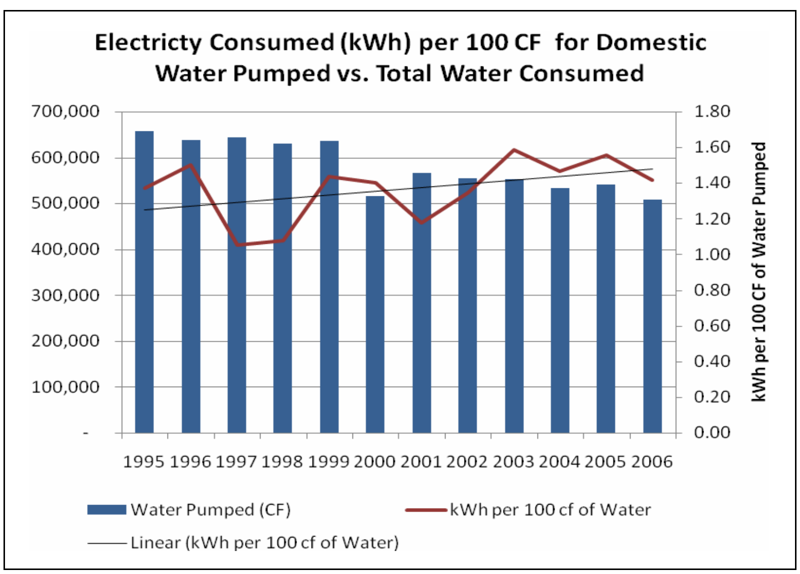
The table below presents electricity consumption per 100 cubic feet of wastewater that is collected and treated for the years 1990, 1995, 2000, and 2006.

Year	Electric Power for Wastewater Collection (kWh)	Electric Power for Wastewater Treatment (kWh)	Wastewater Treated (100 cf water)	Power per 100 CF of Wastewater (kWh/100 cf)
1990*		~827,984		
1995		929,673		
2000		986,362		
2006	812,544	1,124,337		
Average				

*1990 estimated at 6% less than 1995

Energy efficiency upgrades at the treatment plant have included installation of variable speed pumps. Upgrades that increased electricity consumption at the treatment plant included the installation of an ultraviolet treatment process, additional filter presses, and fine bubble diffusers. These additional improvements to the wastewater treatment plant resulted in improved quality of effluent and were completed as part of periodic re-permitting process for the facility.

Year	Electric Power for Water Distribution (kWh)	Electric Power for Water Treatment (kWh)
1990	269,591	450,000
1995	545,970	356,094
2000	419,072	303,168
2006	369,823	347,256



Net Metering in Ipswich

For electric consumers who have their own generating units, net metering allows unused electricity to flow back into the grid. This "surplus" power is essentially sold back to the utility. In 1982, Massachusetts first adopted net metering rules (220 Code of Massachusetts Regulation, Section 8.04(2)(C)). In 1987, the Massachusetts Department of Telecommunications and Energy (DTE) amended the program. The original rules provided that renewable-energy and combined-heat-and-power (CHP) systems with a generating capacity up to 30 kilowatts (kW) were eligible for net metering, and net excess generation (NEG) was purchased at the utility's avoided-cost rate. In 1997 the state increased the maximum system capacity to 60 kW and allowed customer-generators to carry NEG forward -- credited at the average monthly market rate -- to the next month's bill. The state's net metering regulations apply to investor-owned utilities. Municipal utilities are exempt from the rules.

In late 2006, the Ipswich Electric Commissioners voluntarily approved a new policy which allows small generating units (<10 kW) to be developed privately and connected to the grid and credited for any surplus power put into the grid. The net metering policy applies to the following electric generating equipment:

- Photovoltaic solar panels;
- Wind turbines;
- Fuel cells;
- Hydro electric generators; and,
- Combined heat and power.

The benefit to the customer is that surplus electricity generated onsite can be discharged back into the grid causing the meter to run backwards. The details are as follows:

- If during any given billing period, the customer uses more electricity than it feeds back into the utility's system, the customer will be billed based on the rate applicable to the customer's class of service;
- If, during a billing period, the customer feeds back into the grid more electricity than supplied by the utility, the customer is billed the minimum charge applicable to the customer's class of service and is credited for the excess electricity;
- For the billing periods ending March of each year, if any unused credits have accumulated during the previous 12 months, the utility will credit the customer's account an amount equal to the unused credit kilowatt hours times the average of the Purchased Power Fuel adjustment (PPFA) cost plus one cent for the previous 12 month period.

The net metering policy includes the following stipulations:

- The customer must complete a net metering application and sign a net metering and interconnection agreement.
- The customer must provide a safety disconnect device located adjacent to the IMLD's metering equipment;
- IMLD shall have the right to inspect the disconnect equipment;
- IMLD may disconnect the customer generators net metering facility from the power system if it determines that the safety and stability of the utility's system may be compromised;
- IMLD may limit the cumulative generating capacity of all net metering systems to one half of 1% of its historic single hour peak load (as of 2006 this limit is 14 systems).

In the fall 2006, several members of the Commission surveyed municipal electric utilities located in the Boston metropolitan area. In total, 16 municipal electric utilities were surveyed about energy conservation/demand side programs including: net metering policies, rebates for energy efficient appliances, heating and air-conditioning systems, programmable thermostats, compact fluorescent light bulbs, et cetera.

Only 7 of the 15 municipal utilities surveyed had net metering policies in place. Of those utilities with net metering policies, only 11 customers had installed their own generation equipment and were participating in the net metering program.

Because of the surge in demand for small-scale generation equipment, new products are being developed every year. We anticipate that the rate of installation of small generation equipment in Ipswich will increase every year.

Renewable Energy Portfolio Standards

The Massachusetts Renewable Energy Portfolio Standard (RPS) was created in 1997 as part of legislation restructuring the electric utility industry (MGL Chapter 205A section 11F). The RPS pertains to investor owned, retail providers of electricity. Municipal electric companies are not subject to the state's renewable energy legislation.

Target Year	Renewable Energy Portfolio Standard
2008	5% (Montana)
2010	5% (Massachusetts – new renewables) 8.3% (New Jersey) 10% (Montana) 12% (Nevada) 10% (Connecticut) 10% (Hawaii) 20% (California)
2011	10% (New Mexico)
2013	8 % (Illinois) 24% (New York)
2015	7.5% (Florida) 10% (Wisconsin) 10% (Massachusetts) 13% (New Jersey) 15% (Hawaii) 15% (New Mexico) 20% (Nevada)
2017	10% (Maine - new renewables) 10% (Missouri)
2019	10% (Delaware)

Target Year	Renewable Energy Portfolio Standard
2020	10% (Colorado not inc. IOUs) 15% (Washington) 16% (Rhode Island) 18% (Pennsylvania) 20% (Hawaii) 20% (IOUs in Colorado) 30% (California) 30% (Minnesota – Xcel Energy) 30% (Texas)
2021	22.5% (New Jersey)
2022	15% (Missouri)
2025	15% (Arizona) 25% (Minnesota)

Many states have pursued new legislation regarding renewable energy portfolio standards. Legislative activity that was pending in 2007 is summarized below: [96]

State	Renewable Portfolio Standard Legislative Proposals
Colorado	Increase existing RPS to 20% by 2020
Iowa	10% by 2010, 15% by 2015, and 20% by 2020
Illinois	10% by 2015, 75% of renewable energy must be from wind
Illinois	25% by 2025, 75% of renewable energy must be from wind
Indiana	10% by 2017, includes solar energy mandate
Missouri	Goal of 10% by 2020;
Missouri	Requires 10% by 2022
Nebraska	10% by 2019

[96] Select State Actions to Address Climate Change; *Compiled by the National Caucus of Environmental Legislators (NCEL), 3/20/07*

State	Renewable Portfolio Standard Legislative Proposals
New Hampshire	Prescribes the % of power that must come from 4 separate classes of renewable energy sources
North Carolina	20% by 2020
Nevada	Increase existing RPS to 25% for 2019 and beyond
Oregon	25% by 2025
Virginia	20% by 2016

In 2006, 21 states and the District of Columbia had RPSs, yet just over 2% of electricity generated in the United States was from renewable sources. Nevertheless, there has been a flurry of activity as states revisit their RPS requirements with an eye toward increasing the minimums. Since 2003, more than half of the states have increased or accelerated their renewable energy requirements. A study of the Union of Concerned Scientists found that 46,000 MW of renewable energy will be generated as a result of the RPSs by the year 2020. This is enough power to meet the electricity needs of 28 million homes. It also equals about 6% of the United States electricity supply by the year 2020.

In Massachusetts, the RPS specifies that 1% of electricity be generated from renewable sources in 2003 increasing annually at a rate of 0.5% per year through 2009. Thereafter, the minimum increases 1% each year until Massachusetts Division of Energy Resources (DOER) sets a date for freezing the minimum percentage. The table below summarizes the requirement.

Year	Massachusetts % Renewable Generation Requirement
2003	1.0%
2004	1.5%
2005	2.0%
2006	2.5%
2007	3.0%
2008	3.5%
2009	4.0%
2010	5.0%
2015	10.0%
2020	15.0%

The law stipulates that only approved renewable energy generation put in service after December 31, 1997 qualifies under the law. The Massachusetts RPS stipulates no minimum size for a generating unit. Eligible resources include the following:

- Solar photovoltaic or solar thermal electric energy; wind energy;
- Ocean thermal, wave and tidal energy;
- Fuel cells using an eligible new renewable fuel;
- Landfill methane gas and anaerobic digester gas;
- Low emission, advanced biomass power conversion technologies using an eligible biomass fuel (such as brush, stumps, lumber ends and trimmings, wood pallets, bark, woodchips, shavings, agricultural waste, food material and vegetative material, energy crops, biogas, and organic refuse derived fuel).

A regulated utility may choose to discharge some or all of its obligations under the law by making an Alternative Compliance Payment (ACP) to the Massachusetts Technology Park Corporation (i.e. the Mass Technology Collaborative). The ACP rate is adjusted annually. For 2007 the ACP rate is $57.12 per MWh.

Funding Requirements for Renewable Energy and Energy Efficiency

Because of the very low cost of energy efficiency when compared to power generation (as a means of enhancing system capacity to meet customer demands), many states have established legislation that stipulates minimum funding requirements for utilities relating to renewable energy, low income energy, and energy efficiency.

Under the Massachusetts Electric Restructuring Act (signed into law in November 1997), comprehensive legislation was authorized that deregulated the electric utility industry in the state. Included in the legislation were requirements for investor owned utilities to deliver energy efficiency programs to their customers.

Municipal electric utility companies were given considerably more operational latitude than the state's investor-owned utilities. Because of mandated renewable energy and energy efficiency requirements, the state's investor owned utilities are considerably better organized and are substantially more involved in energy efficiency/demand side management programs when compared to the state's municipal electric companies.

In Massachusetts, the investor-owned utilities' minimum requirements exceed the minimum requirements for municipal electric companies by a factor of eight. Specifically, investor-owned utilities are required to have minimum funding requirements in all three categories (Renewable Energy; Low Income Energy Efficiency, and Energy Efficiency). Municipal electric utilities have no renewable energy funding mandate and there is no minimum requirement for renewable energy as a percentage of total energy sales (known commonly as the Renewable Portfolio Standard) and there is no minimum requirement for municipal electric companies for low income energy efficiency expenditures.

The extent of the municipal electric energy efficiency requirements is summed up in the Department of Energy Resources regulation "Residential Conservation Service Program" (225 CMR 4.00). Some of the key provisions of this regulation are quoted below:

- "The Massachusetts RCS Program is designed to encourage residential energy consumers to conserve energy by providing them with:
    - accurate information concerning what they can do to save energy in their own homes;
    - assistance in locating reliable contractors and arrangement for the installation of energy conservation and renewable resource measures;
    - such services and programs as are practicable to facilitate financing the installation of program measures; and,
    - consumer protection through education, inspections, warranties, complaint conciliation procedures, and redress procedures for poor work."

- Residential customers "are eligible to receive RCS program services…if they own or occupy a Residential Building, and receive a bill or bills from a Program Administrator for individually metered energy…"
- "Municipal utilities …may file municipal action plans either solely or in coordination with other municipal utilities. Submission of a municipal action plan commits municipal utilities to achieve program Outcomes."
- "Information requirements for annual municipal action plans will be outlined in the State Plan."
- "Municipal utilities must report annually to DOER their program Outcomes in an electronic format described in the State Plan."
- "The program budget for a municipal utility shall be at an annual level equal to and not less than 1/4 of 1% of its gross annual retail revenues."

Appliance Efficiency Standards

The state and the federal government are involved in setting efficiency standards that have the potential to significantly reduce the amount of electricity required to power appliances – and consequently, the amount of carbon emissions related to appliance usage. The American Council for an Energy Efficient Economy (ACEEE) estimates that existing standards, including new standards enacted as a result of EPAct 2005, will save an amount equal to about 11 percent of the U.S. energy consumption in 2006. In addition, in February 2006, ACEEE estimated that updating all of the standards pending at DOE would save about 5 percent of 2006 electricity use.

At the federal level, minimum appliance standards were established in 1987 and revised in 1992 and 2005. However, many of the additions and revisions proposed in 2005 were not enacted and the related congressional deadlines passed. As a result, 15 states sued the Department of Energy, which in 2006, proposed to complete the rulemakings by 2011. Efficiency standards for two of the most significant items, residential refrigerators and furnace fans, are not expected to be updated until 2012 or later.

Fortunately, the federal law provides a pathway for states to adopt more stringent standards for appliances that are already regulated by the federal government and in 2005, Massachusetts adopted amendments to the State's minimum energy efficiency standards[97]

This appendix lists the appliance efficiency standards put forth by the federal government in 1987, 1992 and 2005. The backlog of rulemakings for the 2005 proposals are also listed, as are the more rigorous standards adopted by Massachusetts in 2005.

The table below lists appliances affected by federal legislation:

[97] The new law, recorded in Chapter 139 of the Acts of 2005, amended Massachusetts General Laws Chapter 25b, Section 2.

Products Included in the National Appliance Energy Conservation Act of 1987	
Refrigerator-freezers	Clothes washers
Freezers	Clothes dryers
Room air conditioners	Dishwashers
Central air conditioners and heat pumps	Ranges and ovens
Furnaces & boilers	Pool heaters
Water heaters	Fluorescent lamp ballasts
Direct-fired space heaters	Televisions
Products Added in the Energy Policy Act of 1992	
Fluorescent lamps	Shower heads
Incandescent reflector lamps	Faucets and aerators
Electric motors (1 – 200 hp)	Toilets
Commercial AC and heat pumps	Distribution transformers
Commercial furnaces and boilers	Small electric motors (<1 hp)
Commercial water heaters	High-intensity discharge lamps
Products Added in the Energy Policy Act of 2005	
Torchiere light fixtures	Refrigerators and freezers
Ceiling fan light fixtures	Mercury vapor lamp ballasts
Dehumidifiers	Traffic signals
Compact fluorescent light bulbs	Clothes washers
Fluorescent lamp ballasts (F34 and F96 ES types)	Dishwasher pre-rinse spray valves
Ice makers (cube type 50 – 2,500 lbs/day)	Electric distribution transformers (low voltage)
Exit signs	Natural gas unit heaters
Large air conditioners and heat pumps (unitary equipment 240 – 760 k Btu/hour)	Pedestrian traffic signals

The American Council for an Energy Efficient Economy (ACEEE) estimates that existing standards, including new standards enacted as a result of EPAct 2005, will save an amount equal to about 11 percent of the U.S. energy consumption in 2006. In addition, in February 2006, ACEEE estimated that updating all of the standards pending at DOE would save about 5 percent of 2006 electricity use.

This chart lists products that are backlogged, as well as the final action dates for efficiency rulings.

Product Category	Rule Type[98]	Product(s)	EPACT 2005, Backlog, Other	Final Action Date
Heating	S	Furnaces and Boilers (Residential) including Mobile Home and Small Furnaces	Backlog	9/2007
		Water Heaters (Residential) Direct Heating Equipment Pool Heaters	Backlog Backlog Backlog	3/2010
Transformers and Motors	DA	Small Electric Motors	Backlog	6/2006
	S	Distribution Transformers, MV Dry-Type and Liquid-Immersed	Backlog	9/2007
		Electric Motors, 1-200 HP	Backlog	6/2011
	TP	Distribution Transformers	Backlog	4/2006
Lighting	DA	High-Intensity Discharge Lamps	Backlog	6/2010
	S	Ceiling Fan Light Kits (other than those with prescribed standards)	EPACT 2005	1/2007
		Incandescent Reflector Lamps Fluorescent Lamps Incandescent General Service Lamps	Backlog Backlog Backlog	6/2009
		Fluorescent Lamp Ballasts	Backlog	6/2011
Home Appliances	S	Dishwashers (Residential) Ranges and Ovens (Electric and Gas) and Microwave Ovens Dehumidifiers (Residential) Clothes Washers (Commercial)	Backlog Backlog EPACT 2005 EPACT 2005	3/2009
		Clothes Dryers (Residential) Room Air Conditioners	Backlog Backlog	6/2011
Space Cooling	S	Packaged Terminal Air Conditioners and Heat Pumps	Backlog	9/2008
		Central Air Conditioners and Heat Pumps (Residential)	Backlog	6/2011
	TP	Central Air Conditioners and Heat Pumps (Residential)	Other	9/2007
Commercial Refrigeration	S	Refrigerated Bottle or Canned Beverage Vending Machines	EPACT 2005	8/2009

[98] Rule Type: Test Procedure (TP); Determination Analysis (DA); Standards (S)

Product Category	Rule Type[98]	Product(s)	EPACT 2005, Backlog, Other	Final Action Date
		Ice-Cream Freezers, Self-Contained Commercial Refrigerators, Freezers, and Refrigerator-Freezers without Doors, and Remote-Condensing Commercial Refrigerators, Freezers and Refrigerator-Freezers (initial)	EPACT 2005	1/2009
	TP	Ice-Cream Freezers, Self-Contained Commercial Refrigerators, Freezers, and Refrigerator-Freezers without Doors, and Remote-Condensing Commercial Refrigerators, Freezers and Refrigerator-Freezers	EPACT 2005	1/2008
Battery Chargers and External Power Supplies	DA	Battery Chargers and External Power Supplies	EPACT 2005	8/2008
	S	Battery Chargers and External Power Supplies (Contingent on Determination)	EPACT 2005	8/2011
	TP	Battery Chargers and External Power Supplies	EPACT 2005	2/2007
Other EPACT 2005	TP	11 Test Procedures Prescribed by EPACT 2005	EPACT 2005	11/2006

In 2005, Massachusetts adopted amendments to the State's minimum energy efficiency standards.[99] (The federal law provides a pathway for states to adopt more stringent standards for appliances that are already regulated by the federal government.) The revised Massachusetts standards are summarized below:

Massachusetts Amendments to the Minimum Energy Efficiency Standards, 2005
Residential Furnace and Boilers (effective date TBD[100]) Minimum energy efficiency standards were set as follows: o Gas and propane furnaces 90% AFUE; o Oil furnaces 83% AFUE; o Gas and propane hot water boilers 84% AFUE; o Oil fired hot water boilers 84% AFUE; o Gas and propane steam boilers 82% AFUE; and o Oil fired steam boilers 82% AFUE.
Residential Furnace Air Handlers (effective date TBD) Shall have an ER of 2% or less (except residential oil furnaces with a capacity of less than 94,000 BTU per hour shall have an ER of 2.3% or less.
Single Voltage AC to DC Power Supplies (effective date 2008) Shall meet the Tier 1 energy efficiency requirements of the California Code of Regulations. These common small black boxes that come standard with many electronic devices are typically on 25 – 60% efficient. In other words, 40 - 75% of the energy is dissipated as heat. These power supplies typically use several watts of power

99 Chapter 139 of the Acts of 2005 amended Massachusetts General Laws Chapter 25b, Section 2.
100 Massachusetts is seeking a waiver of federal preemption. The effective date is yet to be determined.

even when the device is powered off. The Tier 1 California standard took effect January 1, 2007 and requires power supplies with a nameplate output of < 49 watts be 50% efficient. All others must be 84% efficient. The maximum no-load energy consumption is 0.5 watts for power supplies with a nameplate output of 10 watts and 0.75 for larger units.
Incandescent Reflector Lamps (effective date 2008) State-regulated incandescent reflector lamps shall meet the minimum average efficiency requirements of federally-regulated incandescent reflector lamps.
Metal Halide Lamp Fixtures (effective date 2009) On or after January 1, 2009, no new metal halide lamp fixture may be sold or offered for sale in the state unless it meets the energy efficiency standards. Metal halide lamp fixtures operating at a rating of 150 -- 500 W shall not contain a probe start metal halide ballast.
Medium Voltage Dry Type Distribution Transformers[101] (effective date 2008) Shall meet minimum efficiency levels 3/10 of a percentage point higher than the class one efficiency levels for medium voltage distribution transformers as established by the National Electrical Manufacturers Association.

The amendment also set forth a requirement that the Commissioner of the Department of Energy Resources conduct an annual study of the effectiveness of energy efficiency and recommend new or increased efficiency standards on or before September 1 of the year before each new legislative session. The reports are forwarded to the Joint Committee on Telecommunications, Utilities and Energy.

