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Analyzing Municipal Energy Performance in Worcester

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ANALYZING MUNICIPAL ENERGY PERFORMANCE IN WORCESTER

A Major Qualifying Project Report

by

Alexander Nittel

submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Arts

An Interactive Qualifying Project Report

by

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submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

Date: April 28, 2011

approved by:
Professor J. Scott Jiusto, Major Advisor
Dean Richard F. Vaz, Co-Advisor

Abstract

This project focused on testing and evaluating a new tool for municipal energy analysis, Mass Energy Insight (MEI). In cooperation with the City of Worcester, the team performed a preliminary analysis using MEI. Specifically, to identify and prioritize the buildings for which energy efficiency upgrades would best benefit the city. In addition, the team developed a user guide for MEI that includes a series of recommendations to improve the software.

Executive Summary

Given the present concerns over climate change and economic wellbeing, municipalities have an incentive to reduce their energy consumption. By reducing energy consumption, a municipality can decrease greenhouse gas emissions as well as reduce operating costs, thus saving the city and ultimately taxpayers' money. Buildings are a good starting point for reduction of energy consumption, as they are often a municipality's biggest energy consumers.

Reducing energy consumption is a daunting challenge; we worked with Mr. John Odell, Manager of the City of Worcester's Energy Efficiency and Conservation Program, in exploring a variety of project topics to address this. Worcester is a medium-sized city with a wide range of buildings of differing ages and conditions. Initially, the project focused on how to measure the impact of a more energy efficient building code on residential energy consumption. This new code, the Stretch Code, represents an opportunity for Worcester to reduce its energy consumption, while simultaneously being a challenge to implement. As the needs of Mr. Odell changed, the project focus shifted from residences to municipally owned buildings.

It became our task to evaluate how one might use an analysis tool called Mass Energy Insight (MEI) for such types of analysis. MEI is an online software package created to give Massachusetts municipalities a better way to analyze the energy efficiency of their operations. The software works by automatically importing fuel and electric usage data for municipal buildings and provides a series of plots and calculations to help in analyzing the data. The program has potential to make energy efficiency analysis easier for Worcester, but due to the relatively new nature of MEI, the city had no previous experience with it. We soon realized that laying the groundwork for future users of the software would be a valuable asset that we could

provide. We accomplished this by performing a preliminary analysis along with producing a user guide for MEI.

Mission and Objectives

Our goal was to help Mr. Odell evaluate how the city can use MEI. Future users of this tool can benefit from our experiences and be better prepared to use it. Our analysis demonstrates how Worcester can determine where to best allocate its funds in becoming a more energy efficient city. Our central objectives in reaching this goal included:

- **Understanding energy use in buildings**—To understand the fundamentals behind Mass Energy Insight as well as how buildings consume energy.
- **Reconciling the energy accounts and data** – To have accurate and useful data in Mass Energy Insight as well as throughout the project.
- **Analyzing the utility data** –To understand the various messages and underlying meanings found throughout the data.
- **Documenting our work and reporting our findings** – To communicate the useful information we expected to find in the course of analyzing the data.

Methodology

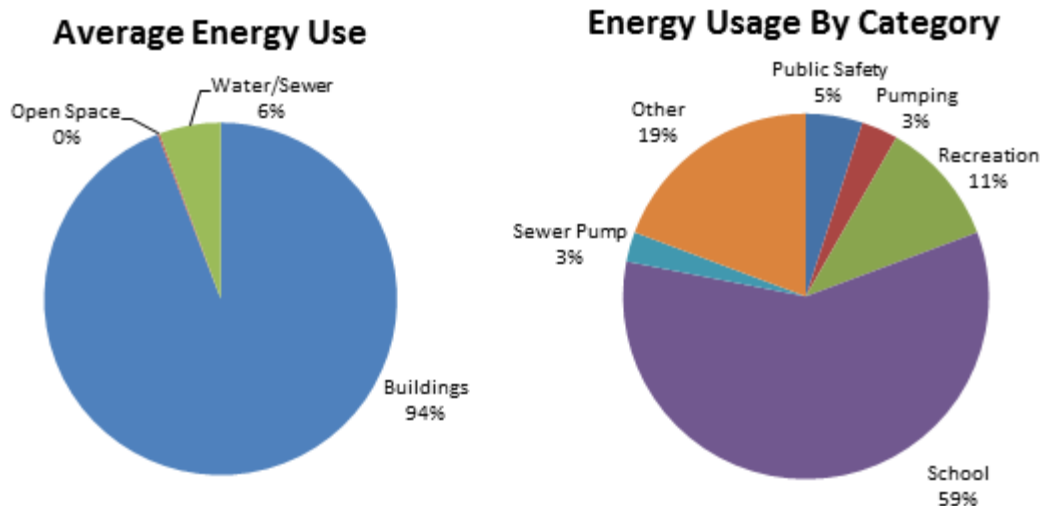
We began to address our objectives by learning about MEI’s functionality and watching its webinar tutorial. After gaining background knowledge of the tool, we researched how other cities had used MEI in their municipal energy analyses. Next, we focused on data preparation by matching the energy accounts with a list of buildings provided by Mr. Odell. We paid careful attention to data input as it directly affects results.

Once the accounts were reconciled, we were then able to download the data into an Excel spreadsheet. Downloading the data allowed us to manipulate it in ways not provided by MEI. We then considered the specific information deemed essential in giving Mr. Odell a knowledgeable recommendation and performing a preliminary analysis. First, we observed Worcester’s municipal energy use at the macro level. Next, we gathered information about energy use in various subcategories of buildings. Finally, we used an innovative metric to identify the

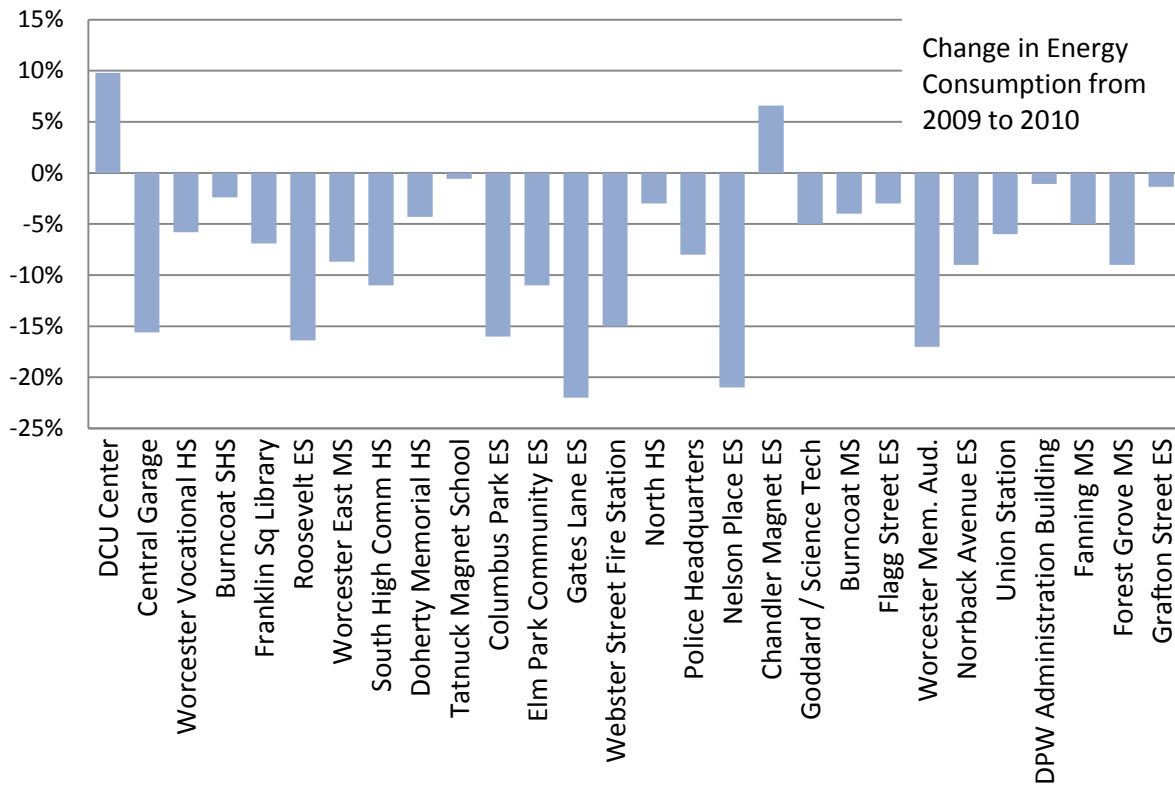
buildings that were most likely to need energy efficiency upgrades. Overall, the aforementioned steps brought us closer to making recommendations about which buildings the City of Worcester should investigate further. More importantly, we laid the foundation for future users of MEI.

Findings

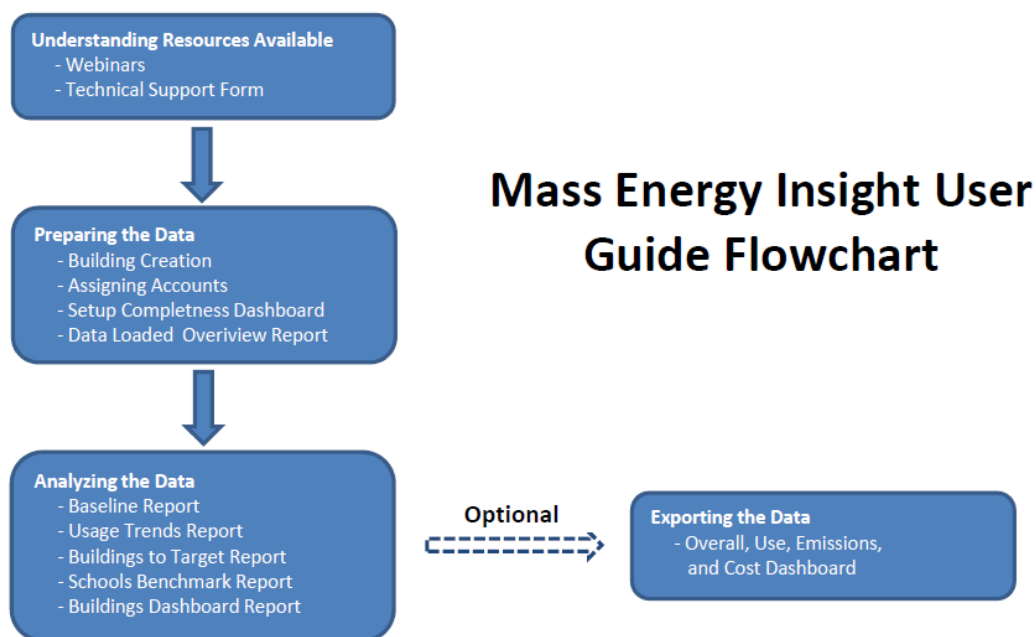
Our findings are broken into two categories: a preliminary analysis of Worcester’s municipal energy consumption and a set of techniques to using MEI. Our preliminary analysis was broken down into three levels: city, category, and building. At the city level, the majority of Worcester’s municipal energy use, excluding vehicles, comes from buildings. Amongst buildings, schools are the biggest energy users.



Several schools exhibited particularly interesting behavior: the Worcester Vocational High School, South High Community School, and Doherty Memorial High School. Each was unique in that either they consumed the same amount of energy from year to year, consumed more, or consumed less. At the building level, our analysis also included a list of select municipal buildings ranked in terms of energy efficiency and energy use. Buildings from this list include the DCU Center and Central Garage, which are two of the largest consumers of energy in the City of Worcester. Even a small reduction in their consumption could potentially save Worcester tens of thousands of dollars, due to the hundreds of thousands of dollars in operating costs for these buildings.



Finally, to convey the set of techniques used, we created a user guide for MEI to help future energy analysts. Due to the relatively recent creation of Mass Energy Insight, there is no user guide for new users. As such, the team thought it would be worthwhile to develop one. After following a series of simple steps, one will have a more informed idea of how to analyze energy usage. Illustrated below are four steps essential to maximizing one's experience with MEI.



In addition to the user guide, we have several recommendations for the City of Worcester regarding MEI:

- Make certain that all the data is entered reliably
- Allocate resources to conduct further analysis
- Organize the buildings by complexes and by units

Through the use of our user guide, observations about our analytical process, and consideration of our recommendations, a future user should be aided in their efforts to analyze municipal energy use. We are confident that the use of MEI can greatly enhance Worcester's decision-making process concerning energy efficiency upgrades and are pleased to have had the opportunity to lay the groundwork for such a useful tool.

