Preparing Auburn for a
Climate Action Plan

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        Town of Auburn

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ABSTRACT

This report, prepared for the municipal government of Auburn, Massachusetts, will describe methods that can be taken in order to prepare the town for the creation of a Climate Action Plan (CAP). Using information drawn from literature and interviews, we will outline health and economic challenges facing Auburn, why a CAP is needed, and procedures to complete a CAP specialized for Auburn's unique situation. We will analyze emissions sources within Auburn and make recommendations on mitigation of these emissions.

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AUTHORSHIP

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Executive Summary - Tyler Chambers

Chapter 1 – Introduction - Ina Duka

Chapter 2 - High Cost And Pollution In Auburn - Ina Duka

Chapter 3 – Transportation Emissions Sources

- Introduction and Sections 3.1, 3.2.1,3.2.2, 3.2.5,3.2.6 – Thomas Jones
- Sections 3.2.3, 3.2.4 – Tyler Chambers

Chapter 4 – Auburn's Energy, Waste And Fuel Emissions

- Introduction and Sections 4.1.5, 4.1.6, 4.1.7 – Thomas Jones
- Sections 4.1, 4.2, 4.3, 4.4 – Tyler Chambers

Chapter 5 – Recommendations For Future Data Collection And Increase Energy Efficiency

- Sections 5.1, 5.3 – Tyler Chamber
- Section 5.2 – Ina Duka

Chapter 6 – Background Research - Fabrice Kengne

Chapter 7 – Design and Implementation of a Database for the Town of Auburn - Fabrice Kengne

Chapter 8 - Conclusion – Fabrice Kengne

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EXECUTIVE SUMMARY

The purpose of this IQP was to prepare the town of Auburn, Massachusetts to complete a climate action plan so that they would have the tools to complete a climate action plan later on. Auburn is a family oriented community and it would also like to be regarded as an environmentally friendly one. The climate action plan is a plan with the primary goal being to reduce greenhouse gas emissions. Not only does the climate action plan aim to reduce greenhouse gas emissions but it also holds the potential to create, economic, health and even quality of life benefits. There are two main reasons why a climate action plan would be ideal for Auburn right now, the economy and the rising air pollution. Auburn is forced to cope with the government proposed 2011-2012 local aid budget cuts, which have been reduced by nearly $60 million. Furthermore according to the Environmental Protection Agency Auburn contains a harmful level of ground level ozone. The climate action plan will target both of those areas by reducing costs through energy efficiency and also reducing the amount of greenhouse gases being released. The organization that created the climate action plan and set up all of the standards for completing the climate action plan is ICLEI. ICLEI created the 5 milestone process that makes up the climate action plan. The first milestone which is to inventory the emissions data was what our team was tasked with doing. The inventory is one of the main parts of the climate action plan and most of the other milestones are based off of the data that is collected in the inventory.

Our project ended up being split into two separate parts the inventory and the creation of a database. The inventory is just what was stated in the first milestone. Our team decided that it would be in Auburn's best interest if we created a database for them. The purpose of creating the database was so that once when Auburn was doing the climate action plan they would be able to plug all of the data that was collected for the inventory into the database. By doing this all of the data that is needed for the climate action plan is in one place and easily accessible. The database is also able to double as a place to keep any town data that might be needed like monthly/yearly electricity or fuel use.

For the inventory it is separated into two categories, local government and community. Each one of these categories has sections within them. For the local government category there were seven sections that we had to inventory. Those sections were buildings and facilities, streetlights and traffic signals, solid waste facilities, wastewater facilities, vehicle fleet, and water delivery facilities. For the community category there were five sections that we had to inventory. Those sections were industrial, commercial, residential, transportation and waste. ICLEI has specific data that has to be collected for each individual section they outline what exactly needs to be collected and who it can be collected from. In order to collect this data we had to contact all of the people in charge of the individual sections. Due to the short termed nature of the project and people not responding to us we were unable to collect all of the data that needs to be collected in order to have a complete inventory. Since we weren't able to complete an entire inventory our team made a comprehensive guide for the data that we collected and the data that we were unable to collect. This guide lays out what specific data has to be collected for each section and who exactly to contact to gather that information.

At the end of the project we are leaving Auburn with the database that we made and a guide on how to create a climate action plan. Using these tools the town of Auburn will be able to create their own climate action plan which will bring additional benefits. Auburn will become a leader for the surround cities to follow their lead and create climate action plans to reduce their own greenhouse gases. They will join a growing network of communities who have completed and are working on climate action plans which number over 2,000 cities across the world. One of the most beneficial aspects of creating the climate action plan is that Auburn will be one step closer to achieving the green community status. With this status it will make Auburn eligible for grant money due to becoming a green community.

CHAPTER 1 – INTRODUCTION

Auburn, Massachusetts is a family oriented community with the desire to also be regarded as an environmentally friendly one. The primary goal of a Climate Action Plan (CAP) is to reduce greenhouse gas emissions. The CAP also holds the potential to create economic, health and more quality of life benefits in Auburn. The actions that are undertaken by the CAP can bring green businesses, creating new local green jobs, and allow neighborhoods to thrive in Auburn. With the reduction of fuel consumption, Auburn can reduce the fossil fuel dependence, reduce local air pollutants and improve public health.

The International Council for Local Environmental Initiatives (ICLEI) is the creator of the CAP. ICLEI was founded in 1990 with a few initial members. Today ICLEI boasts over 1200 Climate Action Plans, and the number keeps growing. To complete their CAP, ICLEI provides its members with wealth of information regarding all matters environmental, "5 Milestones", and a list of protocols. The "5 Milestones" are the achievements, outlined by ICLEI that local governments can follow to reach their desired reduction targets. After each milestone is completed, ICLEI issues the city/town a certificate, verifying the success. Completing all ICLEI 5 Milestones takes an estimated ten years. The town of Belmont, Massac, is similar in demographics to Auburn and was facing similar economic and environmental difficulties as Auburn. Belmont, Massachusetts, is experiencing high air pollution, top ten percent of most polluted in 2002, and excessive costs. It joined ICLEI in 2006, and has completed three of the 5 Milestones. Currently, Belmont has developed its local CAP and it working to implement the new policies and measures. The team was focused on inventory of data, Milestone 1, the ICLEI protocols were used as a foundation for the project as they have been proven to work.

Auburn faces two important challenges: a lagging economy and rising air pollution. Auburn is forced to cope with the government proposed 2011-2012 local aid budget cuts, which have been reduced by nearly $60 million. Furthermore, according to Environmental Protection Agency (EPA), the New England area contains a harmful quantity of ground level ozone. The CAP will target the root of the issues. Completing the CAP will be a lengthy process, taking roughly five years. By having Auburn take the first steps towards a CAP, it will have initiated the process of making a better community for the residents. The key benefits associated with this action are: connecting Auburn to a network of other cities striving for the same goal (which

provide support and guidance), eligibility for grants, and reducing greenhouse gasses. Furthermore, Auburn will be able to move forward with their motto of "*Think Globally, Act Locally"*, a sentiment shared both by ICLEI and all of its members. After the completion of the CAP, Auburn will have to monitor and ensure all resources are being utilized in manner outlined by the CAP.

Our project, then, is broken into two parts: the actual CAP inventory and the development of a new database. For part one, the inventory, the team collected data on energy and fuel usage in Auburn. To obtain the data for the inventory, the team followed the ICLEI protocols on obtaining data by contacting the officials in each of Auburn's government departments. ICLEI's protocols were used as they offered the best methods on data collection, as determined by the team, and have shown high success rates in other towns. With the collected data, the team used software, provided by ICLEI, to compute emissions figures. With the computed data, the team made recommendations for improvements to Auburn.

In part two, the team created the database, as there was not one prior, to aid in further collection and storage of energy and fuel consumption data. This database is now the location for Auburn to maintain accurate records of its usage. With the database, Auburn will be able to monitor its fuel and energy usage of its government facilities and vehicles that are critical in reducing emissions.

CHAPTER 2 – HIGH COST AND POLLUTION IN AUBURN

The motives behind Auburn's drive to complete the CAP is the current economic and environmental challenge in Auburn which must be addressed. This chapter is divided into three parts, which examine:

- The rising energy costs in the town of Auburn
- The types of and effects of air pollution on the Auburn community
- International Council for Local Environmental Initiatives (ICLEI) and what it means for Auburn

The first two parts of the chapter are aimed at understanding how the slumped economy has affected Auburn and how the worsening environment is causing a rise in health problems; since these are the main reasons for Auburn undertaking the actions to complete a CAP. The third section discusses ICLEI, which is the foundation for the CAP, and why this organization's principles in particular were chosen for Auburn.

2.1 Rising Energy Costs in The Town Auburn

Auburn was adversely affected by the most recent economic recession. NBER (National Bureau of Economic Research) defines a recession to be: "a significant decline in economic activity spread across the economy, lasting more than a few months." (NBER). The New York Times published an article saying "A committee of the National Bureau of Economic Research has declared that the United States is in recession, and has been in it since December 2007". The primary cause of the recession is assumed to be the housing downturn, i.e. the fall of housing prices. As a result of the price decrease, there was a sharp rise in mortgage foreclosures . This caused hundreds of billions of dollars to be lost and a tightening on credit.

For many of local communities throughout the United States, the recession took its toll. The full extent of the recession is clearly visible when the state budget cuts are exceptionally high. Figure 1 shows just how much the budget cuts were throughout the U.S, but it also shows a good projected recovery. The figure also shows a comparison of budget cuts in the last recession and the current one.
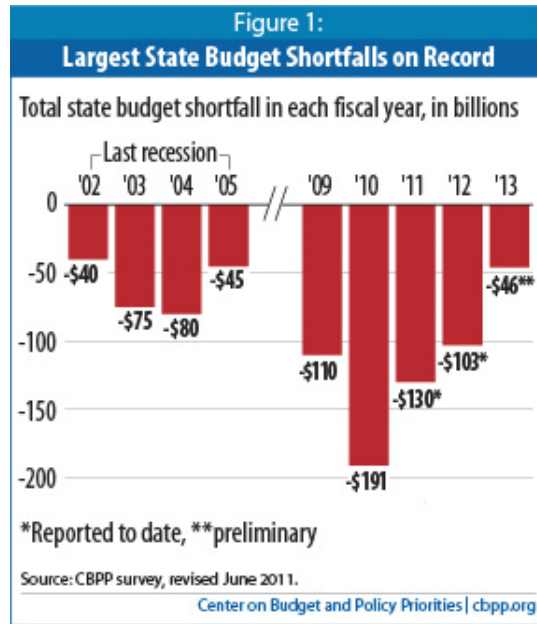
Figure 1 - State budget shortfalls

As marked in the figure, the last recession budget cuts did not exceed $100 billion in cuts. The current recession, shown from 2009, had a maximum low at $191 billion, in 2010.Although for the current year, 2011, and following year 2012, the budget cuts are getting smaller, the figures are still quite substantial. The projected 2013 figures bring hope that the recession is coming to an end, and that budgets may be returned to a more manageable figure. For Auburn, these budget cuts imply that it will have to utilize all of the limited aid in a very efficient and effective way. Through the completion of the CAP, Auburn will be able to understand how to use the resources effectively.

MassBudget's report, published on May 23, 2011, is of particular relevance to Auburn as one of the most significant budget cuts that is to be made is for unrestricted local aid which has restricted Auburn's spending capability for its community. The unrestricted local aid refers general aid offered to a local government, i.e. Auburn, for use on all government spending necessities. The report is titled "*The Senate Ways & Means Fiscal Year 2012 Budget"*. The budget cuts must be made in order to reform initiatives to close the $1.9 billion gap between the expected available revenues and costs of providing the services currently. The Senate Ways & Means Fiscal Year 2012 budget proposes that the funding of local aid be $868.4 million. This figure would be a $56.8 million decrease (roughly 6.1%) from the current 2011 fiscal year level.

When adjusted for inflation and compared to the 2009 fiscal year, the cut represents a staggering 37.8%. Figure 2 below illustrates this.

Fiscal Year 2012 Senate Ways & Means	**$868,400,293**
Fiscal Year 2011 Current	**$925,212,293**
Change from Fiscal Year 2011 Current *Percent Change*	*-$56,812,000* *-6.1%*

Figure 2 - State budget cut amount

To further analyze the budget cuts for the 2012 fiscal year, the proposed budget for local aid is divided into sectors, with specific quantities assigned to each. Figure 3 shows this sector breakdown with associated values.

Sector	Amount (Millions)
Unrestricted General Government Local Aid	**$834.0**
Reimbursements to Cities in Lieu of Taxes on State Owned Land	**$25.3**
Payments to Cities and Towns for Local Share of Racing Tax Revenue	**$1.2**
Regionalization and Efficiency Incentive Grant Program	**$8.0**
Division of Local Services	**$4.0**
Department of Elementary and Secondary Education	**$2.0**
Executive Office of Public Safety	**$2.0**

Figure 3 - Sector and amount breakdown

The budget breakdowns give insight to where the funds were going to be used. Unrestricted general government local aid receives the largest portion, as it is free to be used on any and all government expenditures. The division of local services is restricted to use on local government efficiency efforts. These efficiency efforts are any type of action that will decrease fuel and energy consumption. The efforts are not limited to, for example, reduction of fuel consumption

through more fuel efficient vehicles, such as hybrid cars, but rather could be used to bring business to Auburn and require less commuting or shorter delivery routes.

An article in The Boston Herald, published on December 7, 2011 ("*Report: Fiscal Squeeze will continue for cities and towns")*, states that the budget cuts will have a harsh impact on small town local governments, such as Auburn. The report also says how local towns have had to rely more heavily on increasing property taxes. Property taxes have supported 56.5% of local budgets since the tax increases. Auburn, as the report states, is employing higher private property taxes to counteract the budget shortfall that had to be met. According to the Auburn Treasury and Collections Division, in 2007, the residential tax was $10.41. Over the past years (2007-2011) the tax increased 33 percent, to $15.38. The taxes were not increased purely based on inflation, as the current equivalent value to the 2007 tax is $11.37. Figure 4 shows the trend of taxes since 2000.
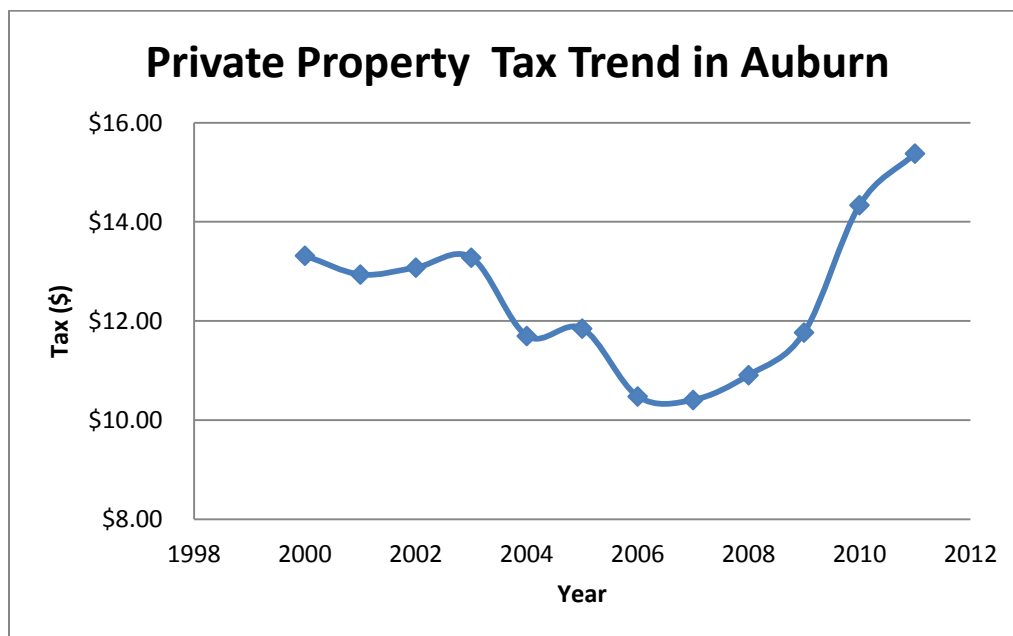
Figure 4 - Private property tax trend in Auburn

Figure 4 shows that the tax was decreasing and hit a low point in 2007. As the economic situation nationwide worsened, and the recession intensified Auburn had been compensating by increasing the private property tax. Based on the trend indicated in the graph, the forecast for a decrease in taxes is grim. For as long as the budget cuts remain very high, Auburn will not be

able to reduce its taxes, because it the taxes were reduced and the budget cuts remained high, Auburn would not have any revenue.

