



Estimate Local Energy Use Baseline

Before identifying energy goals, and consequent strategies to reach those goals, communities must first develop an energy use profile of the community as a whole, including the municipal, residential, commercial and industrial sectors. Unfortunately, residential, commercial and industrial data is currently not available at the municipal level from utilities, so that portion of the profile must be estimated based on census data, labor statistics and building energy survey analyses. This methodology can serve as a baseline for local energy planning efforts and provide insight as to the types and scale of energy use within a community. However, since they are based on static data sources, the baselines derived using this methodology cannot be used to benchmark and monitor subsequent changes in consumption due to an energy efficiency outreach program.

This strategy describes how to derive local energy use baselines for the residential, commercial and industrial sectors in Massachusetts communities. However, this data is publically available on the national level and could be replicated for a community anywhere in the United States (with some modifications to regional-specific assumptions). In the interest of simplicity, these baselines include only electricity, natural gas and fuel oil consumption. Communities that rely heavily on other fuels (e.g., wood, propane or district heating) should consider expanding the methodology to account for those fuel types.

Since different energy types have different units of measure, in order to compare them a common measurement must be used, in this case, Btus (British thermal units). For reference, the following conversion factors are used to compare physical fuel units with Btus:

Table 1: Energy Unit Conversion Factors.

Energy Unit Conversion Factors		
Fuel Type	Units	Factor
Electricity	MMBTU/ kWh	0.003412
Natural Gas	MMBTU/ therm	0.1
Fuel Oil	MMBTU/ gallon	0.139

Residential Sector

Referenced Data Sets

- [American Community Survey \(ACS\), 2011-2015 5-Year Community Estimates](#)
 - Units in Structure
 - Heating Fuel
- [Energy Information Administration \(EIA\) Residential Energy Consumption Survey \(RECS\), 2009](#)
 - Fuel Consumption Totals and Averages, US Homes
 - Fuel Expenditures Totals and Averages, US Homes
 - Structural and Geographic Characteristics, in Northeast Region, Division, and States
 - Consumption and Expenditures, Fuel Consumption Totals and Averages, Northeast Homes

Step-by-Step Instructions

1. Find the number of housing units, by type.

Search for “Units in Structure” for the community in the ACS 2015 5-year estimates to determine the total number of housing units for the following types:

- a. Single-Family, Detached
- b. Single-Family, Attached
- c. Multi-Family, 2-4 Units (Sum of 2-Family and 3-4 Units categories)
- d. Multi-Family, 5+ Units (Sum of 5-19 Units, 20-49 Units, and 50+ Units categories)
- e. Other

2. Determine the percentage of homes within a community that heat with different fuel types.

Search for “House Heating Fuel” for the community in the ACS 2015 5-year estimates and divide the number of units that heat with each of the following major fuel types by the total to determine the percentage:

- a. Utility Gas (natural gas)

- b. Fuel Oil
- c. Electricity

Table 2: Sample results table for different heating fuel sources in a community.

MUNICIPALITY	TOTAL UNITS	SF_DETACHED	SF_ATTACHED	2-4 UNITS	5+ UNITS	% GAS HEAT	% FUEL OIL HEAT
Chelsea	13,009	1,345	594	6,748	4,322	48%	18%

3. Determine state average use and expenditure by fuel type for each housing unit type.

Start with EIA RECS 2009 Consumption and Expenditures, By Fuel and use “Fuel Consumption Totals and Averages, US Homes” and “Fuel Expenditures Totals and Averages, US Homes” to determine average consumption and expenditures by housing type. These numbers are national averages. Because there are some differences in the percentage breakdown of housing unit types in Massachusetts and the US, the national averages must first be weighted by the percentages of housing unit types at the state level.

Example: Calculate the average annual electricity consumption of a single-family, detached home in Massachusetts. Data on types of housing units in Massachusetts can be found in the EIA survey under “Structural and Geographic Characteristics, in Northeast Region, Division, and States.” EIA provides the number of units for each type; divide them by the total of all households to get the percentage. Data on Massachusetts average electricity consumption can be found in the EIA survey under “Consumption and Expenditures, Fuel Consumption Totals and Averages, Northeast Homes.”

Table 3: Calculating average electricity consumption by housing type in Massachusetts.

	A	B	C	D	E
1		US Average Electricity Consumption (kWh)	% Units in US	% Units in MA	MA Average Electricity Consumption
2	All Households	11,320	100%	100%	6,967
3	Single Family, Detached	13,173	63%	48%	?
4	Single Family, Attached	9,036	6%	4%	?
5	2-4 Units	7,159	8%	24%	?
6	5+ Units	6,376	17%	20%	?
7	Other	13,362	6%	4%	?