Acknowledgements

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Chapter 1: Introduction

Climate change is a major issue currently confronting the world. Sharp reductions in greenhouse emissions are critical in combating this issue. Without tangible changes, scientists predict dire effects on biodiversity and the planet's ability to sustain life. According to Karl, Melillo and Peterson, "climate changes are already affecting our water, energy, transportation, agriculture, ecosystems, and health" (Karl, Melillo, & Peterson, 2009). The detrimental greenhouse gases produced worldwide need to be regulated and reduced to prevent disastrous global changes. The main culprit in the creation of greenhouse gases is energy, as "the vast majority of U.S. greenhouse gas emissions, about 87 percent, come from energy production and use" (Karl, Melillo, & Peterson, 2009). Furthermore, an increase in energy efficiency can lower energy bills. As such, one way to help combat climate change, which has anthropogenic origins, is to reform humanity's energy use habits on an individual, but more importantly, a municipal level.

Energy renovation projects, such as government subsidized home renovations or an upgrade by a municipality that reduces energy consumption, can be implemented on a relatively short timeframe and yield quick returns on investment (Zobler & Sauchelli, 2009). Most of the technologies used in these projects are mature and ready to be deployed at an affordable cost (National Action Plan for Energy Efficiency, 2008). These technologies include products such as more energy efficient building heating and cooling systems, sound structural integrity against elements, programmable thermostats which reduce temperatures at night and energy efficient lighting, such as compact fluorescents (CFLs). Implementation of these small to moderate projects can have a direct impact on the local economy, providing a municipality with more disposable income as utility costs decrease and efficiency increases over time.

Energy efficiency improvements offer one way that cities can respond to the climate crisis now, with existing technology. Recently cities in Massachusetts have been using software programs such as Mass Energy Insight to examine the state of their municipal buildings: first by reconciling all of the energy accounts for these buildings and then analyzing the data via various graphical representations (Commonwealth of Massachusetts, 2011; Town of Hatfield, 2010;

Town of Hopkinton, 2010). In doing this it becomes apparent where the city should focus its renovations.

Our goal was to help the City of Worcester's Energy and Efficiency Manager, Mr. John Odell, evaluate how the city can use a new energy analysis tool called Mass Energy Insight (MEI). Future uses of this tool will be able to refer to our work and use the tool to determine where Worcester can best allocate its funds in becoming a more energy efficient city, by analyzing the city's municipal energy use data.

We planned to accomplish this by:

- **Understanding energy use in buildings**—To understand the fundamentals behind Mass Energy Insight as well as how buildings consume energy.
- **Reconciling the energy accounts and data** – To have accurate and useful data in Mass Energy Insight as well as throughout the project.
- **Analyzing the utility data** –To understand the various messages and underlying meanings found throughout the data.
- **Documenting our work and reporting our findings** – To communicate the useful information we expected to find in the course of analyzing the data.

By using the objectives above, we developed a method of analysis and made a series of recommendations to Mr. Odell, the developers of Mass Energy Insight, and all future energy researchers.

Chapter 2: Background Information

In this chapter, we will explore how the growing climate and energy dilemmas have begun to affect municipalities, and how they are responding. We will first recognize that climate change is a global problem that has drawn national attention and legislation. Furthermore, we will explore how software tools have been developed to help municipalities manage the energy efficiency of their city-owned buildings. Additionally, we will provide an overview of these energy efficiency management tools that have been developed. In particular, we will focus on one developed specifically for Massachusetts, called Mass Energy Insight.

2.1 Framing the Problem

Energy consumption has been an increasingly serious concern across the world. Climate scientists around the globe are in agreement that the human population has done irreparable damage to the earth (Karl et al, 2009). The reality of climate change has quickly set forth a global effort to cap and possibly reverse some of its effects. To do so, a vast reform of humanity's energy use habits is in order; we must look to transition our world into "green" communities that rely on renewable resources to meet their energy needs. In an effort to do just that, many countries have imposed legislation that companies and citizens must uphold: be it automobile, factory, business, or home energy standards.

Given the challenge of reducing energy consumption from polluting sources, there needs to be a transition to an economy that uses more renewable energy and has more of an emphasis on energy efficiency. Energy efficiency represents one of the most cost effective ways to reduce energy consumption and emissions. Simple improvements can reap long-term dividends. Both renewables and energy efficiency need to be promoted, despite renewables' present higher cost than efficiency measures. Renewable energy plays an ever-increasing role in this global energy dilemma and relies on energy sources that are continually replenished by nature: the Sun, the wind, water, or the Earth's natural heat. Renewable energy technologies turn these sources into usable forms of energy. The United States has been heavily reliant on limited fuel sources, primarily fossil fuels such as coal and oil products. Additionally, because of safety concerns and waste disposal issues, the United States will work to retire much of its nuclear capacity by 2020 which comprises a large portion of the remaining energy sources (DOE, 2004). In the meantime, the nation's energy needs are expected to grow by 30 percent during the next 20 years (Rogers,

2003). As a result renewable energy will undoubtedly be needed to fill the energy gap. Support from government is crucial to ensure this transition.

The improvement of technology, along with its increasing affordability, has opened the door for legislation to make an impact. Government has begun to implement grants into their policies to help create more "green communities." There are constantly changing "green" standards to which cities and others are held, ranging across everything from building codes to automobile standards. According to the American Council for an Energy Efficient Economy, Massachusetts is a leading state with a long, successful record of implementing energy efficiency and renewable energy programs (ACEEE, 2010). Worcester is one of the larger cities in Massachusetts and has taken the initiative to become serious about reforming city energy consumption. With the adoption of stricter energy policies imminent the city of Worcester has decided it is worth examining its municipal fleet of buildings. By using existing energy analysis tools the city is able to distinguish various attributes about their buildings, such as which ones are using the most energy and which buildings are least efficient. By targeting these buildings the city can determine where their money will be best spent to make the biggest and fastest impact on the city's energy consumption and emissions.

2.2 Energy Analysis Tools: Mass Energy Insight

In this section, we will discuss the use of software tools to help analyze energy consumption and identify areas of a building that are inefficient. Software tools can greatly simplify the process of performing these types of analysis, but they require "early adopters" to evaluate their strengths, limitations, and how best to use them. For this project our tool of choice was Mass Energy Insight which is available to Massachusetts cities and towns at no cost. Mass Energy Insight, or MEI, is an online software tool that Mr. Odell requested we use. Such programs are especially effective for cities of Worcester's size, as opposed to smaller towns, due to the simple fact that they have many more accounts and buildings to monitor. MEI was created with the goal of aiding local governments in their participation in the Green Communities Program and was developed by the Peregrine Energy Group.

2.2.1 Overview

Mass Energy Insight is a web-based tool offered by the (Massachusetts Department of Energy Resources (MA DOER) that gives Massachusetts local governments the ability to

monitor and analyze the energy use of its various municipal holdings (Commonwealth of Massachusetts, 2011). The software is designed to automatically import the monthly utility bills for all the municipally owned electric and natural gas accounts, the two primary forms of energy consumption for buildings. Various graphs can then be generated depicting a wide range of information such as total energy consumption broken down into its constituent components as well as establishing a baseline energy use. For a complete list of graphs that can be generated by Mass Energy Insight see *Appendix B*. Furthermore, the underlying data can be exported into an Excel spreadsheet, which allows for easier analysis and additional manipulation not provided by MEI. Finally, if the proper confidentiality agreements are in place, municipalities can compare the efficiency of their buildings against a statewide average of similar buildings, enabling an additional level of analysis that cannot be performed by the other analysis tools previously mentioned.

2.2.2 Usage in Massachusetts

At the time of writing, we were aware of at least two communities throughout Massachusetts that had actively used Mass Energy Insight to varying levels to aid them in generating an energy reduction plan. One such community is the Town of Hopkinton, which primarily used the software to establish a baseline energy use as well as identify which buildings to target for the greatest energy savings (Town of Hopkinton, 2010). The town of Hatfield has also developed a similar report detailing its use of Mass Energy Insight (Town of Hatfield, 2010). However, as far as our team has been able to determine, Hopkinton is the largest community with the most number of municipally owned buildings, thirteen, that has developed a report with Mass Energy Insight. The City of Worcester on the other hand has approximately 159 municipally owned buildings and several hundred individual natural gas and electricity accounts that are being tracked.

2.3 Other Energy Analysis Tools

Initially, we decided to look into a variety of software analysis tools to compare with MEI. We contacted Aimee Powelka, Municipal Efficiency Coordinator for the Green Communities Program at the Massachusetts Department of Energy Resources (MA DOER), to determine what other software tools Massachusetts municipalities have used to analyze the efficiency of their buildings (Powelka, 2011).

The first tool mentioned by Ms. Powelka was Energy Star's Portfolio Manager. This online tool allows users to track energy and water usage, as well as costs. Users can generate an inventory of greenhouse gas emissions, compare energy efficiency of similar buildings, and even earn a commendation for exemplary performance from the EPA. In addition, the tool allows users to "set investment priorities" and "verify and track progress of improvement projects" (Energy Star). The Portfolio Manager is comparable to several other tools on the market, including Mass Energy Insight, in that it allows for tracking of energy usage. Overall, however, the Portfolio Manager has more functionality than the other offerings we reviewed.

Another similar tool that Massachusetts municipalities have used is SchoolDude. SchoolDude offers an online software tool called UtilityDirect, which is targeted at educational institutions. Utility Direct "audits, tracks and analyzes utility consumption and costs to identify utility savings opportunities" (SchoolDude, 2011). This tool is similar to Mass Energy Insight in that its primary focus is tracking utility cost and usage data.

Finally, an organization called Clean Air - Cool Planet offers an "on-line Campus Climate Action Toolkit." This tool is focused on helping institutions of higher education develop a plan to reduce their emissions (Clean Air - Cool Planet, 2008). This tool is the least similar to Mass Energy Insight in that it does not focus on tracking utility cost and usage data, but rather focuses on emissions reduction, which is only one element of Mass Energy Insight.

2.4 Summary

With respect to the world's changing climate, it is imperative to take every possible and reasonable action in advancing energy efficiency, controlling our energy use, and reducing CO₂ emissions. To do this with precision and on any sort of large scale, such as a city, energy analysis tools are necessary. Municipalities have been using these tools for several years in Massachusetts, which is a leading state for renewable energy and energy efficiency, to monitor their buildings' energy performance. Recently, cities in Massachusetts have adopted a new online-based program called Mass Energy Insight. This program enables users to link all city energy accounts and gives access to multiple graphs and data representations. Using these graphs and processes of analysis, cities can generate energy reports to determine where they can best allocate their attention and funds. By so doing, Massachusetts cities and towns are doing their part to mitigate the effects climate change.

Chapter 3: Methodology

The goal of this project was to critically evaluate Mass Energy Insight and prepare it for future users. We tested the MEI software, loaded in information about Worcester's municipal energy use, and prepared recommendations for Worcester. This step was important to Worcester because the city has many municipal buildings and knowing how to evaluate the efficiency of them better can aid decision makers who are allocating resources for energy efficiency upgrades.

To aid us in achieving our goal we decided to break the project up into several smaller components

- **Understanding energy use in buildings**—To understand the fundamentals behind Mass Energy Insight as well as how buildings consume energy.
- **Reconciling the energy accounts and data** – To have accurate and useful data in Mass Energy Insight as well as throughout the project.
- **Analyzing the utility data** –To understand the various messages and underlying meanings found throughout the data.
- **Documenting our work and reporting our findings** – To communicate the useful information we expected to find in the course of analyzing the data.

The initial scope of this project looked very different than it does at project's end. The project goals and overall focus during the first semester was directed at the residential sector of Worcester. The project dealt with the energy efficiency codes of Massachusetts. More specifically, we explored the governing energy efficiency code in Massachusetts: The Stretch Code. We were primarily focused on the energy auditing process, hoping to conduct research for lend our services the people of Worcester to help them make the best decisions concerning energy retrofitting their homes.

Our initial project goal was: Make a substantive contribution to the reduction of barriers to implementing residential energy portion of the stretch code in Worcester, through research and interaction with the local community.

We have been working with Mr. Odell throughout the entire process of our project, but it was not until nearly February that we were prompted to change the direction of our project and assist him in analyzing the city's building fleet. As a result, some of our previous work, while not entirely relevant now, is included for its educational benefit of enabling us to make informed

decisions. By building off this knowledge and the knowledge gained during the initial research phase a course of action was determined to best assist Mr. Odell to determine where to best allocate the City's resources for energy efficiency improvements.

