Ripe for an Energy Efficiency Retrofit?

An Analysis of Residential Energy Consumption in Somerville

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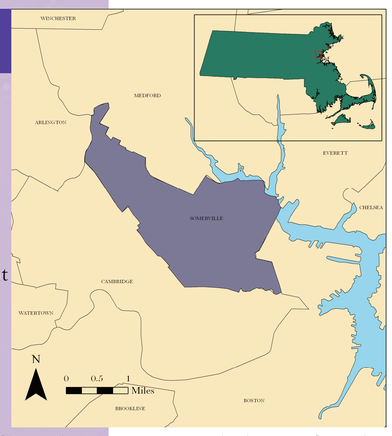
April 2010
Projection: Massachusetts State Plane Mainland, NAD 1983, meters
Sources: MassGIS, U.S. Census Bureau, Somerville Assessor's Database

Overview



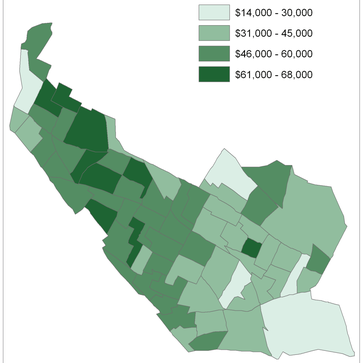
As the United States works to reduce its greenhouse gas emissions and fossil fuel dependence, the role of residential energy efficiency in reducing energy consumption must be recognized. In 2006, residential buildings were responsible for 37 percent of the country's electricity consumption[1] and 2,236 million metric tons of carbon dioxide emissions,[2] largely the result of an inefficient national housing stock.

For a municipal government interested in promoting residential energy efficiency, it is important to know how much energy is being consumed. Unfortunately, utility data documenting each household's energy use is sometimes impossible to obtain. Therefore, this analysis attempts to calculate residential energy consumption in Somerville by using 2000 U.S. Census data, Assessor's data, and a statistical regression model that predicts the influence of several socioeconomic variables on residential energy consumption.[2] The model considers the following variables: percent of homes built by decade, percent of rental units, percent of seniors, median household income, heating fuel type, and average number of people per household. Somerville has an old housing stock, a high renter population, and a relatively low median income, all of which has an effect on its energy consumption.

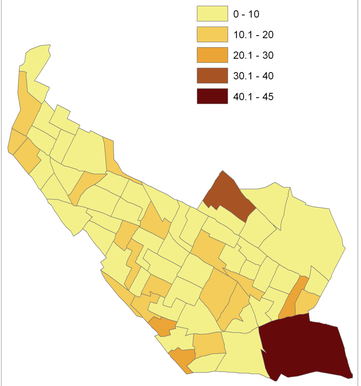
GIS is an ideal tool for this kind of analysis because: (1) the model requires that residential parcels are isolated from parcels with other uses and that they are spatially aggregated to the census block group level from the parcel level, and (2) GIS allows the results to be clearly displayed in a map and shared with the public.

[1] U.S. Department of Energy. (n.d.b). *Carbon Dioxide Emissions for U.S. Buildings*. Retrieved March 26, 2010, from Buildings Energy Databook: http://buildingsdatabook.eren.doe.gov/TableView. aspx?table=1.4.1
[2] U.S. Department of Energy. (n.d.b). *Carbon Dioxide Emissions for U.S. Buildings*. Retrieved March 26, 2010, from Buildings Energy Databook: http://buildingsdatabook.eren.doe.gov/TableView. aspx?table=1.4.1
[3] The statistical regression model was developed by Tufts University student, Neil Veilleux, for his Master's thesis: *Energy Mapping for Community Energy Efficiency Initiatives* and is based on the national Residential Energy Consumption survey