2.1.1 Auburn Utilities and Gasoline Analysis

With the budget shortfalls Auburn, alternative sources of losses must be examined. The sources are that the area of Auburn incurs a higher cost for electricity, natural gas, and potentially gasoline than that of the U.S. city average, according to the U.S. Bureau of Labor Statistics. The three items that are analyzed as sources of increased costs for Auburn are:

- Electricity
- Natural/Piped Gas
- Gasoline

Each of the three sources contributes to the loss of revenue and increased pollution for Auburn individually. However, if the effects the three are put together, the impact is quite substantial. Through the analysis and identification of costs, Auburn will be aware of sources of high expenses.

Electricity

The cost of a Kilowatt-hour (kWh) of in Auburn (August 2011) was 4.5 percent less than a year prior. Nationwide prices were raised 1.5 percent in this same time period. However, even with this rise, Auburn was still above the national average. At the current trend the national average and Auburn's average will normalize and be very close, if not equal. Figure 5 illustrates this trend. This represents a cost decrease for Auburn, while it is an increase for the national average.

per kilowatt-hour

Source: U.S. Bureau of Labor Statistics
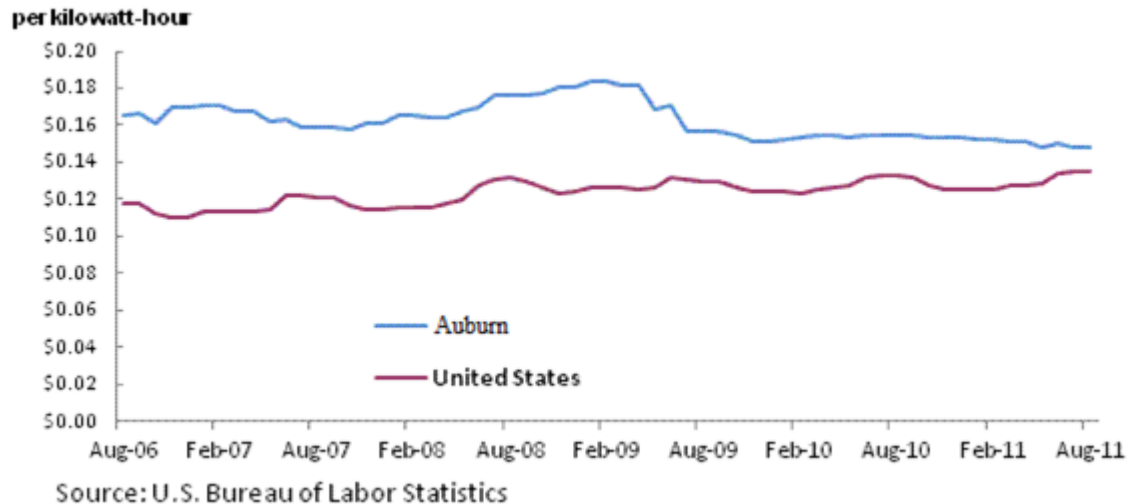
Figure 5 - Average prices for electricity, Auburn and the United State, August 2006-11

Even though the two might normalize, the trend of the prices is still increasing. At this rate, cost in Auburn can be expected to go up 1.5 percent. Furthermore, the normalization with the U.S. average implies that Auburn is not expending more in costs than what is expected, i.e. Auburn is at the level of the national average, not spending more on electricity than other towns. With further improvements to the energy use, Auburn would in fact drop below the national average and incur savings.

Natural/Piped Gas

Auburn relies on natural gas, or utility gas, as the primary source of heating. The prices in Auburn for natural gas increased by 14.5 percent since 2010. At this rate, the town is expected to pay 30 cent more per therm in the 2011 winter. Auburn maintains lower natural gas prices during the summer months, while during the winter, the price is increased, when comparing to the nationwide prices. Figure 6 shows the natural piped gas prices.

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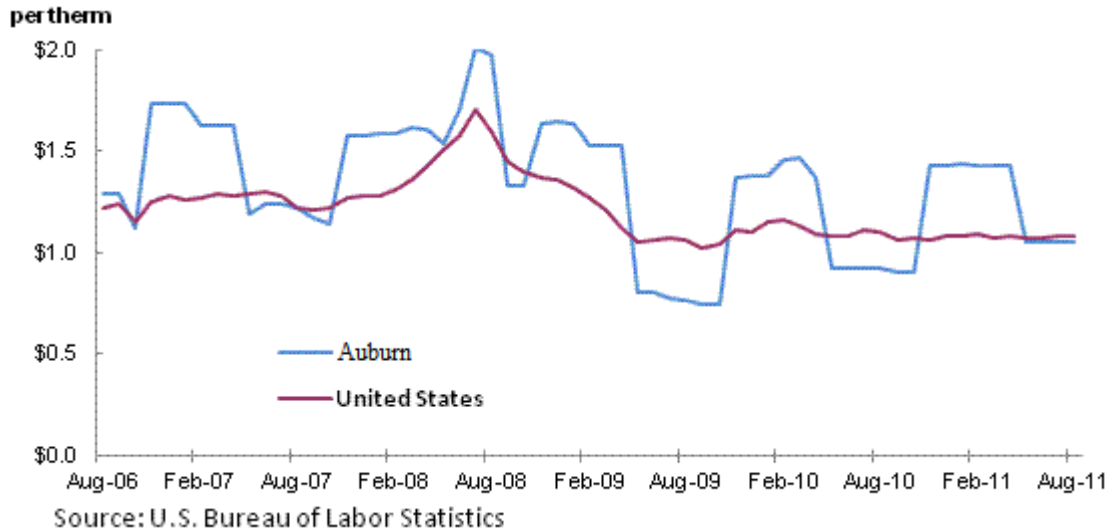
Figure 6 - Average prices for utility gas, Auburn and the United State, August 2006-11

The demand for natural gas increases in the winter causing the price to increase as well, as can be seen in the chart. With these high prices, when compared to the national average, it is imperative that Auburn makes use of alternative energy sources and good environmental practices. By placing emphasis on better home insulation and monitoring heating, there would not be as much expenses. In this way, Auburn will be able to avoid being subject to the higher local costs.

Gasoline

Roughly 45% of Auburn's households have two vehicles, and another 32% have one vehicle (U.S. Census Bureau), which leads to high fuel usage and greater pollution. In fact, only 4% of the homes in Auburn do not have a vehicle. The average number of vehicles per household is 2.30. The Massachusetts national average is 2.10 vehicles per (U.S. Census Bureau). Gasoline in August of 2011 was priced at 5 cents higher in Auburn than the national average. With such a high percentage of vehicles in Auburn per household, residents pay 11.5 cent more than the national average. Also, the local government employees average one-way commute to work is 13.16 miles, which cost $1.32 cent more per day to go to work. Figure 7 shows the trend of gas prices, local and nationwide.
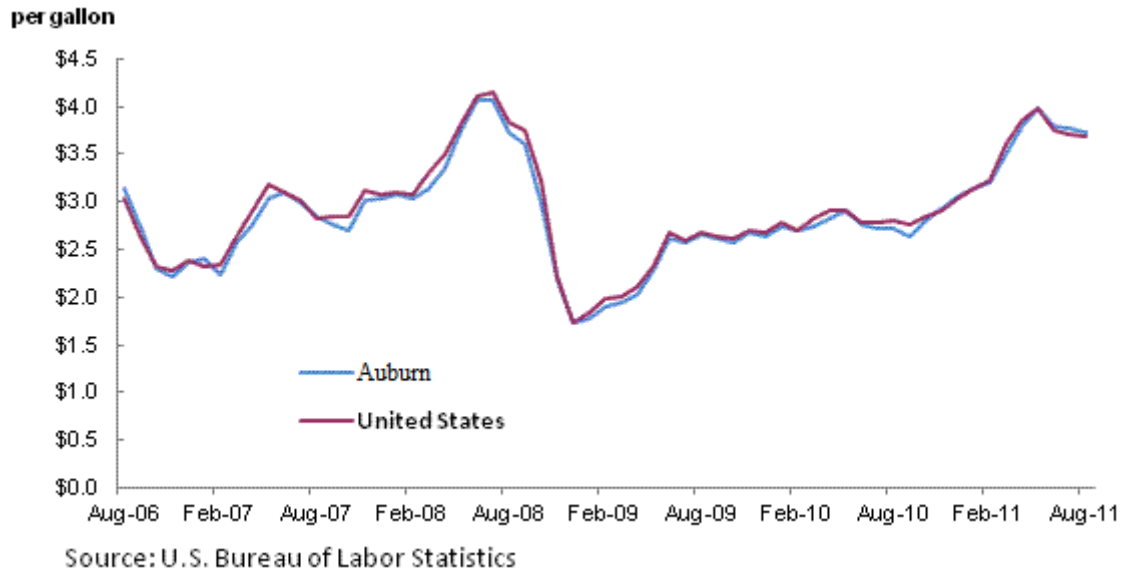
Figure 7 - Average prices for gasoline

The prices of gasoline tend to vary from month to month. As an overall, the prices in Auburn area and that of the nationwide have been moving almost in unison, as Chart 2 shows. At some points, such as August 2010, the gas price was lower in Auburn. Overall Auburn is spending more money on gasoline than the national average.

2.1.2 Summary

The decrease in budgets coupled with higher than average costs for utilities in gas in Auburn have led to a deficit in local funding. Auburn is responding to these changes by increasing local taxes. The CAP will be used to instruct Auburn how to utilize its resources to maximize fuel and energy efficiency and bring down the costs. When this is paired with the prospect that budget cuts will subside, Auburn will we able to thrive and reduce the taxation of its residents.

2.2 Air pollution

Auburn's second area of focus is the air quality. Currently Auburn is experiencing high levels of air pollution which is having negative effects on its population. The population of Auburn is largely deemed to be in the "sensitive" group for which the air pollution is particularly harmful to.

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'Climate change' is a problem that is affecting people and the environment both globally and regionally. According to the Environmental Protection Agency of United States:

Throughout the world, the prevalence of some diseases and other threats to human health depend largely of local climate. Extreme temperatures can lead directly to loss of life.... In addition, warm temperatures can increase air and water pollution, while in turn harms human health. (Health section)

Rising average global temperatures are already affecting the worldwide climate and that of Auburn. According to the Intergovernmental Panel on Climate Change 2007 special report some observed global changes include "shrinking of the glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of growing seasons, shifts in plants and animal ranges and earlier flowering of trees"(IPCC, 135). If greenhouse gas emission continues to increase the climate change will continue to be affected and Auburn's population will continue to suffer.

In the New England region, residents have come to expect and accept the ever-changing weather, without considering the reasoning as to why such frequent changes occur. The New England Regional Assessment (NERA) report in 2000 shows some of the local perspectives:

People assume that these greenhouse gases come from industrial sources located in mid-western states, and thus, are beyond regional control. In addition, a common view is that global warming is global in scale and it is not obvious to the average person how local action could have any impact on such a large-scale problem (Chapter 1).

Many other citizens are just tired of the cold winters and snow that they would mind milder winters and longer growing seasons. These local perspectives are misguided because "when we think of climate change, it is only natural to think of the physical climate factors such as temperature and rainfall" (NERA).

To understand the problems connected to climate change, recognition must be given to the fact that the term "climate" can refer to both physical climate (temperature, precipitation and cloud cover) and chemical climate (including the chemical composition of the atmosphere and precipitation)(NERA). The two types of climates are interconnected. During the summer

months, hot days are conductive to the formation of elevated levels of ground-level ozone (GLO) or smog. Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC (EPA.gov). The GLO is a harmful pollutant. Figure 8 below displays the eight-hour peak ozone map for September 2011. The Town of Auburn, which in the Worcester County, had a GLO concentration categorized as "unhealthy for sensitive groups".
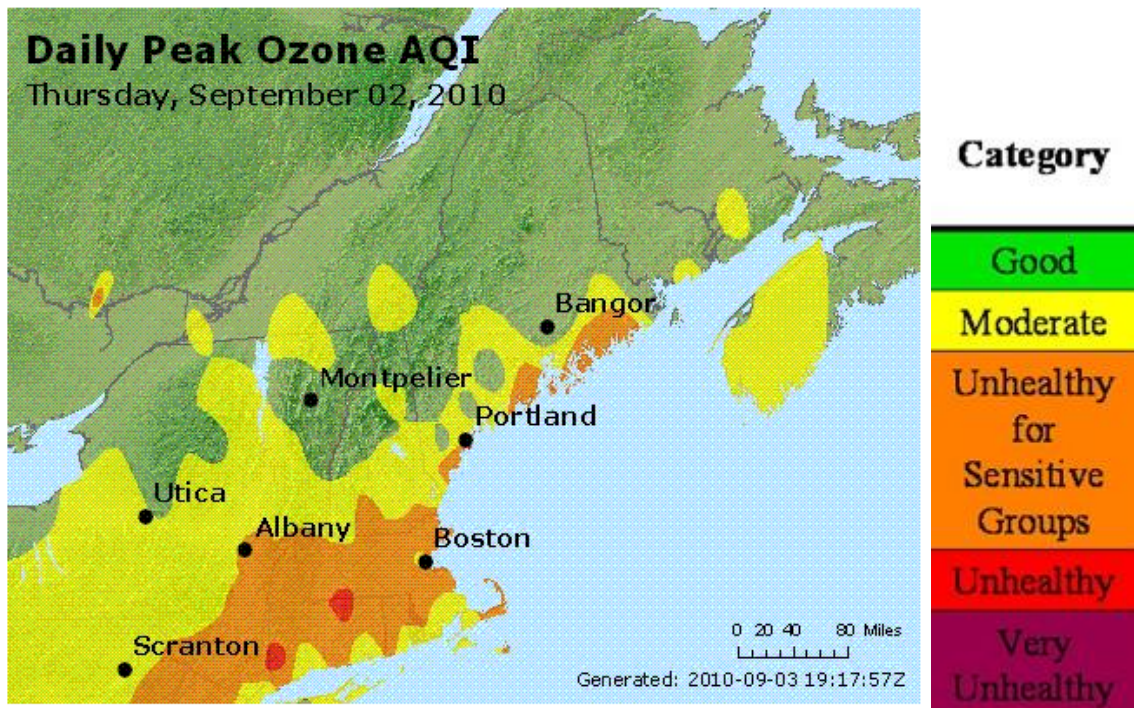
Figure 8 - Daily peak ozone for September 2010

http://www.epa.gov/region1/airquality/ma_over.html#Ware

According to the Environmental Protection Agency (EPA), the people that are included in the sensitive groups and that are most at risk of unhealthy concentration of ground-level ozone are shown in the figure below. The three groups are: infants and young children, elderly and adults with prolonged outdoor exposure.

Air Quality Index	Protect Your Health
Good (0-50)	No health impacts are expected when air quality is in this range.
Moderate (51-100)	Unusually sensitive people should consider limiting prolonged outdoor exertion.
Unhealthy for Sensitive Groups (101-150)	The following groups should limit prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors
Unhealthy (151-200)	The following groups should avoid prolonged outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors Everyone else should limit prolonged outdoor exertion.
Very Unhealthy (201-300)	The following groups should avoid all outdoor exertion: • People with lung disease, such as asthma • Children and older adults • People who are active outdoors Everyone else should limit outdoor exertion.

Figure 9 - Air quality index and effects

The groups of people that should limit prolonged outdoor exertion are people with lung disease (such as asthma), children and older adults, and people who are active outdoors(epa.gov). In the Auburn about 17% of the population is children, age zero to fourteen, and about 16% is older adults, 62 and over (census.gov). These sensitive groups make up one third of Auburn's population.

Population by Age
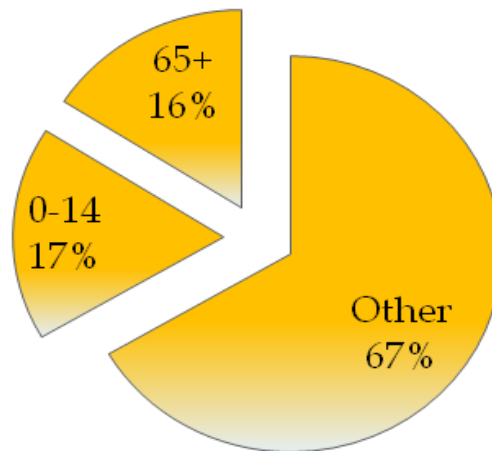
Figure 10 - Percentage of Auburn's population by age

But the smog is not just harmful for the sensitive groups; anyone, such as healthy adults, construction workers and other outdoor workers, can be affected by the smog in the environment during the summer months. According to the air quality guide, when GLO is inhaled, even at very low levels, it can:

- cause acute respiratory problems;
- aggravate asthma;
- cause significant temporary decreases in lung capacity of 15 to over 20 percent in some healthy adults;
- cause inflammation of lung tissue;
- Impair the body's immune system defenses, making people more susceptible to respiratory illnesses, including bronchitis and pneumonia.