The following sections outline the work that went into each step in attaining our goal. All results can be found in the following chapter, *Chapter 5: Results and Analysis*.

3.1 Understanding Energy Use in Buildings

Before we could begin analyzing Worcester's municipal energy efficiency, we needed to gain an initial understanding of energy audits and methods used to determine energy efficiency. Ultimately, this objective helped us in our initial project topic focused on energy efficiency auditing of residences, as well as our final topic of municipal energy efficiency. To accomplish this objective, we researched currently available energy auditing techniques, methods of amateur and professional auditors alike, as well as previous case studies of various types of energy audits. For example, we examined the cash-flow analysis the Vermont Energy Investment Corporation (VEIC) did in Cambridge with respect to the Stretch Code, an energy efficient building code, on a triple-decker home. We also examined the studies the Pacific Northwest National Laboratories did in various cities across the country, specifically in Massachusetts. These demonstrations of analysis were helpful in determining what types of inventory need to be taken with the various pieces of data occurring during an energy audit.

The next logical phase of our research was gaining perspective on the auditing process by conducting a routine walk-through audit on one of our group member's apartment (See *Appendix A*). We decided to use this approach in conducting our research because even though we do not have access to high-tech equipment used for professional audits, we need to understand the kinds of things auditors look for and the standard measurements that are made. In this process, we were able to get an initial understanding of the various energy applications in a building and potential problems that can be found by following a general procedure of noting:

- Any major appliances or uses of energy in a room
- The size of the room
- The number of windows and doors, as well as their condition.

- The type and quality of the heating and cooling system used for the building.

By compiling a list of these major elements the energy usage patterns of the building in question can begin to be understood.

3.2 Reconciling the Accounts on Mass Energy Insight

As the project evolved, we shifted our role to analyzing the energy efficiency of municipal buildings in light of Mr. Odell's needs. By taking measures to increase municipal energy efficiency, Worcester can save its taxpayers money and help reduce its contribution to climate change. Toward that end, Mr. Odell gave us access to the online software package Mass Energy Insight. As previously mentioned, this software tool allows cities to compare the energy efficiency of their buildings within the city and with other select cities. Data from the utilities on usage and cost for each energy account is automatically imported and updated by the software. The software permits the city to input information about its buildings and it outputs a variety of graphs intended as decision making aids. In using this software, the City of Worcester hopes to identify opportunities for increasing its buildings' energy efficiency.

First, Mr. Odell provided us access to Mass Energy Insight and a series of Excel spreadsheets from the City of Worcester that contained data to input into the software. This data included a list of Worcester's municipal buildings, addresses, floor areas and the associated utility accounts for natural gas and electricity. Mass Energy Insight requires this information; this data was distributed across two different spreadsheets. Our first task was to collect the data all in one place and organize it into a format that was easier to input into Mass Energy Insight.

To achieve this we created a new spreadsheet in Google Docs, which has a collaboration feature that allowed us to work on the project simultaneously. This new spreadsheet included information such as the name, the address, and the zip code of each building, along with the category and any National Grid electric accounts and NSTAR natural gas accounts associated with it. We also included a cell to indicate the status of the entry, whether it was finalized, needed checking, or had problems that could not be immediately resolved. The final piece of information included was a note of any problems we had with the entry.

The next step in reconciling the accounts was migrating the data from our spreadsheet into Mass Energy Insight. The effort and time this step demanded varied from building to building. For some buildings, most of the information was already entered into the Mass Energy

Insight database. In such cases, we checked that the associated accounts matched the accounts we were given by Mr. Odell in the spreadsheets.

At the other extreme, some buildings were not already in the database and had to be added manually. This step required associating the proper electric and natural gas accounts with the new entries. We then searched for either the account number provided in the spreadsheet or identifying features about the account such as the address that would associate it to the building in question. Finally, once we had found the accounts, they were associated with the proper building.

The final step of the data entry process was to check our work. We started at the beginning of our spreadsheet and corrected any problems we had noted with the entries. Once an entry was completed, we marked its status as “Done”, highlighted in green. At the conclusion of this process, it became clear that the data were mostly complete and reliable, although there were a few lingering problems with some of the buildings. These problems were primarily missing account numbers or floor areas, and lack of a building sub-category. We also noticed that some of the data from fiscal year 2007 was missing. Future users of Mass Energy Insight would benefit from entering the missing information. A more complete set of data would yield more accurate results for future users of the software. To aid future users, we are providing Mr. Odell with a spreadsheet that notes the missing data.

3.3 Analyzing the Data

Once the data was reliably entered into Mass Energy Insight, we began the process of analyzing it. First, we sought to find out what other towns had done for their analysis by contacting the tech support personnel at Mass Energy Insight. The support staff for Mass Energy Insight was unable to provide us with other town’s reports because towns prefer to keep their energy usage confidential and agreements would need to be in place for us to gain access to such reports.

Next, we contacted MA DOER to see if the state agency would have any such reports on file and they provided us with a list of reports that had been compiled using Mass Energy Insight, but after we had decided on the types of analyses we were to run. Nevertheless, we found some of these reports independently, through Google, and they proved useful in determining what type of analysis would be useful as well as the direction of how to display and explain our findings. In the future, users of Mass Energy Insight can get ideas about how to use the software from the list

of reports on the MA DOER website (MA DOER, 2011). Specifically, these reports are plans for how the municipality plans to reduce its energy consumption.

3.3.1 Determining the Types of Analysis to Be Done

We began the process of determining what type of analysis to conduct by brainstorming a list that the City of Worcester would be interested to see. We also solicited Mr. Odell's opinion as to what kind of analysis he wanted. Our list consisted the following:

- How many energy using entities does the city own?
- How many entities of each type such as schools, recreation, water/sewer, administration does the city own?
- How much energy does the city use as a whole?
- What is the percentage of total energy use that is gas vs. electric?
- What is the percentage of total energy that goes to the various categories of buildings?
- What buildings would be on a list of outliers that use a disproportionately high amount of energy or are disproportionately inefficient?

Next, we researched how other cities and towns used the Mass Energy Insight software to analyze the energy efficiency of their municipal buildings. At the time, the only available reports were from the towns of Hopkinton (Town of Hopkinton, 2010) and Hatfield (Town of Hatfield, 2010). These reports included the analyses similar to those we had preliminarily identified, and suggested others, including establishing a baseline year for analysis and a prioritized list of building improvement projects (Town of Hatfield, 2010).

3.3.2 How the Data was Analyzed

In order to run several of the analyses, we exported the data into Microsoft Excel. Mass Energy Insight proved to a cumbersome analysis tool for certain purposes, despite its numerous graphs. Thus, exporting the data was essential for us to best manipulate it. We accomplished this task by using the export data feature of Mass Energy Insight and found that the underlying data from the "Buildings to Target" report would be most useful for our purposes. Then, a series of tables and graphs was generated to best communicate our results. It was at this point in the process that the fiscal year 2009 was selected as the baseline year for energy usage, as this was

the first complete year of data. Fiscal year 2008 is mostly complete, however there were a few accounts missing data, enough to cause us to reject the year entirely. The fiscal year for Worcester runs from July to June.

3.3.2.1 Overview of Worcester's Energy Use

We began with an overview of Worcester's energy use over the past three years. First, we copied the data from the "Baseline Report" page of Mass Energy Insight, excluding the null and blank categories. We chose to analyze only the last two complete fiscal years, 2009 and 2010, as both 2007 and 2008 had a significantly lesser energy usage. We attributed this discrepancy to 2007 and 2008 being years that did not have all their energy data imported into Mass Energy Insight. All numbers, excluding the percentages, in this first section of analysis were in units of MMBTU, or millions of British Thermal Units (BTUs).

To determine how much energy the City of Worcester uses, we took an average of the energy use per year across the last two years for both gas and electric and produced an average total energy usage for the city as a whole. Next, we calculated the percentage of total energy use attributed to gas and electricity. Since the usage data was broken down into three categories, buildings, open space, and water/sewer, we calculated the average energy use by these three categories. Finally, we generated a series of plots and tables to best display this information. It is worth noting that our analysis does not include transportation fuel or heating oil, as MEI does not automatically import this usage data automatically in most cases.

3.3.2.2 Breakdown of Building Use and Emissions

The next step of our analysis was understanding how Worcester's municipal buildings contribute to the overall energy consumption. This step was accomplished by filtering the exported data into buildings followed by summing the energy consumption total (both natural gas and electricity) for each building type. This process was repeated for each of the two fiscal years previously established as well as for carbon dioxide emissions. We exported the data because Mass Energy Insight's representation of the data was incorrect for the project's needs. We noticed that when looking at certain graphs MEI offered, if the user selected multiple years to view simultaneously, the software added the value of these years together instead of averaging them. So, instead of getting the average efficiency over a three year span, it represented sum of

three years of efficiency data. This issue is not as problematic due to the fairly large upgrade Mass Energy Insight went through partway through the project. However, the new version of MEI does not allow for multiple years to be selected on numerous reports.

The final step was to understand the role buildings and building types contribute to the City of Worcester's total energy consumption. To do this, we established exactly how many buildings of each type there were. This task was accomplished by filtering the exported data into buildings and then sorting alphabetically by building name. Next, the total number of unique structures in each category was summed as well as the total square footage of each category. By comparing these numbers to the energy use by category we were able to ascertain whether a certain category used a disproportionately high amount of energy.

3.3.2.3 Background on Worcester's Top Energy Users

Once we had an initial picture of Worcester's general energy use, we decided to focus our attention deeper into the data. The last piece of analysis left to conduct from our list was to determine what buildings use a disproportionately high amount of energy and/or are disproportionately inefficient.

Our initial effort to try and understand the correlation between energy usage and energy efficiency was to simply order the buildings from highest to lowest in those two respective categories. It quickly became apparent that this did not suffice in giving useful data to begin making a thoughtful recommendation. This realization occurred while examining the two lists simultaneously; the lists only shared one building, the DCU Center. We understood from our energy audit studies that there was a more intimate relationship between the two categories. Once more, we knew that this relationship could be used to focus our attention to a smaller population of buildings to target. However, whether this smaller population was to be an entire subcategory of buildings or a list of various buildings, remained to be seen.

To get a better picture of what buildings needed the most attention, we decided to multiply the energy efficiency and the energy use. The rationale for this operation was that it is the simplest way to cross-tabulate efficiency and use. This product would give us MMBTU² per square foot, or an **energy prioritization factor**. This factor makes clear the buildings that need energy efficiency upgrades the most, for a building can be grossly inefficient but if it does not use a substantial amount of energy, it is not of as big of a concern as other buildings.

To complement the prioritization factor, we also recognized buildings that could be of interest to us in a different manner. We put most of the emphasis on the actual efficiency, but crossed referenced it with the energy use of the building. Meaning, we ordered the buildings in terms of their efficiency and made note of the worst ones. We then made sure that those buildings were still using enough energy to make them relevant to our purposes; these buildings are highlighted in *Table 4* in *Chapter 5 Section 3*. The rationale for this process was the same as for creating the prioritization factor. The two methods proved, sensibly, to provide similar but different buildings to target. The buildings that use the most energy, with efficiencies above what is to be expected for their building type, present an opportunity to save the city the most money. This is because any increase in efficiency will directly decrease the energy use (the more the building actually uses the greater this decrease is). Put simply, the more energy a building uses the more opportunity there is for the city to save money and energy.

Finally, we decided to determine the percent change of energy use between our baseline year of 2009 and most recent completed fiscal year of 2010 (*Table 4*). This percentage change will identify whether the buildings that have been flagged as the most in need of an upgrade are improving or getting worse. This information is important to us because buildings that are subsequently getting better are of less interest to us than the buildings that have already been identified as underachievers and seem to be actually getting worse. All of these factors were to be taking into consideration in making our final recommendation.

3.4 Summary

All in all, Mass Energy Insight proved to be a valuable tool for aggregating data, but cumbersome for analyzing the energy efficiency of Worcester's municipal buildings. It did not have the capability to run all the analyses that we wanted. In order to use the software for our analysis, we first had to reconcile the energy accounts with data provided to us on several Excel spreadsheets. Once the data was entered, we then had to determine how we were going to analyze it. By reviewing how some other communities had utilized Mass Energy Insight, we were able to determine the analyses that we wanted to perform. First, we observed Worcester's municipal energy use at the macro level. Next, we gathered information about energy use in various subcategories of buildings. Finally, we used an innovative metric to identify the buildings that were in most need of energy efficiency upgrades. Overall, the aforementioned steps brought us closer to making recommendations about which buildings the City of Worcester

should upgrade, but more importantly we laid the foundation for future users of Mass Energy Insight. The next chapter offers a user guide that explains the process of how we used MEI step-by-step.