Additionally, the Commissioner of the Division of Energy Resources, in consultation with the heads of other appropriate agencies, shall no later than June 1, 2006 adopt regulations to establish minimum energy efficiency standards in accordance with MGL Chapter 25b, for the types of new products set forth in the amendment. The law was approved November 22, 2005.

Municipal Appliance Rebate Program

To encourage efficient energy use, IMLD offers rebates on many Energy Star-qualified appliances. The table below lists the rebates schedule for 2006 and the enhanced rebate program for 2007 and 2008.

	2006 Rebates[102]	2007-08 Rebates
Clothes washer	$50	$50 $100
Refrigerator	$50	$100
Dishwasher	$50	$25 (energy factor < .67) $50 (energy factor of .98 or higher)
Room air conditioner	$25	$25 (EER rating of > 10)
Programmable thermostat	$25	50% of cost

[101] With an input voltage of more than 600 V but less than or equal to 34,500 V, is air-cooled, and does not use oil as a coolant, and is rated for operation at a frequency of 60 Hz.

[102] One rebate per each of the items listed below, except room air conditioners up to four.

Dehumidifier	None	$20
Central air conditioner	$100	$325 (SEER rating of 14) $475 (SEER rating of 15+)

Since 1992, IMLD has funded no-cost home energy audits for its residential customers. Presently, Massachusetts Municipal Wholesale Electric Company (MMWEC) administers this program on behalf of IMLD through its Home Energy Loss Prevention Service (HELPS). Ipswich customers can avail themselves of the home energy audit by calling a toll-free telephone number. Ipswich customers can also use the toll-free number simply to get advice about home energy conservation. In 2007, IMLD added new website links about energy efficiency on the home page of the Town website. These links provide useful information and are described below:

- **Home Energy Saver** – a website that helps consumers identify the best ways to save energy in their homes. The site was authored by the Lawrence Berkeley National Laboratory and funded by the U.S. Department of Energy (DOE), as part of the national ENERGY STAR Program. The site includes energy calculators, energy efficiency tips, case studies and links to a variety of databases.

- **Energy Efficiency World –** Energy efficiency website geared to children ages 8 through 12. Includes a teacher's guide and the game "Stop the Guzzler."

Appendix 6: Heating Oil

- Residential Heating Oil Emissions: Trends, Methodology and Calculations
- Commercial and Industrial Heating Oil Emissions: Trends, Methodology and Calculations

Residential Heating Oil Emissions: Trends, Methodology and Calculations

6.1.1 Introduction

This section assesses the residential consumption of fuel oil and corresponding greenhouse gas emissions in Ipswich. Estimates for fuel oil consumption were difficult to obtain because, unlike electricity and natural gas distribution systems, residential fuel oil is purchased from multiple, private oil delivery services throughout the area. For example, there are approximately 75 different fuel oil distributors in Essex County alone. Fuel oil consumption for the residential sector was estimated using data from the U.S. Census Bureau, the Department of Energy's Energy Information Administration, and the Town of Ipswich Assessor's Office.

It should be noted that fuel consumption for space heating, and to a lesser degree domestic hot water, is dependent on the weather during the heating season for a given year. This is usually expressed in heating-degree-days (HDD) and is a measure of how cold it is compared to a base temperature of 65º F. For example, if the average temperature of a given day is 40º F, there would be 25 HDD for that day (i.e. 65 - 40 = 25). The sum of the daily HDD in a calendar year would represent the annual HDD for a specific area. The influence of weather should be factored into comparisons of fuel oil consumption between years (DOE/EIA 1993).

6.1.2 National and Regional Trends

Fuel oil, primarily no. 2 fuel oil, is an important heating fuel type in the northeastern U.S. Fuel oil is used for space heating and, to a lesser degree, domestic hot water. Nationally, natural gas is a more important fuel for residential heating and domestic hot water compared to fuel oil. In 2001, natural gas comprised approximately 71% of the energy used for space heating and hot water in the U.S., while fuel oil was only 11.3% of the national total (Fig. 6.1).

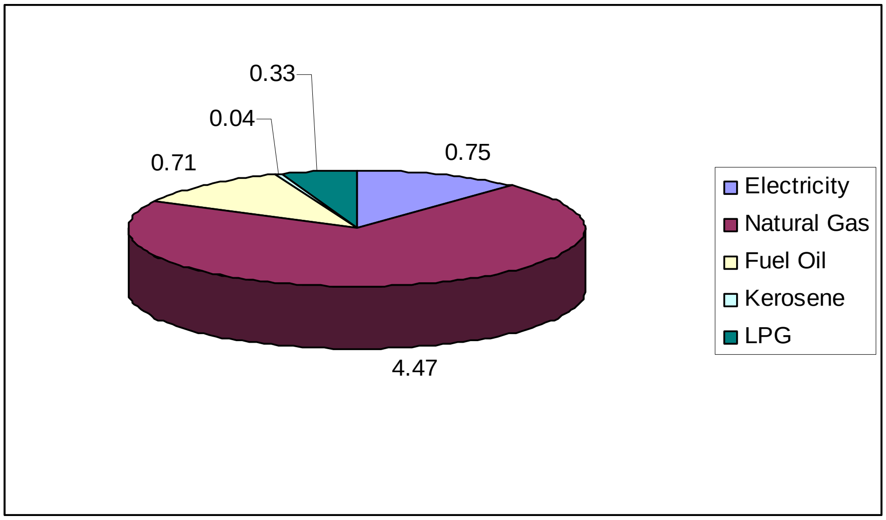


Figure 6.1. Major sources of fuel for space heating and domestic hot water in the U.S. for 2001 (in quadrillion Btu) (DOE/EIA).

The northeastern U.S. consumes the majority of fuel oil in the U.S. In 2001, homes in the Northeast census region consumed approximately 80% of the fuel oil in the U.S. (DOE/EIA) (Table 6.1). In that same year, the New England census division represented approximately 40% of the entire U.S. fuel oil consumption (DOE/EIA) For most homes in the Northeast region, including New England, space heating represents between 70 and 80% of all residential fuel oil consumption (DOE/EIA).

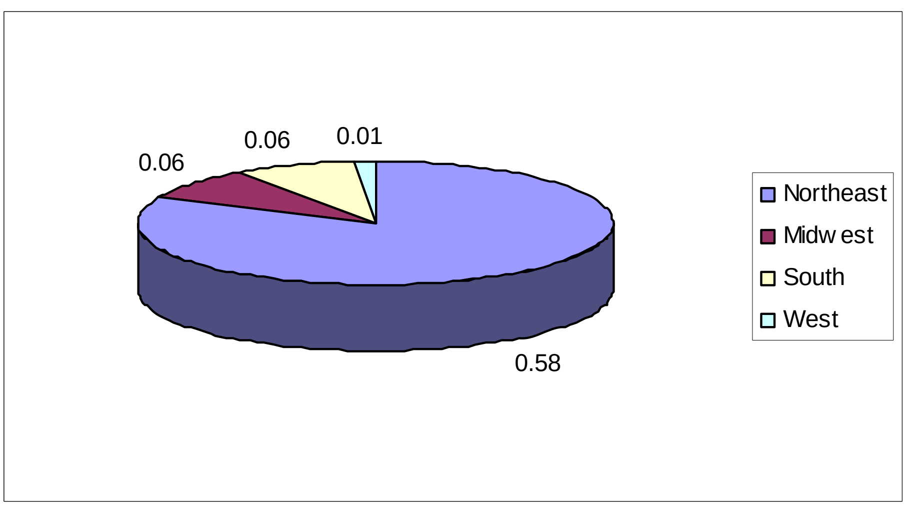


Fig. 6.2. Fuel oil consumption (quadrillion Btu) for all census regions of the U.S. in 2001 (DOE/EIA).

Prior to the 1980s fuel oil was a much more prevalent heat source in U.S. than it is today. For example, in 1960 fuel oil was used in approximately 32% of all U.S. homes and natural gas comprised about 43% of all homes. By 1997, fuel oil made up only 10% of the total while natural gas was used in over 51% of all homes (DOE/EIA 2006). Fuel oil consumption has continued to decline in the U.S. by about 30%. Fuel oil in 2005 was used in only 8% of homes in the U.S. (DOE/EIA 2006).

Total Annual Residential Fuel Oil Consumption									
	Entire U.S.			Northeast			New England		
Year	Billion Gals.	Quad-rillion Btu	Million House - holds	Billion Gals.	Quad-rillion Btu	Million House -holds	Billion Gals.	Quad-rillion Btu	Million House -holds
1993	7.38	1.02	10.8	5.46	0.76	7.4	2.10	0.29	2.6
1997	7.27	1.01	10.0	5.82	0.81	7.5	2.38	0.33	2.9
2001	5.11	0.71	8.7	4.17	0.58	6.6	1.97	0.28	2.7
2005	6.24	0.86	8.4	5.19	0.72	6.5	2.16	0.30	2.5

Table 6.1. Annual residential fuel oil consumption in the U.S., Northeast, and New England (DOE/EIA).

There has been an approximate 50% reduction in the amount of fuel oil consumed in the Northeast Census region from 1978-2001 (Figure 6.3).

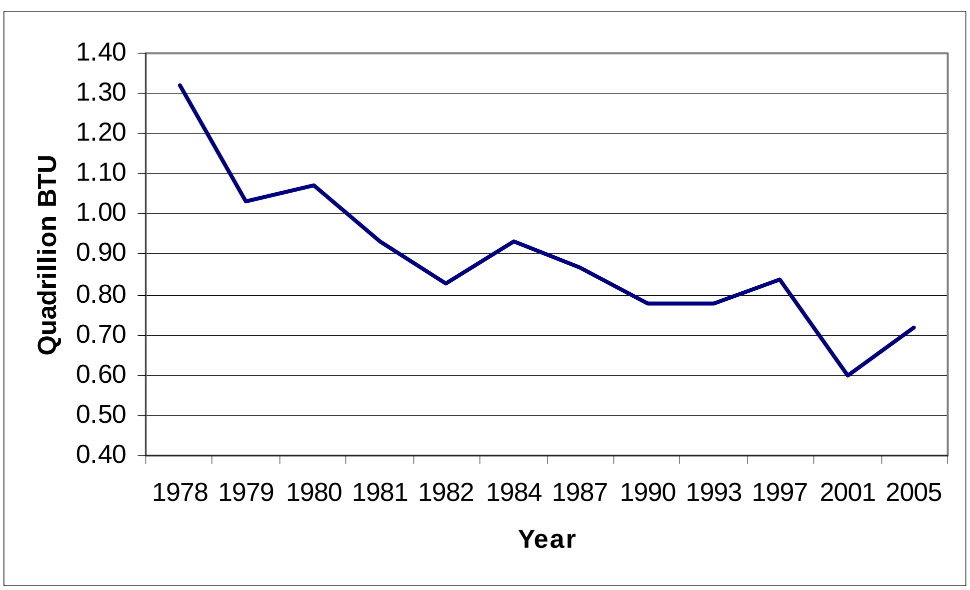


Fig. 6.3. Fuel oil consumption (in quadrillion Btu) in the Northeast Region, 1978-2005 (DOE/EIA 2006)

Like the U.S. as a whole, annual residential fuel oil consumption in Massachusetts dropped sharply in the late 1970s (Fig. 6.4). Fuel oil consumption in Massachusetts between 1981 and 2004 has varied between about 99 and 133 trillion Btu per year (DOE/EIA).

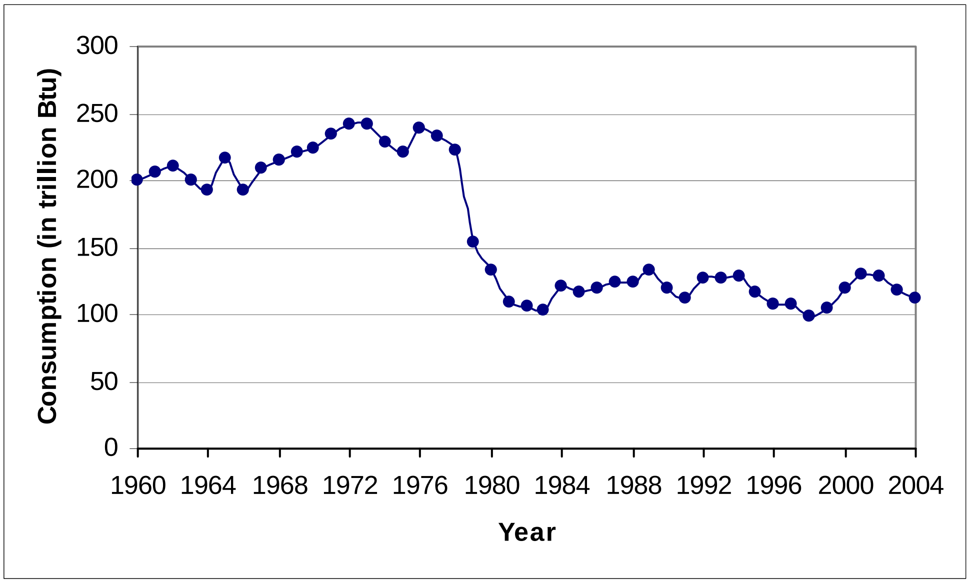


Fig. 6.4. Annual residential fuel oil consumption in Massachusetts (in trillion Btu), 1960-2004 (DOE/EIA)

Despite reduced usage across the U.S. and the Northeast Region and New England, fuel oil continues to be important space heating fuel in the region. While only about 8% of all U.S. homes used fuel oil as the primary space heating fuel in 2005, nearly 32% of Northeast households and almost 45% of all New England households used fuel oil (DOE/EIA). In 1990 and 2000, approximately 44 and 40%, respectively, of households in Massachusetts used fuel oil for space heating (U.S. Census Bureau). Data gathered from the Town of Ipswich Assessor's Office indicates that in 2001, approximately 69% of all residential building units reported using fuel oil as the primary fuel source (Town of Ipswich Assessor).

The fuel oil consumption per household between 1990 and 2005 has risen somewhat across the U.S., the Northeast region, and in the New England region (Table 6.2). The EIA's Residential Energy Consumption Survey (RECS) data indicated a reduction in consumption per household in 2001, but an overall trend of increasing consumption.

Annual Fuel Oil Consumption Per Household						
	Entire U.S.		Northeast		New England	
Year	Gals.	Million Btu	Gals.	Million Btu	Gals.	Million Btu
1990	606	83.4	631[1]	86.9[1]	709[2]	97.9[2]
1993	684	94.7	740	102.6	794	110.1
1997	730	101.2	779	108.0	836	115.9
2001	589	81.7	630	87.3	716	99.3
2005	742	102.9	798	110.7	855	118.6

Table 6.2. Annual fuel oil consumption per household for the U.S., Northeast Region, and New England, 1990-2005 (DOE/EIA).

[1] Estimate was based upon the RECS data average for homes in Climate Zones 1-4

[2] Estimate was based upon RECS data for homes in Climate Zone 2

Compared to historic usage, the overall consumption of space heating fuels per household has dropped in the U.S. In 1978, an average of 91 million Btu per household (all fuels) was consumed for space heating in the U.S. (DOE/EIA 1999), while in 2005 the average consumption dropped to about 40 million Btu per household (DOE/EIA 2009). This represents a 56% decrease in space heating energy usage per household. The reduced fuel consumption for space heating is likely to have been influenced, at least partially, on improved energy efficiency of heating systems and insulation of homes.

Fuel oil consumption for homes in Massachusetts may be higher per household than for the New England region as a whole. According to the DOE/EIA, 20.5 million barrels of residential fuel oil was consumed in Massachusetts for 1990. A review of the U.S. Census Bureau data indicates that 989,299 households in Massachusetts used oil for heating in 1990, which equates to approximately 872 gallons per household (U.S. Census Bureau 1990). In 2000, residential fuel oil in Massachusetts decreased slightly to 20.4 million barrels. However, only 963,353 households used oil for heating that year (U.S. Census Bureau), indicating that per household fuel oil consumption increased slightly to 891 gallons (DOE/EIA

6.1.3 Residential Fuel Oil Consumption for Ipswich

Data on the consumption of fuel oil for residential buildings in Ipswich were not available. For these consumption estimates we used calculations based on space heating intensity (SHI) modified from methodologies used by the DOE/EIA RECS program. This method uses the formula:

GPH = SHI x [HDD x (HSF/1000)], where

GPH = gallons of fuel oil used for space heating per household

SHI = space heating intensity;

HDD = heating-degree-days; and

HSF = heated square footage

Because 2001 RECS data on estimated fuel oil consumption were available for New England households, we were able to compare those data with estimates for Ipswich homes using the SHI formula above. The SHI value for Ipswich homes was estimated using DOE/EIA 2001 RECS data, which for Climate Zone 2 was 0.044 (Massachusetts and most of New England is in Zone 2-between 5,500 and 7,000 HDD). The cumulative heating-degree-days from July 2000 through June 2001 for Massachusetts were reported to be 6,359 (National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service). The HSF was estimated using the Town of Ipswich Assessor's data. The average square footage for one-family homes built in 2001 or earlier and using fuel oil as the primary source of heat was 2,024 square feet. Below is the calculation for estimated gallons per household of fuel oil consumed in 2001 for space heating by one-family homes in Ipswich:

Gallons of fuel oil used per year for space heating per household = 0.044 x [6,359 x (2,024/1000)] = 566 gal.

Next, the consumption of residential fuel oil used for domestic hot water was estimated for 2001. Because the Town of Ipswich Assessor's data did not include fuel sources for domestic hot water, it was assumed that most homes in Ipswich that heated their homes with oil also heated hot water with oil (need to check this with the Ipswich Building Department). The per household consumption of fuel oil for water heating was estimated using the DOE/EIA 2001 RECS data for New England households. Those data indicated 220 gallons were consumed per household for an average 2.4 person household, which is consistent with the average household size for Ipswich in 2000 (U.S. Census Bureau 2000). Therefore, our estimated fuel oil consumption for combined space heating and hot water for an average one-family household in Ipswich was 786 gallons. This estimate for fuel oil consumption per household in Ipswich was compared to the estimates for New England using the 2001 DOE/EIA RECS data, which was 716 gallons. Although our per household estimated fuel oil consumption was slightly higher than the DOE/EIA estimate, it appears to be an acceptable estimate given that it is approximately mid-point between the DOE/EIA 2001 New England estimate and the 2000 per household estimate for the State of Massachusetts using the U.S. Census Bureau data.

The SHI value was then used to estimate the consumption of fuel oil for all residential dwellings in Ipswich in 2001 using the Town of Ipswich Assessor's Office data for dwellings that reported using fuel oil as the primary source (Table 6.3).

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	2,454	4,967,392
Condo	83	102,222
Mobile Home	2	2,188
Two-Family	142	375,357
Three-Family	28	100,395
Multi-Family	40	194,751
Apt. Unit (4-8)	18	86,450
Apt. Unit (+8)	3	51,766
Total	2,770	5,880,521

Table 6.3. Residential units using fuel oil in Ipswich for 2001 (Town of Ipswich Assessor).

Using the SHI formula, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich for 2001:

= 0.044 x [6,359 x (5,880,521/1000)]

= 1,645,346 gallons

To calculate the total fuel oil consumed for domestic hot water in Ipswich for 2001, the estimated consumption of fuel oil for water heating per households in New England (DOE/EIA 2001), 220 gallons, was multiplied by the total number of households in Ipswich using fuel oil as the primary heating source. Table 6.3 above lists the number of buildings for each dwelling type. For one-family homes, condos, and mobile homes, the number of buildings represents the number of households. For two-family and three-family dwellings, the number of buildings was multiplied by 2 and 3, respectively, to determine the number of households. Because the number of households for the multi-home and apartment unit dwelling types were not provided in the Town of Ipswich Assessor's data, we divided the total square footage for each of these dwelling types by 1,373 (the mean square footage per household in 1-, 2- and 3-family homes, condos, and mobile homes) to estimate the number of households for these two dwelling types. For example, dividing the total square footage for multi-family homes (194,751) by 1,373 results in an estimated 142 households living in multi-family homes for 2001. The results of these calculations are listed in Table 6.4.

Dwelling Type	Number of Buildings	Number of Households	Estimated Gallons of Fuel Oil Used for Hot Water
One-Family	2,454	2,454	539,880
Condo	83	83	18,260
Mobile Home	2	2	440
Two-Family	142	284	62,480
Three-Family	28	84	18,480
Multi-Family	40	142[1]	31,240
Apt. Unit (4-8)	18	63[1]	13,860
Apt. Unit (+8)	3	38[1]	8,360
Total	2,770	3,150	693,000

Table 6.4. Fuel oil consumed for hot water in all residential units in Ipswich for 2001 (Town of Ipswich Assessor).

[1]Number of households for multi-family and apartment units was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,373).

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 2001 was estimated to be: 1,645,346 gallons + 693,000 gallons = 2,338,346 gallons.

These calculations were repeated using the Town of Ipswich Assessor's data for residential buildings in 2000. Below are the results of those calculations:

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	2,437	4,911,731
Condo	83	102,222
Mobile Home	2	2,188
Two-Family	142	375,357
Three-Family	28	100,395
Multi-Family	40	194,751
Apt. Unit (4-8)	18	86,450
Apt. Unit (+8)	3	32,700
Total	2,753	5,805,794

Table 6.5. Residential units using fuel oil in Ipswich for 2000 (Town of Ipswich Assessor).