Auburn has taken these effects very seriously and is concerned for the well being of its population. Through the CAP Auburn wants to reduce the levels to a point that is not detrimental to its citizens.

The harmful concentration of smog in the hot summer days leads to more than expected hospital admissions and emergency room visits. In the north-east about 10 to 20 percent of all summertime respiratory-related hospital visits are associated with ozone pollution (Cadman

2010). The health related problems with climate change will continue to worsen unless preventative measures are taken. If no action is taken by Auburn town workers to reduce their emissions, the health care net cost will enlarge.

The climate change impact on the health and environment will increase unless steps to reduce greenhouse gas emissions are taken. Health and environmental problems related to climate change will cause an economic crisis, especially for small towns such as Auburn. There is a need for reduction of greenhouse gas emission so people can live in healthier environments.

2.2.1 Summary

The air quality in Auburn is considered to be a hazard to a minimum of a third of its population. With such a low air quality Auburn must undergo actions to reduce the pollution and provide a greater living environment to its residents. The issue of air pollution is not only focused in Auburn, it is a worldwide occurrence. Auburn is taking the steps to make not only its air quality higher, but rather, join the global effort in combating air pollution.

2.3 International Council for Local Environmental Initiatives (ICLEI)

ICLEI is an association that is committed to sustainable development. The association was founded in 1990 with 200 local governments. Today ICLEI has 1220 local government members and spans 70 countries. The main aspects of ICLEI, and why it is beneficial to Auburn are that it provides:

- Training and technical consulting
- Share knowledge and information services to build capacity
- Support local government in the implementation of sustainable development

The listed topics are discussed in more detail in the following sections. They will provide a fundamental understanding of what ICLEI has to offer to Auburn and any local community.

Training and Technical Consulting

ICLEI offers training on a regular basis that help government staff quickly learn the fundamentals of climate action planning. Included in this training is how to compute greenhouse gas emission inventory. set GHG reduction targets. and use ICLEI's tools to develop the CAP. One of ICLEI's tools is the CACP 2009 software use for eC02 computations. ICLEI also has a resource of online recorded training videos that are easy accessible online from icleiusa.org. These recorded training videos include: CACP 2009 software training, greenhouse gas emissions inventory training, greenhouse gas protocol training and climate and air pollution planning assistant training. Auburn can use the training videos along with this report to have full knowledge base of any needed information.

Share knowledge and information services to build capacity

Knowledge is shared by ICLEI to its members, but also amongst its members through workshops. ICLEI makes full use of online and virtual resources to distribute the latest information regarding climate change. However, ICLEI also holds regular workshops throughout the year. These workshops target a specific topic such as: green power purchasing to increasing energy efficiency of buildings. This opportunity to attend workshops gives Auburn officials to hear firsthand about green techniques, ask questions, and network with other cities.

Support local government in the implementation of sustainable development

ICLEI offers full support to its members through the technical training via online recorded videos and in-person workshops. The workshops can also be observed virtually, by use of streaming videos. Auburn would not be left on its own to create and implement the CAP.

2.3.1 The Climate Action Plan

The CAP is one of the main creations of ICLEI. ICLEI had designed set of actions that can be followed in order to complete the CAP. The focus of the CAP is not to necessarily create new government operations, rather, modify existing systems and operations in order to make them more efficient.

Auburn, much like every town in the U.S., has the power to directly influence the main sources of pollution and energy waste. The town regulates the amount of energy used and the waste generated by the community through zoning and building codes. The ICLEI designed actions would be incorporated to Auburn's operations to reduce the waste.

Taken directly from the CAP, the benefits are:
- Save Taxpayer Dollars
- Build the Local Economy and Create Jobs
- Improve Air Quality and Public Health
- Improve Community Livability
- Create a Legacy of Leadership

With the benefits of the CAP, Auburn stands to gain a considerable improvement on its current economic and environmental situation. The benefits of the CAP are explained in more detail in the following sections.

Save Taxpayer Dollars

Actions that are taken by Auburn to reduce greenhouse gasses will also reduce electricity and fuel usage, which minimize energy costs for the residents and business of Auburn. ICLEI reports that in 2005 the 160 local governments in the U.S. (ICLEI members) reported a collective savings of $600 million in fuel and energy costs. Furthermore, they were able to reduce over 23 million tonnes of air pollution.

Build the Local Economy and Create Jobs

Auburn does not have local companies that specialize in green energy technologies and services (i.e. energy efficiency and renewable energy). The implementation of the green technologies would bring to Auburn new private firms to Auburn, as well as the creation of local government firms, while decreasing energy costs. The decreased energy costs increase the demand for energy efficient products and services, which creates new jobs in Auburn.

Improve Air Quality and Public Health

Air quality is a concern in Auburn as the current quality is rated as dangerous for sensitive groups, which comprise a third of Auburn's population. Reducing air pollution allows Auburn to comply with federal air quality regulations and preserves federal funding for local projects. These strategies create less air pollution and result in fewer impacts on the population of Auburn.

Improve Community Livability

Measures for reducing air pollution consist of reducing traffic congestion, cleaning the air, and utilizing the land more effectively (make more walk able neighborhoods), which increase the livability of Auburn. As Auburn becomes a more livable community the local economy will thrive as the population will increase and more local business will be crated to support the increased number of residents.

Create a Legacy of Leadership

If Auburn takes action now, it will create benefits for its residents today, while ensuring that future generations gain access to the resources that support healthy and livable communities. Furthermore, Auburn will set an example for other local communities that are similar in demographics, that it is possible to achieve an emissions reduction and stimulate the local economy.

2.3.1.1 ICLEI 5 Milestones

Auburn would follow the ICLEI 5 Milestones to reach the lower emissions and waste goal it has set. These milestones provide a step-by-step process on how to have a successful program. The steps are outlined below in Figure 11.
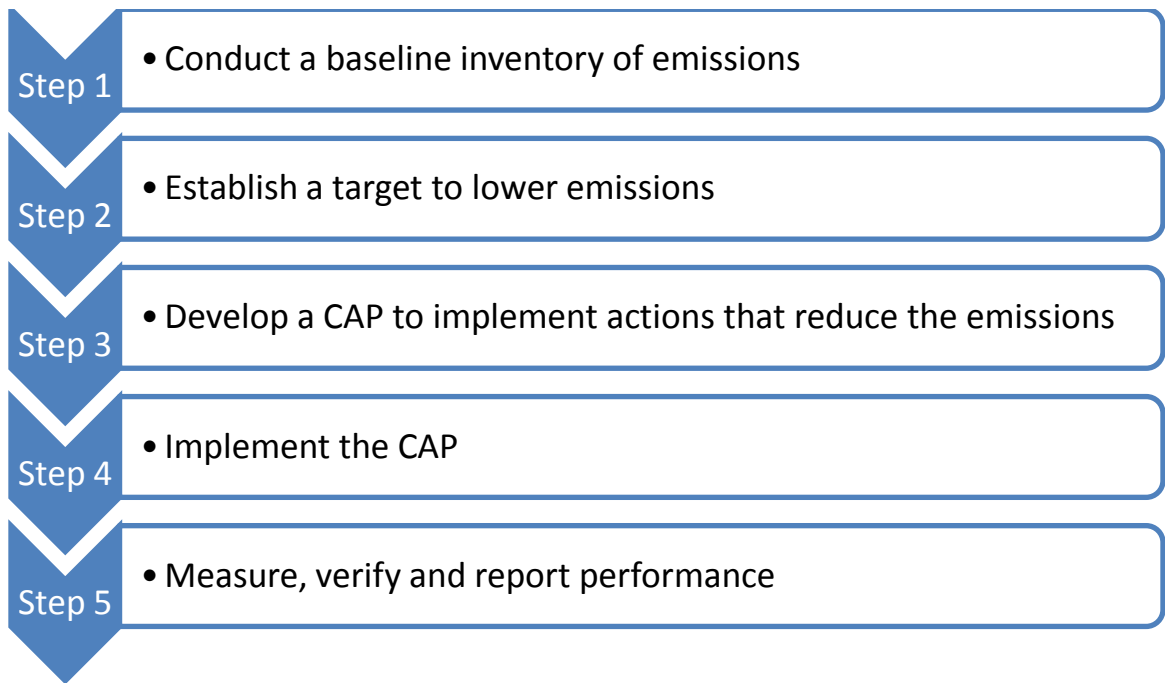
Figure 11 - ICLEI 5 Milestones

As soon as a new member joins ICLEI, i.e. Auburn, a webpage with that towns progress is created on ICLEI's website. This webpage contains the general information about the town and the milestones that were completed. For each completed milestone, a report is submitted to ICLEI for verification. If ICLEI verifies that the milestone is completed, the town receives a 'checkmark' next to the milestone on the website.

Conduct a baseline inventory of emissions

The baseline inventory of emissions is a snapshot of Auburn's emissions in a given year. For the purposes of this project, the base year is 2009. The scopes are a way to organize the data so that the most critical data is collected first and prioritized. Scope 1 is mandatory and is all direct GHG emissions. Scope 2 is also mandatory and is indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. Scope 3 is optional and is all other indirect GHG emissions not covered by scope 2.

Establish a target to lower emissions

Establishing a target sets up the goal for which Auburn needs to reach in order to be deemed successful in its energy reduction. The emissions target also draws support from the community, as now there is an attainable goal rather than general advice.

Develop a CAP to implement actions that reduce the emissions

The CAP is the plan that puts the first to steps together to then figure out a method to reach the emissions reduction target. Furthermore, the CAP lays the groundwork for the final two steps and gives Auburn a physical document that can always be accessed as a resource, should Auburn not be sure of where to turn to next.

Implement the CAP and Measure, verify, and report performance

The implementation of the CAP is when Auburn puts the policies outlined in into action. While the policies are being acted on there needs to be constant measurement whether every item is being fully implemented and addressed. This action calls to constant verification of the actions. Auburn must maintain accurate reports of the performance for future analysis to determine whether the emissions target was in fact reached.

2.4 Conclusion

The information presented in Chapter 2 offer the fundamental understanding as to why it is critical for Auburn to undertake the CAP: its current economic and environmental issues. ICLEI is the primary source for use as a guideline to guide Auburn in the appropriate methods to achieve its goals, and provide support. Though it may take close to a decade, the CAP will be instrumental to Auburn in resolving its economic and environmental situations.

Part I – The Inventory

CHAPTER 3 – TRANSPORTATION EMISSIONS SOURCES

Transportation is the fastest growing source of GHG emissions. In 2006, transportation accounted for 28% of total GHG emissions. (U.S. Department of Transportation, n.d.) This is mainly due to the large increase in the burning of petroleum to fuel on-road vehicles in the U.S. The burning of fossil fuels is responsible for 97% of the total transportation emissions. Only electricity generation had a larger share of GHGs, with 34%. In addition, since 1990 transportation accounted for 47% of the net increase in U.S. GHG emissions. (EPA, 2006) Transportation is the largest end-use sector that emits CO2, with CO2 being the most prevalent GHG. This is the largest net increase by any sector over that time period. In the same time period, passenger car and light truck use has more than doubled, with a 3% growth per year. (Greene 2003) This highlights the increased use of on road vehicles due to the increase in vehicle use among the population. This figure will continue to rise in the future, and if nothing is done to reduce emissions from all of the new and old vehicles, GHG emissions will continue to soar. Reducing emissions from this sector will go far in reducing overall emissions. (National Transportation Library 2010) By inventorying emissions sources from transportation in Auburn, strategies can be employed to reduce emissions in this sector. With a large percentage of overall emissions coming from transportation, and transportation use projected to increase with future population increases, it is imperative to include these sources in any emissions inventory in the town.

Many measures that can be taken to reduce vehicle emissions have the added benefit of saving money. One way to mitigate tailpipe emissions is to decrease fuel consumption in vehicles. Auburn can achieve this through either reducing the number of vehicles on the road or increasing the efficiency of the vehicles. Increasing the efficiency can be fuel efficiency or travel efficiency, anything that decreases overall fuel consumption. Decreasing this fuel consumption can greatly reduce the amount of ground level ozone in Auburn, leading to a reduction in the health risks the citizens of the town are currently facing. As discussed in Chapter 2, Auburn is not isolated from the current economic downturn and is searching for ways to save money where possible. By cutting vehicle fuel usage, for which costs have risen 37% in the last year alone, the town will be able to save money while shielding itself against the volatile price of

gasoline.   Some of this vehicle fuel usage decrease can be achieved through the use of biofuels. This requires the production of certain crops which, if grown locally, can help the local economy and create jobs.

The first step in achieving these transportation emissions reductions that will lead to Auburn's overall goals is to inventory the current vehicle emissions in the town. Auburn's vehicle emissions inventory will allow the town to target particularly inefficient vehicles and spot sources that use an abnormal amount of fuel. This will allow Auburn to create policies and methods by which less fuel can be consumed, increasing quality of health and cost savings. The inventory is also the first step in the pursuit of an ICLEI certification. An ICLEI certification will make Auburn eligible for outside grant money, adding to the benefit of cost savings and decreased health risks citizens are facing.

The following Chapter outlines methods, data analysis, and recommendations for the transportation emission sources in the town of Auburn. Section 3.1 is a guide including methods used for the collection of the raw data needed for each transportation section in Auburn. These methods are specified for Auburn's unique situation and include sectors that still need information collected for them. Section 3.2 details the causes of transportation emissions in Auburn and ways to reduce them. The analysis of the emissions from the transportation sectors is included as well as recommendations for each sector. Following the guidance of this chapter will ensure a comprehensive transportation inventory for Auburn in addition to taking a start to mitigating the emissions in the town. This will allow Auburn to reduce costs, boost the local economy, and reduce ground level ozone that leads to health risks among citizens.

3.1 Transportation Emissions Source Data Collection

The ICLEI protocol regarding data collection and entry is the method used for Auburn's transportation sector. ICLEI has strict requirements regarding what emissions sources need to be included and tracked into future years. The emissions sources chosen to be included are based around what a local government can directly affect while reaching their overall goals. Auburn wants to increase the air quality in the town by reducing GHGs and particulate matter that contribute to pollution and the creation of ground level ozone. The town also wants to create jobs

and boost the local economy in the process of reducing emissions. Auburn wants to decrease overall government costs by reducing fuel and energy consumption. By including all vehicles the government owns, as mandated under the ICLEI protocol, it allows for Auburn to see all emissions that are a direct result of government operations. This type of inventory allows all areas to be considered for possible reduction measures and can allow the targeting of inefficient vehicles to create the best possible list of actions to be taken. By looking at each vehicle the town owns, as opposed to just looking at overall fuel consumed by the town, the ability to replace older, more inefficient vehicles based on concrete data arises. This reduces fuel consumption and emissions in a logical manner. These cars can be purchased from local vendors, helping to boost the local economy.

The protocol is designed to complement the CACP 2009 software, which takes raw data and translates it into eCO2 emissions in addition to forecasting emissions into future years and generating detailed reports of emissions. Using CACP 2009 will allow Auburn to easily track emissions data from year to year to measure progress towards their reduction goal and see how much the actions taken have impacted the GHG emissions. The software is useful in setting a reduction target since its forecasting tool forecasts emissions data in any year in the future if current emissions and population trends are followed. The software also allows for the easy transformation of the raw data collected into GHG emissions without too much extra work. This is ideal for a town such as Auburn that has limited initial resources to spend on the inventory.

Towns and cities in varying situations have used this method to obtain completed emissions inventories. Cities such as Worcester, MA, Pittsburgh, PA, and Medford, MA have followed these same guidelines and achieved a successful inventory. Also, smaller towns such as Belmont, MA, Amherst, MA, and Ross, CA have followed the same methods to complete inventories.

The following sections outline data collection needed to complete a transportation emissions inventory that complies with ICLEI standards. Specific information regarding what transportation sectors need to be inventoried and what data is needed is included. If Auburn follows these instructions, they will have a transportation inventory that is comprehensive

enough to ensure them an ICLEI certification, while providing them with enough information so that action can be taken to meet their original goals, regardless of any ICLEI certification.

3.1.1 Data Collection

Only Scope 1 information, which comes from sources directly owned by Auburn, is necessary to include under the ICLEI guidelines. Scope 1 emissions consist of vehicles operated by departments that Auburn has direct control over. Only three departments in Auburn own vehicles, the Fire Department, the Police Department, and the Department of Public Works.