Chapter 4: Mass Energy Insight User Guide

Mass Energy Insight offers Massachusetts municipalities a new interactive way to analyze the energy efficiency of their municipal buildings. In the process, Mass Energy Insight can help towns and cities best decide how to allocate their resources. Like many pieces of software, it has its flaws. There are ways to compensate for them, however: tips and tricks to get the most out of this extremely valuable software. The rest of this section will walk a new user through the four basic steps needed in order to get up and running.

4.1 Understanding Resources Available

The first step in the process of setting up a Mass Energy Insight account is to understand the resources provided to the user by the developers of MEI, the Peregrine Energy Group. These resources primarily come in the form of a one hour overview webinar, a web-based training seminar, as well as a tech support service (*Figure 1*). The overview webinar covers the basics of Mass Energy Insight, walking the viewer through the reports that can be displayed as well as the process of adding new buildings and assigning accounts to said buildings. Overall this webinar is fairly useful to watch, however the user could also gain the same level of understanding of MEI by simply exploring the website independently. However, there is also a training webinar that the user is required to attend in order to gain full access to MEI. This webinar is more comprehensive than the overview webinar. Additionally, part of the training webinar is a Q&A during which new users can ask questions of the developers of MEI.



MassEnergyInsight
POWERING EFFICIENCY

Overview ... **Training** ... Support

MassEnergyInsight Training Schedule [Download Training schedule](#)

Attendance at a 75-minute instructional **MassEnergyInsight Introduction** webinar is required for new users to access and get the most out of MassEnergyInsight. Additional webinars are available to answer follow-up questions and to explore specific topics in detail.

Authorization letters must be on file with the DOER for you to receive your MassEnergyInsight username and password upon webinar completion:

- User authorization letter - required - (authorization guidelines & template: [Word](#) / [PDF](#))
- Data sharing authorization letter - required - (authorization guidelines & template: [Word](#) / [PDF](#))

To **submit** your authorization letters and **register** for any webinar, please contact your local DOER Green Communities Regional Coordinator.

MONTH	TOPIC	DATE/TIME
April	Registration deadline	Rolling registration
	MassEnergyInsight Introduction (required for new users)	Tuesday, April 12, 2011 2:00 PM to 3:15 PM
	Follow-up Q & A (recommended for new users; open to any authorized user)	Friday, April 29, 2011 2:00 PM to 3:15 PM

Overview Webinar
Running Time: 45:41

Figure 1: Location of the Webinars

The tech support form (*Figure 2*) is fairly comprehensive and straight forward, including several categories of support from which to choose such as: Entering Data, Viewing Reports, and Program Questions. Over the course of our project the team used this resource several times, ranging from asking a simple question or inquiring about the underlying data structure. In all cases the responses were timely and helpful. This is a very important resource to utilize if a new user has any questions regarding any aspect of Mass Energy Insight. By using this resource, as well as the webinars, a new user should have a fairly clear grasp of the functionality of MEI even before using it.

MassEnergyInsight
POWERING EFFICIENCY

Overview Training **Support** ←

Technical Support
Questions about the Green Communities Division or Massachusetts Department of Energy Resources (DOER) policies should be directed to your local Green Communities Coordinator.

Please use the following form only for:

- Technical questions/ issues about using MassEnergyInsight
- Enhancement suggestions for MassEnergyInsight reports

*First Name: *Last Name:

*Email address: *Phone number:

*Town:

*Subject: *Browser and version:

*Message:

*Required Field

PEREGRINE Energy Group
DOER

Figure 2: Location of the Technical Support Form

First time users of Mass Energy Insight might also consider conducting research into how other communities have used MEI. Such research will provide new users with a good understanding of what kinds of analysis are effective for different sized municipalities. Analyzing municipal performance for a town with a dozen municipal buildings and for a city the size of Worcester are two very different tasks. The way in which one uses Mass Energy Insight changes as the number of buildings increases, as working with the data outside the software becomes essential. In order for another municipality the size of Worcester to fully realize the software's potential, we recommend surveying how other similarly sized cities have used MEI and other energy analysis tools. Fortunately, the Green Communities program website includes links to various reports (MA DOER, 2011).

4.2 Preparing the Data

The next step in setting up a new Mass Energy Insight account is to fix the data in preparation for analyzing it. The primary goal of this step is to ensure the completeness and reliability of the underlying data. For MEI this means that each building has had the proper information such as square footage entered correctly, the correct accounts have been assigned, and that those accounts do have usage data loaded. Verifying the utility data includes making sure that each year under consideration has utility data for the full year, without any missing months. We noticed very late in our process that several of the larger buildings in question had missing data which accounted for an apparently large increase in gas usage from FY2008. Spending more time reviewing the data would have prevented this problem.

To begin preparing the data, log into Mass Energy Insight and click on “Organize your data” (*Figure 3*). From there the user is brought to MEI’s data management tree. To add a new building or department click create new and fill out the appropriate fields. In order to get the most out of MEI pay particular attention to the category and subcategories as well as square footage. Mass Energy Insight’s reports utilize this data regularly so the reliability of this information is particularly important.



Figure 3: Beginning of Data Preparation

Next, the appropriate account(s) needs to be assigned to the building. This is accomplished by clicking the “accounts” button (located next to the “create new” button) this pulls up the entire list of accounts that have been imported into MEI initially (*Figure 4*). Clicking on the account number will bring the user to a page where account information can be input and the account assigned to a particular building (*Figure 5*).

Organize data

This "Tree" shows your municipality, departments, complexes, buildings or facilities, and units.

Click the plus sign (+) to expand the tree and the minus sign (-) to collapse it.

Click [accounts](#) to see a list of accounts for any item. Click [create new](#) to create a new item.

NEW! Click **Show accounts within tree** to integrate your accounts into the tree, then drag-and-drop them to new locations in the tree.

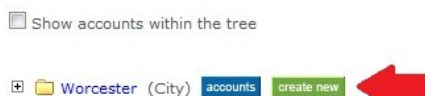


Figure 4: MEI's Data Tree

The user should associate all of their energy accounts with the corresponding buildings. Despite our best efforts, only approximately 45% of the energy accounts automatically imported into Mass Energy Insight were paired with buildings. This could potentially mean that data from obsolete accounts for past years is going unaccounted for. Additionally, the accounts that MEI automatically links with buildings should be checked for accuracy. We observed several instances in which buildings had been associated with the wrong account. It is also recommended that special effort be made to input the floor area for all buildings, as the efficiency calculations done in Mass Energy Insight are based on square footage. Errors in floor area data reduce the usefulness of the software by producing incorrect numbers for energy efficiency, an important metric. This problem could be avoided by carefully checking that each building has floor area data.

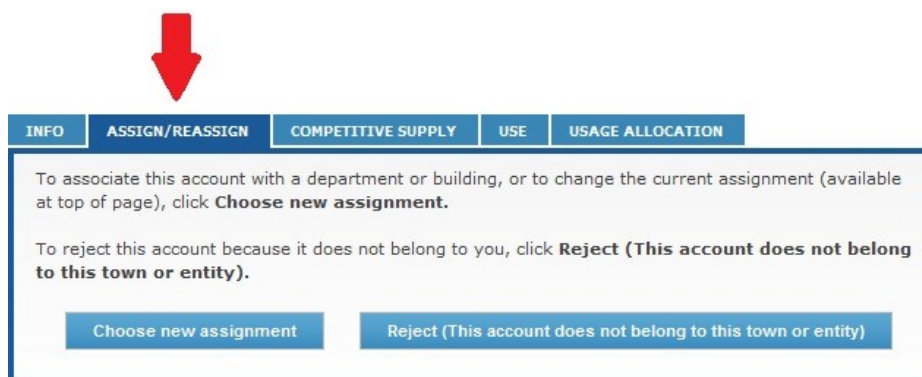


Figure 5: Assigning Accounts

Once every building has been created and all accounts are assigned to it, the next and arguably most crucial step is ensuring that all the data for those accounts has been loaded. This is accomplished by viewing the "Setup Completeness Dashboard" and "Data Loaded – Overview" reports. These are located in the "View Reports" section of Mass Energy Insight (*Figure 6*). One

thing to note is that for this version of Mass Energy Insight it is normal for long loading times of the reports to occur.

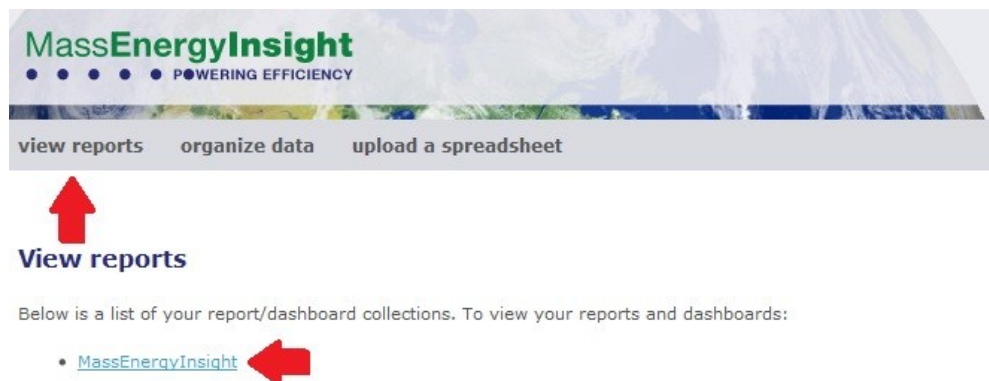


Figure 6: Viewing Reports in MEI

The “Setup Completeness Dashboard” highlights any buildings that have not been assigned a category, sub-category, and square footage (Figure 7). The dashboard also reveals any accounts that have been imported but have not been assigned to a building. This report is useful at bringing attention to any mistakes the user might have made when creating the buildings. To reach various tabs such as the “Setup Completeness Dashboard” the user will need to use the side scrolling arrows to view every one.

Facility Counts by Type

Facility Category	FY 2008	FY 2009	FY 2010	FY 2011
Building	104	104	103	102
Open Space	11	11	11	11
Water/Sewer	45	45	45	45
Grand Total	160	160	159	158

Assign these accounts

These accounts have not been assigned to a complex, building or unit. Assign these accounts to ensure their data is reported properly.

Account #	Provider	Fuel	Account Address	Null	FY 1999	FY 2008	FY 2007	FY 2008	FY 2009	FY 2010	FY 20
1252184	Global Partn.	Oil	363 BELMONT ST						4,901		
0048996025	National Grid	Electric	Providence St Worcester MA		0	6,197	4,261	1,332	1,549	8	
0047803029	National Grid	Electric	606 Cambridge St Worcester M.		0	1,616	906	609	660	4	
0050341029	National Grid	Electric	Grafton St Pole 98 Worcester ..		0	4,541	3,196	1,468	1,707	1.0	
0050423025	National Grid	Electric	Riverside St Pole 1 Worcester ..		0	9,424	9,504	8,904	9,819	6.4	
0127286044	National Grid	Electric	Canton St Pole 7 Worcester MA			66,000	66,840	60,040	46,360	36.6	
0127288028	National Grid	Electric	Thomas St Worcester MA		0	5,239	3,669	1,484	1,505	1.0	
0128278025	National Grid	Electric	Grafton Water Isct Worcester ..		0	5,020	3,318	1,362	1,351	8	
0128307022	National Grid	Electric	Burnside Ct Worcester MA		0	3,265	4,096	5,308	4,996	3.9	
0128354021	National Grid	Electric	Postler St Worcester MA		0	12,698	9,789	11,943	9,907	6.1	
0128379037	National Grid	Electric	Cor Ely St Worcester MA			910	1,346	854	183		
0128380028	National Grid	Electric	S Front St Worcester MA		0	8,045	9,466	10,656	10,091	6.9	
0128393028	National Grid	Electric	32 Franklin St Worcester MA		0	8,274	7,316	5,870	6,542	4.3	
0128440022	National Grid	Electric	Summer Asylum Isct Worcester.		0	30,668	29,563	30,248	28,846	20.4	
0428788077	National Grid	Electric	Commercial St Worcester MA		0	9,784	9,192	11,817	13,073	9.1	

Figure 7: Setup Completeness Dashboard

The “Data Loaded – Overview” report will be useful to the user in ensuring the completeness of the underlying data (Figure 8). It addresses, in a tabular format, which accounts

are missing data for which months. Any month that has a white space indicates it is missing data. In the team's experience, if Mass Energy Insight loads a month's data it is generally the correct amount. The problem is when MEI does not load the data. If this error occurs the user has two options: they can locate the data and enter it manually by uploading a spreadsheet or if the data cannot be located, the user needs to mentally note how much data is missing. While missing data is undesirable and can lead to inaccurate results; the larger problem is when data is missing for consecutive months.

