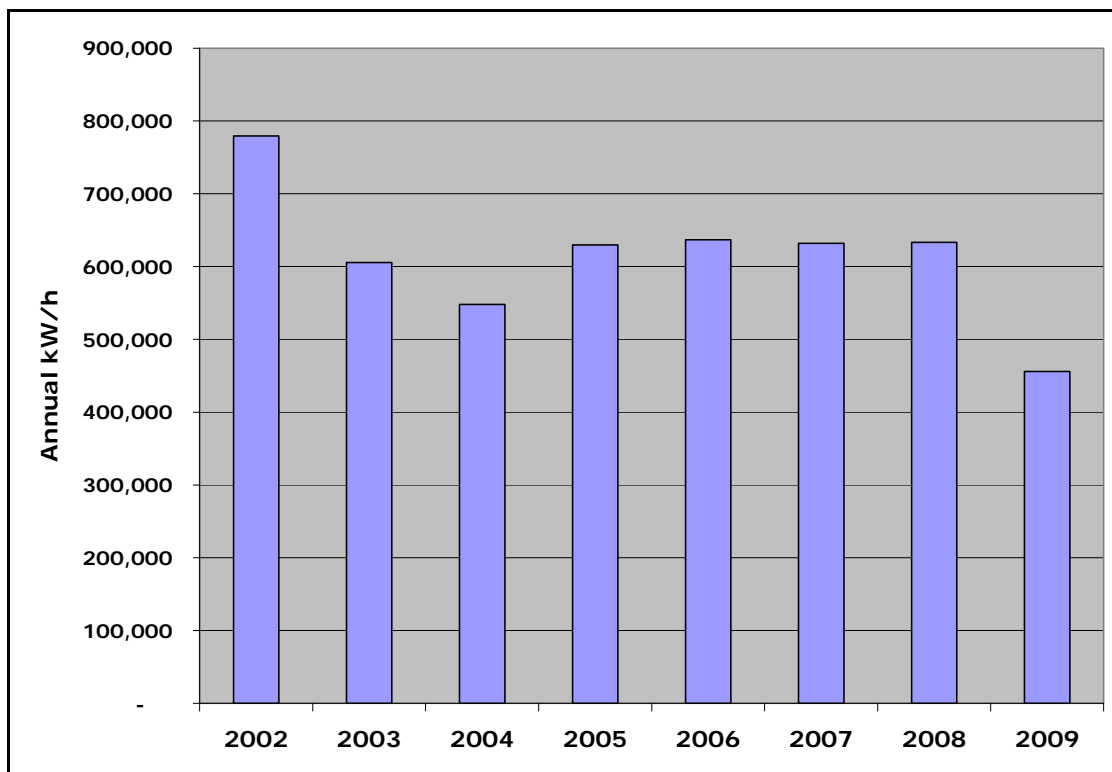


Figure 9.3 shows the electricity used in Acton's street lights. The drop in 2009 electricity use is due to the replacement of the old lights.

Figure 9.3: Electricity Use for Acton Street Lighting by Calendar Year



Source: NStar

Total annual energy use in public buildings is approximately 10.375 million kilowatt hours (kWh) and 522,000 therms of natural gas. Converting these units to millions of BTU⁴s (mmBTU) gives a total use in public buildings of 87,590 mmBTU. This number is significant primarily as a benchmark for comparison with future energy use.

Community-wide Carbon Footprint

Acton's total "carbon footprint," i.e., its total energy use, converted to annual tons of carbon dioxide, is composed of six major parts:

- Home, business, and public electricity use for lighting, cooking, water heating and some space heating;
- Home, business, and public natural gas use for space and water heating and cooking;
- Home, business, and public heating oil use for space heating;
- Fuel use for private and public transportation;
- Energy embodied in the production, use and disposal of objects;
- Energy associated with solid waste.

⁴ 1 mmBTU = 10 therms; 1 mmBTU = 293.1 kW hours.

The first four items in this list comprise the “primary” footprint, i.e., energy directly used by households, businesses, and town government; the last two items are the “secondary” footprint, which comprises energy used to produce the material goods used in Acton. The energy use in the secondary footprint may occur anywhere in the world, including overseas where many consumer goods are produced; it is as relevant to climate change as the energy actually used within the Town.