In order to complete the most comprehensive inventory possible that includes all of the emissions sources that occur within Auburn, all Scope 3 emissions are also included in this inventory. This is due to the fact that many emissions in Auburn come from contracted services, so excluding them from the inventory will not give a clear picture of Auburn's emissions. Scope 3 emissions consist of emissions from sources that are contracted out to private companies and include, for Auburn, vehicles used for curbside trash pickup, public transportation, and school transportation. Including Scope 3 emissions sources even though not mandated by ICLEI allows Auburn to see every possible source of transportation emissions that can be targeted for reduction. This provides the town with more policy options to reach the ultimate reduction target.

For all sources of vehicle emissions, similar data is collected. This data is, for each vehicle being inventoried, the make, model, model year, annual vehicle miles traveled, fuel type, and whenever possible the fuel efficiency. For contracted services, it is generally only possible to collect total vehicle miles traveled by the entire fleet, and fuel types used due to the information collected by the companies that own the vehicles. This data is collected because of the software being used and the information that Auburn has on hand regarding its own vehicles. Since Auburn does not collect data regarding fuel usage by vehicle or even department, collecting vehicle miles travelled by each vehicle allows for the most specific inventory possible to be collected. This information is available and can be collected from department heads. This reasoning is why this information was collected for each of the following sections, with all information collected being entered into the CACP 2009 software following the guidelines outlined in Appendix A.

Fire Department

Information regarding the vehicles operated by the Auburn Fire Department is collected by contacting Stephen Coleman, the Fire Chief. The information collected includes the following for each vehicle used by the department: make, model, model year, annual vehicle miles traveled, and fuel type. This was gathered from Mr. Coleman through email by filling out a spreadsheet which can be seen in Appendix B.

Department of Public Works

Information regarding the vehicles used by the Department of Public Works was collected in a similar way as the Auburn Fire Department data. Patricia D'Agostino in the department was emailed a spreadsheet requesting the following information for each vehicle: make, model, model year, annual vehicle miles traveled, fuel type, and mpg.

Public Transportation

For the data needed regarding the Scope 3 public bus transportation, Mary Ellen Blunt of the Central Mass Regional Planning Council was contacted via email and supplied the team with the necessary information – the fuel type and number of vehicle miles traveled annually by buses in Auburn. All of the vehicles operated by the Worcester Regional Transit Authority in Auburn travel 70,905 miles annually, all of which run on diesel fuel.

School Transportation

Information regarding school transportation was gathered via email with the School Business Manager Daniel Deedy. The town contracts ten buses used for regular education transportation and three mini-buses used for the Pupil Services department. Mr. Deedy supplied the team with the daily miles traveled for each of these thirteen vehicles. With this information, the annual vehicle miles traveled for all of the buses were able to be calculated.

Community Transportation

Transportation for the community analysis requires two pieces of information, the annual vehicle miles traveled and the average miles per gallon rating for all the vehicles in the

community. The daily vehicle miles traveled was collected by email from Sujatha Mohanakrishnan, the Transportation Project Manager of the Central Massachusetts Regional Planning Commission (CMRPC). This number was estimated using the CMRPC Travel Demand Model. For information regarding this model, see Appendix C. The daily VMT was multiplied by 365 to estimate the annual VMT traveled by the community in Auburn.

To estimate the average fuel efficiencies of Auburn's vehicles, the following formula was used:

(annual VMT per licensed driver ÷ licensed drivers per vehicle ÷ gallons of fuel per vehicle per year)

This number came out to be 21.5 mpg. Information for this formula was retrieved from the Massachusetts Transportation Facts 2004 Report.

Government Employee Commute

Emissions due to government employee commute, although not directly under the control of the government, and therefore Scope 3, must be included in the inventory according to the ICLEI protocol. In order to gather this information, an Employee Commuter Survey was employed.   This survey gained the Worcester Polytechnic Institute's Institutional Review Board exemption, ensuring the survey will remain anonymous, and was disseminated to all of the town's employees via the Town Manager, Julie Jacobson. The surveys were sent out on 11/28/11 and returned on 12/3/11. A copy of the survey is included in Appendix D and the results of this survey are shown discussed in section 3.2

Curbside Trash Pickup Fleet

The curbside trash pickup is contracted to Central MASS Disposal. The vehicle information needed was the size of the fleet, vehicle make and model, and vehicle miles traveled. This was supplied to the team by Melody Gibbons, the Finance Director of the company. The fleet consists of one 2005 MACK LE613 automated truck which runs on diesel, using 5,900 gallons per year, and travels 2,500 miles annually.

Police Department

Auburn Police Department vehicles data is needed in order to create a completed inventory. The data needed includes, for each vehicle, the make, model, model year, annual

vehicle miles traveled, and fuel type. A spreadsheet containing all of the vehicles owned and operated by the Police Department was emailed to the Police Chief, Mark Maas. Due to time constraints, the information required was unable to be supplied. A copy of the spreadsheet is included in Appendix E.

Department of Public Works

Department of Public Works vehicle information is needed to have a complete inventory. To collect the information, a spreadsheet was emailed to Patricia D'Agostino in the department. Information needed for each vehicle is the make, model, model year, annual vehicle miles traveled, fuel type, and fuel efficiency. A copy of the spreadsheet is included in the Appendix G.

3.2 Causes of Transportation Emissions in Auburn

Recommendations that are logical for Auburn to follow based on their specific situation are described in section 3.2. These recommendations are based on the analysis of the information gathered outlined in the previous section. The data was entered into the CACP 2009 software using the methods that can be found in Appendix A. The CACP 2009 software allows for the quantification of emissions using the data we collected. The analysis and subsequent recommendations in this chapter are separated into municipal, employee government commute, and community transportation sections. This separation allows for the data to be broken up in such a way that allows for the municipality of Auburn to identify actions they can specifically take as opposed to actions that need to be taken by the community.

3.2.1 Municipal Sources

Currently, Auburn's municipal transportation GHG emissions are similar to other towns that have completed a climate action plan, which indicates that it is possible for Auburn to make emissions cuts in similar areas. Vehicles used by the Fire Department, school transportation, curbside trash pickup, and public transportation emit 600 tonnes of eCO2 emissions each year. This number does not take into account the Police Department and Department of Public Works vehicles. The following per capita emissions of several towns with a climate action plan contextualizes this number.

City/ CAP Year	Municipal Transportation eCO2 Emissions (tons)	Population	Municipal Per Capita Emissions
Worcester(2002)	10,076.90	175,333	0.057472923
Medford (1998)	1,662.43	55,763	0.02981242
Belmont (2005)	4,998	24,462	0.2043169
Amherst (1997)	40,394.67	34,874	1.158303321
Auburn (2009)	600	15,730	0.038143675

Figure 12 - Per capita emissions of several towns (municipal)

This table is comprised of information drawn from each town's climate action plan and helps place Auburn's municipal emissions in relation to these towns. The municipal per capita emissions were calculated by dividing the total municipal transportation eCO2 emissions in each respective town by the population in this town. As can be seen from the Amherst, MA CAP from 1997, the per capita emissions are 1.158 tonnes of eCO2 per person in the town. This is much higher than Auburn's per capita emissions of .0381 tonnes eCO2 per person. However, from Medford's CAP in 1998, the per capita emissions were .02981242 tonnes eCO2 per person, which is lower than Auburn's per capita emissions. Worcester's emissions are .0575 tonnes eCO2 per person, which is slightly higher than Auburn's emissions. Based on the per capita municipal transportation emissions from other towns with climate action plans, Auburn's municipal transportation emissions are within a normal range for a local government. Although on the lower end of this range, Auburn does not have the lowest per capita emissions. This shows that reductions can be made in this sector.

Preliminary inventory data shows that vehicles do in fact release a large amount of GHGs into the air, making the transportation sector a large contributor to the health and economic costs currently experienced by Auburn. This presents Auburn with an opportunity to cut down emissions in this sector. 23% of emissions come from the FD, 47% from school transportation, 20% from public transportation, and 10% from curbside trash pickup shown in the figure below.
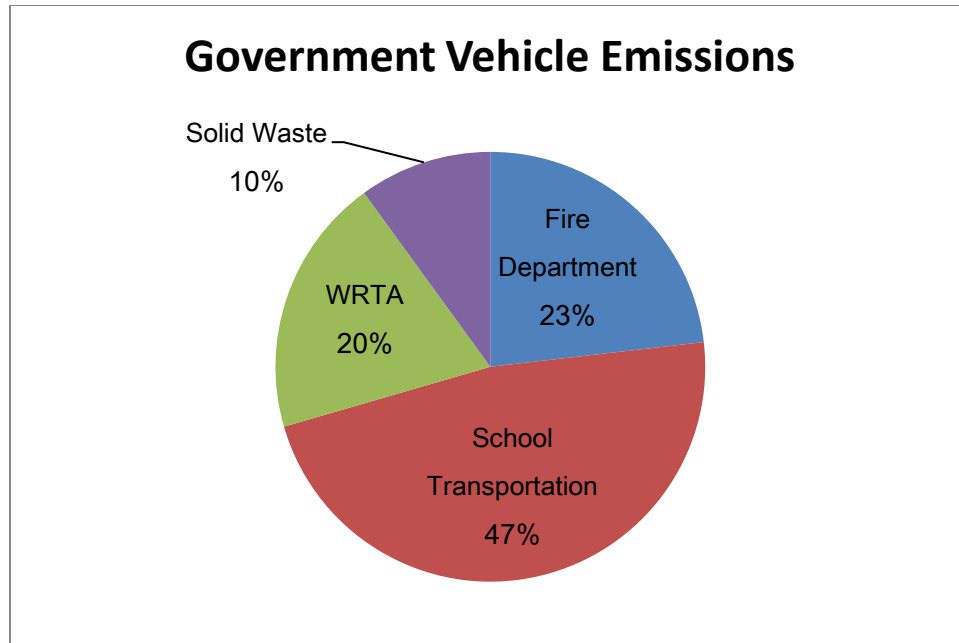
Figure 13 - Government vehicle emissions

The largest emitter of vehicle emissions in the town is school transportation. However, this sector is greatly important to Auburn in order to remain the family friendly community with provided services that encourage families to live in the town. Therefore, when making recommendations for this transportation sector, it is imperative to keep in mind the need to stay family friendly. Even though the remaining sectors emit less than half of the emissions of school transportation, emissions can be reduced for most of the transportation sectors. Recommendations on doing so are discussed further in the next section.

3.2.2 Municipal Recommendations

The following list shows all of the recommendations that are made for the municipal portion of Auburn's transportation sector.

- Gather emissions source data regarding Police and Department of Public Works vehicles
- Replace older vehicles with newer, more fuel efficient models
- Include green initiatives in all Scope 3 contracted services
- Switch the municipal diesel fleet to biodiesel fuel

Auburn should first focus on completing the municipal transportation emissions inventory. To do this, the information outlined in section 3.1 regarding the Police Department and Department of Public Works vehicles needs to be collected. By having a complete inventory, Auburn will know exactly how much emissions are being directly emitted by the government. This will supply the town with more areas and more policy options to reduce emissions in the transportation sector. This will allow actions to increase fuel efficiency and increase air quality to be made.

School Transportation

School transportation is one area where emissions can be reduced. Due to the Scope 3 nature of this source, policy changes regarding the contracts for buses are the primary mechanism for dealing with this source of emissions. Adding green initiatives in contracts will reduce emissions.

Including mandatory emissions reduction technologies for any bus used is one possible inclusion in future contracts. By doing so, the town would ensure that less of the harmful pollutants and particulates emitted from school buses would make it into the atmosphere. This would in turn cause less of the health risks associated with them– lung tissue damage, respiratory illness, and exacerbation of existing asthma – for both the children on the bus and on school property. These benefits will allow Auburn to live up to its image as a family friendly town. These emissions reduction technologies include purchasing oxidation catalysts for buses, which reduce particulate matter emissions by 20 to 30 percent and only cost around $1,000 to $2,000. This cost can be offset through procurement of government grants. Buying from and installation of this equipment locally can help boost Auburn's economy. The state of Washington retrofitted around 56% of its statewide bus fleet with emissions reduction technology in 2008 using federal and organizational grant money. This reduced emissions in the state by an amount between 50-90%. If Auburn's school bus fleet experienced a reduction in emissions of 50%, a reduction of around 142 tonnes of eCO2 emissions could be achieved, reducing the municipal transportation emissions by almost 25% overall. (EPA 2003)

Auburn can include a clause stating the use of biodiesel being mandatory. Biodiesel has many benefits that are discussed at the end of this section. The Medford, NJ school district

changed its entire fleet of buses to B20 biodiesel in 1998. In the ten years after, the district experienced amazing results. Their buses had traveled over four million miles, consumed 615,000 gallons of B20, eliminated 127,000 lbs of emissions and 428 lbs of particulate matter, and reduced the cost of fleet operations by $80,000. Looking at these numbers, the district saved $10,000 a year consuming 76,875 gallons of B20 fuel. This amounts to around $7.69 saved per gallon of B20 fuel used over conventional diesel fuel, a great argument for Auburn to use when including this in any future contract. (National Biodiesel Board, n.d.)

Since school transportation is a high priority service in Auburn, due to the large amount of families, reducing the number of buses or the length of the routes traveled to reduce emissions is not a feasible option. However, by including emissions reduction technologies and biodiesel as mandatory in any bus contract, Auburn can still reduce emissions in this sector. This will allow Auburn to experience the benefit of cleaner, healthier air for its students since they would be exposed to far less GHG emissions as well as far less ground level ozone. This is a primary concern since children are at a risk of detrimental health effects due to ground level ozone and Auburn has a higher amount than what is healthy. In addition, the purchase of these technologies will help to bolster the local economy well into the future.

Fire Department

GHG reduction can occur through changes in the Fire Department. One recommendation for the sector in Auburn is to replace older vehicles with new, more fuel efficient models. The Fire Department currently uses six vehicles that were manufactured prior to 2000. These vehicles have much lower fuel efficiencies than their newer counterparts. Three of these vehicles are rescue vehicles and it may not be in the best interest to replace these due to large costs that outweigh the money saved on fuel. However, the remaining vehicles are not, and could be a place to target for emissions reductions.

The cars in question are a 1999 Ford Pickup (14 mpg), 1990 Dodge Ram/Van (19 mpg), and a 1993 Ford Pickup (fuel efficiency unavailable). While a more fuel efficient replacement for the 1990 Dodge Ram/Van is not available, there are for the other two vehicles. Using the 1999 Ford Pickup mpg for the 1993 model due to the unavailability, if the Fire Department were

to purchase new models with best in class fuel efficiency (such as a 2009 GMC Sierra 1500 Hybrid) of 20 mpg, they would save an average of $333 each year. Assuming vehicle lifetimes of 12 and 19 years, based on the replacement of the vehicles next year, the department would save $4476 over the entire life of the vehicles (fueleconomy.gov). The 2009 GMC Sierra 1500 Hybrid costs $26,817. Purchasing newer vehicles would mitigate emissions from this sector. This would again help to increase overall health through the decrease of ground level ozone while saving the town on fuel costs. While it may not seem worth it to the town to buy new vehicles to save around $4500 on fuel costs, the vehicles will need to be replaced soon anyway due to age. Also, if marketed, the town could use this as an example for the community.

The department could also switch to using biodiesel instead of regular diesel fuel. The benefits of biodiesel are discussed further at the end of this section. This has been proven effective at Boston's Fire Department, which fuels all of its diesel trucks with biodiesel

Curbside Trash Pickup and Public Transportation

The remaining two transportation sectors, curbside solid waste pickup and public transportation emit fewer emissions than the Fire Department and school transportation sectors and the town should focus on reducing emissions elsewhere. The curbside pickup vehicle fleet consists of only one vehicle. This vehicle provides a very necessary service, so not much can be done to reduce emissions from this sector. The vehicle, a 2005 Mack LE613, travels 2500 miles each year and consumes 5,900 gallons of diesel fuel. If the vehicle was changed to biodiesel, this would amount to a .549 tonne decrease in emissions according to the information presented in the school transportation recommendations earlier in this section. This amounts to only .000915% of overall emissions. While any emissions reductions are beneficial, it would be better use of town resources to focus on other areas.

The public transportation sector emits 20% of total municipal vehicle emissions. This sector provides a valuable service to Auburn that reduces the number of single occupant vehicles traveling in Auburn and actually does a lot to reduce emissions in the town by allowing one vehicle to transport many people. With an average of .9% of people using public transportation in Auburn, 142 single occupant vehicles are taken off of the road due to public transportation. This decreases overall emissions from the community transportation sector. Auburn can

encourage the WRTA, who provides the bus service, to switch to hybrid buses as was done in San Francisco, CA. The hybrid buses used decrease GHG emissions by 30%, increase fuel efficiency by 30%, and increase the lifetime of the vehicle. The $150,000 extra price premium over conventional diesel buses would be recovered throughout the life of the vehicle. This would mean a 35 tonne eCO2 reduction and a 3425 decrease in gallons of diesel used on only the Auburn bus routes each year. The 30% emissions reduction would help decrease the emissions that lead to the production of ground level ozone that affects the health of the citizens of Auburn. (San Francisco Regional Transportation Authority, n.d.) Reducing the number of public buses or reducing the length of their routes would reduce the direct emissions from this sector, but it would only add to the already extremely large amount of emissions from the community. Instead, the government should focus on increasing this .9% of people that use the public transportation and getting the buses switched to hybrid versions.