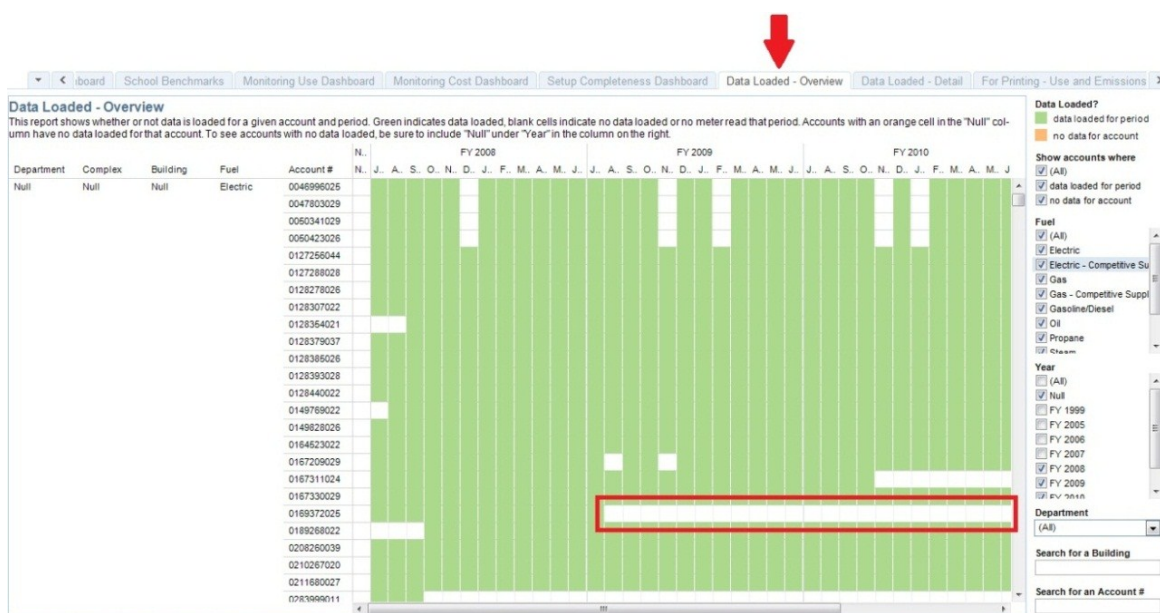


Figure 8: Data Loaded – Overview Report

By this point, the user should have data that is both reliable and valid, meaning they can proceed to the next stage.

4.3 Analyzing the Data

A general process for analyzing the data can be broken down into the reports below. By viewing the reports in this order the user can gain a general understanding of their municipality's energy use from a top down manner; beginning with the general energy use for the municipality and ending with a specific energy usage for individual buildings.

- Baseline
- Usage Trends
- Buildings to Target

- Schools Benchmark
- Buildings Dashboard

To begin, the team found that the most useful report to give the user a “big picture” of energy use is the “Baseline Dashboard” (*Figure 9*). An overall percent change in energy usage from the baseline year is one of the most useful graphs on this page. It gives the user an idea on whether the energy use is increasing, decreasing, or staying the same. Next, the breakdown of use by facility will enable the user to understand how the municipality’s energy is apportioned amongst, buildings, open space, and water/sewer. For most municipalities, the primary consumer of energy is going to be the Buildings category. The establishment of a baseline year is an important step for analysis and should be done from this report. Start by selecting all the years available in the “Baseline Dashboard,” then remove any years that have a significant portion of missing data and are noticeably lower than the most complete year. A good baseline year will be the start of a consistent trend of energy usage data.



Figure 9: Baseline Report

The next graph to view is the “Usage Trends – Town” (*Figure 10*). This report drills down further into the municipality’s energy use, providing general trends for all major energy types. This report provides a good opportunity to see if the chosen baseline year is appropriate. An appropriate baseline year is one in which trends of energy usage can be seen over the intervening years.



Figure 10: Usage Trends Report

The next logical step would be to look at building consumption as buildings are the primary contributors to energy consumption. There are several reports that display building information; however the best one to view next is “Buildings to Target” (*Figure 11*). From this report one can easily identify which buildings use the most energy and how they rank in terms of efficiency against the rest of the buildings. One thing to understand about the way Mass Energy Insight calculates efficiency is it is energy per area (measured as kBtu per square foot). What this means is a more efficient building will have a lower value than a less efficient building because it consumes less energy per square foot. The chart titled Efficiency and Use which is divided into four quadrants is a good preliminary indicator of which buildings need additional analysis. The upper right quadrant is the key, as buildings in this quadrant, such as the DCU Center in Worcester, are not only the least efficient buildings but also the highest energy consumers.



Figure 11: Buildings to Target Report

For a large municipality such as Worcester, many buildings fall into the category of schools. Mass Energy Insight has an excellent report, "School Benchmark" report (*Figure 12*), that allows users to compare the efficiency of their schools against others throughout Massachusetts. The user has the option to select different years as well as filter the results by type of school analyzed. More efficient schools are to the right while the less efficient schools are on the left. While this graph is an excellent tool, the type of school will significantly change its energy consumption habits. For instance, a high school which presumably has significantly more computers and high energy consumption devices will consume more than an elementary school. In this case it is natural for the high school to use more energy per square foot.



Figure 12: School Benchmark Report

The final step in the top down analysis approach is to look at each building identified by either the “Buildings to Target” report or “School Benchmark” report in detail. This is accomplished by the “Building Dashboard” (*Figure 13*) which lets the user examine the detailed energy consumption patterns for a specific building. By looking at this report the user can identify whether the building’s unusual energy usage is due to missing or incorrect utility data as well as how much each fuel type contributes to the overall energy consumption.



Figure 13: Building Dashboard Report


For users wishing to perform another level of analysis, the next logical step would be performing the same top down style of analysis except on each of the major fuel sources individually.

4.4 Exporting the Data (Optional)

For users wishing to perform advanced analysis on the underlying data, it is crucial to export the data. Fortunately this is a fairly simple process in Mass Energy Insight. First navigate to the “Overall, Use, Emissions, and Cost Dashboard” and select all the years for which you would like to export the data (*Figure 14*). Next, with the “Overall Use, Emissions and Cost by Fuel as a Percent Total” graph selected, click the leftmost icon in the group at the center of the page at the bottom. This will present the user with a screen saying “View Data: The data has been generated”, click download. A new window will open up containing a select portion of the data for view immediately. In order to gain access to all of the data the user needs to click on “here” making sure to check the box labeled “show all columns”; after which a comma separated values, or CSV, file will be downloaded (*Figure 15*). This type of file is easily opened in numerous programs such as Microsoft Excel at which point the data can be manipulated at will. For the larger municipalities such as Worcester this CSV file can be quite large, often several megabytes, which can be an issue depending upon the speed of your connection.



Figure 14: Step 1 in Exporting the Underlying Data



Showing 200 out of 20094 rows
Click [here](#) to download all rows as text file

Show all columns

Town Filter	Usage End Date (null filter)	Fuel (family)	Building
True	3/9/2011	Electric	Wawecus Road ES
True	2/11/2011	Electric	Wawecus Road ES
True	1/10/2011	Electric	Wawecus Road ES
True	12/14/2010	Electric	Wawecus Road ES
True	11/8/2010	Electric	Wawecus Road ES
True	10/11/2010	Electric	Wawecus Road ES
True	9/13/2010	Electric	Wawecus Road ES
True	8/13/2010	Electric	Wawecus Road ES
True	7/13/2010	Electric	Wawecus Road ES

Figure 15: Step 2 in Exporting the Underlying Data

4.5 Conclusion

Mass Energy Insight is a useful tool for Massachusetts municipalities for performing energy analysis. Because MEI is a new and innovative software tool, this user guide is designed to help expand the understanding of the features provided to current users. This expansion is broken down into four steps and upon completion any user to Mass Energy Insight should be able to analyze their municipality's energy performance. The types of analysis made possible by MEI enable users to make appropriate decisions as to where to best spend the resources available to maximize both financial and environmental gains.

Chapter 5: Results and Analysis

Our research was intended to show how Worcester's municipal buildings use energy and what buildings represent the best opportunities for energy efficiency upgrades. First, we provide a background of Worcester's energy usage over the last two years, 2009 and 2010. Then, we focused on usage and emissions by building type. Finally, we explored specific building use and efficiency. We were forced to use such a small data set due to the fact that, currently, the pre-2009 data in Mass Energy Insight is incomplete and would thus create illegitimate results. At the time of writing, it is worth noting that the data for the fiscal year 2011 is almost complete and will be available soon for future analysis.

5.1 Overview of Worcester's Energy Use

The following graphs show how the City of Worcester consumed energy from 2009 to 2010. Each plot is accompanied by a bulleted list of insights that can be drawn from the graphs. All data used in the following graphs is compiled from the table below.

Type	FY 2009		FY 2010		% Change, 2009-2010	
	Gas	Electric	Gas	Electric	Gas	Electric
Building	266,756	166,703	248,749	161,209	-7%	-3%
Water/Sewer	1,858	23,729	1,549	23,244	-17%	-2%
Open Space	313	612	266	500	-15%	-18%
Total	268,927	191,044	250,564	184,953	-7%	-3%

Table 1: Municipal Energy Use for Worcester in MMBTU, FY 2009 & FY2010

- Electric usage by the City of Worcester has decreased slightly over the last two years.
- Gas usage over the last two years has fluctuated from a high of 268,927 MMBTU to a low of 250,564 MMBTU (*Figure 16*).¹

¹ There was an apparent large leap in gas usage from 2008 to 2009, an increase of 36%. We attribute this gap partially to a colder year and partially to missing data for the following buildings: Clark Street Community ES, May Street ES, South High Community HS, Sullivan MS, Union Station, Vernon Hill ES, Worcester Memorial

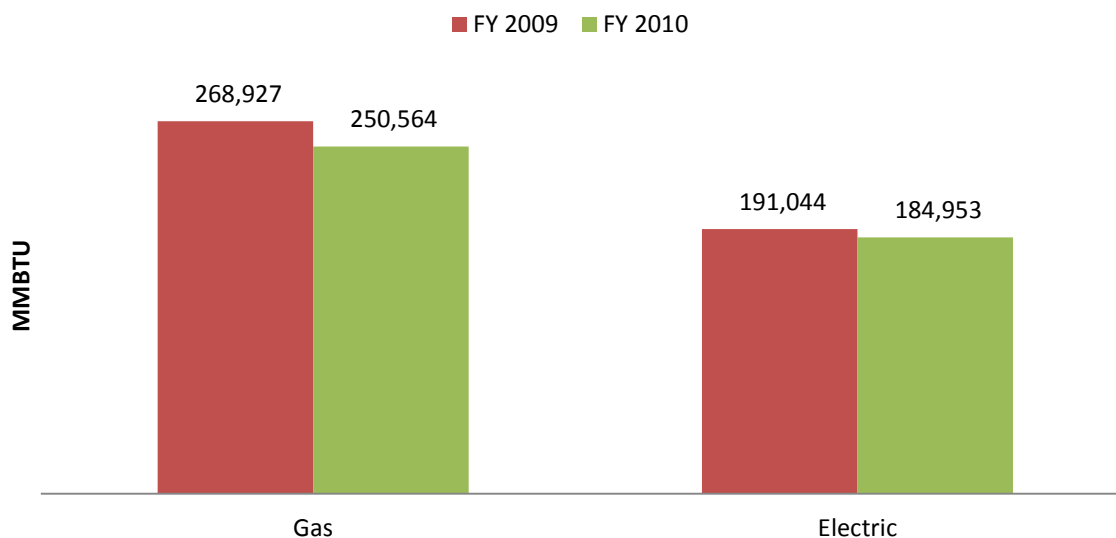


Figure 16: Municipal Energy Use for Worcester by Fuel Type

- Heating degree days are a measure of the severity of weather; a higher number means a cooler year and vice versa. The 6.7% drop in natural gas use, from FY 2009 to FY 2010, is marked by a 9.3% decrease in heating degree days (NOAA, 2011). It is precarious to make a direct connection between the drops in natural gas use and heating degree days, especially with only two years to compare. The most concrete thing that can be said about the correlation is if Worcester's buildings were closer to an optimal overall efficiency, the percent decrease in natural gas would have been nearly parallel with the percent decrease in degree days.