The available data on residential energy use are not entirely consistent, so the estimates that go into the overall carbon footprint will remain somewhat uncertain, at least until the detailed information from the 2010 U.S. Census becomes available in 2012. Data on the fuel used for home heating comes from the 2000 Census and the 2009 Census Bureau American Community Survey, as well as data provided by National Grid for natural gas.

Table 9.3: U.S. Census Data on Heating Fuel Used in Acton Housing Units, 2000

Type of Heating Fuel	2000		2009	
	Number of Households	Pct of Total	Number of Households	Pct of Total
Natural Gas from Utility	3,109	41.5%	3,266	44.2%
Fuel oil, kerosene, etc.	2,994	39.9%	2,657	36.0%
Electricity	1,176	15.7%	1,058	14.3%
Bottled, tank, or LP gas	163	2.2%	335	4.5%
Wood	35	0.5%	49	0.7%
Solar energy	6	0.1%	0	0.0%
Coal or coke	0	0.0%	0	0.0%
Other Fuel			23	0.3%
Total Housing Units	7,495	100%	7,388	100%

Source U.S. Census 2000, U.S. Census Bureau American Community Survey, 2009

Note: The 2009 figures are an estimate based on a small sample of Acton households; it underestimates the number of households (8,415), but the percentage breakdown is probably representative of all households.

It is noteworthy that while approximately 81 percent of households used natural gas or heating oil in 2000, nearly 16 percent used electric heating, which is substantially more costly. The American Community Survey estimates for 2009 are based on a small sample which is probably not sufficient for comparison for the small numbers such as bottled gas, solar, or wood; but the estimates seem to indicate some shift away from heating oil and electric heat and toward natural gas from National Grid, the utility that provides gas to Acton residences. (However, National Grid data indicates a greater shift than estimated by the Census Bureau for 2009.)

The use of electric heating by roughly one-sixth of the households in Acton increases average use of electricity, as discussed below, compared to the majority of households that use natural gas, oil, or other sources of heat.

Natural Gas

National Grid provided information on the amount of natural gas they supplied in 2009 and 2010. This data is shown in Table 9.4.

Table 9.4 Natural Gas Use by Residential and Non-Residential Customers, 2009-2010

Rate Group	2009		2010		Consumption per Account		
	Number of Accounts	Total Gas Consumption (therms)	Number of Accounts	Total Gas Consumption (therms)	2009	2010	Percent Change
Residential Heat	3,963	4,315,667	4,192	4,114,452	1,089	982	-4.7%
Residential Non-Heat	105	24,016	104	20,481	229	197	-14.7%
Commercial/Industrial/Public	646	4,455,738	660	4,101,121	6,897	6,214	-8.0%
Total		8,795,421		8,236,054			-6.4%
Heating Degree Days					10,224	9,402	-8.0%

Sources: National Grid; degree days from www.degreedays.net at Acton Great Hill weather station.

The table shows that non-residential use of natural gas for heating (which includes public buildings as well as private business and industry) is roughly the same magnitude as all residential customers. Residential use of natural gas per account decreased from 2009 to 2010; however, the number of heating degree-days was smaller in 2010 by a larger margin, indicating that the use of energy for heating would have increased slightly if the weather had been the same in both years.

Using the data from Table 9.3, approximately 44 percent of Acton households used natural gas for heating in 2009; applying this percentage to the estimated 8,415 households yields 3,720 households heating with gas. However, the data from National Grid is probably more reliable than the American Community Survey estimate; 4,192 household accounts is equivalent to 49.8 percent of Acton's 8,415 households. It is likely that there are some National Grid accounts for large multifamily buildings in which there is not a separate gas meter for each unit, and this would further increase the estimated number of households using natural gas heat.

There are 410 households in Acton living in buildings with 50 or more units and 708 living in buildings with 20 to 49 units. If only the largest buildings (50 or more units per building) had a single gas meter, there would be an additional 409 households with gas heating, raising the total to 4,601 households (55% of all Acton households) using natural gas for heating. If half of the buildings with 25 to 49 units also have a common gas meter for all units, this would raise the total to 4,954 households with gas heat (59% of Acton households). These estimates are substantially higher than the 44% from the 2009

American Community Survey, indicating smaller percentages of homes that use heating oil or electricity for heat.