Switching to Biodiesel

When comparing biodiesel to petroleum diesel, the advantages are noticeable right away. The biodiesel fuel actually works as a lubricant for the engine. This reduces wear and extends the life of the engine, minimizing servicing costs of diesel fleets. This lessened service cost could help offset the extra price of the biodiesel. Furthermore, the fuel economy generally increases from 5 to 10 percent with biodiesel, which can also help offset the cost of the fuel.

Biodiesel is susceptible to similar problems as petroleum diesel. The main problem most diesel vehicles are faced with are cold temperatures. Since diesel engines rely on pressure to start, and not a spark as a gasoline vehicle, the cold weather causes problems with engines failing to turn over. Both biodiesel and petroleum diesel combat this problem with special additives in the fuel. Keene, NH was able to use the B20 biodiesel throughout the winter with no problems, so the special additives can combat this problem.

Engine manufacturers are becoming more aware of the benefits of using biodiesel. So much so, that they now have their warranties cover vehicles that use B20. Any initial worries by the municipality regarding warranty coverage can be put at ease. Biodiesel also takes on the task of creating a more energy independent system. The efficiency of biodiesel is far greater than that of fossil fuels and the use of biodiesel helps reduce dependence on a volatile oil system.

Switching to biodiesel will reduce emissions. A close neighbor to Auburn, Keene, NH, uses B20 biodiesel as their primary fuel. Operators of the vehicles have reported headaches that occur with the use of regular diesel disappear when operating a B20 fueled vehicle. The particulate matter at the Keene transfer station has been reduced by 50%, showing that the switch has made a true difference. (Mass Department of Energy, n.d.) The same type of action should be undertaken by Auburn for their government fleet. Auburn's government fleet consists mostly of heavy (greater than 8,500 pound) vehicles that run on diesel. By switching to a B20 blend Auburn could experience similar benefits as Keene has. The city of Portland, Oregon also currently uses biodiesel to fuel its entire municipal fleet (including school transportation) at a blend of 50%. The city experiences increased air quality as a result with only a $.07 premium of petrodiesel. In addition, local jobs were created to produce the crop necessary to create biodiesel. These same benefits could be experienced by Auburn.

There has been a vast array of improvements to biodiesel since its creation. Currently, there are many suppliers of biodiesel. Furthermore, biodiesel can be used in any existing diesel engine without there being almost any discernable difference to performance versus conventional diesel.

Soybean oil is the preferred source for the creation of biodiesel in the United States. The production of biodiesel uses a well-established process of transesterification. Biodiesel can be used in its pure form, referred to as B100, or as a mix of typically 20 percent biodiesel 80 percent petroleum diesel, aka B20. Local jobs for farmers could be created by growing the soybean needed in state, giving a boost to the economy.

We highly recommended that Auburn take in the advances in biodiesel technology to help in the creating of a better environment and reducing costs. The raw cost per gallon of biodiesel is higher than petroleum diesel. When coupled with all of the advantages that biodiesel brings forth, the cost of biodiesel is noticeably less. Auburn will be able to indulge increased health benefits due to reduced emissions and particulate matter that Keene, NH is experiencing by switching to the B20 biodiesel. Local jobs can be created by growing the needed crops locally.

Following these municipal recommendations could be of great benefit to Auburn. Cost savings can be realized and any cost rises due to green initiatives could be offset through the procurement of grants. Air quality increases will be realized due to the decrease in emissions that contribute to ground level ozone.

Local jobs can be created since the growing of crops is needed for biodiesel. Also retrofitting vehicles with emissions reducing technology can be performed locally as well as purchased locally.

3.2.3 Government Employee Commute

The employees of the town of Auburn, on average, live very close to their place of work and therefore spend less time commuting to work. Based on the data the majority of workers in Auburn have a one way commute to work of 25 minutes or less with an average of 17.6 minutes. Compared to the national average of 23 minutes for a one way commute to work Auburn has a significantly shorter one way commute being a 5.4 minute difference (Carroll, 2007). This means that regarding the work commute times the employees of Auburn emit less GHGs. In the table under LDGV (Light Duty Gas Vehicle aka passenger car) and LDGT (Light Duty Gas Truck) it lists the pollutants emitted per minute. Auburn's employee's commute takes 0.75 times that of the national average. Based on that Auburn's employees are only emitting 0.75 times the pollutants than the national average (EPA, n.d.). Based on the data in the tables and national average commuting times Auburn emits significantly less GHGs due to work commute than the national average. For example for a light duty gasoline vehicle would only emit 4.64 g/min of carbon monoxide while the average national commuter would emit 6.19 g/min of carbon monoxide. This is a significant difference in pollutants being emitted between Auburn and the national average. Even though based on the commute time compared to national averages Auburn's employees aren't emitting as many GHG emissions, more can still be done to reduce GHGs. What Alameda County did to reduce emissions was to promote the use of biking to work if it was within reach. In order to promote this Alameda County installed bike racks at municipal buildings and other buildings around town. Auburn could install bike racks at their municipal buildings and also offer incentives like showers and possible raises for people who bike. By doing this GHG emissions will be reduced by all employees who bike to work instead of driving.

Winter Conditions (30°F, 13.0 psi RVP gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	21.1	30.7	44.6	3.63	4.79	12.6	20.1
	g/min	0.352	0.512	0.734	0.061	0.080	0.211	0.335
CO	g/hr	371	487	682	10.1	11.5	94.6	388
	g/min	6.19	8.12	11.4	0.168	0.191	1.58	6.47
NOx	g/hr	6.16	7.47	11.8	6.66	6.89	56.7	2.51
	g/min	0.103	0.125	0.196	0.111	0.115	0.945	0.042

Summer Conditions (75°F, 9.0 psi RVP Gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	16.1	24.1	35.8	3.53	4.63	12.5	19.4
	g/min	0.269	0.401	0.597	0.059	0.077	0.208	0.324
CO	g/hr	229	339	738	9.97	11.2	94.0	435
	g/min	3.82	5.65	12.3	0.166	0.187	1.57	7.26
NOx	g/hr	4.72	5.71	10.2	6.50	6.67	55.0	1.69
	g/min	0.079	0.095	0.170	0.108	0.111	0.917	0.028

Figure 14 - The amount of pollutants emitted by different types of vehicles for winter and summer

Average Commute (min)	# of People	Percentage
0-5	75	26.32%
6-10	44	15.44%
11-15	38	13.33%
16-20	45	15.79%
21-25	29	10.18%
26-30	20	7.02%
31-35	10	3.51%
36-40	10	3.51%
41-45	9	3.16%
46-50	0	0%
51-55	3	1.05%
56-60	2	0.70%

Figure 15 - The amount of time it takes Auburn's employees to get to work

How Many Minutes is Your One Way Commute from Home to Work?

- 26.32% — 0-5
- 15.44% — 6-10
- 13.33% — 11-15
- 15.79% — 16-20
- 10.18% — 21-25
- 7.02% — 26-30
- 3.51% — 31-35
- 3.51% — 36-40
- 3.16% — 41-45
- 0% — 46-50
- 1.05% — 51-55
- 0.70% — 56-60
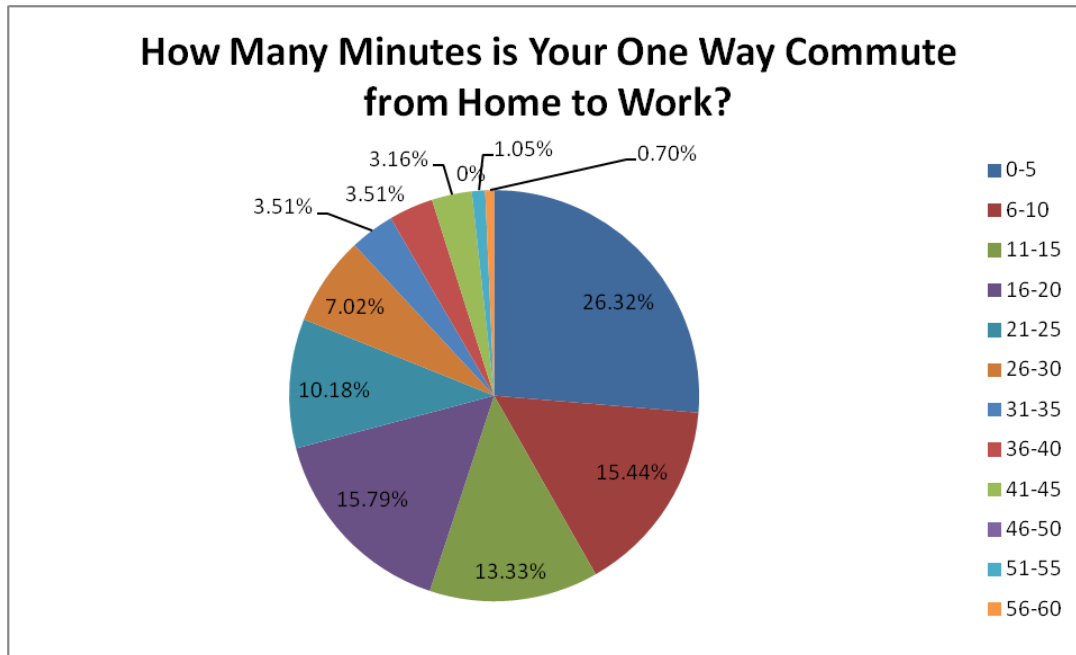
Figure 16 - Auburn employee commute time from home to work

The miles per gallon (MPG) of a vehicle are an excellent representation of the vehicles GHG emissions. The lower the MPG of a vehicle typically the more GHG emissions are going to be emitted. The Corporate Average Fuel Economy (CAFE) is a regulation which is intended to raise the average MPG of vehicles in America. In 2011 the CAFE standards for a passenger car is 30.2 and for a light truck it is 24.1 (nhtsa.gov, 2005). Auburn's employees are just about split right down the middle with owning a passenger car or light truck it is 152 and 130 respectively. The average MPG of all of the employee's vehicles in Auburn is 21.5 which is significantly lower than both of the CAFE standards for a passenger car and light trucks. In the previous recommendation it stated that Auburn's employees emit less GHGs due to their low commute time. This recommendation shows that due to a different aspect (MPGs) that there are an unnecessary amount of GHGs being emitted. Only about 14%–26% of the energy from the fuel you put in your tank gets used to move your car down the road (fueleconomy.gov, 2011). Even less of that energy is used for fuel inefficient cars. The energy that is lost in these vehicles is lost to engine and driveline inefficiencies. Due to these inefficiencies and especially those in low MPG vehicles more GHGs are being emitted. Businesses like Bank of America offer "$3,000

toward the purchase of a hybrid vehicle to all employees who work at least 20 hours per week (hybridcenter.org, n.d.)." Auburn could offer its employees similar discounts if they would be willing to purchase hybrids or vehicles with specific fuel efficiencies. By doing this it could encourage employees to go out and buy new vehicles which would increase the overall fuel efficiency of Auburn's employees which in exchange would yield a reduction in GHGs emitted.

Type of Vehicle	# of People	Percentage
Passenger Car	152	52.96%
Light Truck	130	45.30%
Heavy Truck	2	0.70%
Motorcycle	3	1.05%

Figure 17 - The types of vehicles and the number of Auburn employees who owns each one
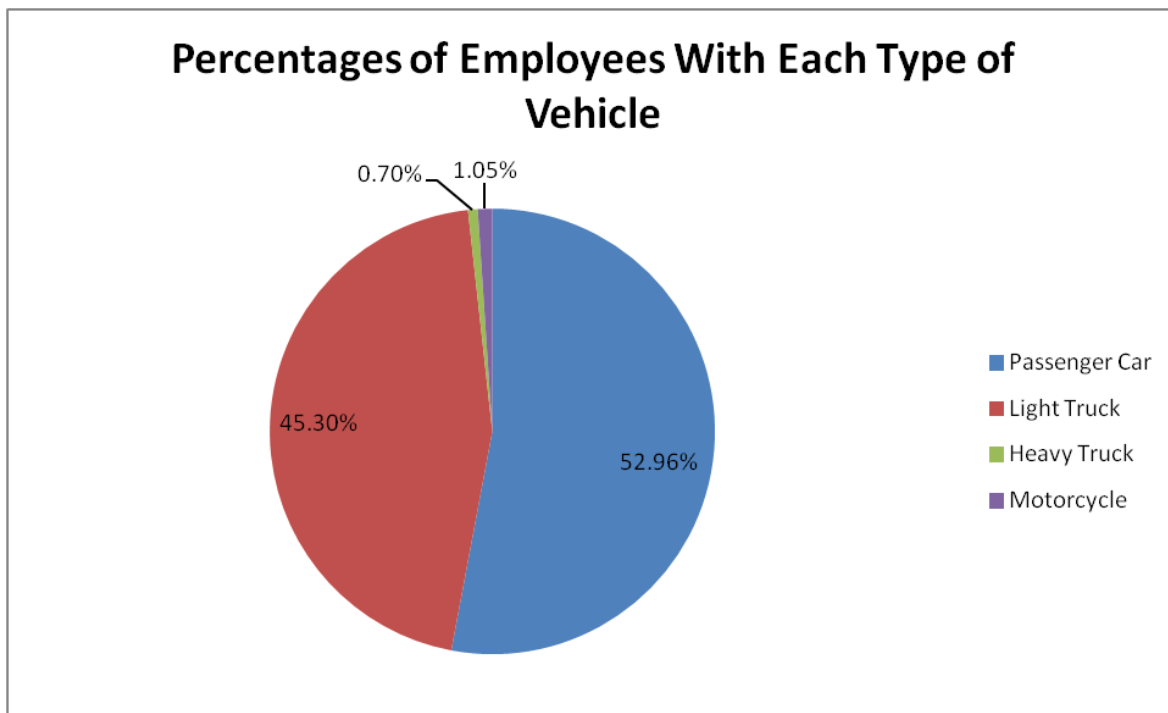

Figure 18 - The percentages of Auburn's employees who drive specific types of vehicles

The miles that someone travels to work combined with the amount of time it takes to get to work is another way to estimate the effect on the environment. Auburn's employees mostly travel less than 30 miles with an average of 13.16 miles traveled to work. The national average

of miles traveled to work is 16 miles which Auburn's employees are well under (Langer, 2005). When the average miles and minutes commuted by the employees are combined it results in 13.16 miles and 17.6 minutes. These results show that the employees are traveling at roughly 1.34 minutes per mile. This means that there isn't much stopping for traffic, which results in less GHGs emitted due to idling. Auburn's commute to work takes 0.82 times the miles of that of the national average. Due to this Auburn's employees are only emitting 0.82 times the GHGs per mile shown in the table below (epa.gov, 2000). There is a significant amount of GHGs that are being prevented by Auburn's employees for living so close to work. Even though all of this data shows that Auburn emits less GHGs due to their commute compared to national averages that doesn't mean that there aren't ways to reduce GHGs even more. The town of Belmont surveyed employees and found that the majority of them 52% live within 5 miles of work. In order to further decrease GHG emissions Belmont set up organized car/vanpools. This could possibly be a very feasible option for Auburn to adopt because by doing this for even just a couple employees it will take their vehicles off the road so that they aren't contributing to the GHG emissions.

Passenger Car

Component	Emission Rate and Fuel Consumption per mile (mi)[1]	Calculation	Total Annual Pollution Emitted and Fuel Consumed
Hydrocarbons	2.80 grams (g)	(2.80 g/mi) x (12,500 mi) x (1 lb/454 g)	77.1 pounds of hydrocarbons
Carbon Monoxide	20.9 grams	(20.9 g/mi) x (12,500 mi) x (1 lb/454g)	575 pounds of carbon monoxide
Oxides of Nitrogen	1.39 grams	(1.39 g/mi) x (12,500 mi) x (1 lb/454g)	38.2 pounds of oxides of nitrogen
Carbon Dioxide[2]	0.916 pound (lb)	(0.916 lb/mi) x (12,500)	11,450 pounds of carbon dioxide
Gasoline	0.0465 gallon	(0.0465 gallon/mi) x (12,500 mi)	581 gallons of gasoline

Light Truck

Component	Emission Rate and Fuel Consumption per mile (mi)[1]	Calculation	Total Annual Pollution Emitted and Fuel Consumed[3]
Hydrocarbons	3.51 grams (g)	(3.51 g/mi) x (14,000 mi) x (1 lb/454 g)	108 pounds of hydrocarbons
Carbon Monoxide	27.7 grams	(27.7 g/mi) x (14,000 mi) x (1 lb/454g)	854 pounds of carbon monoxide
Oxides of Nitrogen	1.81 grams	(1.81 g/mi) x (14,000 mi) x (1 lb/454g)	55.8 pounds of oxides of nitrogen
Carbon Dioxide[2]	1.15 pounds (lb)	(1.15 lb/mi) x (14,000 mi)	16,035 pounds of carbon dioxide
Gasoline	0.0581 gallon	(.0.581 gallon/mi) x (14,000 mi)	813 gallons of gasoline

Figure 19 - The emission rate per mile of each GHG component for passenger cars and light trucks.