Applying the SHI value for 2001 (0.044) and the HDD for 2000, the estimated consumption of fuel oil for all residential dwellings in Ipswich for 2000 was:

= 0.044 x [5,754 x (5,805,794/1000)]

= 1,469,888 gallons

Dwelling Type	Number of Buildings	Number of Households	Estimated Gallons of Fuel Oil Used for Hot Water[2]
One-Family	2,437	2,437	536,140
Condo	83	83	18,260
Mobile Home	2	2	440
Two-Family	142	284	62,480
Three-Family	28	84	18,480
Multi-Family	40	142[1]	31,240
Apt. Unit (4-8)	18	63[1]	13,860
Apt. Unit (+8)	3	24[1]	5,280
Total	2,753	3,119	686,180

Table 6.6. Fuel oil consumed for hot water in all residential units in Ipswich for 2000 (Town of Ipswich Assessor)

[1]Number of households for multi-family and apartment units was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,372).

[2]Gallons of fuel oil used was estimated by using 2001 DOE/EIA estimate of 220 gallons per household for New England multiplied by the number of households.

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 2000 was estimated to be: 1,469,888 gallons + 686,180 gallons = 2,156,068 gallons.

These calculations were repeated using the Town of Ipswich Assessor's data for residential buildings in 2005. Below are the results of those calculations.

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	2,499	5,096,510
Condo	87	108,309
Mobile Home	2	2,188
Two-Family	143	377,601
Three-Family	28	100,395
Multi-Family	40	194,751
Apt. Unit (4-8)	18	86,450
Apt. Unit (+8)	4	131,098
Total	2,821	6,097,302

Table 6.5. Residential units using fuel oil in Ipswich for 2005 (Town of Ipswich Assessor)

Using the SHI formula, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich for 2005:

= 0.055 x [6,522 x (6,097,302/1000)]

= 2,187,163 gallons

Dwelling Type	Number of Buildings	Number of Households	Estimated Gallons of Fuel Oil Used for Hot Water[2]
One-Family	2,499	2,499	574,770
Condo	87	87	20,010
Mobile Home	2	2	460
Two-Family	143	286	65,780
Three-Family	28	84	19,320
Multi-Family	40	141[1]	32,430
Apt. Unit (4-8)	18	63[1]	14,490
Apt. Unit (+8)	4	95[1]	21,850
Total	2,821	3,257	749,110

Table 6.6. Fuel oil consumed for hot water in all residential units in Ipswich for 2005 (Town of Ipswich Assessor).

[1]Number of households for multi-family and apartment units was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,379).

[2]Gallons of fuel oil used was estimated by using the 2005 DOE/EIA estimate of 230 gallons per household for New England multiplied by the number of households.

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 2005 was estimated to be: 2,187,163 gallons + 749,110 gallons = 2,936,273 gallons.

In order to compare the long term trend estimates of residential fuel oil consumption in Ipswich with the DOE/EIA RECS data, we repeating these calculations for 1990, 1993, 1995, and 1997.

Dwelling Type	Number of Buildings				Total Square Feet			
	1990	1993	1995	1997	1990	1993	1995	1997
One-Family	2,230	2,285	2,331	2,365	4,345,437	4,494,657	4,612,938	4,712,506
Condo	48	60	66	66	56,560	70,966	79,553	79,553
Mobile Home	2	2	2	2	2,188	2,188	2,188	2,188
Two-Family	142	142	142	142	375,357	375,357	375,357	375,357
Three-Family	28	28	28	28	100,395	100,395	100,395	100,395
Multi-Family	40	40	40	40	194,751	194,751	194,751	194,751
Apt. Unit (4-8)	18	18	18	18	86,450	86,450	86,450	86,450
Apt. Unit (+8)	2	2	2	3	19,066	19,066	19,066	32,700
Total	2,510	2,577	2,629	2,664	5,180,204	5,343,830	5,470,698	5,583,900

Table 6.7. Residential units using fuel oil in Ipswich for 1990, 1993, 1995, and 1997 (Town of Ipswich Assessor).

Using the SHI formula, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich for 1990 is provided below. The SHI value for 1990 was 0.064 (DOE/EIA 1993).

= 0.064 x [6,317 x (5,180,204/1000)]

= 2,094,294 gallons

Using the SHI formula for 1993, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich is provided below. The SHI value for 1993 was 0.054 (DOE/EIA 1995).

= 0.054 x [6,643 x (5,343,830/1000)]

= 1,916,649 gallons

Using the SHI formula for 1995, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich is provided below (an average of 1993 and 1997 SHI values was used for 1995 = 0.055).

= 0.055 x [5,959 x (5,470,698/1000)]

= 1,792,994 gallons

Using the SHI formula for 1997, gallons of fuel oil used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of fuel oil for all residential dwellings in Ipswich is provided below (SHI value for 1997 = 0.056).

= 0.056 x [6,237 x (5,583,900/1000)]

= 1,950,300 gallons

To calculate the total fuel oil consumed for domestic hot water in Ipswich for 1990, the estimate of 166 gallons per household was used based upon DOE/EIA data (i.e., climate zone with between 5,500 and 7,000 heating degree days). Fuel oil consumption for water heating in 1993 and 1997 was estimated using DOE/EIA data for fuel oil consumption for water heating per households in New England, 189 gallons and 219 gallons, respectively (DOE/EIA). Fuel oil consumption for water heating in 1995 was estimated using the average of the 1993 and 1997 DOE/EIA data for fuel oil consumption for water heating per households in New England (204 gallons). The total fuel oil consumption for hot water for these years was multiplied by the total number of households in Ipswich using fuel oil as the primary heating source.

Dwelling Type	Number of Buildings				Number of Households				Estimated Gallons of Fuel Oil Used for Hot Water[2]			
	1990	1993	1995	1997	1990	1993	1995	1997	1990	1993	1995	1997
One-Family	2,230	2,285	2,331	2,365	2,230	2,285	2,331	2,365	370,180	431,865	475,524	517,935
Condo	48	60	66	66	48	60	66	66	7,968	11,340	13,464	14,454
Mobile Home	2	2	2	2	2	2	2	2	332	378	408	438
Two-Family	142	142	142	142	284	284	284	284	47,144	53,676	57,936	62,196
Three-Family	28	28	28	28	84	84	84	84	13,944	15,876	17,136	18,396
Multi-Family	40	40	40	40	144[1]	144[1]	143[1]	143[1]	23,904	27,216	29,172	31,317
Apt. Unit (4-8)	18	18	18	18	64[1]	64[1]	64[1]	63[1]	10,624	12,096	13,056	13,797
Apt. Unit (+8)	2	2	2	3	14[1]	14[1]	14[1]	24[1]	2,324	2,646	2,856	5,256
Total	2,510	2,577	2,629	2,664	2,870	2,937	2,988	3,031	476,420	555,093	609,552	663,789

Table 6.8. Fuel oil consumed for hot water in all residential units in Ipswich for 1990, 1993, 1995, and 1997 (Town of Ipswich Assessor).

[1]Number of households for multi-family and apartment units in 1990, 1993, 1995, and 1997 was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,348, 1,352, 1359, and 1,362, respectively).

[2]Gallons of fuel oil used in 1990, 1993, and 1997 was estimated by multiplying the number of households by the DOE/EIA estimates of per household fuel oil consumption for water heating in New England (166 gallons, 189 gallons, and 219 gallons, respectively). 1995 estimate was calculated by multiplying the number of households by averaging the 1993 and 1997 DOE/EIA estimates of per household fuel oil consumption for water heating in New England (204 gallons).

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 1990 was estimated to be: 2,094,294 gallons + 476,420 gallons = 2,570,714 gallons.

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 1993 was estimated to be: 1,916,649 gallons + 555,093 gallons = 2,471,742 gallons.

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 1995 was estimated to be: 1,792,994 gallons + 609,552 gallons = 2,402,546 gallons.

The total fuel oil consumed for residential space heating and domestic hot water in Ipswich for 1997 was estimated to be: 1,950,300 gallons + 663,789 gallons = 2,614,089 gallons.

The estimated total gallons of fuel oil consumed and resultant greenhouse gas emission in Ipswich for residential buildings in 1990, 1993, 1995, 1997, 2000, 2001, and 2005 are listed in Table 6.9. According to these estimates, the consumption of fuel oil has been relatively consistent during this 15-year period despite a steady increase in the total square footage of residential buildings using fuel oil for space heat. The total area of residential buildings heated with fuel oil increased by approximately 18% from 5.2 million square feet in 1990 to 6.1 million square feet in 2005, while the consumption of fuel oil has been variable throughout this period. Although the consumption of fuel oil has increased by about 14% in 2005 compared to 1990, there have been some years (i.e., 2000 and 2001) that have seen decreased fuel oil consumption (Table 6.9 and Fig. 6.7).

Year	Number of Residential Households	Total Space Heated (square feet)	Annual Fuel Oil Consumed (gallons)	Annual Greenhouse Gas Emissions (metric tons)
1990	2,799	5,180,204	2,570,714	25,824
1993	2,865	5,343,830	2,471,742	24,830
1995	2,988	5,470,698	2,402,546	24,134
1997	2,956	5,583,900	2,614,089	26,259
2000	3,119	5,805,794	2,156,068	21,658
2001	3,150	5,880,521	2,338,346	23,490
2005	3,257	6,097,302	2,936,273	29,496

Table 6.9. Estimated residential fuel oil consumption and greenhouse gas emissions for Ipswich, 1990, 1993, 1995, 1997, 2000, 2001, and 2005.

These estimates suggest that residential fuel oil consumption in Ipswich has remained relatively consistent between 1990 and 2005. The lowest estimated consumption was in 2000, when 2.156 million gallons were used. Residential fuel oil consumption has increased steadily since 2000 (Fig. 6.7). The historic trend of fuel oil consumption for Ipswich matches closely with that of both New England and the Northeast region (Table 6.1).

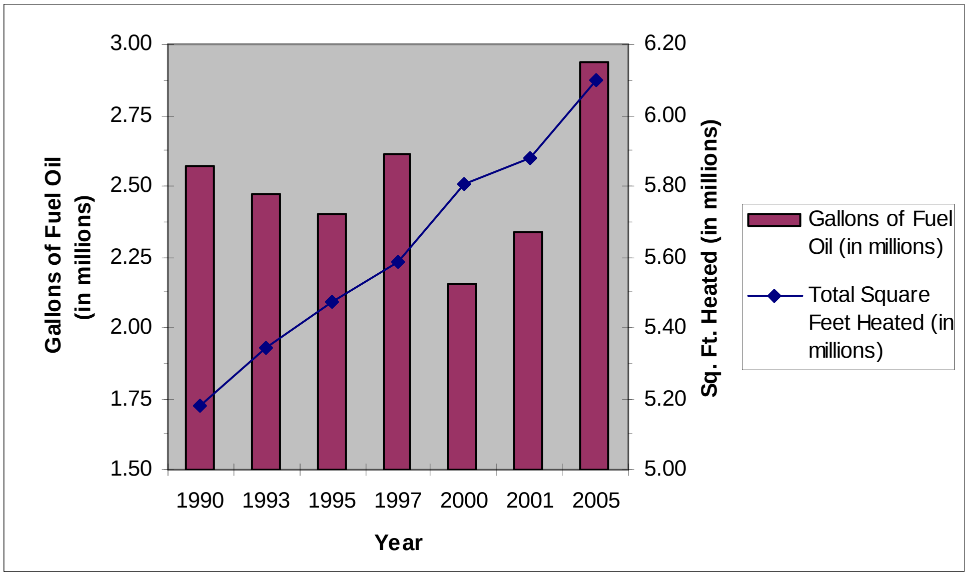


Fig. 6.7. Estimated residential fuel oil consumption for Ipswich, 1990-2005, with total square footage of heated space.

As discussed previously, consumption of fuels for space heating is highly dependent upon the weather. Colder winters result in greater space heating demands (i.e., increased HDD) and, hence, higher consumption of space-heating fuels. A rule-of-thumb is that a 10% increase in heating-degree-days increases fuel required for space heating by 10% (DOE/EIA). Figure 6.8 below depicts the relationship between estimated fuel oil consumption in Ipswich and heating-degree-days for Massachusetts.

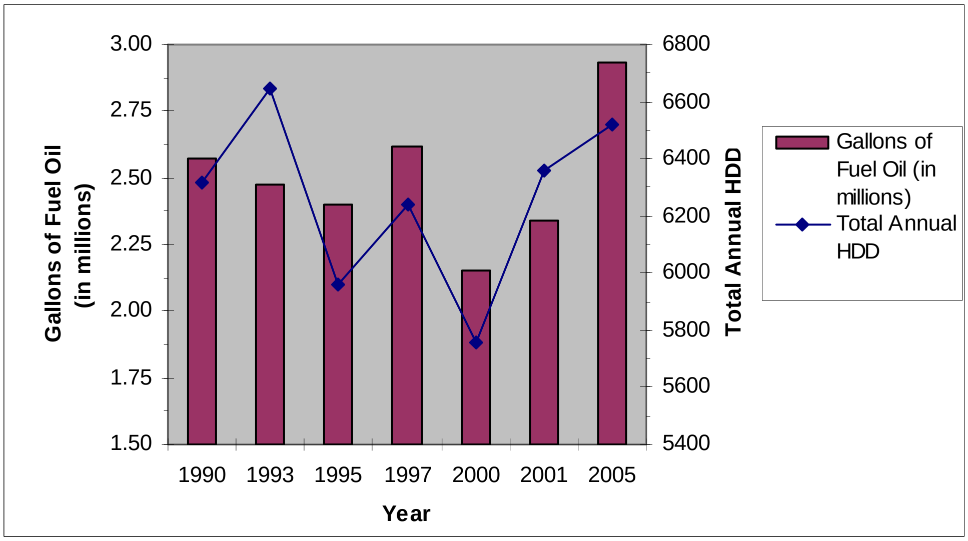


Fig. 6.8. Estimated residential fuel oil consumption for Ipswich, 1990-2005, with the annual HDD for Massachusetts.

Another factor that may have influenced the amount of fuel oil consumed in Ipswich is price. Average retail prices (excluding taxes) of fuel oil in Massachusetts remained at or below $1 per gallon between 1992 and 1999 (DOE/EIA 2008). Average price for fuel oil jumped from $0.84 per gallon in 1999 to $1.27 per gallon in 2000, and has climbed steadily since then (DOE/EIA 2008). The sudden spike above historic fuel oil price at the beginning of the 2000/2001 winter, combined with relatively mild temperatures during most of the heating season may have contributed to the decline in consumption in 2000. Another factor that may have influenced fuel oil consumption in Ipswich is an increased number of homes that have been converted to natural gas heating. Increased growth in new residential construction and more typical winter temperatures in 2001 and 2005 may be responsible for the increased consumption of fuel oil in these two years.

6.1.4 Projections for Residential Fuel Oil Consumption in Ipswich

Projections for future consumption of residential fuel oil in Ipswich will be partially dependent upon future weather patterns in New England. Between 1970 and 2000, the average winter temperature in the Northeast Region of the U.S. has increased by more than 4º F above historical average; winter temperatures are projected to increase by another 2.5º F to 4º F over the next few decades (Frumhoff et al. 2007). Increased winter temperatures will result in reduced demand for and consumption of fuel oil in Ipswich.

Other factors that may influence future residential fuel oil consumption in Ipswich are 1) energy efficiency improvements of new and existing homes; 2) fuel oil prices; 3) the average size of new homes; 4) the rate of new home construction; and 5) the proportion of homes heated with oil. Although the energy use for space heating in the U.S. grew by 0.8% per year from 1990 to 2003, future growth is expected to be slowed by improved heating equipment efficiency and more stringent building codes that require more insulation, better windows, and more efficient building design (EIA Annual Energy Outlook 2005). Higher fuel oil prices are expected to induce energy conservation behaviors and measures by homeowners. In addition, trends towards the shifting of space heating and water heating from fuel oil to natural gas and electricity are expected to continue in New England.

According to the EIA's Annual Energy Outlook (AEO) report, the total residential fuel oil consumption in New England for the years 2010, 2015, 2020, and 2030 is projected to be 0.276, 0.277, 0.270, and 0.244 quadrillion Btu, respectively (AEO 2008). For the reasons listed above, the AEO projects decreased residential fuel oil in its reference case. Relative to the New England 2005 consumption of 0.316 quadrillion Btu, those projections reflect a decreased residential fuel oil consumption of 12.7%, 12.3%, 14.6%, and 22.8%, for the years 2010, 2015, 2020, and 2030, respectively. Using these projections for future New England consumption, we estimated future residential fuel oil consumption in Ipswich from our 2005 Ipswich consumption estimate as the baseline. Table 6.10 contains the projected consumption of residential fuel oil and greenhouse gas emissions for Ipswich for 2010, 2015, 2020, and 2030, and Figure 6.9 depicts the historic and project consumption of fuel oil in Ipswich.

Year	Annual Fuel Oil Consumed (million gallons)	Annual Greenhouse Gas Emissions (metric tons)
2005	2,936,273	29,496
2010	2,563,366	25,750
2015	2,575,111	25,868
2020	2,507,577	25,189
2030	2,266,803	22,771

Table 6.10. Projected residential fuel oil consumption and greenhouse gas emissions for Ipswich, 2010-2030, relative to the 2005 baseline.

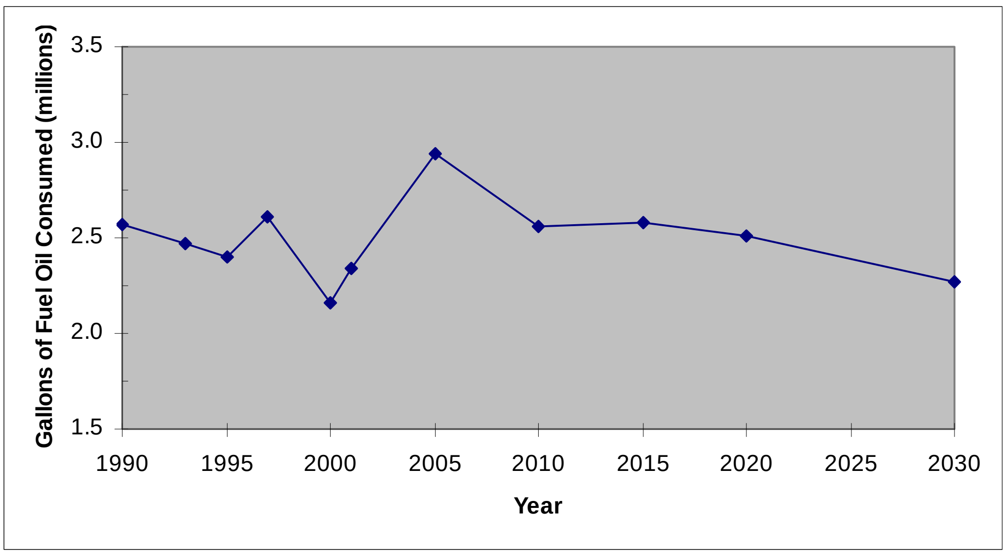


Fig. 6.9. Historic and projected residential fuel oil consumption for Ipswich, 1990-2030.

Commercial and Industrial Heating Oil Emissions: Trends, Methodology and Calculations

6.2.1 Introduction

This section assesses the commercial and industrial consumption of fuel oil and corresponding greenhouse gas emissions in Ipswich. Commercial and industrial uses of fuel oil are believed to be relatively small compared to residential uses. Most commercial and industrial businesses in Ipswich use natural gas as the primary type of space and water heating fuel (Town of Ipswich Assessor). Accurate estimates for commercial and industrial fuel oil consumption were difficult to obtain because, as with the residential sector, fuel oil for commercial and industrial buildings are purchased from multiple, private oil delivery services throughout the area.

The assessment of fuel oil consumption for commercial and industrial buildings in Ipswich was completed using data from the Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS) and the Manufacturing Energy Consumption Survey (MECS). In addition, we used the Town of Ipswich Assessor data to determine the total square footage of commercial and industrial buildings that used oil as a space and water heating fuel.

For the purposes of this assessment, commercial buildings include retail businesses, inns and motels, commercial condominiums and offices, religious and fraternal organizations, banks, and mixed commercial/residential buildings. Commercial buildings in Ipswich are primarily dominated by small businesses. According to the 2005 Ipswich Assessor's Office data, there were 102 commercial buildings in Ipswich using fuel oil as the primary source for space heating and hot water with an average size of 5,097 square feet. Nine commercial buildings were between 10,000 and 20,000 square feet, and only one was larger than 20,000 square feet (i.e. 138,751 square feet) (Town of Ipswich Assessor).

The types of industrial facilities using fuel oil include general manufacturing, industrial warehouse, research and development facilities, and sand and gravel operations. As of 2006, industrial facilities in Ipswich using fuel oil consisted of 10 buildings, with an average size of 25,968 square feet; however, only one industrial building was larger than 26,000 square feet (109,138 square feet). The remaining nine buildings averaged 16,426 square feet in size (Town of Ipswich Assessor).

As with residential buildings, fuel oil consumption for commercial and industrial buildings is influenced by the weather during the heating season. Warmer winter weather translates into lower HDD and hence, reduced fuel oil demand and consumption compared to years with colder winter weather. Therefore, the influence of weather should be factored into comparisons of fuel oil consumption between years (DOE/EIA 1993). Although some commercial and industrial businesses may use fuel oil for processes other than space and domestic water heating, such uses were not included in this analysis because the data were not available.