Dividing total residential gas consumption in 2010 by 4,601 gives a per-unit average of 894 therms per household. This is higher than the statewide average of 850 therms reported by NStar, the other major natural gas utility. Dividing by the higher estimate of 4,954 households gives a per-unit estimate of 830 therms per household.

More data is needed to observe any trends in energy use that result from efforts to encourage conservation by residents and businesses. However, the above data provides a rough estimate that can be refined when 2010 Census data becomes available and a baseline against which future energy consumption can be evaluated.

Therms are converted to pounds of CO₂ at the rate of 11 pounds per therm in the footprint summary Table 9.7 below.

Heating Oil and Electric Heat

As noted above in the calculation of natural gas use, 55% to 59% of Acton households use gas for heating, leaving 41% to 45% that use heating oil, electricity, or other fuels such as wood or bottled gas. Based on the calculation and Census data and estimate in Table 9.3, it is likely that heating oil customers account for approximately 65% of the non-gas households (27-29% of all households), and users of electric heat account for approximately 30% of non-gas households (10-11% of all households).

Table 9.5 provides a rough proportion of heating fuel shares, based on the National Grid data and Census estimates.

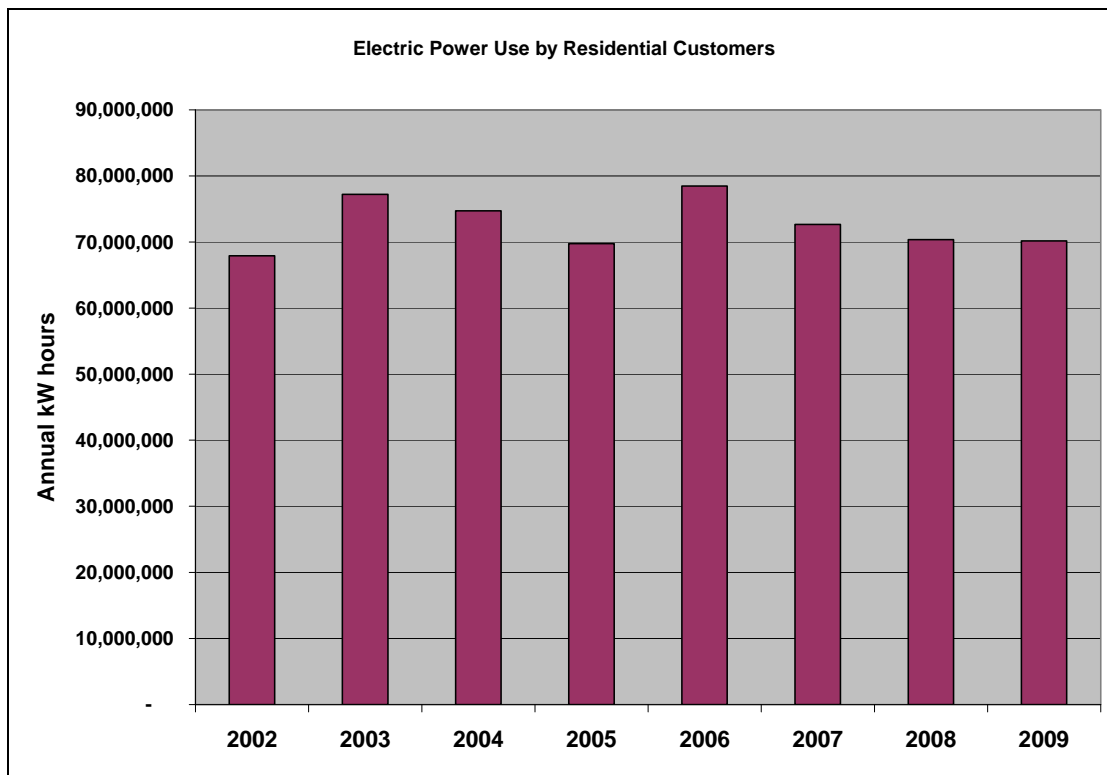
Table 9.5 Assumed Shares of Residential Heating Fuels

Number of Households	Number of Households	Percent of Households
Natural Gas from National Grid	4,600 – 4,950	55% - 59%
Heating Oil	2,250 – 2,475	27% - 29%
Electricity	870 – 960	10% - 11%
Other Fuels	300 – 380	4% - 5%
All Households	8,415	100%

The electricity used for home heating is already included in the total residential electricity use. The amount of heating oil used by Acton households can be roughly estimated by using a typical figure of 800 gallons of heating oil per year; this translates into approximately 41,000,000 gallons per year for all households using heating oil. This figure is converted to pounds of CO₂ in the footprint summary Table 9.7 below, using a conversion value of 22 lbs CO₂ per gallon of heating oil.