Year	Heating Degree Days	Change in Heating Degree Days	Change in Gas Use
<i>FY 2009</i> ²	6460	--	--
<i>FY 2010</i> ²	5858	-9.3%	-6.7%

Table 2: Heating Degree Days

Auditorium, and Worcester Vocational HS. Again, due to this missing data, we are excluding the year 2008 from our analysis.

² <http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hdd.200707-200906.pdf>

- On average, over the last two years, most of the energy used by the City of Worcester came from natural gas, at 58% or 259,746 MMBTU – see *Figure 17*. Since natural gas is mainly used for heating, this fact suggests that heating systems should be scrutinized for efficiency. Moreover, parts of buildings where heat loss can occur should be examined, as excessive heat loss through windows, doors, or inadequate insulation would force natural gas heating systems to use more fuel.
- Another reason to focus on natural gas consumption is that electric consumption has been decreasing over the last two years per *Figure 16*. We are unsure if this decrease is due to rising efficiency, lower heating degree days, or if it is symptomatic of the reduced economic activity present in a recession. All are potentially valid, and likely active, reasons to explain the decrease. Likewise, natural gas consumption decreased from 2009 to 2010, also per *Figure 16*, warranting further investigation.

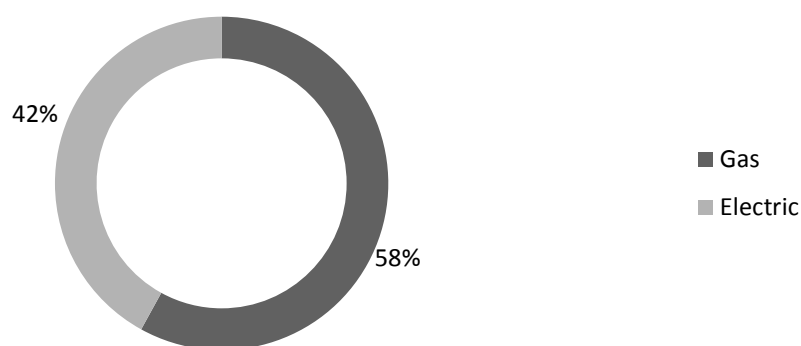


Figure 17: Percentage Breakdown of Average Total Energy Use for FY 2009 & FY 2010

- Excluding fuel oil and fuel for transportation, most of the City of Worcester's energy consumption comes from buildings, at 94% (*Figure 18*). Given such, Worcester would be wise to make energy efficiency improvements to its building stock. This exclusion is because the software of Mass Energy Insight does not encompass the use of transportation energy and the city of Worcester does not use fuel oil with any regularity at all.
- A small amount of the City's energy consumption comes from water/sewer components, at 6%. These sources of energy consumption are largely water and sewer pumps, but also includes drinking water and wastewater treatment plants. A minimal amount of the City's energy consumption comes from open space. Open space includes public recreation areas like parks (*Figure 18*).

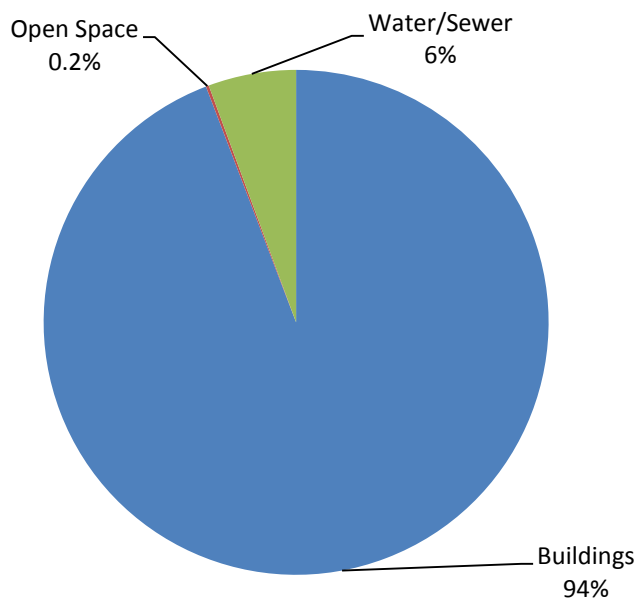


Figure 18: Average Energy Usage Percentage Breakdown by Category

5.2 Breakdown of Building Use and Emissions

The following graphs show how buildings and building type contribute to Worcester’s energy consumption and emissions. To better understand Worcester’s energy usage patterns the values from the two fiscal years were averaged together for each building type. For this level of analysis, using an average of the CO₂ emissions and usage data minimizes the effects of any outliers, thus providing a better understanding of each building type. This can be seen in *Table 3*, depicting the percentage of the buildings by building type, the energy that each building type consumes, as well as the emissions associated with each building type in pounds.

Additionally, a more visual representation of the same data can be seen later in *Figures 19 and 20*. To simplify the presentation of the data several categories have been bundled into “Other”. As such they have been included in the table but not in either of the graphs.

Building Type	Number of Buildings	Percent of Total Square Footage	CO ₂ Emissions (LBS)	MMBTU
<i>School</i>	52	77.2	40,751,654	257,047
<i>Recreation</i>	23	5.4	8,520,286	47,385
<i>Public Safety</i>	13	4.8	3,984,980	20,204
<i>Pumping</i>	26	0	3,275,187	12,665
<i>Sewer Pump</i>	19	0	2,937,375	11,293
<i>Other</i>	26	12.6	16,795,343	82,734
<i>Public Works</i>	6	1.8	7,952,189	31,653
<i>Miscellaneous</i>	11	3.2	9,349,065	13,895
<i>Garage</i>	2	1.7	2,370,046	15,567
<i>Administration</i>	3	3.7	2,161,055	10,833
<i>Library</i>	2	1.6	1,862,198	9,348
<i>Treatment Plant</i>	1	0.6	253,990	1,424
<i>Drinking WTP</i>	1	0	3,771	14
Total:	159	100	76,264,826	431,328

Table 3: Breakdown of Energy Consumption and Emissions by Building Type

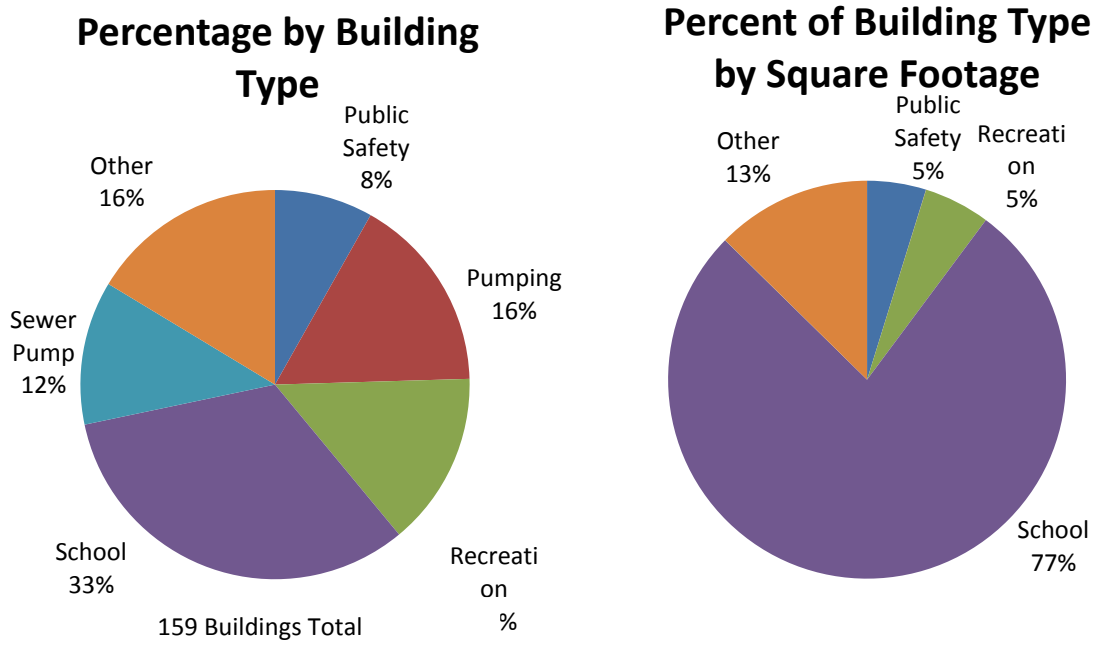


Figure 19: General Breakdown of Building Types

- In total, the City of Worcester has 159 municipal buildings. The largest subcategory is schools with 52, while pumping is the second largest subcategory with 26.
- Additionally schools attribute the largest percentage of floor space. This number is slightly inflated however (due to the lack of square footage for both pumping categories).

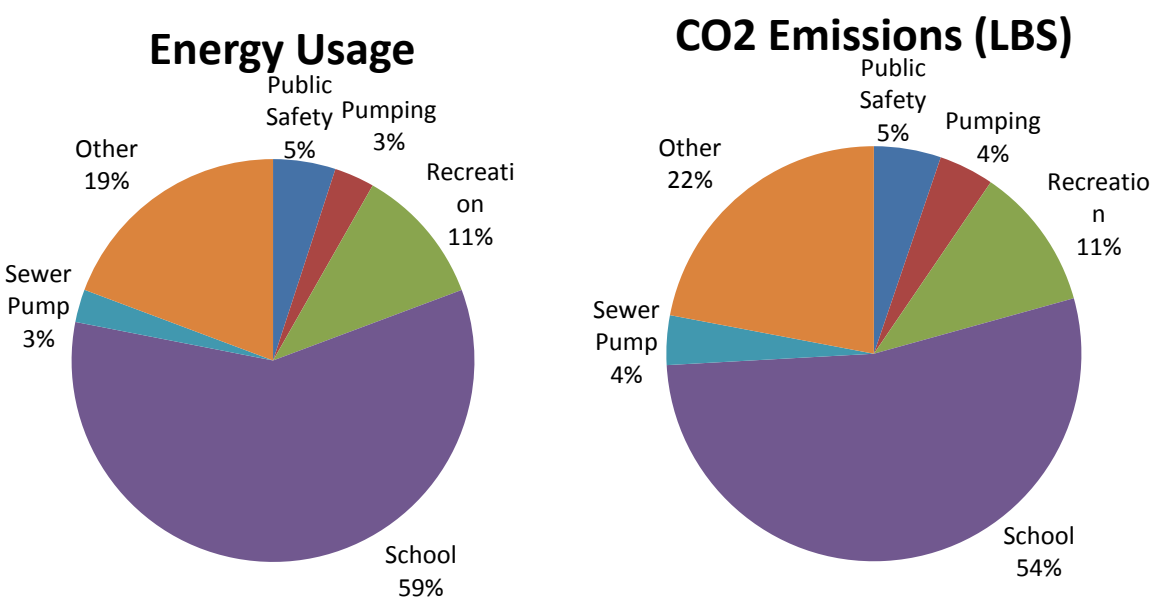


Figure 20: Energy Use and Emissions by Building Type

- The majority (59%) of Worcester's energy consumption by buildings comes from schools. While schools only account for about a third of the total number of buildings they contribute approximately 60% of the total energy consumption. When combined with the knowledge that schools are 77% of the City's total floor space this does not seem unreasonable. However, as will be seen later, schools are still a good category to look further into regarding potential energy saving measures such as energy reduction plans or upgrades to the building.
- The second largest energy consumption by buildings comes from recreational buildings, primarily the DCU Center. Due to the size and complexity of the DCU Center, analyzing it is out of the realm of this study. The DCU Center has still been included as a reference building in the rest of this report. However it was not given priority by the team when considering which buildings to focus on for the City of Worcester to best spend its funding.
- Similar to energy use, the majority (53%) of Worcester's CO₂ emissions by buildings comes from schools. Also the second largest emitter of greenhouse gasses by buildings comes from recreational buildings, primarily the DCU Center. Energy use and CO₂ emissions are closely linked but may vary from each other, depending on the type of energy being used (i.e. natural gas vs. electricity).

5.3 Targeting Buildings by Means of an Energy Use / Efficiency Indicator

Table 4 displays the top buildings for analysis according to our prioritization factor, which we derived by multiplying energy use by efficiency to get a product with units of MMBTU²/foot². See *Section 3.3.2.3* for more information. This factor can be interpreted to be a tangible way to distinguish what buildings are going to be of highest priority to the City of Worcester for energy analysis and improvements. *Table 4* shows the data for the year 2010. Also included in the chart is a percent change from the baseline year of 2009.