6.2.2 National and Regional Trends-Commercial

Nationally, the number of units and the total amount of floor space for commercial buildings increased between 1979 and 2003, while total energy consumption has remained relatively flat (EIA/CBECS). Between 1992 and 2003, in terms of total energy consumed for commercial buildings, fuel oil has ranked behind electricity, natural gas, and district heat for the entire U.S. (EIA/CBECS) (Fig. 6.7). The Northeast Region's commercial building energy consumption has followed a similar pattern during this period. However, in New England fuel oil has played a larger proportional role in energy consumption for commercial buildings compared to other regions (Fig. 6.8).

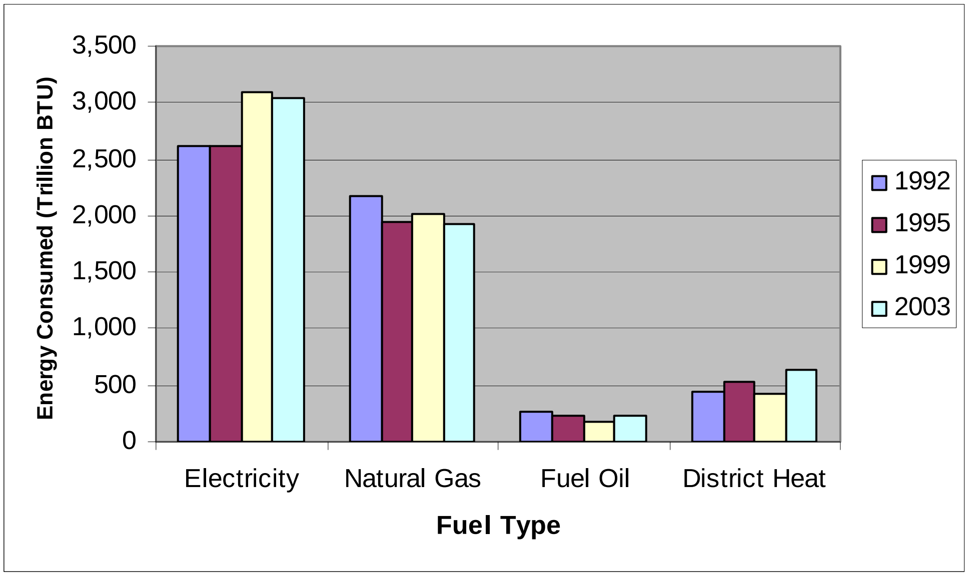


Fig. 6.7. Total annual energy consumption by fuel type for commercial buildings in the U.S. between 1992 and 2003 (EIA/CBECS).

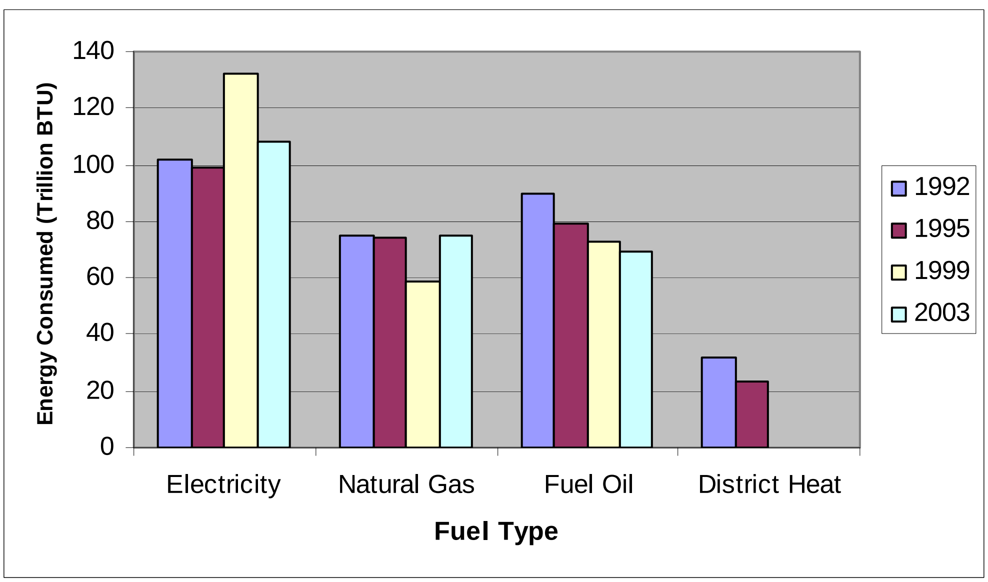


Fig. 6.8. Total annual energy consumption by fuel type for commercial buildings in New England between 1992 and 2003 (EIA/CBECS).

Similar to national trends for residential fuel oil use, the majority of fuel oil use in the U.S. for commercial buildings has been consumed in the Northeast Region (Fig. 6.9).

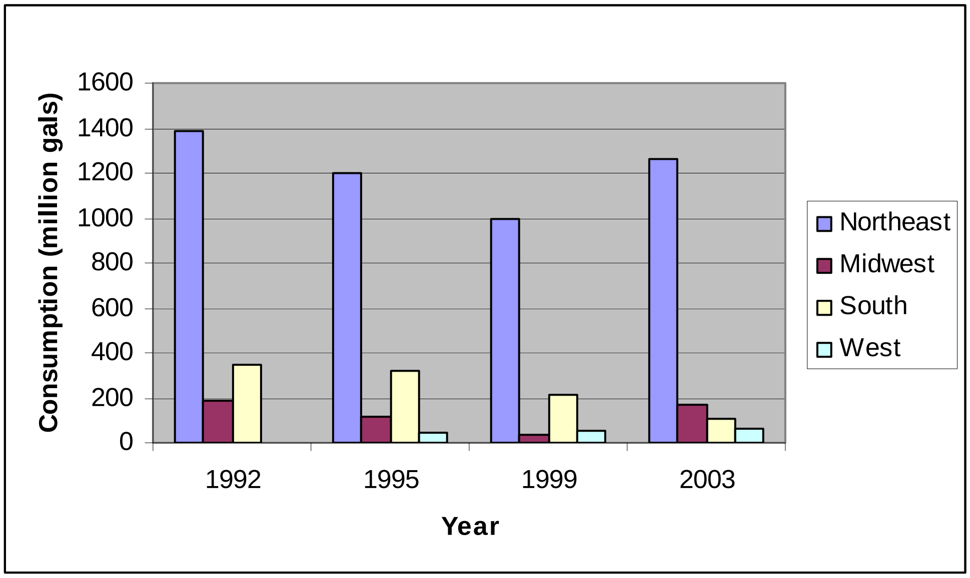


Fig. 6.9. U.S. commercial fuel oil consumption by region (EIA/CBECS).

Although fuel oil has been a staple fuel type for New England commercial buildings, its use has generally been decreasing since at least 1992. While some of the reduction in fuel oil consumption has been replaced by an increase in electricity use, improvements in the efficiencies of heating systems and building insulation may also be a factor.

6.2.3 National and Regional Trends-Industrial

According to the MECS data summary, fuel oil has historically played a minor role as an industrial energy source in the U.S. Between 1974 and 2002, industrial manufacturers in the U.S. have reduced their consumption of fuel oil. Distillate fuel oil represented 5.5% of all fuels used in 1974, 1.2% in 1994, and 0.87% in 2002. In 2002, approximately 138 trillion Btu of energy was consumed as fuel in industry from distillate fuel oil in the industrial sector (Fig. 6.13) (EIA/MECS 2006).

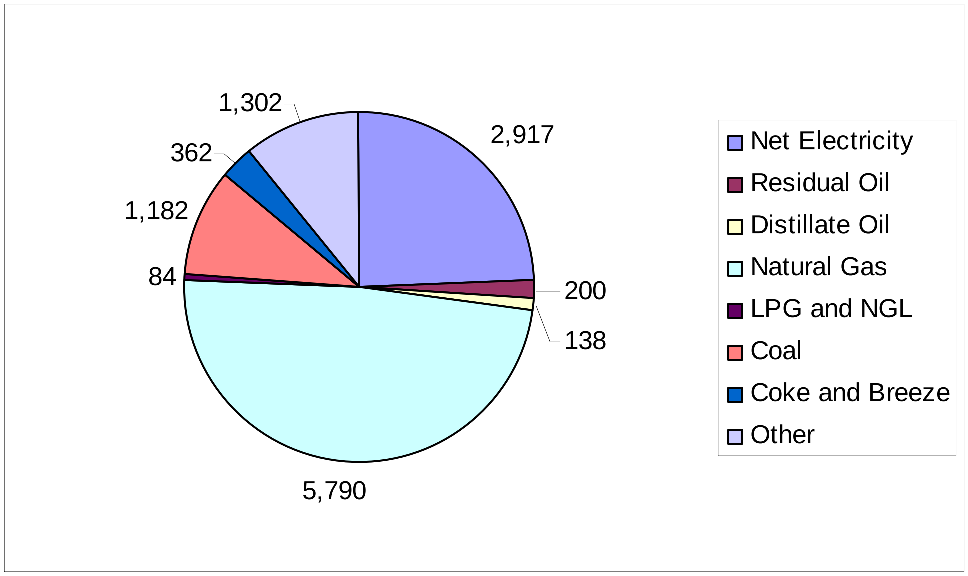


Fig. 6.13. Offsite produced energy sources consumed (trillion Btu) as fuel in the U.S. industrial sector in 2002 (EIA/MECS 2006).

As with other industrial energy sources in the U.S., the consumption of fuel oil has followed a downward trend between 1997 and 2006. The reduction in fuel oil consumption throughout this period can be attributed to manufacturers switching to natural gas as a preferred fuel. Natural gas can be preferable to distillate fuel oil because of the lower cost of on-site storage, as well as the added environmental hazards brought about by faulty underground storage tanks (EIA MECS 1994 Most recently, the reduction of industrial energy consumption has been attributed to economic weakness between 2000 and 2003, hurricanes in 2005 that disrupted some industrial subsectors, and rising energy prices (EIA Annual Energy Outlook 2008).

6.2.4 Commercial and Industrial Fuel Oil Consumption in Ipswich

As with residential consumption estimates, data on the actual consumption of fuel oil for commercial and industrial buildings in Ipswich were not available. For these consumption estimates we used the relationships between the Energy Intensity Factors developed by CBECS, and the total annual heating degree days (HDD) for New England in the four survey years to generate an average relationship value of 19,657 (Table 6.11).

Year	Energy Intensity Factor (gal/sq ft)	Total Annual HDD	HDD/ Energy Intensity Factor
1992	0.37	6447	17,424
1995	0.28	5959	21,282
1999	0.23	4254	18,496
2003	0.32	6856	21,425
		Average =	19,657

Table 6.11. Commercial and industrial fuel oil intensity factor and HDD for CBECS survey years, 1992-2003 (EIA/CBECS).

The estimated fuel oil intensity factors for the years 1990, 2000, and 2005 were calculated by dividing the annual HDD by the average relationship value (19,657). The total square footage of commercial and industrial buildings in Ipswich and the fuel oil intensity factors obtained from the CBECS and those estimated from the calculations above were used to estimate the fuel oil consumption from 1990-2005 (Table 6.12).

Year	Total Annual HDD	Total Space Heated (square feet)	Energy Intensity Factor (gal/sq ft)	Annual Fuel Oil Consumed (gallons)	Annual Greenhouse Gas Emissions (metric tons)
1990	6317	641,098	0.32[1]	205,151	2,061
1992	6447	645,898	0.37	238,982	2,401
1995	5959	648,987	0.28	181,716	1,825
1999	4254	651,545	0.23	149,855	1,505
2000	5754	651,545	0.29[1]	188,948	1,898
2003	6856	774,880	0.32	247,962	2,491
2005	6522	776,832	0.33[1]	256,355	2,575

Table 6.12. Estimated commercial/industrial fuel oil consumption and greenhouse gas emissions for Ipswich, 1990-2005.
[1]Calculated from the average relationship value and the total HDD for those years

The total square footage of commercial and industrial buildings heated with oil has increased by about 136 thousand square feet (21%) between 1990 and 2005, or an average of about 9 thousand square feet per year. The largest growth occurred in 2003 after the construction of a 109,138 square-foot industrial building, in addition to a 14,197 square-foot combined commercial/residential building in 2001 (Fig. 6.10). Improvements in energy efficiency (e.g., insulation value and more efficient heating systems) in commercial and industrial buildings in the

15 years between 1990 and 2005 and a modest increase in commercial and industrial buildings using fuel oil in Ipswich has led to a very small increase in fuel oil consumption.

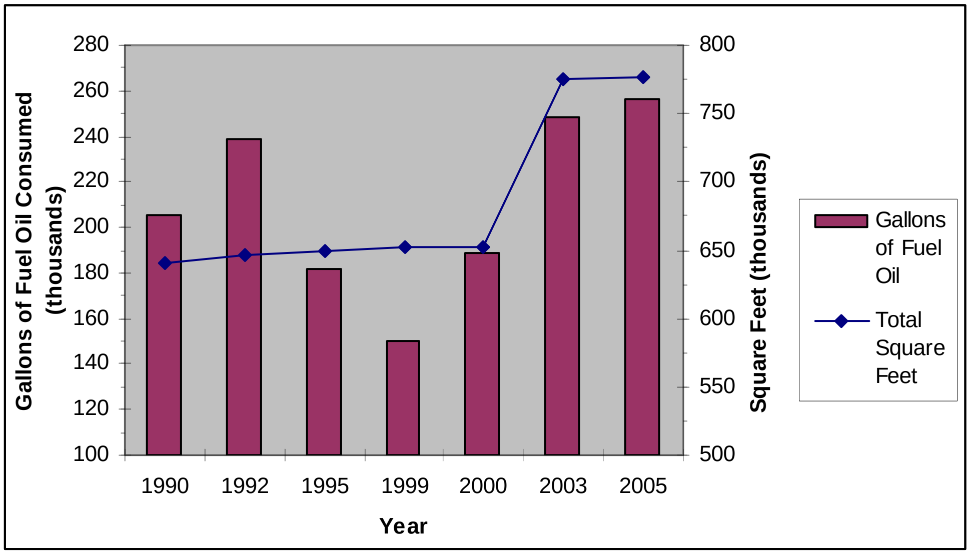


Fig. 6.10. Estimated commercial and industrial fuel oil consumption and square footage of heated space for Ipswich, 1990-2005.

As discussed above, the fuel oil consumption for commercial and industrial buildings is strongly influenced by the weather during the heating season. Warmer winter weather translates into lower HDD and reduced fuel oil consumption compared to years with colder winter weather. Figure 6.11 illustrates the relationship between fuel oil consumption and HDD.

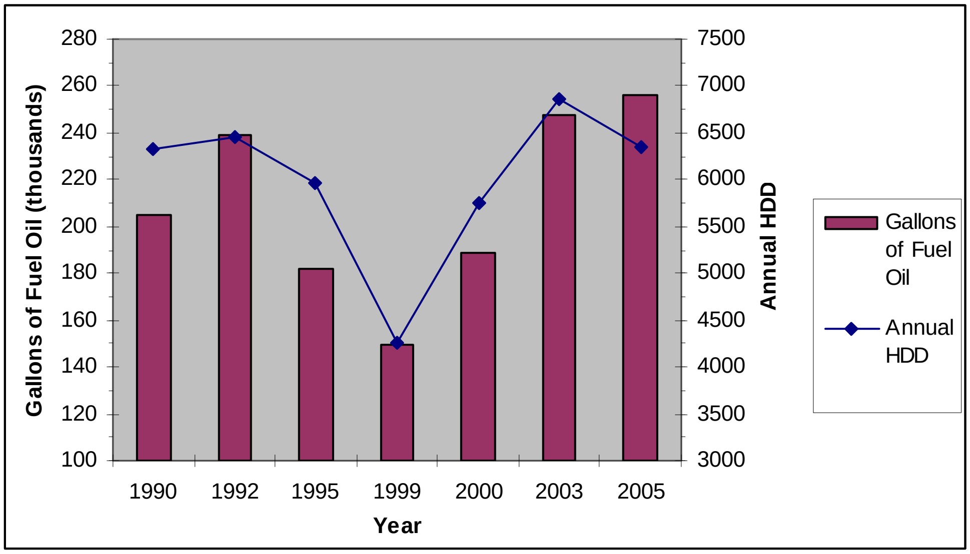


Fig. 6.11. Estimated commercial and industrial fuel oil consumption and heating degree days for Massachusetts, 1990-2005.

6.2.5 Projections for Commercial and Industrial Fuel Oil Consumption in Ipswich

As discussed elsewhere, the consumption of fuels for space heating is highly dependent upon the weather. Therefore, projections for future consumption of commercial and industrial fuel oil in Ipswich will be somewhat dependent upon weather patterns that may be experienced in New England. Average winter temperatures in the region over the past 30 years are greater than historic averages and are projected to increase further over the next few decades (Frumhoff et al. 2007). Increased winter temperatures will result in reduced commercial and industrial demand for and consumption of fuel oil in Ipswich. However, industrial consumption may not be as dependent upon weather as residential and commercial buildings due to the nature of these facilities. For example, industrial buildings are often not heated or are heated to lower temperatures than residential or commercial buildings.

Factors that may influence the commercial and industrial fuel oil consumption in Ipswich are 1) energy efficiency improvements in buildings; 2) higher fuel oil prices; and 3) slower growth in commercial square footage; 4) a reduction in commercial and industrial buildings using fuel oil; and 5) slower growth in energy-intensive industries (EIA Annual Energy Outlook 2008). As with residential buildings, improved heating equipment efficiency and more stringent building codes that require more insulation, better windows, and more efficient building design are expected to reduce consumption of fuel oil in commercial and industrial buildings.

According to the EIA's 2008 Annual Energy Outlook (AEO) report, the use of fuel oil in commercial buildings in the U.S. is projected to decrease over the next two decades (AEO 2008). The AEO report predicts the total commercial distillate fuel oil consumption in New England, which includes commercial heating oil, for the years 2010, 2015, 2020, and 2030 to be 0.085, 0.089, 0.087, and 0.086 quadrillion Btu, respectively (AEO 2007). Relative to the estimated 2005 consumption in New England of 0.093 quadrillion Btu, the projected commercial fuel oil consumption suggests a reduced consumption for years 2010, 2015, 2020, and 2030 of about 8.6%, 4.3%, 6.5%, and 7.5%, respectively.

The use of fuel oil in the industrial sector in the U.S. is projected to decrease over the next two decades (EIA Annual Energy Outlook 2008). The EIA's 2008 Annual Energy Outlook (AEO) report suggests the industrial use of distillate fuel oil in the U.S. will decrease by about 2.4% per year between 2005 and 2030. For New England, the AEO report predicts the total industrial distillate fuel oil consumption for the years 2010, 2015, 2020, and 2030 to be 0.033, 0.029, 0.028, and 0.028 quadrillion Btu, respectively (AEO 2008). Relative to the estimated 2005 consumption in New England of 0.037 quadrillion Btu, the AEO projected industrial fuel oil consumption suggests a decrease of 10.8% in 2010, 21.6% in 2015, and a decrease of 24.3% in both 2020 and 2030.

In order to project the combined commercial and industrial fuel oil consumption for future years, we used the average of the commercial and industrial AEO projection trends (i.e., 2010 = 10%; 2015 = 13%; 2020 = 15%; 2030 = 16%). Using the 2005 heating oil consumption for the combined commercial and industrial sectors in Ipswich as the baseline, the projected consumption of commercial fuel oil and greenhouse gas emissions for Ipswich for 2010, 2015, 2020, and 2030 are listed in Table 6.13.

Year	Annual Fuel Oil Consumed (gallons)	Annual Greenhouse Gas Emissions (metric tons)
2005	256,355	2,575
2010	230,720	2,318
2015	223,029	2,240
2020	217,902	2,189
2030	215,338	2,163

Table 6.13. Projected commercial and industrial fuel oil consumption and greenhouse gas emissions for Ipswich, 2010-2030, relative to the 2005 baseline.

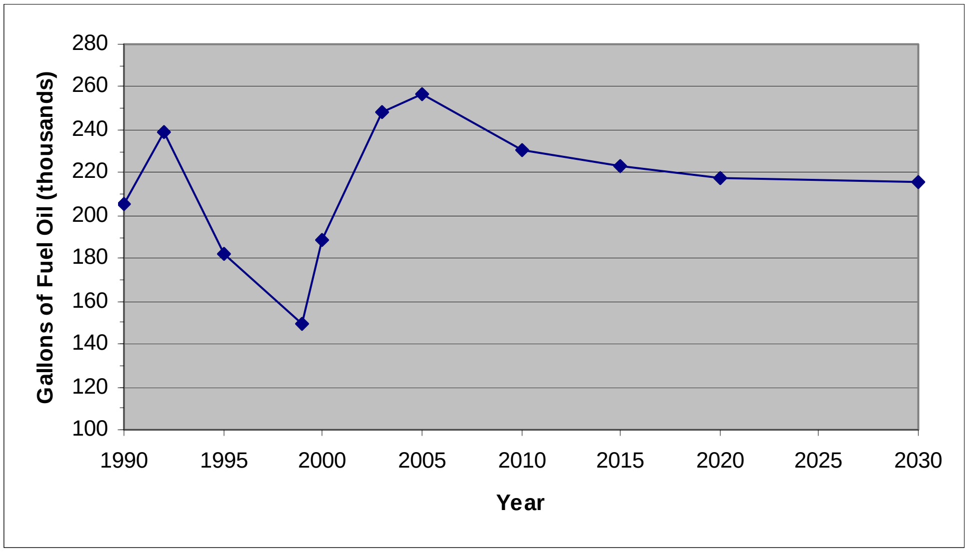


Fig. 6.12. Historic and projected commercial and industrial fuel oil consumption for Ipswich, 1990-2030.