Electricity

Figure 9.4 shows residential electricity use, based on data provided by NStar



Source: NStar

The data does not show a significant trend until 2006; since then residential electric use has declined by 10.6 percent, which may reflect consumer awareness of the need to conserve and particularly the replacement of incandescent lighting with compact fluorescent lamps. Stated another way, the residential electricity use in 2008 and 2009 was approximately 3.2% to 3.4% less than the average for 2002 through 2009.

For non-residential customers (including public buildings), the electricity use in 2009 was approximately 5.7% less than the average of 102 million kWh for 2002 through 2009.

Based on the 2009 total of approximately 70,000,000 kWh, the 8415 households in Acton had an average electricity use of approximately 8,300 kWh. According to NStar's carbon calculator website, the average residential customer uses 6,000 kWh per year, indicating that Acton households use substantially more than the average. This may be due in part to the proportion of households that have electric heat.

The CO₂ emissions per kilowatt hour of electricity depend on the efficiency of each electricity generation plant that contributes to the electrical grid and the type of fuel used by each generator. This can vary widely from place to place and over time from over 2 lbs CO₂ per kWh where coal is the energy source to zero for hydro and nuclear. The conversion factor used in this inventory report is 1.4 lbs per kWh, which is the value currently used by NStar in their on-line carbon calculator.

Transportation

The third major use of energy by residents of Acton is for transportation. Nationally, 28 percent of energy⁵ is used in transportation of all kinds, and the predominant mode is automobile transportation. A major part of the sustainability problem is that, while automobiles can achieve higher fuel economy through engineering and use of technologies like hybrid power trains, these gains are wiped out by rising trends in vehicle miles traveled (VMT). Therefore, reducing VMT is a major part of achieving sustainability.

The data in Chapter 6 on modes of transportation in commuting to work indicate that 80.8 percent of Acton residents commuted to work in 2000 by driving alone; another 7.4 percent used car pools, and 4.5 percent used public transportation; the remaining 7.7 percent walked, biked, or worked at home. National data indicates that commuting accounts for slightly less than two trips per day per household, despite the fact that households with two wage earners may have four commute trips per day; however, many households have retirees who do not commute at all. On the other hand, the total number of trips per household is typically between eight and nine, including the commuting trips. This means that trips for shopping, entertainment, socializing, medical appointments, and other purposes outweigh commuting trips by more than four to one. This is significant because even those residents who use modes other than driving alone to commute are likely to drive to most other destinations.

Chapter 6 discusses transportation and the potential for energy saving modes such as public transportation and shuttle bus, walking, and bicycling. All of these modes are highly dependent on favorable land use patterns that provide enough density to make public transportation feasible and destinations close enough together to make walking and bicycling reasonable alternatives. For people who live in a village like West Acton, there are more non-automobile dependent options for some of the trips they take each day, and it may be feasible to serve other trips such as to Town hall and Memorial Library or to the large supermarkets by shuttle van. More use of shuttles, walking, and bicycling are ways to reduce household energy use for transportation.

Motor Fuel Use

Transportation energy use depends on both the efficiency of the automobiles used for the trips and the total number of miles driven for all purposes. However, an order-of-magnitude estimate is possible. Metropolitan Area Planning Council (the regional planning agency for 101 cities and towns around Boston), working with MIT Department of Urban Studies and Planning, estimated that the average vehicle miles traveled (VMT) by an Acton household is 76.0 miles per day or approximately 28,000 miles per year. (This data is derived from Registry of Motor Vehicle inspection records and thus includes trips for all purposes, not just commuting.) Acton ranks 212 among the 351 Massachusetts cities and towns in VMT.

Table 9.4 shows the average vehicle miles traveled per day by households in Acton and the adjoining communities.

⁵ This figure is based on all energy use, including in its base the use of energy in the production and transportation of goods and provision of government and private sector services.