Average Commute (miles)	# of People	Percentage
0-5	112	39.30%
6-10	45	15.79%
11-15	47	16.49%
16-20	40	14.04%
21-25	13	4.56%
26-30	14	4.91%
31-35	4	1.40%
36-40	5	1.75%
41-45	4	1.40%
46-50	0	0%
51-55	0	0%
56-60	1	0.35%

Figure 20 - The distance each employee of Auburn lives from work

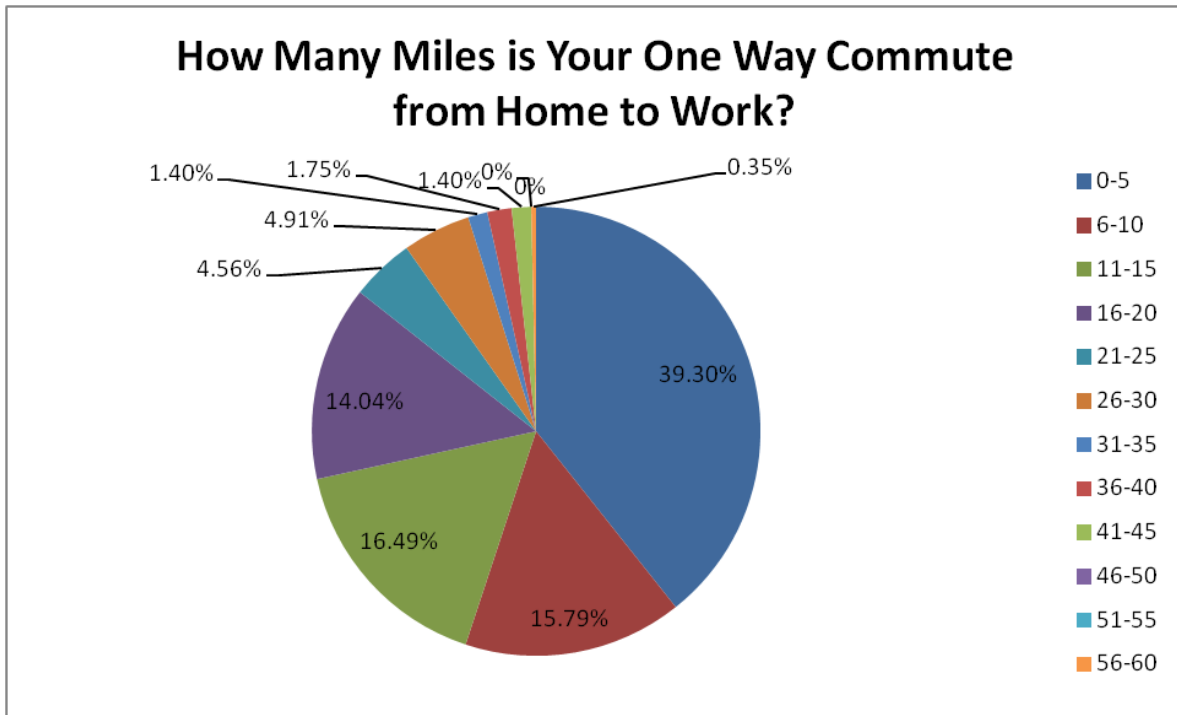## How Many Miles is Your One Way Commute from Home to Work?

Figure 21 - The amounts of miles that Auburn's employees live from work

3.2.4 Government Employee Commute Recommendations

One of the main recommendations that could be made regarding employee commute is carpooling. With 39.3% of Auburn's employees living within 5 miles to work it can safely be assumed that some of the employees live very close to each other, possibly even in the same neighborhood. Living in close proximity to fellow employees gives a great opportunity to carpool with each other without going out of the way to reduce GHG emissions. The City of Auburn could encourage carpooling by municipal employees by educating them about the benefits and making it easy for employees to find others that come from the same areas. If multiple people decide to start carpooling then that's multiple cars that are taken off of the road daily. With these cars being taken off of the road that could drastically cut down on the GHGs that are being emitted annually. Stats show that carpoolers avert 790 pounds of GHGs annually (atsecosolutions.com, n.d.). This is a large reduction by just changing one thing in a daily routine. Each person that switches from driving solo to work to carpooling reduces a substantial amount of GHGs. Not only is this very good for the environment but it also saves money from not purchasing gas about $100-$200 per month. In order to achieve their reduction target

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Worcester added incentives for carpooling. To encourage the employees Worcester educated employees about the benefits of carpooling with fellow employees in the same area. Offer interdepartmental challenges to encourage carpooling among employees. Also offer rides home in cases of emergencies or provide low-emission vehicles that can be signed out (Worcester CAP, 2006). Auburn could follow in these steps and offer the same incentives to their employees to encourage them to carpool among each other. By following the steps outlined by Worcester employees can be encouraged to carpool resulting in a decrease of GHG emissions.

Another recommendation that goes along with living in close proximity to work is walking, biking and taking public transportation to work. When the weather permits walking or biking can be a great means of getting to work and not only does it reduce the GHG emissions that would be emitted by the car but it also saves money by not having to by gas. Alternative methods of transportation to work help both the environment and in instances can even save money. Public transportation is also an excellent means of transportation. The more people that use the public transportation as a means of getting to work the more vehicles that get taken off the road and therefore less GHGs being emitted. Auburn could implement some of Worcester's incentives to forego driving to work. Some of those incentives are subsidizing bus passes, providing places to store bicycles, providing showering areas and offering extra pay for employees who forego a parking space (Worcester CAP, 2006). Public transportation vastly decreases the amount of GHGs emitted as can be seen in the chart below. The transit average is more than half the pounds of carbon dioxide per passenger mile of driving solo (Hodges, 2010). That is a significant amount of GHGs that can be reduced by simply taking public transportation. Auburn can also subsidize bus passes as stated earlier which will be a large incentive to forego personal transportation and use public transportation. Not only does public transportation vastly decrease the amount of GHGs emitted but "according to an APTA study, families that use public transportation can reduce their household expenses by $6,200 annually, more than the average U.S. household spends on food every year (West, n.d.)."

By using public transportation there is a huge cost savings over the long run and also significant reduction in GHGs. In San Francisco a study was done that showed that "a reduction of nine vehicle miles traveled is achieved for every passenger mile of transit service (Berkeley CAP, 2009)." What the town of Berkeley did to encourage public transportation was "integrate

bus routes into broader alternative transportation system, identify gaps in bus service routes and potential scenarios for addressing such gaps, and improve frequency and reliability of bus service where required (Berkeley CAP, 2009)."

Although Auburn isn't San Francisco and it is considerably smaller, similar reductions could be achieved through more people choosing to commute using public transportation. Auburn could take similar actions as Berkeley to encourage the use of public transportation. These actions taken by Berkeley make the public transportation more accessible which in return will greatly increase the chances of employees using public transportation.
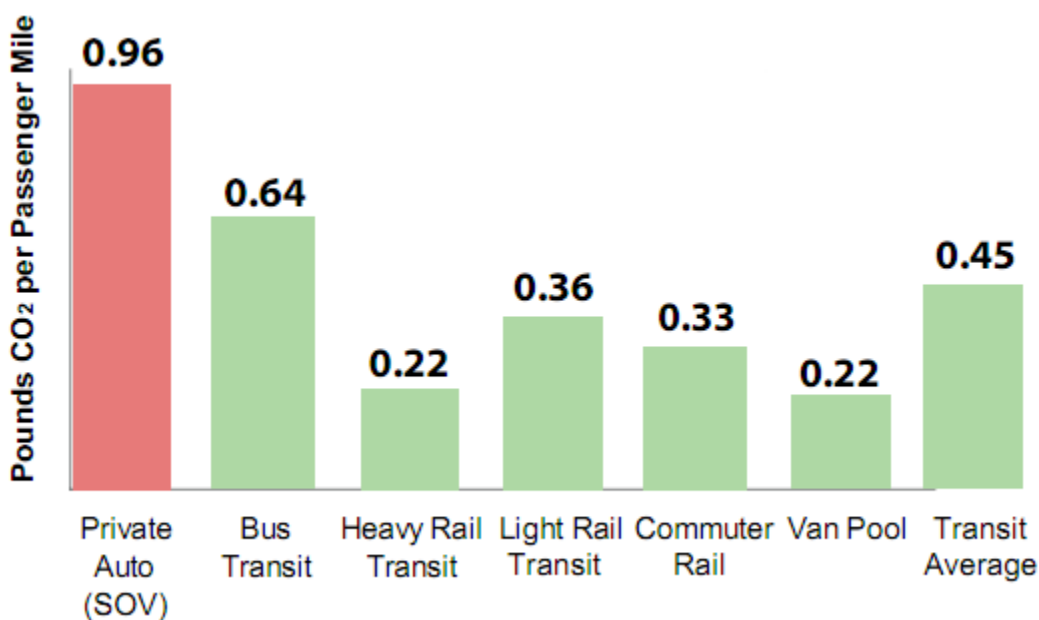

Figure 22 - Pounds of CO_2 per passenger mile of various forms of transportation.

3.2.5 Community Sources

The community transportation sector is one of the largest contributors to the emissions of the town. 191,609 tonnes of eCO2 were emitted by this sector, much more than a town of its size should emit.

City/ CAP Year	Community Transportation eCO2 Emissions	Population	Community per capita emissions
Worcester(2002)	652,678.60	175,333	3.722508598
Medford (1998)	206851	55,763	3.709466851
Belmont (2005)	89,000.00	24,462	3.638296133
Amherst (1997)	28853.3	34,874	0.827358491
Auburn (2009)	191,609	15,730	12.18111888

Figure 23 - Per capita emissions of several towns (community)

These per capita values were calculated by dividing the emissions attributed to community transportation by the population of the town. As can be seen, the majority of these towns have a per capita community emissions of around 3.7 tonnes eCO2 per person with Worcester having 3.723, Medford 3.709, and Belmont 3.638 tonnes per person. Amherst has very low per capita transportation emissions with only 0.827 tonnes per person. However, Auburn emits around 12.18 tonnes of eCO2 per person. The per capita community emissions of Auburn is more than three times the average per capita value for towns that have completed a climate action plan. This high proportion of emissions shows that reducing the emissions in this sector can definitely be accomplished and have a significant effect on reaching the emissions reduction target. These emissions make it a perfect place to target for emissions reductions by the town. Reduction measures that can be taken are discussed in the next section.

3.2.6 Community Recommendations

The following list contains measures that can be taken by Auburn in order to reduce GHG emissions from the community transportation sector.

- Increase public transportation use
- Create a PTDM
- Create a PTDM Ordinance in the bylaws for businesses

Most citizens in Auburn travel alone in vehicles. According to 2010 U.S. Census data, only 5.1% of Auburn citizens carpooled to work while 89.5% traveled alone. The remaining 5.4% used public transportation (.9%), walked (1.4%), or used other means. This is a fairly low

percentage of carpooling and walking considering the small size of Auburn. Showing citizens the health risks they are subjecting themselves to may motivate them to walk or use bicycles more often. The town should also discuss expanding the public bus transportation system in the town. By possibly offering more bus routes in the town, more people would be inclined to use the bus system, therefore lowering the emissions from this sector. The rise in emissions from the public transportation sector would be outweighed by the drop in emissions from the community sector.

One way to cut down on emissions in this sector would be to encourage citizens to use alternative transportation methods, therefore increasing these numbers. Auburn can increase these numbers through the creation of a Plan for Transportation Demand Management (PTDM). A PTDM is aimed at reducing the use of single occupant vehicles (SOVs). Common elements include: charging for parking of SOVs, free parking for carpooling, transit and vanpool subsidies, shower and locker facilities, secure bicycle parking, on site car sharing vehicles, and employee shuttle services among others.

Increasing biking among commuters is essential to a PTDM. Auburn could use tools such as a go green town government website or other green events. Cambridge, MA currently has a Bike Week event every year that encourages participation in bike transit through spring bike tours and discounts at local businesses if they participate in the Bike Week. This also helps bolster the local economy. In addition, they build public and free Bike FixIt stands in areas around the city that contain tools necessary to fix common bike problems (Department of Cambridge Community Development, n.d.). Initiatives such as these have increased biking almost 150% in the last nine years in Cambridge. (The City of Cambridge, n.d.) Boulder, Colorado has also taken biking initiatives to increase the number of commuters using bicycles. One such initiative is a Bikeshare program that has 200 bikes across 25 stations in the city where citizens can rent bikes. The city acquired $250,000 in grant money for the initiative. (City of Boulder Colorado, n.d.)

Changing town bylaws to include mandatory PTDMs for businesses is another great way to increase the alternative commuting numbers. This would require businesses that meet certain criteria to create a PTDM prior to receiving any permits that it requires for operating. Cambridge is one town that has done such a thing. They require businesses that meet the criteria

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to include shower and locker facilities for bicyclists and walkers that are worried about sweating before work, transit and vanpool subsidies for employees to encourage public transportation use, and cheaper parking for carpoolers among other things. These not only reduce the community's emission levels, but can also work in the business' favor by enticing prospective employees to work for them. However, before mandating PTDMs for businesses, the town of Auburn should take the initiative to set an example for the community sector. Auburn should begin to incorporate elements of the PTDMs that they want to include in the ordinance into their everyday governmental operations. This will motivate businesses to do the same, and it may be easier to pass any legislation needed to do this.

Idling of vehicle engines is a significant source of unnecessary emissions. If everyone in the US eliminated 5 minutes of idling then it would reduce 40,000 tons of CO2 emissions and save 3.8 million gallons of gasoline (Hinkle, n.d.). Although everyone in Auburn can't save that much gasoline and CO2 emissions it goes to show how much just 5 minutes of idling can harm the environment and reducing idling will significantly help. It has been economically proven that if the car is only idling for 10-30 seconds leave the engine running (Belmont CAP, 2009). Turning the engine off when possible will reduce engine wear, decrease fuel use and avoid preventable emissions. In Massachusetts it is Illegal to leave a car idling for longer than 5 minutes. "A gasoline vehicle wastes one gallon of fuel and emits 22 pounds of eCO2 for every hour idling (Worcester CAP, 2006)." Worcester plans on implementing a policy that will support the state policy. Worcester is going to educate the community on the negative effects of idling and post signs around the community to remind people not to idle. If Auburn was to go about implementing idling policies they could go through the same steps that Worcester did in order to effectively combat idling. By decreasing or eliminating idling there is a significant decrease in GHGs.