Appendix 7: Natural Gas

Residential Natural Gas Emissions: Trends, Methodology and Calculations

7.1.1 Introduction

This section assesses the residential consumption of natural gas and corresponding greenhouse gas emissions in Ipswich. Natural gas consumption was estimated using data from the U.S. Census Bureau, the Department of Energy's Energy Information Administration (EIA) and Residential Energy Consumption Surveys (RECS), and the Town of Ipswich Assessor. We were able to verify these estimates of natural gas consumption using actual consumption data from the natural gas provider for Ipswich, KeySpan Gas. The use of propane as a fuel for space and water heating and other uses, such as cooking, were not estimated in this greenhouse gas (GHG) inventory. According to the Town of Ipswich Assessor's 2006 database, only three residential buildings and one commercial building reportedly used propane for space heating (uses other than space heating were not identified in the Assessor's database). Although we believe that more residential and commercial buildings in Ipswich likely use propane for heating, because propane is supplied by independent providers similar to fuel oil, data on the consumption in Ipswich were difficult to obtain. However, because it is assumed that the GHG emissions for propane per unit of heat produced is similar to natural gas, all emissions that may have been generated from propane consumption in Ipswich were calculated as natural gas consumption.

As with other space heating fuels, and to a lesser degree domestic hot water, residential natural gas consumption is dependent on the weather during the heating season for a given year. This is usually expressed in heating-degree-days (HDD) and is a measure of how cold it is compared to a base temperature of 65º F. For example, if the average temperature of a given day is 40º F, there would be 25 HDD for that day (i.e. 65 - 40 = 25). The sum of the daily HDD in a calendar year would represent the annual HDD for a specific area. The influence of weather should be factored into comparisons of gas consumption between years (DOE/EIA 1993).

7.1.2 National and Regional Trends

Natural gas is the primary heating fuel type in the U.S. In 2001, natural gas comprised approximately 71% of the energy used for space heating and hot water in the U.S. (Fig. 7.1).

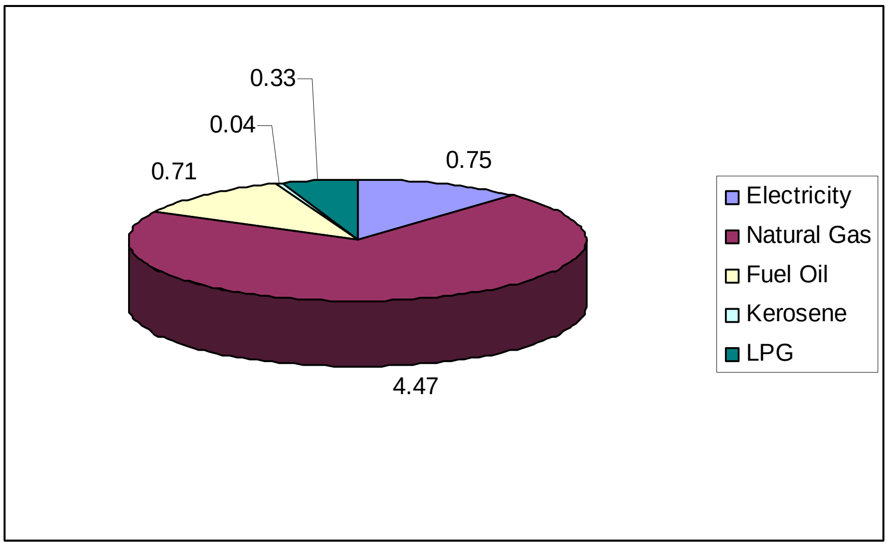


Figure 7.1. Major sources of fuel for space heating and domestic hot water in the U.S. for 2001 (in quadrillion Btu) (DOE/EIA).

The northeastern U.S. ranked third in consumption of natural gas in the U.S. behind the Midwest and the south (Fig. 7.2). Homes in the Northeast census region consumed approximately 20% of the natural gas in the entire U.S. in 2001 (DOE/EIA) (Table 7.1). For most homes in the northeast, space heating represents between 70 and 80% of all natural gas consumption (DOE/EIA).

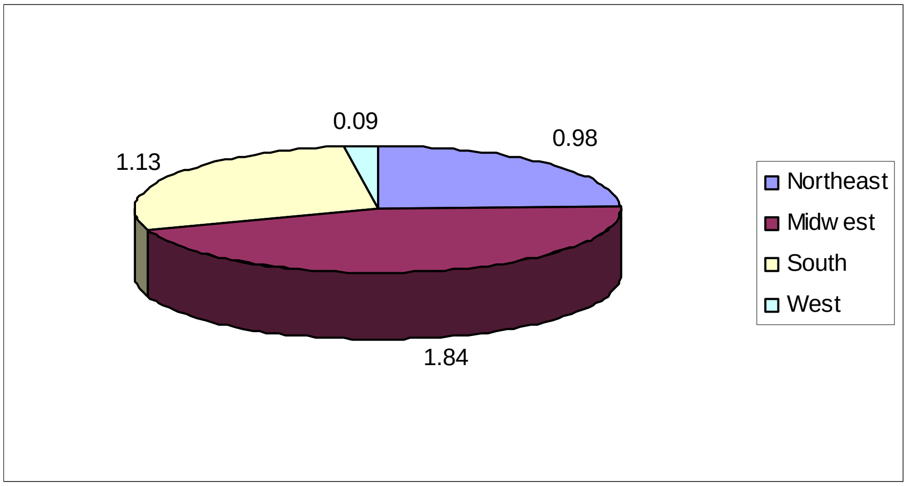


Fig. 7.2. Natural gas consumption (quadrillion Btu) for all census regions of the U.S. in 2001 (DOE/EIA).

Since 1970, the percentage of energy provided by natural gas for residential heat in the U.S. has remained relatively constant. For example, in 1970 natural gas was used in approximately 55% of all U.S. homes. By 1985, that percentage declined slightly to 51% and has remained stable (DOE/EIA 2006). Comparatively, the percentage of homes using fuel oil has declined steadily between 1960 and 2005 (32% and 9%, respectively), while the number of homes using electricity for heat has increased (2% and 32%, respectively) (DOE/EIA 2006). Although the number of households using natural gas has increased in the U.S. by about 18% between 1993 and 2005, the overall consumption has decreased by about 9% (Table 7.1).

Total Annual Residential Natural Gas Consumption									
	Entire U.S.			Northeast			New England		
Year	Billion Cubic Feet	Quad-rillion BTU	Number of House-holds (million)	Billion Cubic Feet	Quad-rillion BTU	Number of House-holds (million)	Billion Cubic Feet	Quad-rillion BTU	Number of House-holds (million)
1993	5,131	5.27	58.7	1,081	1.11	12.2	184	0.19	2.2
1997	5,143	5.28	61.9	1,000	1.03	11.8	165	0.17	1.9
2001	4,708	4.84	66.9	954	0.98	12.5	181	0.19	2.3
2005	4,655	4.79	69.4	1,113	1.15	13.6	239	0.25	2.7

Table 7.1. Annual residential natural gas consumption in the entire U.S., Northeast Census Region and New England. Residential Energy Consumption Survey data (DOE/EIA).

The residential consumption of natural gas in the Northeast Census region has remained relatively stable between 1978 and 2005 (Fig. 7.3).

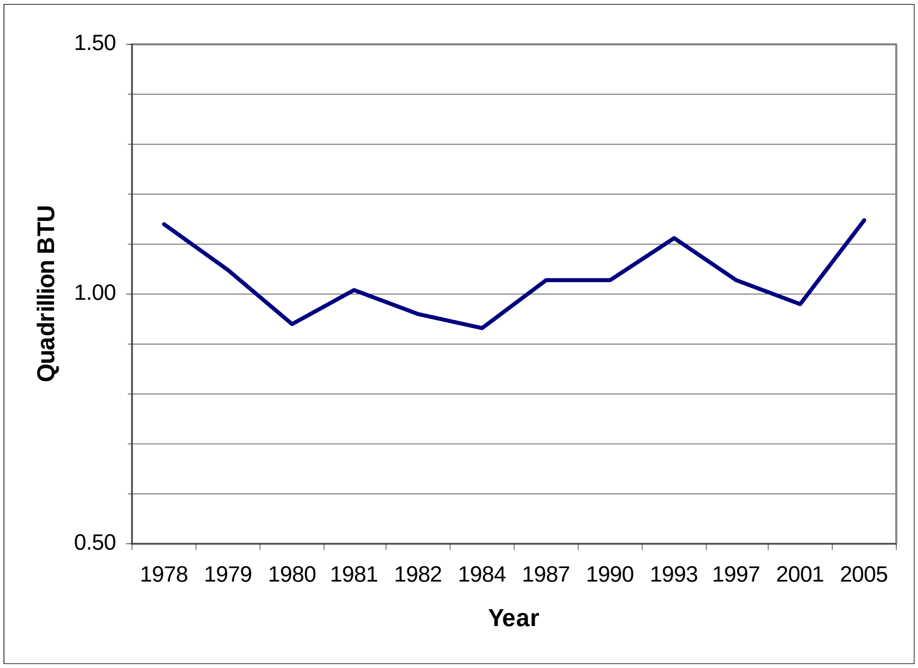


Fig. 7.3. Natural gas consumption (in quadrillion Btu) in the Northeast Region, 1978-2005 (DOE/EIA 2006)

Unlike the Northeast Region as a whole, annual residential natural gas consumption in Massachusetts increased steadily between 1960 and 1989 (Fig. 7.4). Between 1990 and 2004, consumption has fluctuated between 104 and 132 trillion Btu per year (DOE/EIA).

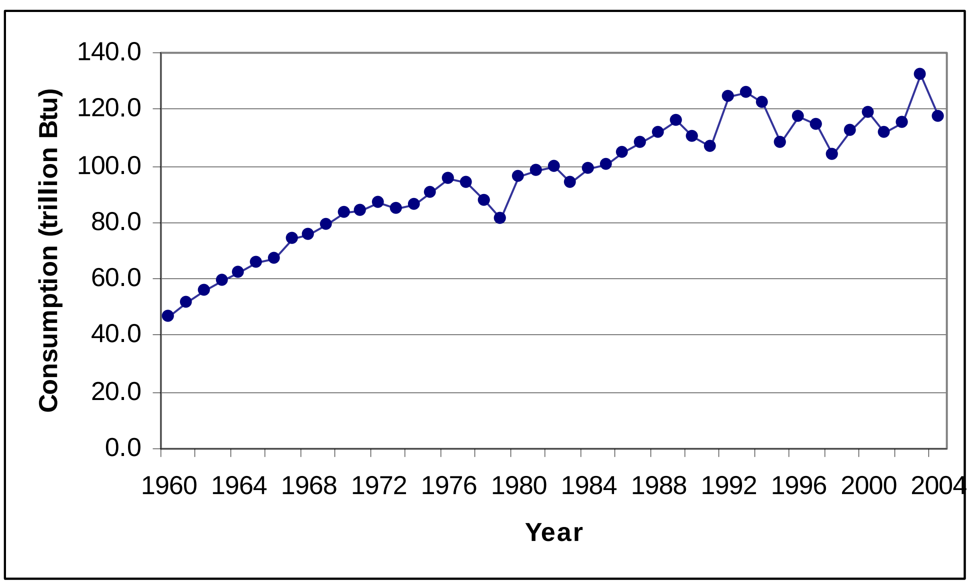


Fig. 7.4. Annual residential natural gas consumption in Massachusetts (in trillion Btu), 1960-2004 (DOE/EIA)

Natural gas is an important space heating fuel in the U.S. and in the Northeast Region. About 56% of all U.S. homes and 52% of all Northeast households used natural gas as the primary space heating fuel in 2001. However, fuel oil continues to dominate the New England census division as the most important type of space heating fuel. Only about 36% of all New England households used natural gas as the primary space heating fuel in 2001 (DOE/EIA 2001). According to the U.S. Census Bureau, approximately 38% and 44% of households in Massachusetts used natural gas for space heating in 1990 and 2000, respectively. Data gathered from the Town of Ipswich Assessor indicates that in 2001, approximately 31% of all residential building units used natural gas as the primary fuel source (Town of Ipswich Assessor).

Between 1990 and 2005, natural gas consumption per household has declined across the U.S., the Northeast Region and in the New England census division (Table 7.2). During this time, household consumption in the U.S., the Northeast Region, and New England census division has declined by 18%, 9%, and 18%, respectively (DOE/EIA 2009).

Annual Natural Gas Consumption Per Household						
	Entire U.S.		Northeast		New England	
Year	Thousand cubic feet	Million BTU	Thousand cubic feet	Million BTU	Thousand cubic feet	Million BTU
1990	82.1	84.2	86.9[1]	89.0[1]	107.9[2]	110.7[2]
1993	87.5	89.9	88.4	90.9	83.4	85.7
1997	83.0	85.3	85.0	86.9	85.0	87.0
2001	70.0	72.4	76.0	78.3	80.0	82.5
2005	67.0	69.0	82.0	84.0	88.0	90.3

Table 7.2. Annual natural gas consumption per household for the U.S., Northeast Region, and New England, 1990-2005 (DOE/EIA).

[1] Estimate was based upon the RECS data average for homes in Climate Zones 1-4

[2] Estimate was based upon RECS data for homes in Climate Zone 2

The trend of reduced household consumption of natural gas is reflected in all space heating fuels in the U.S. In 1978, an average of 91 million Btu per household (all fuels) was consumed for space heating in the U.S. (DOE/EIA 1999), while in 2005 the average consumption dropped to about 40 million Btu per household (DOE/EIA 2009). This represents a 56% decrease in space heating energy usage per household. The reduced fuel consumption for space heating is likely to have been influenced, at least partially, on improved energy efficiency of heating systems and insulation of homes (DOE/EIA). However, as discussed in the introduction, weather is a large factor in the consumption of space heating fuels. As seen in Fig. 7.6 below, although the annual per household consumption of natural gas in New England has increased between 1993 and 2005, consumption decrease by approximately 5% in 2001 compared to 1997 (DOE/EIA). This corresponds very closely with the reduced annual heating-degree-days

(HDD) in 2001, indicating that weather can have a larger factor in natural gas consumption than improvements in home heating energy efficiency and conservation.

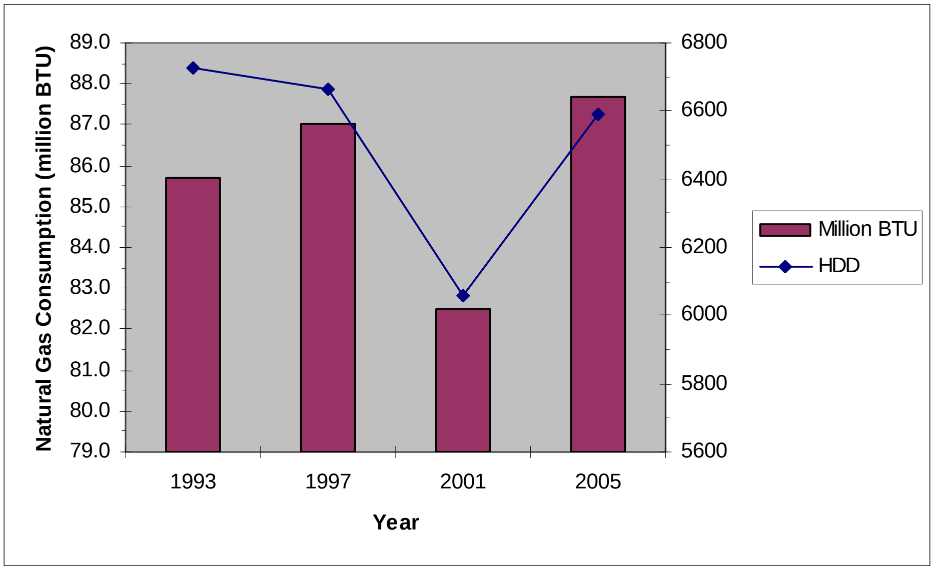


Fig. 7.6. Natural gas consumption per household and annual-heating-degree days (HDD) for New England, 1993-2005 (DOE/EIA).

The data suggests natural gas consumption for homes in Massachusetts may be higher per household than for the New England region as a whole. According to the DOE/EIA, 107 billion cubic feet of natural gas was consumed in Massachusetts for 1990. A review of the U.S. Census Bureau data indicates that 852,905 households in Massachusetts used natural gas for heating in 1990 (U.S. Census Bureau 1990), which equates to approximately 125.4 thousand cubic feet per household. In 2000, residential natural gas consumption in Massachusetts increased to approximately 114 billion cubic feet. However, 1,072,587 households used natural gas for heating that year (U.S. Census Bureau 2000), indicating that per household natural gas consumption decreased to 106.3 thousand cubic feet (DOE/EIA). These estimates for per household consumption of natural gas in Massachusetts are approximately 16% and 33% greater than the average New England region consumption for 1990 and 2001, respectively.

7.1.4 Residential Natural Gas Consumption for Ipswich

For residential natural gas consumption in Ipswich, we used calculations based on space heating intensity (SHI) modified from methodologies used by the DOE/EIA RECS program. We used data on actual consumption of natural gas from the supplier, KeySpan Gas, for years 2003-2007 as a means of verifying the estimates using SHI. The SHI method uses the formula:

TCF = SHI x [HDD x (HSF/1000)], where

TCF = cubic feet of natural gas used per year for space heating per household

SHI = space heating intensity;

HDD = heating-degree-days; and

HSF = heated square footage

Because 2001 RECS data on estimated natural gas consumption were available for New England households, we were able to compare those data with estimates for Ipswich homes using the SHI formula above. The SHI value for Ipswich homes was estimated using DOE/EIA 2001 RECS data, which for Climate Zone 2 was 7.05 (Massachusetts and most of New England is in Zone 2-between 5,500 and 7,000 HDD). The cumulative heating-degree-days from July 2000 through June 2001 for Massachusetts were reported to be 6,359 (National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service). The HSF was estimated using the Town of Ipswich Assessor's Office data. The average square footage for one-family homes built prior to 2002, using natural gas as the primary source of heat was 2,450 square feet. Below is the calculation for estimated natural gas consumption per household in 2001 for space heating by one-family homes in Ipswich.

Natural gas used per year for space heating per household = 7.05 x [6,359 x (2,450/1000)] = 109.8 thousand cubic feet.

Next, the consumption of residential natural gas used for domestic hot water was estimated for 2001. The Town of Ipswich Assessor's data did not include fuel sources for domestic hot water. To calculate the consumption of natural gas used for domestic hot water, it was assumed that most homes in Ipswich that heated their homes with natural gas also heated hot water with natural gas (need to check this with the Ipswich Building Department). The per household consumption of natural gas for water heating was estimated using the DOE/EIA 2001 RECS data for New England households. Those data indicated approximately 18 thousand cubic feet were consumed per household for an average 2.4 person household, which is consistent with the average household size for Ipswich in 2000 (U.S. Census Bureau 2000). The combined space heating and water natural gas consumption in 2001 for an average one-family household in Ipswich was 127.8 thousand cubic feet. This estimate for natural gas consumption per household in Ipswich is higher than the estimates for New England, using the DOE/EIA 2001 RECS data (80 thousand cubic feet) and our estimate for the State of Massachusetts in 2000 (106.3 thousand cubic feet) using the U.S. Census Bureau data.

The SHI value was then used to estimate the consumption of natural gas for all residential dwellings in Ipswich in 2001 using the Town of Ipswich Assessor's data for dwellings that reported using natural gas as the primary source (Table 7.3).

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	860	2,107,034
Condo	281	397,141
Mobile Home	1	520
Two-Family	73	200,494
Three-Family	14	45,038
Multi-Home	10	32,307
Apt. Unit (4-8)	7	36,460
Apt. Unit (+8)	8	239,986
Boarding House	1	5,089
Total	1,255	3,064,069

Table 7.3. Residential units using natural gas in Ipswich for 2001 (Town of Ipswich Assessor).

Using the SHI formula, cubic feet of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 2001:

= 7.05 x [6,359 x (3,064,069/1000)]

= 137,365,124 cubic feet

To calculate the total natural gas consumed for domestic hot water in Ipswich for 2001, the estimated consumption of natural gas for water heating per household in New England, 18,000 cubic feet (DOE/EIA 2001) was multiplied by the total number of households in Ipswich using natural as the primary heating source. Table 7.3 above lists the number of buildings for each dwelling type. For one-family homes, condos, and mobile homes, the number of buildings represents the number of households. For two-family and three-family dwellings, the number of buildings was multiplied by 2 and 3, respectively, to determine the number of households. Because the number of households for the multi-home, apartment unit, and boarding house dwelling types were not provided in the Town of Ipswich Assessor's data, we divided the total square footage for each of these dwelling types by 1,366 (the mean square footage of households for 1-, 2- and 3-family homes, condos, and mobile homes) to estimate the number of households for these two dwelling types. The results of these calculations are listed in Table 7.4.