Table 9.6 Vehicles Miles Traveled and Vehicles per Household, Acton and Adjoining Towns

	Average Daily Vehicle Miles Traveled (VMT) per Household	VMT per Household Rank in Massachusetts ¹	Passenger Vehicles per Household
Acton	76.0	213	2.1
Boxborough	82.3	262	2.1
Carlisle	86.5	290	2.5
Concord	64.4	123	2.0
Littleton	84.2	276	2.2
Maynard	58.4	174	1.8
Stow	85.7	285	2.4
Sudbury	79.2	242	2.3
Westford	88.1	298	2.4
average	78.3		2.2

Source: MAPC; data collected 2005-2007 from Massachusetts Registry of Motor Vehicles

¹ Higher rank indicates higher vehicle miles traveled.

Acton households had the third lowest vehicle miles traveled among the nine adjoining towns, averaging 76.0 miles per day for all purposes. Total vehicle miles traveled is influenced by the availability of an automobile for each driver, by the use of an automobile instead of public transportation, biking, or walking, and by the distances to work, shopping, and other destinations. For comparison, Cambridge and Brookline households averaged 23 and 24 vehicle miles per day and owned an average of 0.9 and 1.0 passenger vehicles; these low numbers are made possible by their urban density and availability of public transportation.

Carbon Footprint from Passenger Vehicles: Assuming 20 miles per gallon and 76.0 vehicle miles traveled per day, the average Acton household uses nearly 1,400 gallons of fuel per year, which results in 13.5 tons of CO₂ emissions per year. For Acton's 8,415 households, the total vehicle miles traveled burn approximately 12 million gallons of fuel, resulting in 117 tons of CO₂ entering the atmosphere⁶.

Overall Summary

Acton has made a serious commitment to sustainability in its membership in ICLEI and its certification under the Massachusetts Green Communities Act. The Town has completed a benchmark survey of its energy use in schools and other public buildings and is working to improve the energy efficiency of these buildings and to encourage behavior that reduces energy use.

⁶ The U.S. Environmental Protection Agency uses the conversion factor 19.4 pounds of CO₂ per gallon of gasoline.

Table 9.7 Estimated Acton Carbon Footprint

Greenhouse Gas Emissions Sources	Lbs of CO2 equiv	Tons of CO2 equiv	Percent
Residential / Electric	98,000,000	49,000	15.1%
Residential / Natural Gas	45,484,263	22,742	7.0%
Residential / Oil	41,000,000	20,500	6.4%
Residential / Gasoline for Vehicles	279,445,381	139,723	43.0%
Commercial+Industrial / Electric	120,135,400	60,068	18.5%
Commercial+Industrial / Natural Gas	39,370,331	19,685	6.1%
Town+School / Electric	14,525,000	7,263	2.2%
Town+School / Natural Gas	5,742,000	2,871	0.9%
Total	643,702,375	321,851	100.0%
Residential Only:	463,929,644	231,965	72%
Per capita (population 21, 924 per US 2010 Census)	21,161	10.6	
Per Household (8415 per Acton Town Clerk)	55,131	27.6	

Source: Calculations in Appendix

Note: This table excludes the energy associated with solid waste.

More refinement of the data is needed, particularly with respect to the amount of oil heat used by Acton residents (see discussion above). Additional work is also needed to estimate the energy and resultant carbon emissions associated with Acton's solid waste. This involves both the rate of recycling and the destination of the solid waste: incineration at a waste-to-energy plant whose electrical power is sold to the electrical grid actually reduces regional carbon emissions compared to coal-fired electrical generation.

However, some observations can be made.

Gasoline for personal transportation is the largest single category of energy use and carbon emissions; it amounts to 43 percent of the Town's carbon footprint and 59 percent of the residential total, while electricity and heating fuels each account for approximately 20 percent.

Acton's per capita energy use for home heating, electricity, and personal transportation is in line with the national average primary footprint, about 10.4 tons of CO₂ per capita, excluding air travel⁷. The footprint calculation leaves out the carbon associated with personal air travel, which might be estimated through a survey. For many American households, the carbon emissions from air travel may be of the order of magnitude of 10 tons of CO₂ equivalent per household.

The tools are in place to advance the other objectives related to sustainability: management of water, wastewater, and stormwater, preservation of agricultural land, and reduction of solid waste and toxic materials that enter the environment. More can be done in all these areas. The following list of opportunities and challenges related to environmental sustainability.

⁷ U.S.EPA Household Emissions Calculator
http://www.epa.gov/climatechange/emissions/ind_calculator.html