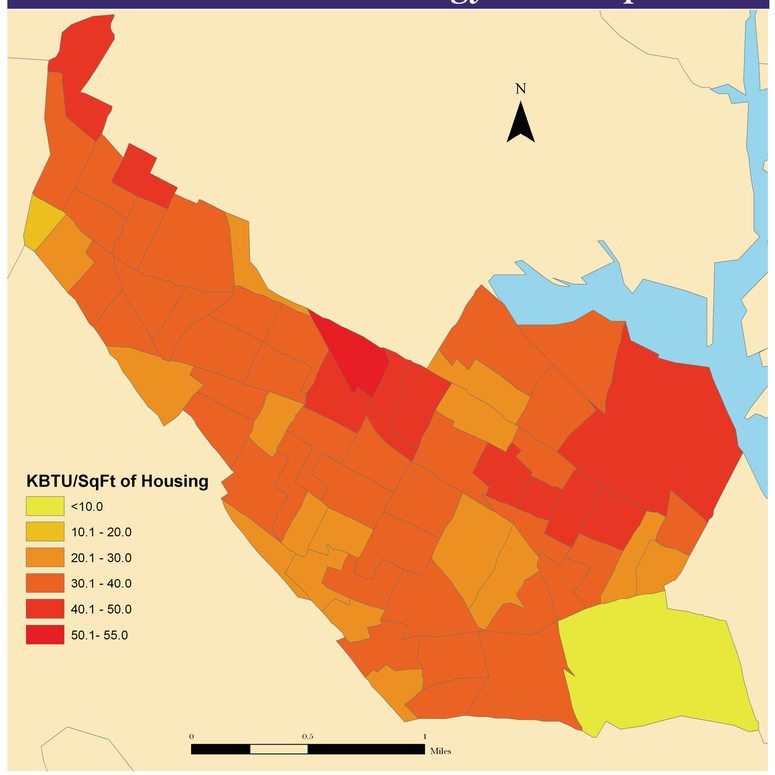
Median Household Income



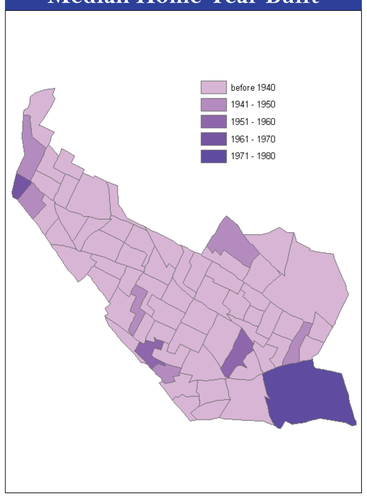
Percent Electric Heat



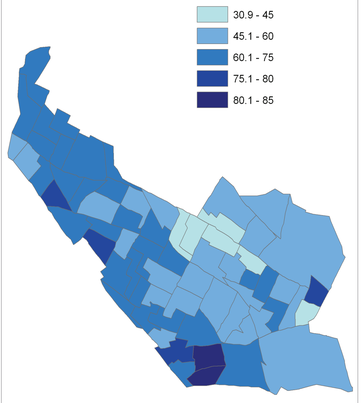
Annual Residential Energy Consumption



Median Home Year Built



Percent Natural Gas Heat



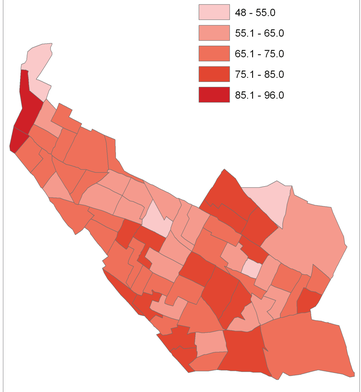
Process & Findings

The data sources for this analysis were the 2000 U.S. Census, the Somerville Assessor's Database, and MassGIS' Somerville census block group (CBG) layer, which were chosen for their public availability and broad accessibility. ArcGIS was used to isolate the Somerville parcels that were zoned "residential." The Assessor's data also had to be aggregated to the CBG level using a point to polygon spatial join in ArcGIS. In Excel, each of the variables was multiplied by its respective energy consumption regression coefficient for each CBG, two variables called heating degree days and cooling degree days which control for Somerville's climate, a New England variable to account for factors such as the region's unique fuel mix, and a control variable to account for the fact that the regression model only explains 57 percent of the variability in residential energy consumption. All of the variables were multiplied together and then divided by the average housing unit square footage for the relevant block group to produce a normalized estimation of residential energy consumption in kBtu/sqft/year for each CBG.

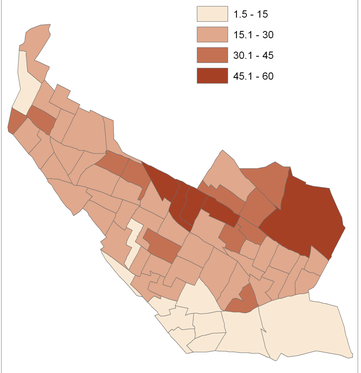
The resulting Energy Usage Index (EUI) for Somerville showed that its homes consume an average of 33 kBtu/sqft/year, with a minimum of 4.8 kBtu/sqft/year and a maximum of 52 kBtu/sqft/year. Homes built before 1960, which includes 82 percent of Somerville's housing stock, had a very high effect on energy consumption. The overall distribution of variation in residential energy consumption by CBG is shown in the "Annual Residential Energy Consumption" map at the top right.

Note: This analysis does have some data quality limitations. In some cases, the Census reported that a home used no fuel for heat, and some reported using coal or another source not specifically accounted for in the regression model, so those were all grouped into an "other fuel" category. Also, although the Census reports the actual year a home was built, some homes have already been retrofitted for energy efficiency or otherwise upgraded and so do not consume energy at the same rate as their contemporaries. These kinds of case-by-case issues may have an unaccounted-for effect on energy consumption.

Percent Renter Occupied



Percent Fuel Oil Heat



Implications for Energy Efficiency

This model has great potential as a tool for promoting widespread residential energy efficiency. If the data limitations associated with the model can be solved, the next step is to verify its accuracy using real utility data. If it could be vetted, this analysis has potential as a tool to circumnavigate the difficulty of accessing utility data, which would allow Somerville or other cities to understand residential energy consumption patterns and develop targeted energy efficiency programs to reduce energy consumption and greenhouse gas emissions.

For example, if the city can determine a baseline of residential energy consumption for each census block group (CBG), their proposed retrofit program's effectiveness can be tracked and a specific reduction goal for the program can be set. A community like Somerville could also take the results of this analysis and look at the impact of specific variables on the city's residential energy consumption. As mentioned before, the city has an exceptionally high rental rate, an old housing stock, and many houses use inefficient fuel oil for heating. Knowing how much each of these variables affect energy consumption will allow the city to target certain homes or block groups for extra support through the retrofit process.

The advantage of having energy consumption aggregated to the census block group level is that that the CBG contains a convenient number of households for focused, community-based energy efficiency retrofit initiatives. Neighborhoods with the highest annual energy consumption can receive targeted outreach from the city, neighbors can share information among themselves, and many small retrofit projects can be "bundled" together to reach a scale that would interest a contractor.

Finally, this analysis model's use of GIS underscores the importance of collecting quality data that can be widely applied. Many cities and states still do not maintain GIS data that can be easily accessed and used for analyses such as these.