Dwelling Type	Number of Buildings	Number of Households	Estimated Cubic Feet of Natural Gas Used for Hot Water[2]
One-Family	860	860	15,480,000
Condo	281	281	5,058,000
Mobile Home	1	1	18,000
Two-Family	73	146	2,628,000
Three-Family	14	42	756,000
Multi-Homes	10	24	432,000
Apt. Unit (4-8)	7	27	486,000
Apt. Unit (+8)	8	176	3,168,000
Boarding House	1	4	72,000
Total	1,254	1,561	28,098,000

Table 7.4. Natural gas consumed for hot water in all residential units in Ipswich for 2001 (Town of Ipswich Assessor).

[1]Number of households for multi-family, apartment units, and the boarding house buildings was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,366).

[2]Cubic feet of natural gas used estimated by using 2001 DOE/EIA estimate of 18,000 cubic feet per household for New England multiplied by the number of households.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 2001 was estimated to be: 137,365,124 cubic feet + 28,098,000 cubic feet = 165,463,124 cubic feet.

These calculations were repeated using the Town of Ipswich Assessor's data for residential buildings in 2000. Below are the results of those calculations:

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	849	2,059,768
Condo	281	397,141
Mobile Home	1	520
Two-Family	73	200,494
Three-Family	14	45,038
Multi-Family	10	32,307
Apt. Unit (4-8)	7	36,460
Apt. Unit (+8)	8	239,986
Boarding House	1	5,089
Total	1,244	3,016,803

Table 7.5. Residential units using natural gas in Ipswich for 2000 (Town of Ipswich Assessor).

Applying the SHI value for 2001 (7.05) and the HDD for 2000, the estimated space heating consumption of natural gas for all residential dwellings in Ipswich for 2000 was:

= 7.05 x [5,754 x (3,016,803/1000)]

= 122,378,725 cubic feet

Dwelling Type	Number of Buildings	Number of Households	Estimated Cubic Feet of Natural Gas Used for Hot Water[2]
One-Family	849	849	15,282,000
Condo	281	281	5,058,000
Mobile Home	1	1	18,000
Two-Family	73	146	2,628,000
Three-Family	14	42	756,000
Multi-Family	10	24[1]	432,000
Apt. Unit (4-8)	7	27[1]	486,000
Apt. Unit (+8)	8	174[1]	3,132,000
Boarding House	1	4[1]	72,000
Total	1,244	1,548	27,864,000

Table 7.6. Natural gas consumed for hot water in all residential units in Ipswich for 2000 (Town of Ipswich Assessor).

[1]Number of households for multi-family, apartment unit, and boarding house buildings was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes in 2000 (1,361).

[2]Cubic feet of natural gas used estimated by using 2001 DOE/EIA estimate of 18,000 cubic feet per household for New England multiplied by the number of households.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 2000 was estimated to be: 122,378,725 cubic feet + 27,864,000 cubic feet = 150,242,725 cubic feet.

These calculations were repeated using the Town of Ipswich Assessor's data for residential buildings in 2005. Below are the results of those calculations.

Dwelling Type	Number of Buildings	Total Square Feet
One-Family	910	2,291,258
Condo	338	524,591
Mobile Home	1	520
Two-Family	77	216,621
Three-Family	14	45,038
Multi-Home	12	40,489
Apt. Unit (4-8)	7	36,460
Apt. Unit (+8)	8	239,986
Boarding House	1	5,089
Total	1,368	3,400,052

Table 7.7. Residential units using natural gas in Ipswich for 2005 (Town of Ipswich Assessor).

Using the SHI formula, cubic feet of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 2005:

= 7.31 x [6,522 x (3,400,052/1000)]

= 162,100,267 cubic feet

Dwelling Type	Number of Buildings	Number of Households	Estimated Cubic Feet of Natural Gas Used for Hot Water[2]
One-Family	910	910	19,110,000
Condo	338	338	7,098,000
Mobile Home	1	1	21,000
Two-Family	77	154	3,234,000
Three-Family	14	42	882,000
Multi-Home	12	29[1]	609,000
Apt. Unit (4-8)	7	26[1]	546,000
Apt. Unit (+8)	8	170[1]	3,570,000
Boarding House	1	4[1]	84,000
Total	1,368	1,674	35,154,000

Table 7.8. Natural gas consumed for hot water in all residential units in Ipswich for 2005 (Town of Ipswich Assessor).

[1]Number of households for multi-family, apartment unit, and boarding house buildings was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes in 2005 (1,414).

[2]Cubic feet of natural gas used estimated by using 2005 DOE/EIA estimate of 21,000 cubic feet per household for New England multiplied by the number of households.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 2005 was estimated to be: 162,100,267 cubic feet + 35,154,000 cubic feet = 197,254,267 cubic feet.

According to data provided by KeySpan Gas, consumption for Ipswich residences in 2005 was 199,206,500 cubic feet of natural gas, which is about 1% higher than our estimates for that year. However, the KeySpan Gas data also included non-heat (i.e., cooking and water heating) consumption. Although our natural gas consumption estimates included water heating use, we did not include cooking use. It is likely that the 1% discrepancy between our estimates and the KeySpan consumption data for 2005 can be attributed to this non-heat consumption. Therefore, we have relatively good confidence that our estimates for other years were good. For the greenhouse gas emissions for natural gas in Ipswich for 2003-2005, we have used the consumption reported by KeySpan Gas.

In order to compare the long term trend estimates of residential natural gas consumption in Ipswich with the DOE/EIA RECS data, we repeating these calculations for 1990, 1993, 1995, and 1997.

	Number of Buildings				Total Square Feet			
Dwelling Type	1990	1993	1995	1997	1990	1993	1995	1997
One-Family	576	623	680	747	1,115,466	1,259,379	1,450,974	1,679,341
Condo	237	256	257	257	328,690	356,542	358,078	358,078
Mobile Home	1	1	1	1	520	520	520	520
Two-Family	72	72	73	73	197,972	197,972	200,494	200,494
Three-Family	14	14	14	14	45,038	45,038	45,038	45,038
Multi-Family	10	10	10	10	32,307	32,307	32,307	32,307
Apt. Unit (4-8)	7	7	7	7	36,460	36,460	36,460	36,460
Apt. Unit (+8)	8	8	8	8	239,986	239,986	239,986	239,986
Boarding House	1	1	1	1	5,089	5,089	5,089	5,089
Total	926	992	1,051	1,118	2,001,528	2,173,293	2,368,946	2,597,313

Table 7.9. Residential units using natural gas in Ipswich for 1990, 1993, 1995, and 1997 (Town of Ipswich Assessor).

Using the SHI formula, cubic feet of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 1990 is provided below. The SHI value for 1990 was 8.5 (DOE/EIA 1993).

= 8.5 x [6,317 x (2,001,528/1000)]

= 107,471,045 cubic feet

Using the SHI formula, cubic feet of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 1993 is provided below. The SHI value for 1993 was 8.3 (DOE/EIA 1995).

= 8.3 x [6,643 x (2,173,293/1000)]

= 119,828,639 cubic feet

Using the SHI formula, cubic feet of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 1995 is provided below (an average of 1993 and 1997 SHI values was used for 1995 = 8.2).

= 8.2 x [5,959 x (2,368,946/1000)]

= 115,755,704 cubic feet

Using the SHI formula, gallons of natural gas used per year for space heating per household = SHI x [HDD x (HSF/1000)], the estimated consumption of natural gas for all residential dwellings in Ipswich for 1997 is provided below. The SHI value for 1997 was 8.0 (DOE/EIA 1999).

= 8.0 x [6,237 x (2,597,313/1000)]

= 129,595,529 cubic feet

To calculate the total natural gas consumed for domestic hot water in Ipswich for 1990, the estimate of 25,400 cubic feet per household was used based upon DOE/EIA data (i.e., climate zone with between 5,500 and 7,000 heating degree days). Natural gas consumption for water heating in 1993 and 1997 was estimated using DOE/EIA data for average natural gas consumption for water heating per households in New England, 24,700 cubic feet and 23,000 cubic feet, respectively (DOE/EIA). The average natural gas consumption for hot water per household for these years was multiplied by the total number of households in Ipswich using natural gas as the primary heating source to estimate the cubic feet of natural gas used for hot water (Table 7.10).

	Number of Buildings				Number of Households				Estimated Cubic Feet of Natural Gas Used for Hot Water(in thousands)[2]			
Dwelling Type	1990	1993	1995	1997	1990	1993	1995	1997	1990	1993	1995	1997
One-Family	576	623	680	747	576	623	680	747	14,630.4	15,388.1	16,218.0	17,181.0
Condo	237	256	257	257	237	256	257	257	6,019.8	6,323.2	6,129.5	5,911.0
Mobile Home	1	1	1	1	1	1	1	1	25.4	24.7	23.9	23.0
Two-Family	72	72	73	73	144	144	146	146	3,657.6	3,556.8	3,482.1	3,358.0
Three-Family	14	14	14	14	42	42	42	42	1,066.8	1,037.4	1,001.7	966.0
Multi-Family	10	10	10	10	26[1]	25[1]	25[1]	24[1]	660.4	617.5	596.3	552.0
Apt. Unit (4-8)	7	7	7	7	29[1]	29[1]	28[1]	28[1]	736.6	716.3	667.8	644.0
Apt. Unit (+8)	8	8	8	8	191[1]	188[1]	185[1]	182[1]	4,851.4	4,643.6	4,412.3	4,186.0
Boarding House	1	1	1	1	4[1]	4[1]	4[1]	4[1]	101.6	98.8	95.4	92.0
Total	926	992	1,051	1,118	1,250	1,312	1,368	1,431	31,750.0	32,406.4	32,627.0	32,913.0

Table 7.10. Natural gas consumed for hot water in all residential units in Ipswich for 1990, 1993 and 1997 (Town of Ipswich Assessor).

[1]Number of households for multi-family and apartment units in 1990, 1993, 1995, and 1997 was estimated by dividing the total square footage for these dwelling types by the mean square footage of one-family, condo, mobile home, two- and three-family homes (1,258, 1,276, 1,299, and 1,321, respectively).

[2]Cubic feet of natural gas used in 1990, 1993, and 1997 was estimated by multiplying the number of households by the DOE/EIA estimates of per household natural gas consumption for water heating in New England (25,400, 24,700, and 23,000, respectively). 1995 estimate was calculated by multiplying the number of households by averaging the 1993 and 1997 DOE/EIA estimates of per household natural gas consumption for water heating in New England (23,850 cubic feet).

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 1990 was estimated to be: 107,471,045 cubic feet + 31,750,000 cubic feet = 139,221,045 cubic feet.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 1993 was estimated to be: 119,828,639 cubic feet + 32,406,400 cubic feet = 152,235,039 cubic feet.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 1995 was estimated to be: 115,755,704 cubic feet + 32,627,000 cubic feet = 148,382,704 cubic feet.

The total natural gas consumed for residential space heating and domestic hot water in Ipswich for 1997 was estimated to be: 129,595,529 cubic feet + 32,913,000 cubic feet = 162,508,529 cubic feet.

Table 7.11 contains the estimated natural gas consumed and resultant greenhouse gas emission in Ipswich for residential buildings in 1990, 1993, 1997, 2000, and 2001, and the KeySpan Gas reported natural gas consumption for 2003-2005.

Year	Number of Residential Households	Total Space Heated (million square feet)	Annual Natural Gas Consumed (million cubic feet)	Annual Greenhouse Gas Emissions (metric tons)
1990	1,250	2.002	139.221[1]	7,392
1993	1,312	2.173	152.235[1]	8,083
1995	1,368	2.369	148.383[1]	7,879
1997	1,431	2.597	162.509[1]	8,629
2000	1,546	3.017	150.243[1]	7,978
2001	1,557	3.064	165.463[1]	8,786
2003	1,592	3.176	204.865[2]	10,878
2004	1,632	3.294	195.971[2]	10,406
2005	1,674	3.400	199.207[2]	10,577

Table 7.11. The residential natural gas consumption and greenhouse gas emissions for Ipswich, 1990-2005.

[1]Estimated natural gas consumption for Ipswich using DOE/EIA and Town of Ipswich Assessor data

[2]Reported natural gas consumption for Ipswich by KeySpan Gas.

The consumption of natural gas in Ipswich has increased steadily from 1990 to 2005. The increase in natural gas consumption correlates closely with an increase in the square footage of residential homes heated with natural gas during this period (Fig. 7.7). Between 1990 and 2005, the square footage of homes heated with natural gas increased by about 70%, and the estimated natural gas consumption increased by about 43%.

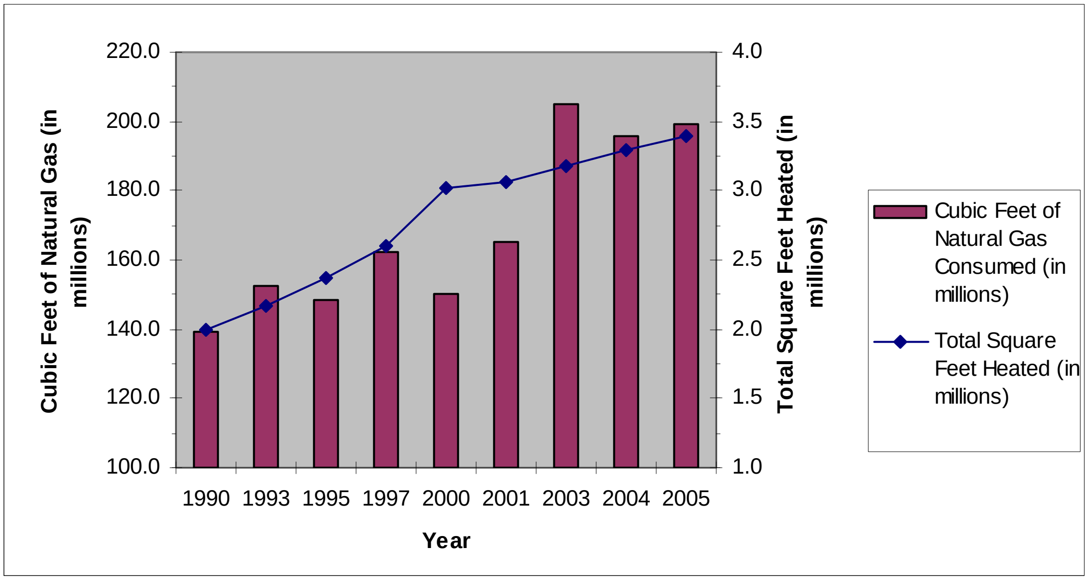


Fig. 7.7. Estimated residential natural gas consumption for Ipswich and total square footage of heated space, 1990-2005.

As discussed previously, consumption of fuels for space heating can be dependent upon the weather. Colder winters result in greater space heating demands (i.e., increased HDD) and, hence, higher consumption of space-heating fuels. However, for residential natural gas consumption in Ipswich, it appears that weather was less important in driving greater natural gas consumption than the increasing square footage of heated space and households using natural gas as the primary heating source. Figure 7.8 below depicts the relationship between estimated natural gas consumption in Ipswich and heating-degree-days for Massachusetts.

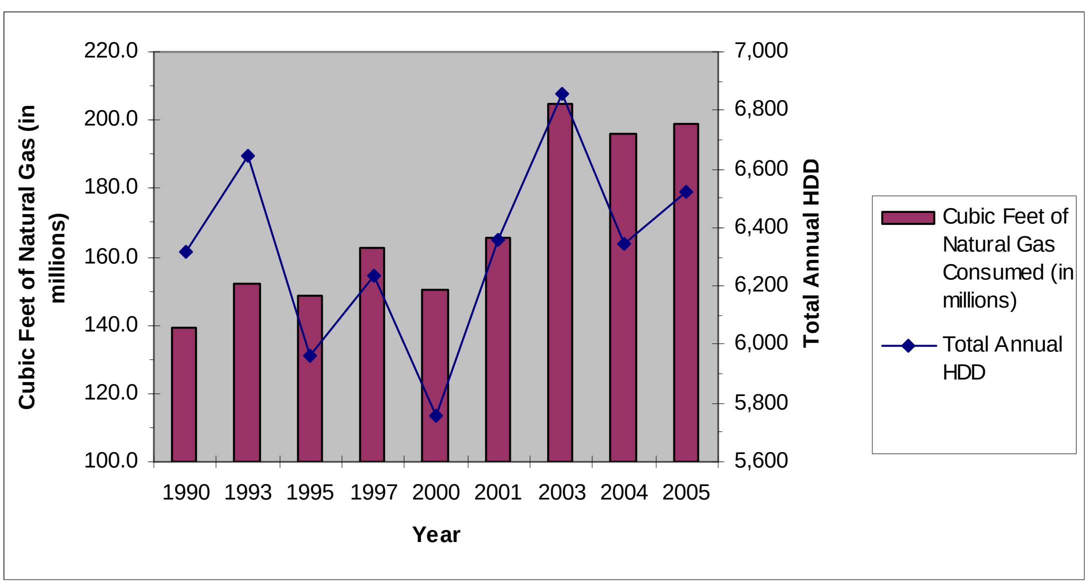


Fig. 7.8. Estimated residential natural gas consumption for Ipswich and annual HDD for Massachusetts, 1990-2005.

7.1.5 Projections for Residential Natural Gas Consumption in Ipswich

As discussed previously, consumption of fuels for space heating is highly dependent upon the weather. Colder winters (higher HDD) result in greater space heating demands and, hence, higher consumption of space-heating fuels. A rule-of-thumb is that a 10 % increase in heating-degree-days increases fuel required for space heating by 10% (DOE/EIA). Therefore, projections for future consumption of residential natural gas in Ipswich will be somewhat dependent upon future weather patterns that may be experienced in New England. Between 1970 and 2000, the average winter temperature in the Northeast Region of the U.S. has increased by more than 4º F above historical average. Winter temperatures are projected to increase by another 2.5º F to 4º F over the next few decades (Frumhoff et al. 2007). Increased winter temperatures will result in reduced demand for and consumption of natural gas in Ipswich.

Other factors that may influence future residential natural gas consumption in Ipswich are 1) energy efficiency improvements of new and existing homes; 2) natural gas prices; 3) the average size of new homes; 4) the rate of new home construction; and 5) the proportion of homes heated with natural gas. Although the overall energy use for space heating in the U.S. grew by 0.8% per year from 1990 to 2003, future growth is expected to be slowed by improved heating equipment efficiency and more stringent building codes that require more insulation, better windows, and more efficient building design (EIA Annual Energy Outlook 2005). Warmer temperatures during the heating season over the past 10 years have somewhat reduced heating demands and this trend is expected to continue into the future (EIA Annual Energy Outlook 2008). Higher natural gas prices are expected to induce energy conservation behaviors and measures by homeowners.

According to the EIA's Annual Energy Outlook report, the total residential natural gas consumption in New England for the years 2010, 2015, 2020, and 2030 is projected to be 0.213, 0.219, 0.220, and 0.217 quadrillion Btu, respectively (AEO 2007). Relative to the New England 2005 consumption of 0.202 quadrillion Btu, those projections reflect an increased residential natural gas consumption of 5.4%, 8.9%, 8.9%, and 7.4%, for the years 2010, 2015, 2020, and 2030, respectively. Based on these projections for future New England residential natural gas consumption, we extrapolated the future residential natural gas consumption in Ipswich using the 2005 estimate as the baseline. Table 7.12 contains the projected consumption of residential natural gas and greenhouse gas emissions for Ipswich for 2010, 2015, 2020, and 2030, and Fig. 7.9 depicts the historic and project consumption of natural gas.

Year	Annual Natural Gas Consumed (million cubic feet)	Annual Greenhouse Gas Emissions (metric tons)
2005	199.207	10,577
2010	209.964	11,148
2015	216.936	11,519
2020	216.936	11,519
2030	213.948	11,360

Table 7.12. Projected residential natural gas consumption and greenhouse gas emissions for Ipswich, 2005-2030.

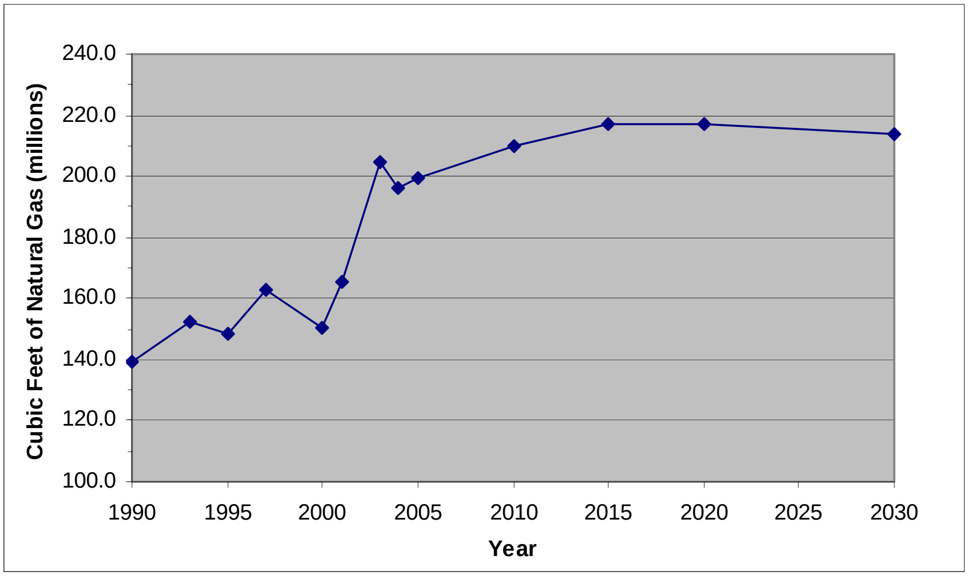


Fig. 7.9. Historic and projected residential natural gas consumption for Ipswich, 1990-2030.