**Total US Environmental Benefit from
Eliminating 5 Minutes of Voluntary Idling**

Daily		Annually	
Gasoline Not Burned	CO2 Not Emitted	Gasoline Not Burned	CO2 Not Emitted
3.8 million gallons	40,000 tons	1.4 billion gallons	13 million tons

Figure 24 - US Environmental benefit of reducing 5 minutes of Idling. Source thehcf.org

What most people don't take into account is that the transportation of food and goods can cause a significant amount of GHG emissions. In 2006 a report from the United Nations found that in the United States 17% of all fossil fuel use is from production, processing, and transportation of food (Belmont CAP, 2009). That is a lot of GHGs being emitted which can be cut down by people not buying foods which are being produced, processed and transported from far away. Local grown farmers markets are also a great way to cut down on "food miles" and help reduce GHGs. Food makes up approximately 14.4% of the total energy used in the US which can be broken down and analyzed more closely (Bomford, 2011). Looking at the graph bellow the wholesale and retail is 2.2%, packing is 0.9%, and processing of food is 2.8% of the entire US energy use. This makes a total of 5.9% of the total energy use in the US. By going and buying food from local farmers markets it is possible to cut down on that 5.9%.
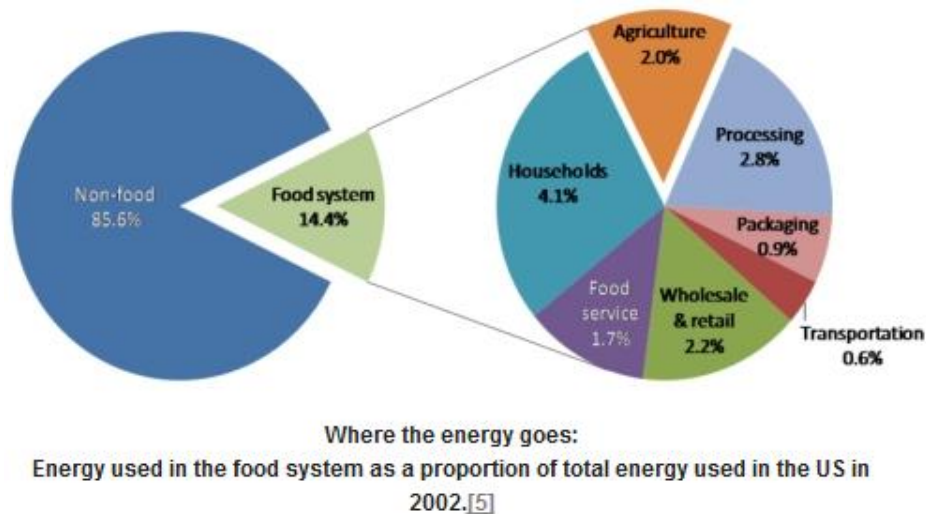

Where the energy goes:
Energy used in the food system as a proportion of total energy used in the US in 2002.[5]

Figure 25 - Total energy use of the US in the food system. Source postcarbon.org

CHAPTER 4 – AUBURN'S ENERGY, WASTE AND FUEL EMISSIONS

When choosing a protocol to follow for the inventory of greenhouse gases, it is necessary to consider the end goal of the local government completing the inventory. Many local governments lack the resources necessary to carry out the most in-depth inventory possible and, in Auburn's case; the most in depth inventory does not necessarily help the town achieve the effects it wants from an emissions inventory. The main goal of Auburn's is to create an economically sustainable set of recommendations whose end effect are to decrease pollution in the area in order to raise the health of citizens, create local jobs and boost the local economy, and save money based on the reduction in electricity and fuel consumption. Including sources such as livestock methane emissions, single backup power generators, or composting would not give any data with which recommendations that achieve these end goals could be made. Many emissions inventories conducted on a federal level include sources such as these, which is the reason these methods were not chosen for Auburn. Auburn operates on the much lower municipal level. It was with these goals in mind that the ICLEI method for data collection was utilized, which was created specifically for governments on the municipal level.

ICLEI's protocol is designed according to one main goal: creating an inventory that is economically feasible while remaining practical for the town. ICLEI recognizes this challenge presented to towns, however still remains fairly comprehensive. While doing so, it aims to remain an achievable feat for both large cities, such as Worcester, and small towns, such as Auburn, alike. This protocol limits included emissions sources to those that can be directly affected by town policy and action. In doing so, it provides Auburn with a set of data that it can base recommendations off of to help meet its end goal.

Even ICLEI's guidelines are not perfect for Auburn. Specific inventory methods were designed for Auburn by taking ICLEI's initial suggestions and tailoring them to meet Auburn's specific needs. This resulted in the inclusion of some emissions sources that may be left out of inventories performed by larger cities - such as the many Scope 3 sources that define public services in Auburn.

In the previous chapter, data collection methods regarding all transportation emissions sources were outlined for the town of Auburn. In this chapter, methods for collecting information for the remaining emissions sources in Auburn are outlined. Transportation emissions source collection methods is a standalone chapter due to the fact that the only data that was able to be obtained was for the transportation sectors of Auburn. Although not included in this methods section, it is an integral part of any emissions inventory in a town.

The methods outlined in this chapter are separated from the transportation methods since it contains guidelines for emissions source sectors that were unable to be obtained. When attempting to collect the data outlined in this chapter, many problems arose. A large portion of the data is not included because of the time constraints placed on the project and incomplete or missing records. Due the incomplete records, it took longer for contacted people to obtain the information and in many instances this led to no information being provided. These problems are the main reason a database, discussed in depth in section 5.1, for record keeping was suggested to the town.

The following sections outline the need to include each emissions source, the initial suggestions from ICLEI to collect the data, the specific methods developed for Auburn, and how and why they were adapted from the ICLEI protocol. Including these emissions sources will allow Auburn to create recommendations that decrease pollution in the area in order to raise the health of citizens, create local jobs and boost the local economy, and save money based on the reduction in electricity and fuel consumption.

4.1 Government Buildings and Facilities

For each building that the government owns, ICLEI states that data needs to be collected in the form of electricity (kWh), natural gas (therm), steam usage (tonnes), fuel oil (gallons), propane (cubic feet) and kerosene (therm). Auburn owns 29 buildings which are all under direct operational control and therefore are classified as scope 1 emissions sources and have to be included in the inventory. This can be collected by contacting the facilities manager, utility bills or Records and the Finance Department.

All forms of data that need to be collected electricity, natural gas, steam usage, fuel, propane and kerosene emit GHG emissions which are harmful to the environment and to health. GHGs cause particulate matter. This particulate matter is the main cause of haze in cities and also parks (EPA, n.d.). Haze causes vision impairment, which is also harmful to breathe in. Auburn has a large majority of parks where children can play. In Auburn children make up a large majority of the population at about 17% so this haze and GHGs are putting them at risk. By collecting the data from the government buildings and facilities it is possible to target large GHG emitters so that it can be made more efficient and to cut down on the haze being produced.

Electricity data needs to be collected in the form of kWh; there are multiple different ways of collecting this data. First method was by looking at old electricity bills. Second method was by contacting the company in charge of distributing electricity to municipal buildings, which was National Grid. Our team contacted Jim Mays the account manager for Auburn at 508-357-4730 and faxed him a spreadsheet. Due to lack of time we were unable to collect the necessary data.

The data that needs to be collected for the heating of each building is natural gas (therm) use and oil (gallons). Similar to the electricity data there were two different ways to collect the heating data. The first method was to look at old utility bills. The second method was to contact the company that supplies the oil and natural gas. Glacial Energy supplies the natural gas to all of Auburn's municipal buildings.

If the buildings and facilities were more energy efficient and efforts were made to reduce energy and fuel use then the buildings and facilities impact on the environment could be greatly reduced. In the Boulder climate action plan steps were taken to reduce energy use by turning thermostats down 2 degrees and by turning off energy consuming devices like computers and lights when not in use. By taking these actions this was able to greatly reduce the 25 million kWh and 510,000 therms of natural gas used each year (Boulder CAP, 2006). If Auburn were to take similar actions in reducing energy and fuel use then GHGs could be reduced like in Boulders case and cost would also be significantly reduced by conserving energy and fuel.

4.2 Solid Waste Facilities

Solid waste and solid waste facilities emit methane as a large amount of the GHGs being emitted. Methane is a GHG commonly found in landfills and solid waste where if collected and used properly can be used to create different types of energy (EPA, n.d.). The solid waste data is important to collect because by collecting the data it is possible to see where the methane and other GHGs are coming from and if it would be feasible to collect it and transform it into energy.

The local government generates solid waste which contributes to GHG emissions. According to ICLEI the data that needs to be collected is the tonnage of waste disposed and waste characterization information. The solid waste facilities information is contracted out and therefore is scope 3 emissions and therefore do not need to be included in the inventory. There are multiple different ways to collect this data which are contacting the landfill operators, facilities manager, finance department and looking at waste hauler bills.

Landfills are also classified under solid waste. If there are any landfills in the town then some data has to be collected for the fugitive emissions that the landfill emits. ICLEI's protocol claims that the data that needs to be collected is the local landfill type and features, total tonnage in place, history of waste deposition and waste characterization information. The way to collect this data is to contact the landfill operators and facility managers.

Many of Auburn's services are scope 3, or contracted out, so even though it is not mandatory to collect the data our group decided to collect it so that we could have as complete of an inventory as possible. ICLEI gives multiple different ways to collect the data but our group decided that the best way to collect the data was to go straight to the source and contact each person in charge. Information from the Casella Auburn Transfer Station is collected from Butch Larsen, the Plant Manager. The information that our group needed to collect from Butch Larsen is the tonnage of waste processed at the facility and waste characterization information as stated by the ICLEI protocol. Our group also had to collect data on the total waste stream from Auburn. To obtain this information our group contacted Melody Gibbons of Central MASS Disposal. The fraction of Auburn's waste stream over the total amount of waste processed at the facility is applied to all emissions from it to calculate the emissions attributed to Auburn.

Recycling is a major part of helping prevent emissions due to solid waste. If trash was correctly recycled then it could prevent an immense amount of emissions and cost reduction. "Net carbon emissions from producing a ton of new material are 4 to 5 times higher than producing with recovered material in the steel, copper, glass and paper industries, and 40 times higher for aluminum (San Francisco CAP, 2004)." By recycling and not constantly gathering new materials the GHGs that can be prevented are substantial. In the San Francisco climate action plan it was found out that by recycling a ton of trash it could save 4200 kWh which is the amount of energy required to power the average San Francisco home for a year (San Francisco CAP, 2004). If Auburn could promote recycling more, especially recycling paper then it would increase the amount of GHGs not being emitted because less energy needs to be generated. It will also save money because it's cheaper to recycle materials than it is to gather and manufacture virgin materials.

4.3 Vehicle Fleet

The town's vehicles are a contributor to GHG emissions. Driving the vehicles to work and on work business causes the GHGs to be emitted. The main cause of vehicles emitting GHGs is due to the burning of fossil fuels. As shown earlier in figure 19 vehicles like passenger cars emit a lot of pollutants like carbon monoxide which is emitted at 20.6 g/mi. The vehicle fleet data is important to collect because it is important to track the emissions caused by the town's vehicles and to see if there are any areas that could be reduced or eliminated in terms of GHG emissions.

The local government has their own fleet of cars which cause some GHG emissions. ICELI's protocol states the data that needs to be collected, which is make, model, model year, annual vehicle miles traveled, and fuel type. The protocol also tells where to get the information which for the vehicle fleet is contact the fleet manager, fuel tracking system or finance department.

ICLEI gives three different ways to collect the data for the vehicle fleet but for Auburn none of these methods were feasible. Auburn doesn't have a fleet manager so it would be impossible to contact the fleet manager. Auburn doesn't have records of fuel use by department, just for the entire fleet so the fuel tracking system didn't work. The finance department also

wasn't possible because Auburn doesn't have that data on file. What our group did in order to get around that obstacle was to get a list of all the departments who had government owned vehicles from Auburn's town planner Adam Burney. With this information our group was able to email the heads of all of these departments a spreadsheet for them to fill in which had all the information that we needed make, model, model year, annual vehicle miles traveled, and fuel type.

Switching the municipal fleet over from conventional gas vehicles to alternative fuel vehicles a little bit each year can greatly reduce GHG emissions and help reduce cost. In the San Francisco climate action plan over the course of about 4 years they purchased approximately 25% of the municipal fleet as alternative vehicles which is about 75 alternative fuel vehicles per year. In 2002 these purchases resulted in 868 tons of CO_2 being prevented and is estimated at over 2000 tons of CO_2 being prevented (San Francisco CAP, 2004). Although Auburn is significantly smaller than San Francisco and has only a fraction of the municipal fleet that San Francisco has it can still make a large difference by slowly switching the municipal fleet over to alternative fuel vehicles year by year. While this is a great way to reduce GHG emissions it also will help the town save a significant amount of money over the long run by not having to purchase as much fuel for the municipal fleet.

4.4 Wastewater Facilities

Wastewater facilities contribute to the GHGs by processing and holding wastewater. If wastewater is not treated correctly large amounts of GHGs can be emitted. "A team of scientists from Columbia University has found evidence that emissions of nitrous oxide from some wastewater treatment plants may be significantly higher than previous estimates. Nitrous oxide is a powerful greenhouse gas that is almost 300 times stronger than carbon dioxide. As for the good news, the team also found indications that much of the problem could be resolved by tweaking operations at existing plants and introducing more efficient design standards in new plants, rather than developing expensive new technology (Casey, 2010)." It is important to collect the data from the wastewater facilities because the nitrous oxide emissions might be significantly higher than necessary and by inventorying the data it will be possible to see if in fact the nitrous oxide levels are too high.

ICLEI classifies wastewater facilities as process emissions because the GHG emissions are mainly caused through processing wastewater. According to the ICLEI protocol the wastewater facility type and features and total volume of wastewater has to be collected for this section. The way to obtain this data is to contact the wastewater utility.

Auburn doesn't have any wastewater facilities because all of their wastewater gets sent to the Upper Blackstone Wastewater Treatment Facility located in Worcester, MA. Since the facility isn't located within Auburn and it isn't operated or controlled by Auburn the emissions are classified as scope 3. The scope 3 emissions aren't mandatory to collect but our group decided to collect them nevertheless so that we could give Auburn a more complete inventory. The first piece of data that our group had to collect was the electricity and fuel consumption of the wastewater facility. In order to collect this data it would be easiest to follow ICLEI's recommendation and directly contact the wastewater facility. The specific person to contact to gather this information is Karen Boulay of administrative services at the facility. Once when the data is collected therms of natural gas, kWh of electricity, and gallons of fuel is entered into the Wastewater Facilities tab of the CACP 2009 software.

When the wastewater is being processed methane and nitrous oxides get directly released into the atmosphere. Digester gas volume, BOD5 load, N load, total volume of wastewater treated, and the populations served by each is collected and entered into the appropriate equations to calculate the eCO2 emissions prior to entering the information into the CACP 2009 software. Karen Boulay is again the person to contact in order to obtain all of this information.

The Upper Blackstone Wastewater Treatment Facility services multiple towns in the Worcester area not just Auburn, so the amount of emissions which are attributed to Auburn has to be calculated. To calculate the emissions that are attributed to Auburn the volume of wastewater leaving Auburn has to be collected. The person to contact to obtain this data is Jeffrey C. Mitchell, the sewer superintendent of Auburn. After collecting the volume of wastewater leaving Auburn the fraction of this volume over the total volume of wastewater treated by the plant is applied to all emissions from the facility to calculate those attributed to Auburn.

4.5 Water Delivery Facilities

Commercial buildings are a large cause of GHGs. This sector contributes 17% to the total GHG emissions in the United States. (Energy Star, n.d.) The water delivery facilities in Auburn are privately owned, and are a part of this sector. Last year, the commercial buildings sector shared 18% of overall energy consumption in the United States. (Meller, n.d.) This large amount of energy usage is what leads to the large share of emissions in this sector.

Auburn should include water delivery facilities in its emissions inventory. The emissions from this sector are directly attributed to the town of Auburn since they serve only Auburn citizens. If not included, then all possible areas of emissions reduction cannot be considered. Including this sector allows Auburn to have all possible policy choices available when taking action to reduce overall emissions. This will allow Auburn to have the biggest impact on reducing the ground level ozone that is a result of the emissions and greatly affecting the town's citizens.

Water Delivery Facility Data Collection

Emissions from this source come from the facilities that supply Auburn with clean drinking water. Although Scope 3, and not mandated to include under the ICLEI protocol, emissions from this source are directly attributed to the town of Auburn. This was the reason why it is included in the emissions inventory of the town.

Auburn has three water delivery districts that serve the community, all of which are privately owned. The three facilities are the Auburn Water District, the Elm Hill Water District, and the Wood Park Water District. The Auburn Water district consists of three buildings, and data must be collected for each. Information from the facilities at the two remaining districts must also be collected. The method for collection laid out by ICLEI is the same method used for Auburn. The recommended ICLEI method for obtaining data for this source is non-specific to water delivery facilities. The data needed is the same as for any other facility – electricity and fuel consumption data. The information needed is obtainable by Auburn without any great deal of difficulty. The data can be collected from the facilities manager at each respective location. Upon collection of this information, it can then be entered into the CACP 2009 software.
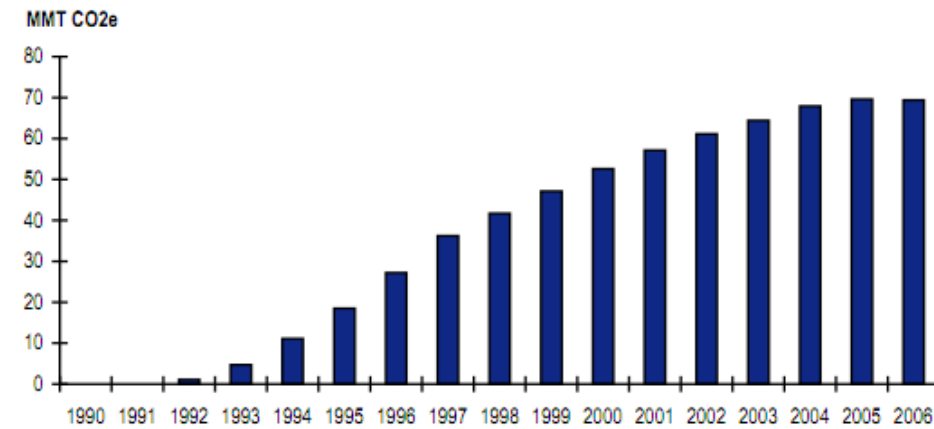
The use of the ICLEI method for the calculation of emissions from this sector ensures that the final report regarding water delivery facilities will be acceptable by ICLEI and will also aid Auburn in completing its overall goals. The inclusion of this emissions source will give Auburn the most realistic report of emissions within the town. This will allow the best policies to be put into place to realize health increases as well as the cost savings that Auburn is looking for from this inventory.