Massachusetts has a lower concentration of single family homes and a higher concentration of two- to four-unit apartments. In order to account for this when comparing an average Massachusetts home with an average US home (averaged across all housing units), the first step is to obtain a weighted US Average Electricity Consumption based on the percentage breakdown of housing unit types in Massachusetts. The following formula is used:

$$=SUMPRODUCT(B3:B7, D3:D7)/SUM(D3:D7)$$

In other words, this represents what average US household electricity consumption would be if housing unit types in the US were the same as they are in Massachusetts. Calculate the ratio of Massachusetts average electricity consumption to this weighted US number ().

Table 4: Calculating an adjustment ratio.

	Electricity Consumption (kWh)
Average MA Household	6,967
Average US Household, MA-Adjusted	10,212
Adjustment Ratio	68%

The average Massachusetts household uses approximately 68% of the electricity that the average US household does, with variations in housing stock held constant. To obtain average electricity use by housing unit type in Massachusetts, simply multiply the amounts in cells B3:B7 by 68%.

	A	B	C	D	E
1		US Average Electricity Consumption (kWh)	% Units in US	% Units in MA	MA Average Electricity Consumption
2	All Households	11,480	100%	100%	6,967
3	Single Family, Detached	13,159	63%	48%	8,987
4	Single Family, Attached	9,240	6%	4%	6,164
5	2-4 Units	7,460	8%	24%	4,884
6	5+ Units	7,001	17%	20%	4,350
7	Other	11,787	6%	4%	9,116

Repeat this process for natural gas, fuel oil, and expenditures.

4. Determine total local energy consumption and expenditures.

Multiply the number of housing units of each type in the municipality by the average Massachusetts consumption for that housing type, and add the results together. Heating fuels (natural gas and oil) are also multiplied by the percentage of units in a community using that fuel.

Commercial Sector

Referenced Data Sets

- [The MA Executive Office of Wages and Labor Division \(EOWLD\)'s ES-202 – Employment and Wages Survey](#)
- [The Energy Information Administration's Commercial Building Energy Survey \(CBECS\), 2012](#)

Step-by-Step Instructions

1. Find the total number of employees and establishments by Primary Building Activity (PBA).

EOWLD ES-202 survey data lists the number of employees and establishments by industry, sorted by North American Industry Classification System (NAICS) codes. EIA CBECS analyzes energy use and consumption data based on Primary Building Activity (PBA). The following [crosswalk](#) (generated by EIA) roughly correlates the PBA codes used in CBECS with standard three-digit NAICS codes between 400 and 1000.

To find employee and establishment data for PBA categories, visit the ES-202 survey webpage. Select the municipality, the most recent year and quarter, private ownership, “Total, All Industries,” & “Category and all sub-categories” on the EOWLD ES-202 query page.

Table 5: NAICS code crosswalk table for identifying Primary Building Activity.

	PBA	NAICS Code (3-digit)
A	Education	611
B	Food Sales	445
C	Food Service	722
D	Inpatient Health Care	622
E	Outpatient Health Care	621
F	Lodging	623, 721
G	Retail (non-mall)	441, 442, 443, 444, 451, 452, 453, 532
H	Retail (mall)	446, 448
I	Office	454, 486, 511, 516, 517, 518, 519, 521, 522, 523, 524, 525, 531, 533, 541, 551, 561, 624, 921, 923, 924, 925, 926, 928
J	Public Assembly	481, 482, 485, 487, 512, 515, 711, 712, 713
K	Public Order/ Safety	922
L	Religious Worship	813
M	Service	447, 483, 484, 488, 491, 492, 811, 812
N	Warehouse/ Storage	423, 424, 493
O	Other	562, 927

To find the total number of employees and establishments by PBA, sum the quantities for the NAICS codes in each PBA category.

2. Determine average energy use and expenditures by employee for each PBA.

In the CBECS 2012 database, tables C14, C24 and C34 (under the 'Consumption & Expenditures' section) provide average energy use and expenditures by building, square footage, and employee for each PBA. Although square footage would be the most reliable factor for scaling up community-level data, information on square footage by PBA on a community level is not easily obtained. Therefore, average use and expenditures by employee is used for the purposes of this methodology. These are all US averages.

Note: Enclosed and Strip Malls – The 2012 CBECS survey employed a different data collection method for mall buildings, and energy data is not available by employee. Use data by building instead.