Commercial and Industrial Natural Gas Emissions: Trends, Methodology and Calculations

7.2.1 Introduction

This section assesses the commercial and industrial consumption of natural gas and corresponding greenhouse gas emissions in Ipswich. Although most commercial businesses and industrial facilities in Ipswich use natural gas as the primary type of space and water heating fuel, the total square footage of commercial and industrial buildings is just over half of the total square footage of residential buildings. For example, in 2005 commercial and industrial buildings using natural gas as the primary heating fuel represented a total of 1.87 million square feet compared to 3.40 million square feet for residential buildings.

The assessment of natural gas consumption for commercial and industrial buildings was completed using data from the Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS) and Manufacturing Energy Consumption Survey (MECS). The Town of Ipswich Assessor data was used to determine the total square footage of buildings using natural gas as a space and water heating fuel. Data provided by KeySpan Gas for combined commercial and industrial sector for years 2003-2005 were used to calibrate the natural gas consumption estimates for earlier years (1990, 1992, 1995, 1999, 2000, and 2000).

For the purposes of this assessment, commercial buildings include retail businesses, inns and motels, restaurants and bars, professional and general offices, commercial condominiums, commercial storage facilities, automobile sales, service and repair, daycare facilities, golf club, gas stations, religious and fraternal organizations, banks, research and development facilities, and mixed commercial/residential buildings. Commercial buildings in Ipswich are primarily dominated by small businesses. According to the 2005 Ipswich Assessor's Office data, there were 133 commercial buildings in Ipswich using natural gas as the primary source of space heating and hot water with an average size of 7,792 square feet. Eleven of those commercial buildings were between 10,000 and 20,000 square feet, and fourteen were larger than 20,000 square feet (Town of Ipswich Assessor).

The types of industrial facilities using natural gas include general manufacturing, industrial warehouse, research and development facilities, and sand and gravel operations. Industrial facilities in Ipswich using natural gas for space and water heating consisted of 57 buildings, with an average size of 18,896 square feet in 2006. Two industrial building were larger than 100,000 square feet, one of which was constructed in 2005 (208,000 square feet) (Town of Ipswich Assessor).

As with residential buildings, natural gas consumption for commercial and industrial buildings is influenced by the weather during the heating season. Warmer winter weather translates into lower HDD and hence, reduced natural gas demand and consumption compared to years with colder winter weather. Therefore, the influence of weather should be factored into comparisons of natural gas consumption between years (DOE/EIA 1993). However, unlike the residential sector, commercial and industrial facilities use natural gas for non-space heating applications. According to data provided by KeySpan Gas, the consumption of natural gas for space heating applications in 2003 and 2005 comprised approximately 67% and 49%, respectively, of all commercial and industrial natural gas consumption in Ipswich.

7.2.2 National and Regional Trends-Commercial

Nationally, the number of units and the total amount of floor space for commercial buildings increased between 1979 and 2003, while total energy consumption has remained relatively flat (EIA/CBECS). Between 1992 and 2003, in terms of total energy consumed for commercial buildings, natural gas has ranked slightly behind electricity, but much greater than both fuel oil and district heat for the entire U.S. (EIA/CBECS) (Fig. 7.10). The Northeast Region's commercial building energy consumption has followed a similar pattern during this period. However, in New England fuel oil has played a larger proportional role in energy consumption for commercial buildings compared to other regions (Fig. 7.11). Until 2003, fuel oil consumption surpassed natural gas for commercial buildings in New England.

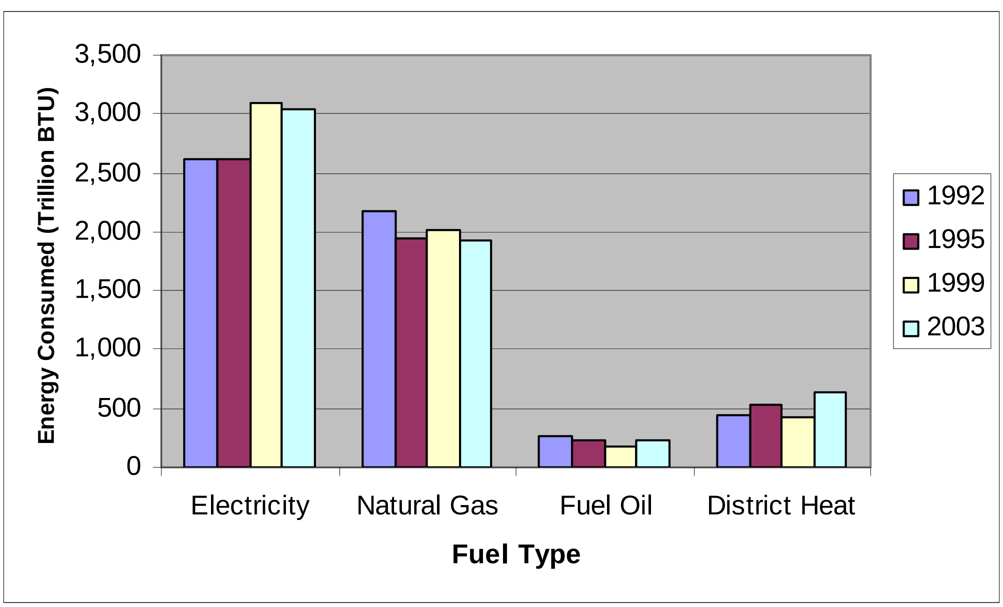


Fig. 7.10. Total annual energy consumption by fuel type for commercial buildings in the U.S. between 1992 and 2003 (EIA/CBECS).

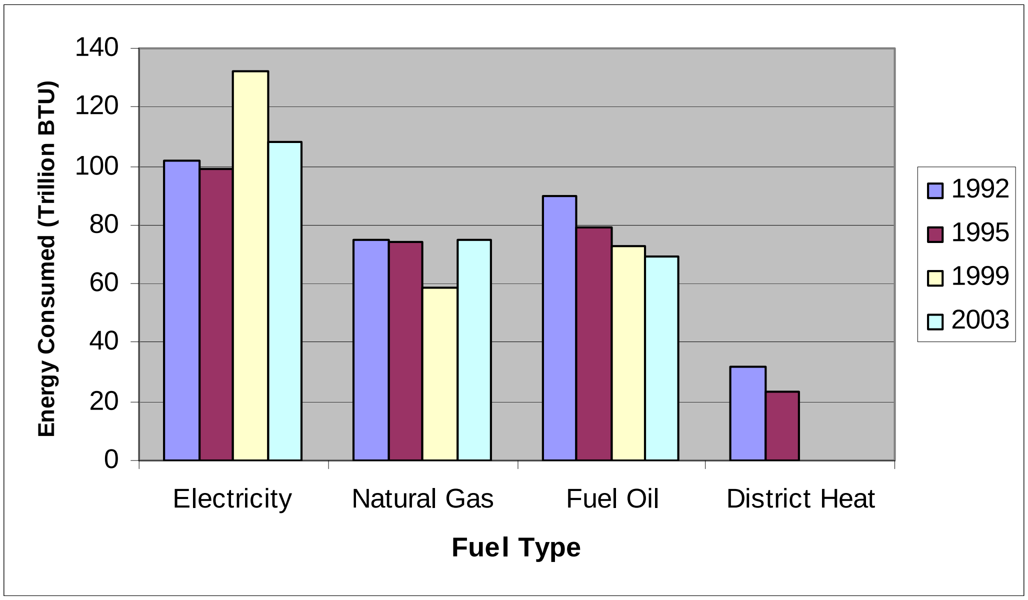


Fig. 7.11. Total annual energy consumption by fuel type for commercial buildings in New England between 1992 and 2003 (EIA/CBECS).

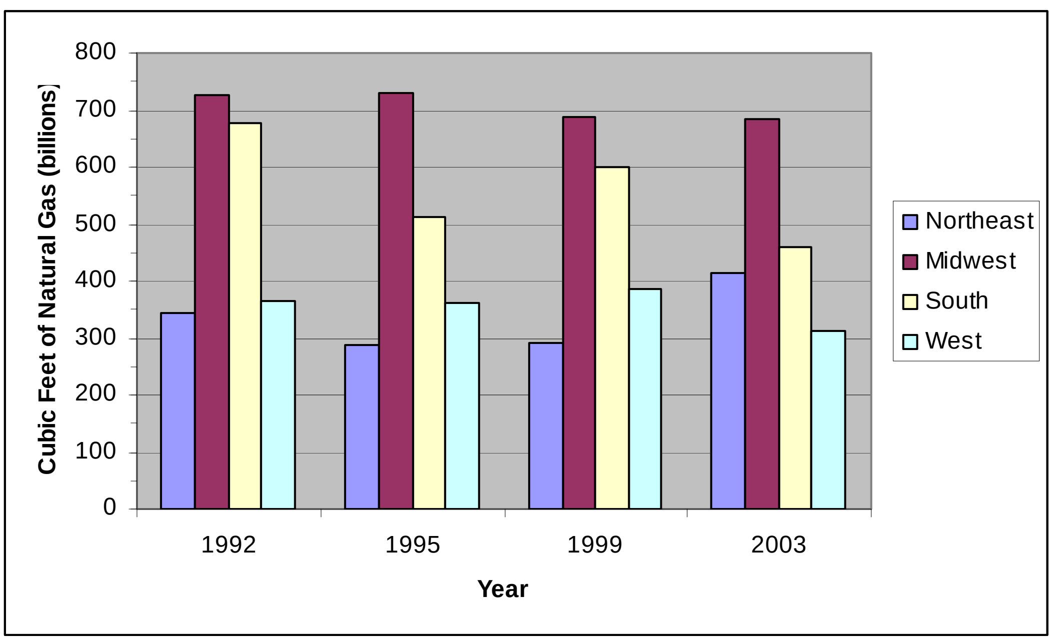


Fig. 7.12. U.S. commercial natural gas consumption by region (EIA/CBECS).

The Mid-West and South Regions of the U.S. consume a proportionally larger share of natural gas for commercial buildings. Historically, the Northeast Region has ranked last in U.S. commercial natural gas consumption, although this has begun to change in recent years (Fig. 7.12).

7.2.3 National and Regional Trends-Industrial

According to the MECS data summary, natural gas has historically played an important role as an industrial energy source in the U.S. Between 1974 and 1994, natural gas consumption by industrial manufacturers in the U.S. has remained relatively stable, ranging from 47 to 50% of all fuels purchased. In 2002, approximately 5,790 trillion Btu of energy was consumed as fuel in industry from natural gas in the U.S. industrial sector (Fig. 7.13) (EIA/MECS 2006).

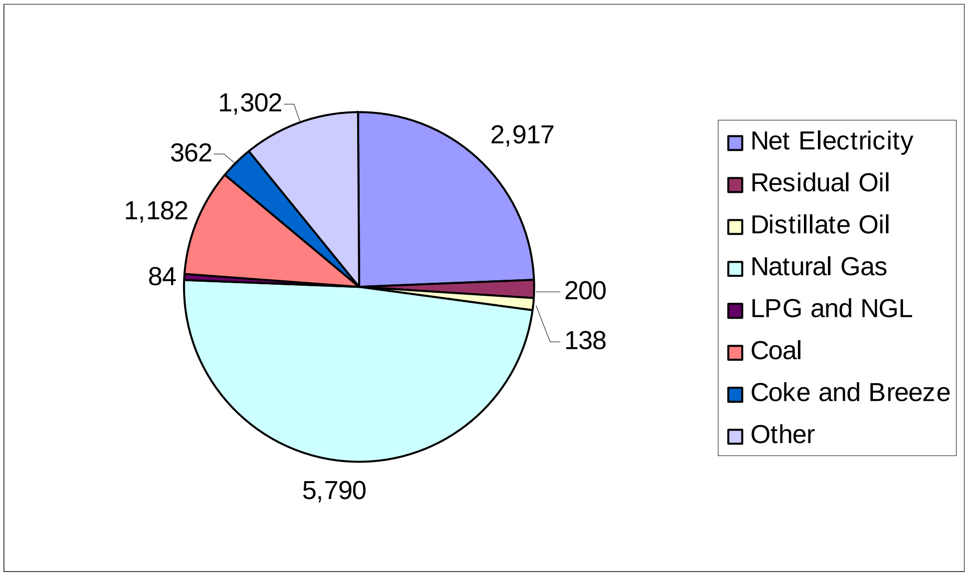


Fig. 7.13. Offsite produced energy sources consumed (trillion Btu) as fuel in the U.S. industrial sector in 2002 (EIA/MECS 2006).

Natural gas can be preferable to distillate fuel oil as an industrial fuel source because of the lower cost of on-site storage and the reduced environmental hazards in storage (EIA MECS 1994 Overall industrial energy consumption in the U.S. has decreased, attributed to economic weakness between 2000 and 2003, hurricanes in 2005 that disrupted some industrial subsectors, and rising energy prices (EIA Annual Energy Outlook 2008).

7.2.4 Commercial and Industrial Natural Gas Consumption in Ipswich

The combined commercial and industrial natural gas consumption data for Ipswich was provided by KeySpan Gas for 2003-2005 (Table 7.13).

Year	Annual Natural Gas Consumed (therms)	Annual Natural Gas Consumed (million cubic feet)
2003	1,618,558	161.856
2004	1,795,723	179.572
2005	2,310,461	231.046

Table 7.13. Natural gas consumption in Ipswich combined commercial and industrial sectors, 2003-2005 (KeySpan Gas)

In order to derive commercial and industrial natural gas consumption estimates for earlier years, we used the relationships between the natural gas energy intensity factors developed by CBECS, and the total annual heating degree days (HDD) for New England in the four survey years to create an average relationship value of 136.02 (Table 7.14).

Year	Energy Intensity Factor (cubic feet/sq ft)	Total Annual HDD	HDD/ Energy Intensity Factor
1992	52.0	6447	123.98
1995	50.0	5959	119.18
1999	35.8	5706	159.39
2003	49.5	6856	138.51
		Average =	136.02

Table 7.14. Commercial natural gas energy intensity factor and HDD for CBECS survey years, 1992-2003 (EIA/CBECS).

The estimated natural gas intensity factors for the years 1990, 2000, and 2005 were calculated by dividing the annual HDD by the average relationship value (136.02). The total square footage of commercial and industrial buildings in Ipswich and the natural gas energy intensity factors obtained from the CBECS and those estimated from the calculations above were used to estimate the natural gas consumption from 1990-2005 (Table 7.15).

Year	Total Annual HDD	Space Heated (million square feet)	Energy Intensity Factor (cubic feet/sq ft)	Annual Natural Gas Consumed (million cubic feet)
1990	6317	1.791	46.4[1]	83.083
1992	6447	1.801	52.0	93.649
1995	5959	1.816	50.0	90.779
1999	5706	1.823	35.8	65.266
2000	5754	1.824	42.3[1]	77.142
2003	6856	1.867	49.5	92.405
2004	6346	1.878	46.7[1]	87.720
2005	6522	2.105	47.9[1]	100.849

Table 7.15. Estimated commercial and industrial natural gas consumption for Ipswich, 1990-2005.

[1]Calculated from the average relationship value and the total HDD for those years

Comparing the actual combined commercial and industrial natural gas consumption data from KeySpan Gas for 2003, 2004, and 2005 with our estimates suggests that we underestimated the natural gas consumption by about 43%, 51%, and 56%, respectively. However, the KeySpan Gas data included both heat and non-heat natural gas use for the commercial and industrial sectors, which our estimates did not. The data from KeySpan Gas indicates the consumption of natural gas attributed to space heating in 2003, 2004, and 2005 comprised approximately 67%, 72%, and 49%, respectively, of all commercial and industrial natural gas consumption in Ipswich. In order to account for the non-heating applications of natural gas in the commercial and industrial sectors, we have increased our consumption estimates for earlier years (1990, 1992, 1995, 1999, and 2000) by a factor of 2.0. The adjusted commercial and industrial natural gas consumption and greenhouse gas emissions are provided in Table 7.16 below.

Year	Space Heated (million square feet)	Annual Natural Gas Consumed (million cubic feet)	Annual Greenhouse Gas Emissions (metric tons)
1990	1.791	166.166	8,823
1992	1.801	187.298	9,945
1995	1.816	181.558	9,640
1999	1.823	130.533	6,931
2000	1.824	154.284	8,192
2003	1.867	161.856[1]	8,594
2004	1.878	179.572[1]	9,535
2005	2.105	231.046[1]	12,268

Table 7.16. Estimated commercial and industrial natural gas consumption and greenhouse gas emissions for Ipswich, 1990-2005.

[1]Reported natural gas consumption for Ipswich by KeySpan Gas.

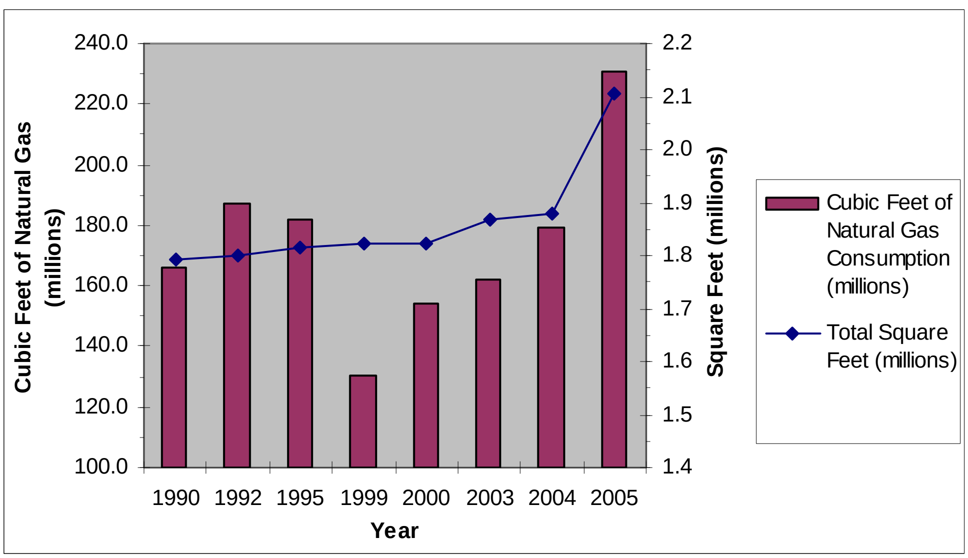


Fig. 7.14. Estimated commercial and industrial natural gas consumption and square footage of heated space for Ipswich, 1990-2005.

The total square footage of commercial and industrial buildings heated with natural gas has increased by about 320,000 square feet (21%) between 1990 and 2005. However, the construction of a 208,000 square foot research facility in 2005 (New England Biolabs) contributed to about two-thirds of the increase in square footage and the natural gas consumption during this time (Fig. 7.13).

As discussed above, the consumption of natural gas for commercial and industrial buildings is strongly influenced by the weather during the heating season. Warmer winter weather translates into lower HDD and reduced natural gas consumption compared to years with colder winters. Figure 7.15 illustrates the relationship between natural gas consumption and HDD.

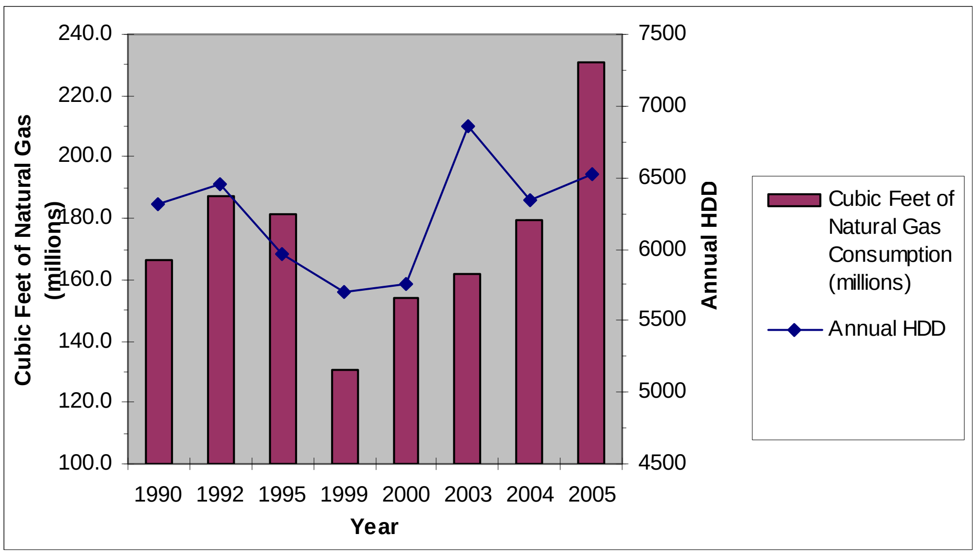


Fig. 7.15. Estimated commercial and industrial natural gas consumption for Ipswich and annual HDD for Massachusetts, 1990-2005.