The chart is ordered from greatest to least according to the prioritization factor. These top five buildings are in bold. The five buildings that are highlighted are to be taken note of as well. These buildings are distinguished for their inefficiency in terms of kBTU/sf. But, as previously

discussed, cross referenced with the building's energy use in MMBTU to assure used enough energy to be of importance to the city.

	Building	Subcategory	Use 2010 (MMBTU)	Efficiency 2010 (kBTU/sf)	Prioritization Factor 2010 (MMBTU ² M MBTU/sf)	Use 2009 (MMBTU)	% Change of Use (MMBTU) 2009-10
1	<i>DCU Center</i>	Recreation	36,032	273	9,846	32,829	-9.8
2	<i>Central Garage</i>	Garage	9,865	391	3,862	11,694	15.6
3	<i>Worcester Vocational HS</i>	School	25,593	63	1,617	27,155	5.8
4	<i>Burncoat HS</i>	School	14,776	102	1,512	15,141	2.4
5	<i>Franklin Sq Library</i>	Library	8,547	113	962	9,189	6.9
6	<i>Tatnuck Magnet School</i>	School	5,846	138	806	5,861	.34
7	<i>Doherty Memorial HS</i>	School	11,211	67	748	11,735	4.3
8	<i>Worcester East MS</i>	School	10,649	69	730	11,704	8.7
9	<i>Chandler Magnet ES</i>	School	8,523	84	712	8,015	-6.6
10	<i>Roosevelt ES</i>	School	9,197	76	701	11,250	16.4
11	<i>North HS</i>	School	9,601	72	691	9,872	2.4
12	<i>Worcester Memorial Auditorium</i>	Recreation	5,444	125	683	4,702	-17

Table 4: 2010 Energy Efficiency and Use

- The DCU Center is the most underachieving building, with a use/efficiency factor of 8,174 in 2009. This increases to 9,846 in 2010 due to an increase in efficiency and a slight increase in overall use. Interestingly, the use of gas increased four times more than the use of electricity, a 16% and 4% increase respectively. The DCU Center's performance declined a considerable amount, about 10%, which means that it deserves the city's attention. With that said, it is such an intricate building that analyzing it is out the scope of this project.
- The Central Garage stands out because it is the least efficient at 338 KBTU/sf. The efficiency gets even worse in 2010 at 391 KBTU/sf. The Central Garage does not use an inordinate amount of energy, at just under 10,000 MMBTU. It is so inefficient, however, that it's second on the list in terms of the prioritization factor. Even though it was also just over 15% better

from 2009 to 2010, the Central Garage is a prime candidate to investigate and improve. It presents a great opportunity for the city to save energy and money.

- The most noteworthy observation is that most of these buildings are schools. Seven out of the twelve from the top users in 2009 are schools, while eight out of twelve are schools in 2010. It will be worth digging deeper as to the causes for schools being the highest consumers of energy, while having such a wide variety energy performance within its buildings. At first glance, the problem can be attributed to energy use rather than energy inefficiency. The standard efficiency for educational buildings in the United States is approximately 83 KBTU/sf. All of the schools, except Tatnuck Magnet School, are within the standard deviation of the average for a school's efficiency. Tatnuck is about 50 KBTU/sf higher than the national standard for schools, so its problem does lie in efficiency rather than use. Otherwise, most of the schools are so high on the Use/efficiency factor chart because of the amount of energy they use, not the energy they lose from inefficiency. This is possibly contributable to the size and population of the schools.

The most intriguing subset of buildings for us to examine is the high schools because of the wide variety of characteristics they cover:

- The Worcester Vocational HS is actually nearly 20 KBTU/sf more efficient than the average for an educational building. This is most likely due to the fact that the Vocational HS is a new building, opening in 2006. Nonetheless, because energy use rivals only the DCU Center at over 25 MMBTU, it has been identified high on the prioritization factor chart. The other noticeable fact is that it became over 5% better with respect to the prioritization factor in 2010 compared to 2009. This is due to a decrease in use and an increase in efficiency, both use of gas and electricity decreasing roughly 5%.
- Burncoat HS does not use an excessive amount of energy, relatively speaking, but it is rather inefficient at nearly 20 KBU/sf worse than the expected efficiency for an educational building. Considering the fact that it is about 5 percent better from 2009, its performance is improving. The gas use did not change any notable amount, meaning the 10% decrease in

electricity use is the driving factor for the improvement. The complete data for FY 2011 would prove useful in determining if this, or any building, is following a trend or is random.

- Doherty Memorial HS has not changed any sizable amount from 2009 to 2010, about a 4% increase in performance. Although it still uses a lot of energy, compared to the standard efficiency for a school it is performing well. This is reinforced by the fact that it has been holding a fairly steady performance, with its gas use decreasing 6%: nearly the same amount as the percent decrease in degree days from 2009 to 2010.
- South High Community HS proved to be more of a concern in 2009, where it was high on the 2009 equivalent of *Table 4*. In 2010 it was still near the top of that Table (not shown due to chart ending after top 12) at number 14. Even though it is still near the top in terms of the prioritization factor, it became abundantly better, nearly 11% better, due to a reduction in gas and electricity use and an increase in efficiency. South High used over 30% less gas in 2010 than 2009, but the gas use is truncated by the electricity use so a larger increase in performance was not observed.

The graph below describes more explicitly the change in MMBTU between the baseline year and 2010. We decided to compare strictly use and not our prioritization factor because said factor uses units of MMBTU². Comparing the change in the prioritization factor would exaggerate any changes in energy use a building may undergo. This is an important distinction to make because we observe, in a more legitimate perspective, what buildings are getting better and what buildings are getting worse. Overtime, this indicator will reveal whether building upgrades have made a tangible difference, or possibly point out something wrong that directly affects a buildings' performance: a failing furnace system or inefficient general operation.

The most notable finding in this graphic is the municipal buildings that are in the greatest need of an upgrade decreased from 2009 to 2010. The graph ties back to *Figure 16* in *Chapter 5 Section 1* because it agrees with the decrease in overall MMBTU use from 2009 to 2010.

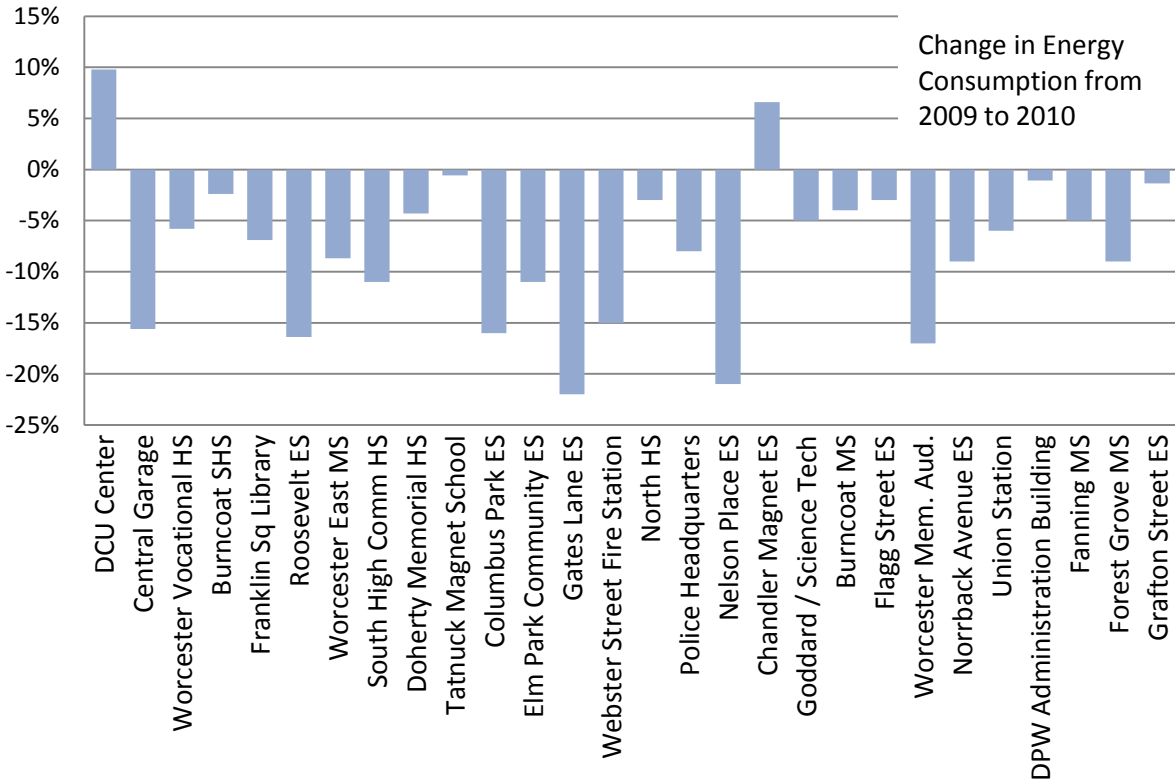


Figure 21: Change in Energy Consumption from 2009 to 2010

Chapter 6: Recommendations

In this chapter, we present our recommendations to the City of Worcester, to other municipalities looking to perform similar types of analysis, and to the developers of Mass Energy Insight. First, we present strategies that the City of Worcester and other municipalities can employ in analyzing the energy efficiency of their buildings. Next, we will describe steps the City can take to best utilize the Mass Energy Insight software. Finally, we will discuss specific ways that Mass Energy Insight can be improved. Note that additional recommendations can be found in *Chapter 4: Mass Energy Insight User Guide*. All these recommendations arose from our firsthand efforts to use MEI to analyze the energy efficiency of Worcester's municipal buildings. We are optimistic that our efforts have illuminated the main problem areas, which will make future analysis efforts the City conducts faster and more productive.

6.1 Recommendations Regarding Future Analysis

Throughout the course of this project, we identified several recommendations that we would like to make to the City of Worcester, as it moves forward, regarding Mass Energy Insight use.

1. **Further work needs to be done to ensure that all of the underlying data in Mass Energy Insight is imported correctly.** MEI can be a very useful tool to a municipality, but only if the data is correct. Incomplete data is primarily to blame for the large increase in natural gas usage from FY2008 to FY2009. Unfortunately by the time these discrepancies were noticed the project was too far along for the changes needed to be enacted. While we do not believe there is much more missing data during the years examined than what has already been identified, it is still important to fix these problems.
2. **Ensure that all energy accounts that are relevant to analyzing Worcester's building fleet are properly assigned in Mass Energy Insight.** Slightly more than 50% of the natural gas or electric accounts that the City of Worcester has available to them on Mass Energy Insight are not assigned. After we had reconciled all of the accounts that we were asked to analyze, there were still many accounts left over. Further work is necessary to identify what facilities these accounts belong to and either assign them to additional buildings or remove them from the system. Additionally, while reconciling the data, there were several buildings that we were not able to complete with 100% accuracy. For

example, 9.43% of buildings did not come with square footages and 9.43% were without building types. These pieces of information are crucial to using Mass Energy Insight to its fullest potential. The square footages are directly involved in the calculations of efficiency, which is possibly one of the most crucial pieces of information. Similarly, if buildings are not categorized well then it is nearly impossible to get a good overall picture of the city's building breakdown as a whole.

3. **Examine the DCU Center and other large, complex buildings such as the Central Garage.** Attempting to do proper analysis on these buildings would have been out of the scope of this project, due to time restraints. As we have explored previously, buildings such as these were at the top of our prioritization factor and if they are approached carefully, they have a large potential to save the city money and to reduce emissions.

6.2 Recommendations Regarding the Functionality of Mass Energy Insight

Below, please find recommendations regarding the functionality of Mass Energy Insight. If these recommendations were to be incorporated in the next release of Mass Energy Insight, the software would have greater value.

1. **Reduce the long initial loading times.** When viewing the reports a user has to wait for all of the reports to load simultaneously instead of the individual graph the user wants to view. This often causes very long initial loadings times, especially when viewed on slower connections. With over a hundred buildings, the graphs and analysis tools provided by Mass Energy Insight become unwieldy. If the response time were improved, MEI would become much more usable.
2. **Allow users to select from a list data to be exported.** Currently the user can download either all the data, or just the data being used in the active report, meaning a user cannot simply select the data needed. It would be very useful to the user if it were possible to, at any time, download the specific data they need.
3. **Allow the user to generate new types of graphs.** Presently, the graphs that can be displayed are limited to those already developed by Mass Energy Insight. This limits the

functionality of MEI as the types of graphs that a city such as Worcester is interested in are likely different from those small towns are interested in.