Note: Fuel Oil – The data available in the 2012 CBECS for fuel oil consumption is incomplete for some PBAs. Two options for estimating the missing data were explored for the purposes of this baseline:

- Option 1: Compare average fuel oil use to average natural gas use in the same building types, using Office buildings as a baseline. For example, if a PBA that uses natural gas uses 50% more natural gas than an Office building, assume that if the same PBA used fuel oil, it would use 50% more fuel oil than an Office building. This is the preferred method, as it yields a more conservative estimate.
- Option 2: Find average fuel oil consumption for an average New England building (across all PBAs) and divide it by the average number of employees in an industry. Use this as the scaling factor.

3. Calculate total energy use and expenditures.

- Multiply the total number of employees in each PBA by the average energy consumption (or average energy expenditures) by fuel type for that PBA. For malls, use the number of establishments instead of employees.
- For natural gas and fuel oil, multiply the result by the percentage of buildings that heat with each fuel type. (For electricity, assume a factor of 100%.) For example, if 30% of the buildings in a community heat with fuel oil, the following equation would be used:

$$(\text{Total Employees}) \times (\text{Average Fuel Oil Consumption by Employee}) \times 30\%$$

Industrial Sector

Referenced Data Sets

- [The Energy Information Administration’s Manufacturing Energy Consumption Survey \(MECS\), 2010](#)
- [The MA Executive Office of Wages and Labor Division \(EOWLD\)’s ES-202 – Employment and Wages Survey](#)

Step-by-Step Instructions

1. Find the total number of employees and establishments by industry type.

EOWLD ES-202 survey data lists the number of employees and establishments by industry, sorted by North American Industry Classification System (NAICS) codes. EIA CBECS analyzes energy use and consumption data based on Primary Building Activity (PBA). To find employee and establishment data for PBA categories, select the municipality, the most recent year and quarter, private ownership, and the NAICS code in question on the EOWLD ES-202 query page.

This sector encompasses NAICS codes between 311 and 339. Industrial energy uses between 100 and 200 (such as power generation and utility operations) are not incorporated in this methodology.

Table 6: Industrial NAICS codes.

NAICS_3	Industry	NAICS_3	Industry
311	Food	326	Plastics and Rubber Products
312	Beverage and Tobacco Products	327	Nonmetallic Mineral Products
313	Textile Mills	331	Primary Metals
314	Textile Product Mills	332	Fabricated Metal Products
315	Apparel	333	Machinery
316	Leather and Allied Products	334	Computer and Electronic Products
321	Wood Products	335	Electrical Equip., Appliances, and Components
322	Paper	336	Transportation Equipment
323	Printing and Related Support	337	Furniture and Related Products
324	Petroleum and Coal Products	339	Miscellaneous
325	Chemicals		

2. Determine average energy consumption by employee for each industry.

“Ratios of Mfg. Fuel Consumption to Economic Characteristics, Table 6.1 By Mfg. Industry & Region” provides a reference table for total MMBTU use per employee for each industry in the Northeast. Multiply the number of employees in each industry by the average MMBTU use for that industry.

3. Approximate the percentage of total energy use for each fuel type.

- “Consumption of Energy for All Purposes (First Use), Table 1. By Mfg. Industry & Region (physical units)” provides a total quantity of energy consumption by industry in trillion Btu.
- “MECS Table 5.4 – End Uses of Fuel Consumption” provides a total quantity of energy consumption by fuel type and industry in trillion Btu.
- Divide the total quantity of energy consumption by fuel type by the total quantity of energy consumption overall to obtain a percentage that can be used to approximate how much of each fuel type is used by each industry in each community.
- Sum the total MMBTU overall and by fuel use for all industry types for each community to obtain total energy use information.

Note: This methodology for the industrial sector currently accounts for energy consumption only. Expenditures are not included.

Example:

	A	B
1	Industry	311 - Food
2	MMBTU/Establishment (US Avg)	83,947
3	MMBTU/employee (Northeast)	435
4	Total Energy Consumption (trillion)	1186
5	Total Electricity Consumption (trillion BTU)	266
6	% Electricity of Total	22%
7	Total NG Consumption (trillion BTU)	635
8	% NG of Total	54%
9	Total Fuel Oil Consumption (trillion BTU)	42
10	% Fuel Oil of Total	4%

Chelsea, MA	# Employees	Total MMBTU	Electricity MMBTU
311 - Food	973	$(973 \times B3) = 422,768$	$(422,768 \times B6) = 93,008$

4. Use the energy baselines as a benchmark for next steps.

The steps outlined in this guide merely serve to provide a community with a more nuanced view of their energy profile across the residential, commercial, and industrial sectors using publicly available data sets. These profiles can then provide the community with any insight on concerning energy consumption trends, and can further inform consequent decisions on energy-related project work.