7.2.5 Projections for Commercial and Industrial Natural Gas Consumption in Ipswich

As discussed elsewhere, the consumption of fuels for space heating is highly dependent upon the weather. Therefore, projections for future consumption of commercial and industrial natural gas in Ipswich will be somewhat dependent upon weather patterns that may be experienced in New England. Average winter temperatures in the region over the past 30 years are greater than historic averages and are projected to increase further over the next few decades (Frumhoff et al. 2007). Increased winter temperatures will result in reduced commercial and industrial demand for and consumption of natural gas in Ipswich. However, industrial consumption may not be as dependent upon weather as residential and commercial buildings due to the nature of these facilities. For example, industrial buildings are often not heated or are heated to lower temperatures than residential or commercial buildings. In addition, non-space heating uses of natural gas for industrial processes will not necessarily be dependent upon weather conditions.

Factors that may influence the commercial and industrial natural gas consumption in Ipswich are 1) energy efficiency improvements in buildings; 2) higher natural gas prices; 3) lower economic growth; 4) slower growth in commercial square footage; and 5) slower growth in energy-intensive industries (EIA Annual Energy Outlook 2008). As with residential buildings, improved heating equipment efficiency and more stringent building codes that require more insulation, better windows, and more efficient building design are expected to reduce consumption of natural gas in commercial and industrial buildings.

According to the EIA's 2008 Annual Energy Outlook (AEO) report, the total commercial natural gas consumption in New England for the years 2010, 2015, 2020, and 2030 to be 0.132, 0.146, 0.157, and 0.181 quadrillion Btu, respectively (AEO 2007). Relative to the estimated 2005 consumption in New England of 0.126 quadrillion Btu, the projected commercial natural consumption indicates increased consumption for years 2010, 2015, 2020, and 2030 of about 4.8%, 15.9%, 24.6%, and 43.7%, respectively.

For the New England industrial sector, the AEO report predicts the total industrial natural gas consumption for the years 2010, 2015, 2020, and 2030 to be 0.123, 0.127, 0.129, and 0.139 quadrillion Btu, respectively (AEO 2008). Relative to the estimated 2005 consumption in New England of 0.090 quadrillion Btu, the AEO projected industrial natural gas consumption suggests an increase of 36.7% in 2010, 43.3% in 2015 and 2020, and 54.4% in 2030.

In order to project the combined commercial and industrial natural gas consumption for future years, we used the average of both the commercial and industrial AEO projection trends (i.e., 2010 = 19%; 2015 = 30%; 2020 = 34%; 2030 = 49%). Using the 2005 natural gas consumption for the combined commercial and industrial sectors in Ipswich as the baseline, the projected consumption of commercial natural gas and greenhouse gas emissions for Ipswich for 2010, 2015, 2020, and 2030 are listed in Table 7.17.

Year	Annual Natural Gas Consumed (million cubic feet)	Annual Greenhouse Gas Emissions (metric tons)
2005	231.046	12,268
2010	274.945	14,599
2015	299.436	15,899
2020	309.602	16,439
2030	344.259	18,279

Table 7.17. Projected commercial and industrial natural gas consumption and greenhouse gas emissions for Ipswich, 2010-2030, relative to the 2005 baseline.

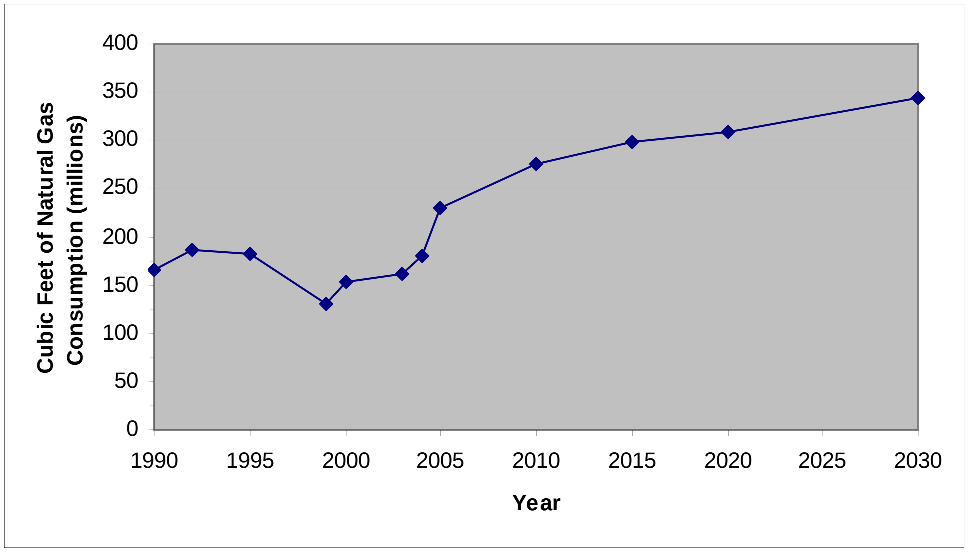


Fig. 7.16. Historic and projected commercial and industrial natural gas consumption for Ipswich, 1990-2030.

Appendix 8: Vehicular Fuels

Regulatory Context

Several federal requirements affect the energy efficiency and potential emissions of automobiles and some other vehicles. Vehicle manufacturers are required to meet Corporate Average Fuel Economy (CAFE) standards for the cars and trucks they manufacture and sell. Changes to the CAFÉ standards were announced in December 2007. The new law included a provision that increased the CAFÉ standard from 25 to 35 mpg by the year 2020. Europe and several other industrialized countries already have similar standards.

The U.S. Environmental Protection Agency recently announced changes in the way fuel economy is estimated, starting with model year 2008 vehicles. The new estimates more accurately reflect the actual fuel economy that the average driver will experience (see www.fueleconomy.gov).

The type of vehicle, engine type, vehicle speed, and how it is driven determines fuel consumption and carbon emissions. Modern engines are typically most fuel efficient when driven at a steady speed. Relatively more fuel is burned when starting up or idling, and carbon dioxide is emitted at a faster rate during these conditions. More energy is required to move heavier vehicles than lighter ones, and diesel fuel powered engines are somewhat more efficient than gasoline engines. No gasoline or diesel engines are more than 35% efficient, so two additional tons of carbon are emitted for each ton of carbon that would be needed to move a "perfect" vehicle with no wasted energy or heat.

Beginning January 1, 2006, federal income tax credits were made available to people who purchase hybrid vehicles, which run on gasoline as well as electricity generated on-board. The credit began to be phased out once a manufacturer sells 60,000 hybrid and lean-burn vehicles post January 1, 2006. On July 1, 2007, the tax credit for Toyota hybrid vehicles entered phase-out mode, with the credit ending September 30, 2007. Purchases of other manufacturers' hybrid vehicles continued for longer periods.

The Massachusetts Air Quality Program has some unique provisions that encourage commuters in Boston and Cambridge (or at large companies) not to drive solo to work. The Massachusetts Rideshare Regulation (310 CMR 7.16) requires companies with more than 250 employees at the same location to develop a plan and set a goal of reducing their "single occupant commuter motor vehicles" (SOCMV) by 25 percent. Specifically, these companies are required to have a carpool program, discuss special bus routes to serve workers with local transit authorities, and survey their SOCMV proportion and trends. There are also "parking freezes" in Boston and Cambridge that limit the number of all-day parking spaces that can be built.

Massachusetts also has an anti-idling law that prohibits motor vehicle idling in excess of five minutes. This regulation does not apply to vehicles that must operate to be serviced, deliver or accept goods for which engine assisted power is necessary and alternate power is not available, or that require auxiliary power for a power demand under certain conditions. Violators are subject to fines of up to $100 - $500, and local boards of health and police, and state and federal officials are authorized to enforce the state anti-idling law.

Methods for Calculating Emissions from Transportation

The most direct method of determining transportation emissions is to take actual fuel consumption data and calculate emissions using time-tested conversion formulas. In Ipswich, the only such data available is in the municipal sector. Specifically, the town keeps records of gasoline and diesel fuel consumption of municipal vehicles and equipment. In calculating the carbon emissions inventory for Ipswich, the Commission did not feel that it would be effective to request sales data from town gasoline stations. Additionally, Ipswich has very few diesel fuel outlets.

As an alternative method, federal or state transportation fuel use data for Massachusetts and its counties can be apportioned to the town on a per capita basis, by roadway use, or by using other factors.

The US Department of Energy (DOE) Energy Information Administration (EIA) collects detailed energy information including fuel data for the nation. Staff at the MA Department of Environmental Protection (DEP) use this method to prepare the Massachusetts emission inventory required under the federal Clean Air Act. They collect fuel sales data for transportation sources down to a county level.

Alternately, vehicle miles traveled (VMT) can be used with an average fuel use factor (miles per gallon) to calculate total transportation fuel use. For a greenhouse gas inventory, the resulting total fuel use can be directly converted to emissions.

Basic vehicle categories are:

- Passenger cars:
  - Light-duty gasoline-fueled vehicles (LDGV)
- SUVs Trucks and Vans:
  - Light-duty gasoline-fueled trucks < 6,000 lbs gross vehicle weight (LDGT1)
  - Heavier trucks and vans - 6,000 - 8,500 lbs. GVW (LDGT2);
- Heavy Duty Trucks:
  - Gasoline-fueled vehicles > 8,500 lbs GVW (HDGV)

The Massachusetts Highway Department conducts traffic counts and calculates vehicle use (for the different classes of vehicles) in terms of vehicle miles traveled (VMT). The state uses this information for a variety of purposes including calculation of vehicle emissions.

In general, pollutant emissions depend on the engine speed and vehicle type, and they are often calculated using a U.S. Environmental Protection Agency (USEPA) model, MOBILE5.[103] This more complex method of calculating transportation emissions evaluates the mix of vehicles, their speed and associated VMT to determine emissions and fuel economy rates. The CEUCP used the results provided by the Metropolitan Area Planning Commission's Central Transportation Planning Staff (CTPS) modeling for Ipswich. This included the number of vehicles of each category, the VMT by vehicle category on each type of road (which determines the average speed) and the average emission rate per mile for each category.

Road categories, and their associated average speeds, include highway, secondary and local roads. In Ipswich, there are no interstate highways or roads with speed limits over 50 mph. Of the 95.7 miles of roads, 76% are roads controlled by the Town (72.9 miles).[104] The Town-controlled roads can be assumed to be local roads, and the remainder can be assumed to be secondary roads (including Routes 1, 133, and 1A) maintained by the Commonwealth. The Town of Ipswich is home to 95.69 miles of roads, 76% of which are controlled by the Town (72.92 miles) [source: MassHighway Road Inventory File].

According to the Central Transportation Planning Staff (CTPS), automotive traffic on Ipswich streets and roads increased 4.4% from 1990-2000 (from an annual 71,567,070 VMT (vehicle miles traveled) to 74,757,516 VMT) and 2.5% from 2000-2006 (from 74,757,516 VMT to 76,671,784 VMT). By 2020, VMT is estimated to increase to 82,124,770, an increase of 7.1% over 2006 values.

The CTPS has determined that gasoline-powered automobiles are responsible for 46.35% of the total VMT, gasoline-powered light trucks and SUVs for 40.63%; gasoline-powered heavy trucks for 3.47%; diesel-powered light duty vehicles for .07%; and diesel-powered heavy duty vehicles for 9.05%.

The proportion of gasoline used in Ipswich can be based on the ratio/percentage of Ipswich VMT to the Commonwealth's VMT, assuming that in general, the mix of vehicle types and roadways is somewhat similar to the Massachusetts averages.

[103] MOBILE4.1 Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume 1: General Guidance for Stationary Sources EPA-450/4-91-016, May 1991
[104] MassHighway Road Inventory File

In summary,

- In 1990, Ipswich residents were responsible for 33% of the total annual vehicle miles traveled in the Town of Ipswich, with 10,946,541 VMT (15% of total VMT) attributable to gasoline-powered automobiles; 9,595,641 VMT (13% of total VMT) to gasoline-powered light trucks and SUVs; 819,515 VMT (1% of total VMT) to gasoline-powered heavy trucks; 101,554 VMT (.14% of total VMT) to gasoline-powered MC; 16,532 VMT (.023% of total VMT) to diesel-powered light duty vehicles; and 2,137,351 VMT (3% of total VMT) to diesel-powered heavy duty vehicles.

- In 2000, Ipswich residents were responsible for 26% of the total annual vehicle miles traveled in Ipswich, with 9,009,028 VMT (12%) attributable to gasoline-powered automobiles; 7,897,234 VMT (11%) to gasoline-powered light trucks and SUVs; 674,462 VMT (.9%) to gasoline-powered heavy trucks; 83,579 VMT (.11%) to gasoline-powered MC; 13,606 VMT (.01%) to diesel-powered light duty vehicles; and 1,759,044 VMT (2.4%) to diesel-powered heavy duty vehicles.

- CTPS predicts that in 2020, Ipswich residents will account for 23% of the total annual vehicle miles traveled in Ipswich, with 8,754,911 VMT (11%) attributable to gasoline-powered automobiles; 7,674,478 VMT (9%) to gasoline-powered light trucks and SUVs; 655,438 VMT (.8%) to gasoline-powered heavy trucks; 81,221 VMT (.1%) to gasoline-powered MC; 13,222 VMT (.02%) to diesel-powered light duty vehicles; and 1,709,427 VMT (2%) to diesel-powered heavy duty vehicles.]

As of February 2007, there were 48 hybrid vehicles with registered owners garaged in Ipswich (of these, 7 had corporation owners and 41 had individual owners). EBSCO plans to go all hybrid with their vehicle fleet, also.

Appendix 9: Solid Waste and Recycling

History of Solid Waste Disposal and Recycling in Ipswich

Solid Waste

Until 1978, solid waste generated in Ipswich was disposed of in a sanitary landfill located on town-owned land at the end of Town Farm Road. The landfill was officially closed in accordance with State regulatory procedures in 1982. Part of this large tract of town-owned land is used as a transfer station. The central portion of the site is used for composting and processing of sewage sludge combined with leaves and other waste products by a commercial operator, Agrisource, under agreement with the town. The Agrisource facility accepts sewage sludge from the Ipswich Wastewater Treatment Plant.

Since 1978, solid waste from Ipswich has been processed at municipal waste combustion facilities including RESCO in Saugus, MA and Mass Refusetec Inc. in North Andover, MA. Each facility has a processing capacity of 1,500 tons per day. While these facilities are regulated and monitored (in terms of particulate matter and other air pollutants) by the MA Department of Environmental Protection, there are no technologies commercially available that remove GHG's from the emissions generated at these waste combustion facilities.

In Ipswich, solid waste generated by residents and businesses is collected in the following manner:

6. **Curbside Pick-up -** Solid waste and recycling materials generated by single-family residences are picked up at curbside. In 2008, the weekly limit for solid waste was three 30-gallon bags. There is no limit to the amount of recyclable materials. White goods, electrical appliances, and cathode ray tubes (old-style TVs and computer monitors) are disposed of curbside by the town's trash collector through the purchase of a $25 sticker that is available at the Public Works office at Town Hall.

7. **Municipal Buildings and Schools –** Solid waste and recycling materials generated at town government facilities and schools are picked up under the same contract.

8. **Multifamily Buildings** - Apartment buildings with more than three units and the Ipswich Country Club arrange for their own trash pickup.

9. **Commercial/Industrial Businesses and Institutions -** Businesses are eligible for curbside pick-up, but they must be able to adhere to the same weekly limit described above.

10. **Transfer Station** – The Transfer Station at the end of Town Farm Road is open on Wednesdays and Saturdays and accepts yard waste only (i.e. grass clippings, leaves, brush, and small branches). Prior to April 30, 2003, the transfer station was open five days a week and also accepted trash, metals, recyclables, white goods, televisions and cathode-ray tubes, and car batteries as well as tires.

Recycling

Prior to 1990, there was no municipal solid waste recycling activity in Ipswich. Since 1990, the town's solid waste disposal/recycling procedures and policies have changed significantly:

Year	Action
1990	Solid Waste Advisory Committee participated in the implementation of the following: • establishment of a permanent drop-off recycling site at the transfer station • establishment of a monthly drop-off recycling program at town Hall
1991	A drop-off recycling program was held monthly at Town Hall with newspaper, tin/aluminum cans, and #1 and #2 plastics. In July, the Transfer Station started accepting newspaper and white goods for recycling as well as yard waste for composting. The town also commenced recycling of office paper from schools and town offices; polystyrene lunch trays from the High School and Middle School; and plastics, tin, and glass at the Doyon School.
1992	Solid Waste Advisory Committee staffed a monthly drop-off site at the Town Hall from January to June.

Year	Action
1992	In July, the town commenced curbside recycling for newspaper, cans and glass.
1994	Ipswich General Bylaws was amended making it mandatory for residents to recycle glass, plastics, tin and newspaper. Commenced collection of button batteries at various locations in town. In January, plastic (#1 and #2) was added to the list of acceptable materials for curbside recycling
1995	Commenced curbside collection of corrugated cardboard and co-mingled paper (including: junk mail, stationary, magazines, etc.); commenced monthly collections of oil-based and latex paint at a newly constructed paint shed at the transfer station.
1998	Town introduced collection of 4 foot fluorescent bulbs at the Transfer Station. Town began a new policy of accepting one large item at curbside each week from each house. Previously, there was one day in the spring and one day in the fall when residents could place large items in unlimited quantities at curbside for pickup.
1999	Commenced curbside collection of paperboard for recycling purposes. Containers for recycling materials that are mechanically loaded by the recycling truck were put into service at schools and town facilities.
2000	Cathode ray tubes banned from the waste stream.
2003	In April, the Transfer Station stopped accepting: trash, metals, recyclables, white goods, televisions and cathode-ray tubes, car batteries and tires. Hours at transfer station reduced to two days a week.
2006 (Feb.)	In February, the town began enforcing the 4-bag/4 x 30 gallon trash can limit and would not pick up trash mixed with recyclables.
2008	In July, the town began enforcing the 3-bag limit.

[Note that scrap iron, tires, etc. are not included in recycling tonnage; in line with the requirements by DEP as part of its grant program that started around 1996/1997.]

Local action aimed at increasing recycling rates in Ipswich has been both voluntary and in direct response to regulatory action at the state level. Waste disposal regulations in Massachusetts have grown progressively more stringent. The table below illustrates the progression of waste bans at landfills, combustion facilities and transfer stations since 1990.

Restricted Material	Effective Date of the Restriction for Landfills or Combustion Facilities	Effective Date For Restrictions For Transfer Facilities
Lead Batteries, Leaves, Tires and White Goods	December 3, 1991	April 1, 2000
Other Yard Waste, Aluminum Containers, Metal or Glass	December 31, 1992	April 1, 2000
Single Polymer Plastics, Recyclable Paper	December 31, 1994	April 1, 2000
Cathode-Ray Tubes	April 1, 2000	April 1, 2000

Restricted Material	Effective Date of the Restriction for Landfills or Combustion Facilities	Effective Date For Restrictions For Transfer Facilities
Asphalt Pavement, Brick, Concrete, Wood, and Metal	July 1, 2006	July 1, 2006

The recycling rate in Ipswich was 0% in 1990. By 1995 the recycling rate was up to 35%. Between 1995 and 2005, the rate has fluctuated between a high of 47% in 2000 and 36% in 2005.

Comparative Recycling Rates, 2005

The calendar year 2005 recycling rates for Ipswich and nearby communities are listed below:

Town	Recycling Rate 2005
Topsfield	51%
Newburyport	46%
Boxford	45%
Rockport	37%
Ipswich	**36%**
Gloucester	36%
Manchester	34%
Wenham	29%
Middleton	26%
Beverly	23%
Essex	22%
Danvers	19%
Hamilton	19%
Newbury	18%
West Newbury	18%
Peabody	15%
Rowley	7%

Appendix 10: To Learn More

Population/Business Statistics:

http://www.umass.edu/miser/population/statesummary.htm

US Environmental Protection Agency Greenhouse Gas Emissions information:

Massachusetts total GHG emissions in 1990 = 21.7 metric tons
http://www.epa.gov/climatechange/emissions/downloads/MASummary.PDF

DOE EIA:

Massachusetts GHG emissions, 1990-2005
http://www.eia.doe.gov/oiaf/1605/ggrpt/excel/tbl_statetotal.xls

Ranking by country
http://en.wikipedia.org/wiki/List_of_countries_by_greenhouse_gas_emissions_per_capita

http://www.swivel.com/data_sets/show/1000279

Boston per capita
http://www.bostonindicators.org/IndicatorsProject/Environment/Indicator.aspx?id=1570

US per capita history
http://globalis.gvu.unu.edu/indicator_detail.cfm?Country=US&IndicatorID=199

2005 US data
http://www.climate-policy-map.econsense.de/factsheets_download/factsheet-greenhouse-gas-emissions.pdf

Climate Changes:

Searise flooding maps
http://flood.firetree.net/?ll=43.3251,-101.6015&z=13

Biofuels:

Biodiesel Use in New England
http://www.epa.gov/ne/eco/diesel/assets/pdfs/biodiesel-factsheet.pdf

Governments and institutions that have incorporated biodiesel into their fleets:

- Keene, NH was one of the pioneers. See http://www.granitestatecleancities.org/news/russellarticle.pdf and http://www.epa.gov/NE/eco/gb3/pdfs/20070502/Biodiesel-Russell-Keene.pdf
- Cambridge, MA http://www.cambridgema.gov/TheWorks/news/biodiesel.htm
- Harvard University http://www.greencampus.harvard.edu/cre/biofuels_case_studies.php
- Medford, MA http://www.medford.org/Pages/MedfordMA_Energy/verp