4. **Include in Mass Energy Insight the option to compare multiple years all for graphs.** A recent upgrade to MEI has removed the option to view multiple years simultaneously on numerous reports. This is a large problem because one of the strengths of tools such as Mass Energy Insight is providing long term analysis, where data from several years is combined to make a decision.
5. **Mass Energy Insight should make its scroll bar interface compatible with more screen resolutions.** Depending on one's screen resolution, the fields with scroll bars presented by MEI do not display properly or at all. This deficiency could prevent a user from reading important information, especially as pertains to the Setup Completeness Dashboard, which sometimes exhibits the flaw.
6. **Developers of MEI should make the graphs easier to read when a large number of buildings are present.** In the case of Worcester, graphs like the Buildings to Target report become cluttered with the data points for the city's many buildings. It becomes hard to select the desired data point and identify which data point is selected. Graphs like the Buildings to Target report should have a zoom feature, thus allowing the user to resize the window to a shape appropriate for the number of buildings displayed.

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Appendix A: Summary of Energy Audits

I. Introduction

Energy audits are a significant part of the residential energy efficiency process. It is the only tangible way to evaluate what the energy efficient state of the home is. Quite simply put, energy audits are the process of determining the efficiency of a building, in terms of the energy used. Energy audits became popular in the 1970s after the energy crisis drove homeowners to look for alternative means of reducing their operating costs other than just simply cutting back. Since the 1970s however, energy audits have become a highly technical process, involving everything from thermal cameras to detailed software models of the building in question.

In the United States energy audits are provided by a variety of sources including utility companies as well as private entities. Depending upon the scope of the audit and the size of the building in question an energy audit can take anywhere from a few hours to a couple weeks and cost from a few hundred dollars to thousands of dollars.

II. Stages of Energy Audits

The phrase “energy audit” encompasses a wide variety of methods, ranging anywhere from a quick walk-through to detailed data analysis with minute-to-minute computer models. With this in mind, the energy audit process can be boiled down to four successive types: the walkthrough audit, utility cost analysis of the home, standard energy audit, and the detailed energy audit. These types are arranged in such an order that they build-off one another and assure each other’s analysis.

The most basic type of energy audit is the walk-through audit. This style of audit consists of just what it implies: a quick on-site walkthrough. The walk-through audit is the least costly of all types and identifies preliminary energy savings (Thumann, 2003, p. 2). The audit includes a visual inspection of the facility which can identify saving possibilities and serves as an opportunity to determine the areas in need of more detailed analysis.

The usual next step up in energy audits is utility cost analysis. This stage of auditing is used to analyze or possibly cross-reference the operating costs of the facility with the operating costs of a similar building under similar weather patterns. The utility data is then used to identify patterns of energy use, peak demands, and weather/seasonal effects (Krarti, 2000, p. 2). From this the energy auditor can determine what areas are prime for retrofitting or renovation.

Generally after a walk-through and utility cost analysis, a standard energy audit is in order. This type of audit requires tests and measurements to quantify energy losses and concretely determine areas that need to be addressed. Along with performing the steps associated with a walk-through and utility cost analysis, the standard energy audit includes determination of baseline energy use of the building and identification of possible energy savings (Krarti, 2000, p. 3).

Finally, the most exhaustive type of energy audit is a detailed energy audit. This type of audit goes one step further than the standard energy audit. It usually contains an evaluation of how much energy is used for each utility such as lighting, HVAC, etc. A model analysis, such as a computer simulation, is generally used in this audit to help determine energy patterns and form a year-round prediction of energy use while taking energy and weather patterns into consideration (Thumann, 2003, p.4). This type of audit is the most comprehensive but quite time consuming, while also requiring the use of expensive equipment. Due to this, the detailed energy audit is generally performed by trained energy auditors and is a costly endeavor, with a standardized test ranging near the \$900 price range.

III. Steps of an Energy Audit

Most often a residential audit is performed by a trained technician from a company or laboratory but it is essential to understand the lengths to which they go in a standard audit. A standard audit uses data from the included walk-through audit as well as a utility cost analysis as a starting point. An auditor will first perform a walk-through audit of the building which consists of visually inspecting for noticeable deficiencies such as drafty windows and doors or inefficient lighting systems. By identifying these deficiencies the auditor is locating the most pressing needs of the building and other areas for study later in the audit process.

The next step in the audit is a utility cost analysis where the auditor will analyze the building's utility bills, such as heat and electricity, for the previous and following year surrounding the initial energy audit. The goal of this analysis is to determine the buildings average energy use throughout the year and, for example, determine if during the summer months an unusual amount of electricity is being used. The typical product of this type of analysis is a graph depicting the energy consumption for the time period in question. The data collected through utility cost analysis helps to later quantify energy savings.

In the final step in a standard audit the auditor targets the deficient areas identified during the walkthrough and makes recommendations to address these issues; while potentially addressing more advanced energy loss issues identified through more high-tech analysis techniques. Typical recommendations include replacing drafty doors and windows, installing more insulation in deficient areas, and repairing any leaks in the HVAC (Karti, 2000, p.3). In addition, several high-tech analysis techniques can be performed. One such technique is using a thermal camera to measure the heat loss of the exterior walls and windows of a building. A thermal camera will also be able to determine if an appropriate amount of insulation is installed uniformly throughout the house. This technique and others like it, while incredibly useful, are not very common due to the high price of the tools required.

As well as using a thermal camera to measure the heat loss a blower door test can also be performed. A blower door is a powerful fan that mounts into the frame of an exterior door. The fan draws air out of the house, lowering the air pressure inside. The higher outside air pressure then flows in through all unsealed cracks and openings near windows, doors, or other home openings. When combined with some type of incense or smoke, leaks in the exterior of the

building can be easily identified and fixed. With a common blower door test the pressure inside the room being tested can be measured and compared before and after any renovations have been performed to ensure a quantifiable change has been observed.

While it is fairly easy and straightforward to perform an energy audit, understanding and interpreting one is where a professional auditor is needed. Their experience and knowledge are invaluable in interpreting the results of the various steps of an energy audit.

IV. Verification of Energy Savings

The effectiveness of energy retrofitting, monetarily and energy-wise, is the most important part of the energy audit process. It is the reason the audit was done in the first place, although there are often discrepancies in predicted and realized savings. This variation in data is why there have been standardized methods for measurement and verification of energy savings. Generally this can be done by comparing energy use pre, during, and post retrofit (Karti, 2000, p.24). Unfortunately, the changes aren't always due to the retrofitting; rather, by changes in weather, residency, or other factors account for such alterations. Even with these variables, there are a few techniques that can be applied such as regression models and time variant models that can still determine the effectiveness of renovations.

Typically, a regression model uses weekly or monthly energy consumption data and daily average temperatures to calculate a linear regression model to determine accurate non-weather dependent energy consumption data (Karti, 2000, p.25). This model is also useful to determine the temperature at which energy consumption began to increase due to heating or cooling and the rate in which energy consumption increased or decreased. Most buildings follow a weekly routine, which means that weekly energy-consumption data is typically a good option for regression model analysis. Although the occupancy of the building and the heating patterns might vary throughout the week, the patterns are usually consistent from one week to the next.

V. Conclusion

Understanding energy audits is a significant part of the residential energy efficiency process. Not only does an energy audit quantify the amount of energy the home in question is using but it also highlights areas for improvement. Both of which are critical components of identifying and increasing a buildings energy efficiency rating.

Appendix B: Types of Graphs Generated By Mass Energy Insight

The complete list of graphs generated by Mass Energy Insight are given below in the order they appear on MEI along with a brief description of each graph.

- **Overall Use and Emissions Dashboard:**
Provides the City's overall use and emissions broken down into percentages by gas and electricity consumption. Also it provides a smaller version of the For Printing - Use and Emissions by Facility graph.
- **Baseline Report:**
The baseline report depicts the City's overall energy use in MMBTUs and tracks the change in use compared to a baseline year. Additionally, the baseline report breaks down the city's energy use by category (i.e. building, open space, water/sewer) but not by subcategory.
- **Use and Cost Table:**
Allows the user to view a tabular breakdown of the municipality's usage and cost for various fuel types and years by departments, complexes, and buildings.
- **Annual Usage Patterns – Town:**
Graphs the data from the Use and Cost Table on a monthly average for all major fuel types.
- **Usage Trends – Town:**
Displays a more detailed version of the Annual Usage Patterns report along with a trend line.
- **Use and Cost This Year to Last:**
Compares the last twelve months of usage and cost to the previous year's energy use and cost.
- **Buildings to Target:**
The buildings to target graph breaks down the city's energy consumption by each individual building. Additionally it graphs each building's energy use (MMBTU) versus its usage per square foot (kBTU/sf). Individual building subcategories can be selected and displayed on this graph.

- **Building Dashboard:**
Provides the usage and cost trends for a specific building for any number of years selected as well as annual usage patterns for said building.
- **School Benchmarks:**
Compares the municipality's schools against other schools throughout Massachusetts as well as providing a state wide average for which the user to compare too. The schools can also be filtered by school type.
- **Monitoring Use Dashboard:**
Provides a similar report to the Monitoring Cost Dashboard except instead of breaking down each individual building's energy use it breaks down cost.
- **Monitoring Cost Dashboard:**
This report provides a cost breakdown for each individual building's energy use by quarter and by year. If a building used less energy than the previous year that year's bar is colored blue, and if it used more than the bar is colored red.
- **Setup Completeness Dashboard:**
Displays the remaining accounts or buildings that have not been completely finished, i.e. accounts that have not been assigned, buildings that have not been assigned a category or subcategory, and buildings that do not have a square footage entered.
- **Data Loaded – Overview**
Breaks down each account's usage and displays whether it was automatically imported correctly or if an account is missing data.
- **Data Loaded – Detail**
Provides the same view as the Data Loaded – Overview report as well as displaying the energy usage for the intervals in question.
- **For Printing - Use and Emissions by Facility:**
Displays large graphs that break down each facility's energy use into percentages for the major fuel types. Additionally, the width of each facility's bar is a visual representation of that facility's CO₂ emissions.
- **For Printing - Building Efficiency, Emissions and Cost:**
Provides large graphs depicting the usage per square foot, CO₂ emissions (in pounds), and the cost for each individual building.

- **ESCO Report - Annual Data:**
Provides a breakdown of each individual National Grid or NSTAR account's usage and the cost associated with that usage.
- **ESCO Report - Monthly Data:**
Provides a breakdown of each individual National Grid or NSTAR account's monthly usage and the cost associated with that usage.
- **ESCO Report - Building Level MMBTUs:**
Similar to the ERP Guidance Table 3b, this report provides, in table format, how much electricity and gas (in MMBTU) each building used in the various fiscal years. Additionally, if an area for that building is given, then its usage per square foot is calculated as well.
- **Energy Reduction Plan Guidance Table 3:**
Displays each building's electric and gas usage in either MMBTU or native fuel units for a single year.

Appendix C: Standard Energy Efficiencies

Note: The units for all of the tables in this appendix are given as such, floor space is millions of square feet, energy use is trillions of BTUs and efficiency is kBTU per square foot.

Building Type

	Floor Space	Energy Use	Efficiency
Education	9,874	820	83.0
Food Sales	1,255	251	200.0
Food Service	1,654	427	258.2
Health Care	3,163	594	187.8
Inpatient	1,905	475	249.3
Outpatient	1,258	119	94.6
Lodging	5,096	510	100.1
Retail (Other Than Mall)	4,317	319	73.9
Office	12,208	1,134	92.9
Public Assembly	3,939	370	93.9
Public Order and Safety	1,090	126	115.6
Religious Worship	3,754	163	43.4
Service	4,050	312	77.0
Warehouse and Storage	10,078	456	45.2
Other	1,738	286	164.6
Vacant	2,567	54	21.0

Region

	Floor Space	Energy Use	Efficiency
Northeast	12,905	1,271	98.5
New England	2,964	294	99.2
Middle Atlantic	9,941	978	98.4

Ownership

	Floor Space	Energy Use	Efficiency
Government Owned	15,363	1,617	105.3
Federal	1,956	303	154.9
State	3,808	513	134.7
Local	9,599	800	83.3

Data Retrieved From: 2003 Commercial Building Energy Consumption Survey (CBECS), Table C-1a
http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set9/2003excel/c1.xls