4.6 Mobile Fugitive Emissions

Mobile fugitive emissions, which refers to the emissions that result from the installation, operation, and disposal of air conditioning equipment in vehicles, is important to include in any emissions inventory. HFCs were introduced in the early 1990s as a new refrigerant for mobile air conditioners and refrigerated freight transport units to replace chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC). This is due to CFC and HCFC being banned under the Montreal Act because of their ability to deplete the ozone layer.

Hydrofluorocarbons, which are used in automobile, truck, and rail air conditioning and refrigeration systems, account for three percent of U.S. transportation emissions. (U.S. Department of Transportation, 2010) HFCs emit only three percent, a seemingly low percentage, due to the fact that most transportation emissions come from carbon dioxide. It is still a significant source of emissions. HFCs are still very potent GHGs with very high global warming potentials. One kg of the most common HFC blend, HFC-134a, has 1300 times the warming potential as one kg of CO2 over a 100 year period. (United Nations, n.d.) This highlights the fact that a small amount of leaked refrigerant can have a large overall effect on the equivalent carbon dioxide emissions of a town. Inventorying these can account for a great source where reductions can be made relatively easily. HFC emissions have hit a plateau since 2005 even though more vehicles are on the road than ever. (U.S. Department of Transportation, 2010)

HFC Emissions from Mobile Air Conditioners and Refrigerated Transport

MMT CO2e

[Bar chart showing HFC emissions in MMT CO2e from 1990 to 2006. Values rise from near 0 in 1990 to approximately 1 in 1992, 5 in 1993, 11 in 1994, 18 in 1995, 27 in 1996, 36 in 1997, 41 in 1998, 47 in 1999, 52 in 2000, 57 in 2001, 61 in 2002, 64 in 2003, 68 in 2004, 69 in 2005, and 69 in 2006.]

Source: U.S. EPA (2008). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2006.*

Figure 26 - HFC Emissions from Mobile Air Conditioners and Refrigerated Transport

This graph shows the leveling off of HFC emissions. This leveling off is due to better training of disposal and handling of air conditioning equipment in addition to there being natural replacements for most blends of refrigerants. (Greenpeace, 2006) This makes it an ideal and easy source to make reductions in.

Auburn should include this emission source in its inventory. Due to the fact that refrigerant emissions, even if only a small amount, can have huge effects on overall emissions, it is vital for Auburn to include. The ease of reduction in this area also provides Auburn with a simple initial action that can be taken to reduce its own emissions. Since the global warming potentials are high for refrigerants, reducing these can reduce the town's emissions. This will allow Auburn to reach its reduction goal quicker, and in the process limit the GHG emissions that are causing high ground level ozone in the town and putting its citizens at risk. The following section is a guide on collecting the source data for mobile refrigerants in Auburn.

Mobile Refrigerant Data Collection

Under the ICLEI protocol, this emissions source is considered Scope 1 and is included in Auburn's inventory. ICLEI recommends collecting data that includes each blend of refrigerant used in vehicle air conditioning units, the total amount of each refrigerant used, total full charge

capacity of the equipment, operating time of the equipment, and information as to if an air conditioning unit was either installed or disposed of. Only refrigerants included in Appendix F are required to be reported. The ICLEI method is the only method available for calculation of emissions from this source, so the same methods are used for Auburn as well.

Since Auburn does not service their own vehicles, it may be difficult to acquire the necessary information. It may take some time to acquire this data, so the company that services the town's vehicles should be alerted to what data is needed well ahead of the time of collection of it. New procedures may need to be put into place to ensure this information is kept on record.

Once the necessary information is obtained regarding the air conditioning equipment, some calculation independent of the CACP 2009 software is needed. Equation 7.13, provided by

Equation 7.13	Estimating Emissions of Each Type of Refrigerant

For each type of refrigerant:

$$\text{Total Annual Emissions (metric tons)} = [\,(C_N \times k) + (C \times x \times T) + (C_D \times y \times (1-z))\,] \div 1{,}000$$

Where:
C_N = quantity of refrigerant charged into the new equipment [1]
C = total full charge (capacity) of the equipment
T = time in years equipment was in use (e.g., 0.5 if used only during half the year and then disposed)
C_D = total full charge (capacity) of equipment being disposed of [2]
k = installation emission factor [1]
x = operating emission factor
y = refrigerant remaining at disposal [2]
z = recovery efficiency [2]

[1] Omitted if no equipment was installed during the reporting year or the installed equipment was pre-charged by the manufacturer
[2] Omitted if no equipment was disposed of during the reporting year

ICLEI, is used to calculate the total metric tons of emissions of each type of refrigerant.

Figure 27 - Estimating Emissions of Each Type of Refrigerant

Although the above equation may seem complicated, many of the terms are omitted if equipment was not installed or disposed of during the year (which is a rare occurrence.) Once the total annual emissions are found for each refrigerant blend, the appropriate global warming potential factors from Appendix F are applied. This converts the tonnage of refrigerant emissions into

eCO2 emissions for each blend. The eCO2 tonnage for each blend is summed together to obtain a single eCO2 amount for all mobile fugitive emissions.

Although it may take some time to acquire the necessary information for this sector, it is a valuable source to include. Since the same protocol provided by ICLEI is followed for the town of Auburn, the calculation of emissions from this source are guaranteed to stand up to ICLEI's standards when the town is applying for ICLEI certification. Since, mobile fugitive emissions can account for a large amount of eCO2 tonnage. This is valuable information to have as it gives the town yet another area for policy to affect overall emissions to reach the overall goals of Auburn to increase the health of its citizens.

4.7 Community Energy Use

Community energy use contributes a large amount to overall emissions. 18% of total emissions are a result of residential energy and fuel use globally. (World Health Organization, n.d.) In a place such as Auburn, the percentage will be much higher, since there are more community members than there are government employees. In Bedford, MA, the residential sector contributed 53% of the overall emissions during the town's baseline inventory. Likewise, the residential sector in Worcester, MA constituted 26% of overall emissions. From 1990 to 2007, emissions from the residential sector in the United States grew by an average of 1.6% per year, resulting in a 29.9% increase over the entire period. (U.S Department of Energy, 2008) The share of emissions from this sector will only increase with the increasing population.

Due to the large percent of emissions from this sector, coupled with the fact that these emissions only rise with population growth, it is imperative for emissions data from this source to be included in Auburn's emissions inventory. The inclusion will help to reduce the rising energy costs incurred by the community by making the citizens feel less of the effect of the increasing prices of the energy markets. This is due to the fact that reducing emissions in this area requires the reduction in energy usage. It provides an area where Auburn can reduce the overall emissions in the town. This reduction in emissions will directly lower the pollution in the town, giving rise to the health risks experienced by citizens. The following section provides information on collected data needed to complete an inventory of this sector.

Community Energy Use Data Collection

Energy usage by the community requires the same information as energy use by municipal buildings. This data includes electricity, heating oil, and natural gas usage. ICLEI recommends contacting each company that provides these services to the town and obtaining the information directly from them. This method is applicable for electricity and natural gas data, since there is only a single supplier for each. However, for heating oil data, there are too many suppliers to contact directly, so an alternative estimation method must be used.

National Grid supplies all of Auburn with electricity while NStar services all the natural gas utilities in the town. Each company should be contacted directly in order to gather the necessary data. In addition, the total number of accounts using natural gas is needed from NStar for heating oil estimation. For the heating oil estimation, some additional data and calculation is required. The number of households in Auburn and the average heating oil used per household in the New England region is needed. Average heating oil/household is available from the EIA. By subtracting the number of households using natural gas from the total number of households in Auburn, an estimation of the number of households that use heating oil is calculated. This estimation is based off of the assumption that any house not heating using natural gas is using heating oil. This number of households using heating oil is multiplied by the average heating oil used per household to obtain a number of gallons of heating oil used by the community.

This emissions source is mandatory to include, and emissions from it are very high. The methods used differ slightly from ICLEI only in calculating heating oil consumption. However, the method used is comprehensive and complete and the use of it will ensure acceptance under ICLEI standards. The inclusion of the source will give Auburn a great sector to focus on for emissions reduction to reach its target. Not only will fewer emissions be emitted, which will reduce ground level ozone associated with health risks faced by Auburn's citizens, but decreased costs will be seen by the community.

The inclusion of all emissions sources laid out in Chapter 4 will allow Auburn to create an action plan that best suits its needs while achieving its goals. In the next chapter, certain recommendations pertaining to these sectors are discussed.

CHAPTER 5 – RECOMMENDATIONS FOR FUTURE DATA COLLECTION AND INCREASE ENERGY EFFICIENCY

5.1 Increasing Energy Efficiency

All of the recommendations in this section are arranged in the way that would be easiest to implement these recommendations and with the lowest initial cost. The recommendations are listed below and are as follows.

- List of Recommendations:
- Convert lights to Light Emitting Diode (LED) lighting
- Increase energy efficiency of buildings
- Switch utilities from oil to natural gas
- Utilize available rebates to accomplish all of these tasks

Buildings and facilities use approximately a third of all of the electricity consumed in the United States and Auburn is no exception to this. If these buildings and energy consuming devices were built more efficiently then it could drastically cut down on the amount of energy and electricity needed to operate them. "Energy Efficient Buildings Could Save More than $500 Billion by 2030 and Cut Global Warming Emissions by a Third by 2050 (Landers, 2009)." If Auburn were to make their buildings more energy efficient than in the long run it will vastly decrease GHG emissions and offer a large cost savings. This section will outline recommendations that the town of Auburn would be able to implement in buildings and other places in order to increase energy efficiency and save money.

LED Lights

The Town of Auburn could benefit from switching from conventional lighting to Light Emitting Diode (LED) lighting. The LED lights will save money and emit less GHGs, which is good for Auburn to save money and emit less GHGs. LED lights last much longer than fluorescent and incandescent light bulbs because there is no filament to burn out or break (led.com, n.d.). LED lights have the potential to last up to 100,000 hours at full brightness which

is over 11 years (lc-led.com, 2007). This life span is twice that of a fluorescent light bulb or 20 times that of an incandescent light bulb, which drastically cuts down on how frequently light bulbs need to be purchased. In the long run this will provide an overall cost savings and those cost savings could be used elsewhere in the government. By purchasing less light bulbs it also cuts down on the GHGs emitted because less light bulbs need to be manufactured.

LED lights are very energy efficient, requiring a lot less energy to operate and effectively using that energy. Incandescent light bulbs lose about 80% of their energy to heat, which only leaves 20% for light (lc-led.com, 2007). LED lights are the exact opposite and only lose 20% to heat. Furthermore, LED lights also operate at 10 to 20% of the power required for an incandescent light bulb at the same brightness (eatheasy.com, n.d.). Since LED lights require much less energy to operate and they use that energy much more efficiently, additional savings can be incurred. Not only is the cost savings important but since these lights use about 80% less energy that's 80% less GHGs being emitted due to lights. Both NSTAR Electric and National Grid Electric are offering instant rebates through retail markdown and buy down promotions for ENERGY STAR qualified residential light fixtures that utilize CFL bulbs and LED bulbs. These LED light bulbs provide cost savings through energy efficiency and life span. They are also currently being marked down to encourage people to buy them causes a smaller initial cost and a faster pay off period. Although LED lights can be a great alternative light, there are some foreseeable downsides. The initial cost and the angle of light distribution (greenledlights.com, n.d.). LED lights have a very large initial cost compared to other lights but due to their large life span and energy efficiency they are still a very viable option to adopt. The angle of light distribution can be very limited, meaning that in the middle, directly under the light it is very bright but then around the perimeter it starts to get dim. This could mean the need for more lights closer together to combat the light distribution. The city of Worcester has implemented LEDs in red traffic lights in an attempt to reach their reduction target for their climate action plan. By implementing these LED lights Worcester has been able to prevent 175 tons of eCO_2 emissions per year (Worcester CAP, 2006). Worcester was able to prevent that much emissions through only red traffic lights. If Auburn was to put these LED lights in all lights possible building lights, traffic lights, street lights, exit signs…etc. then there would be an even larger reduction of GHGs.

Upgrades

Energy efficient upgrades could be made to the government-owned buildings. These upgrades will decrease the GHGs that are emitted due to building usage and will help reach the reduction target that is one of the steps of ICLEI's to create a climate action plan. Many companies, such as National Grid, offer rebates to motivate customers to increase their energy efficiency. National Gird accomplishes this by offering rebates on energy efficient energy consuming appliances like air conditioning units, computers, monitors and refrigerators. By taking advantage of some of these rebates the town of Auburn could save money annually due to a lower electricity bill because of the increased efficiency in some of the appliances that are being purchased. The increased efficiency of these appliances can also drastically help reduce the amount of GHGs that were previously being emitted.

Biodiesel is another great way to reduce the environmental impact and decrease health risks due to burning fuel that can be implemented in both buildings and vehicles. Biodiesel burns much cleaner compared to fuels like petroleum diesel. "Biodiesel reduces net CO_2 emissions by 78% compared to petroleum diesel (biodiesel.org, n.d.)." By switching to biodiesel there is a significant amount of emissions that can be prevented. 78% is a huge decrease which can greatly help reach the emissions reduction target set. Not only is biodiesel very good for the environment, it also is significantly healthier for human beings. "Scientific research confirms that biodiesel exhaust has a less harmful impact on human health than petroleum diesel fuel. Biodiesel emissions have decreased levels of polycyclic aromatic hydrocarbons (PAH) and nitrited PAH compounds that have been identified as potential cancer causing compounds (biodiesel.org, n.d.)." Biodiesel is very health friendly which is very good for Auburn. Biodiesel won't create as much ground level ozone which will greatly help the third of the people in Auburn who are in the sensitive group. It is very easy to change an existing diesel engine to a biodiesel engine. If 100% biodiesel is being used then nothing has to be done but if it's not 100% then additives can be added to the fuel, or an in line tank or fuel line heater may need to be installed (Hoffman, 2003). The lack of needing to purchase a new engine or completely refit an old engine is very helpful for the town of Auburn because this will save a significant amount of money. In reaching their emissions target Worcester planned on switching some vehicles and engines over to B20 fuel which would prevent 4 tons of eCO_2 per year.

Switching to biodiesel is cheap but it also helps eliminate GHG emissions which is a cheap way to help Auburn eliminate GHGs.

Adding motion sensors to light fixtures can help greatly reduce GHG emissions and also save money on lighting. Motion sensors provide automatic on/off control over the lights so that no electricity is wasted by having lights on in unoccupied areas. The city of Boynton-Beach Florida installed "motion sensors at 284 high traffic areas throughout City owned facilities to provide automatic on/off control of lighting is estimated to cost $32,740 and is expected to save over $2,600 and nearly 25,000 kWh a year. The proposed CO2e reduction is 17.800 metric tons (Boynton-beach.org, 2006)." The motion sensors are an easy way to reduce GHG emissions and save money in the long run.

Solar Power

Photovoltaics are another attractive option to cut down energy use and cost in government owned buildings. They also cut down on GHGs being emitted compared with traditional means of electricity generation like coal (http://igitur-archive.library.uu.nl, n.d.). Photovoltaics channel the power of the sun to generate electricity. Taking the power of the sun eliminates the need for power generation plants which cuts down on GHGs being emitted. As seen in the chart photovoltaics emit over 700 less CO_2-eq than coal which is a substantial amount of GHGs being eliminated. By having the electricity generated without the need of a power plant and long wires being run and maintained, the costs are virtually non-existent, except for the initial investment in buying the system. The other benefit of photovoltaics is that it is possible to generate more energy than is needed. In some instances the electricity companies will buy back the electricity that is generated and not used. One downside to photovoltaics is the initial cost which can be substantial. The Massachusetts Solar Campaign offers 15% of off the installation of these photovoltaics systems (solarpowerrocks.com, n.d.). The Commonwealth Solar Rebate Program also gives rebates to people who want to install photovoltaics. These rebates help decrease the initial cost and gives a much faster payback period.
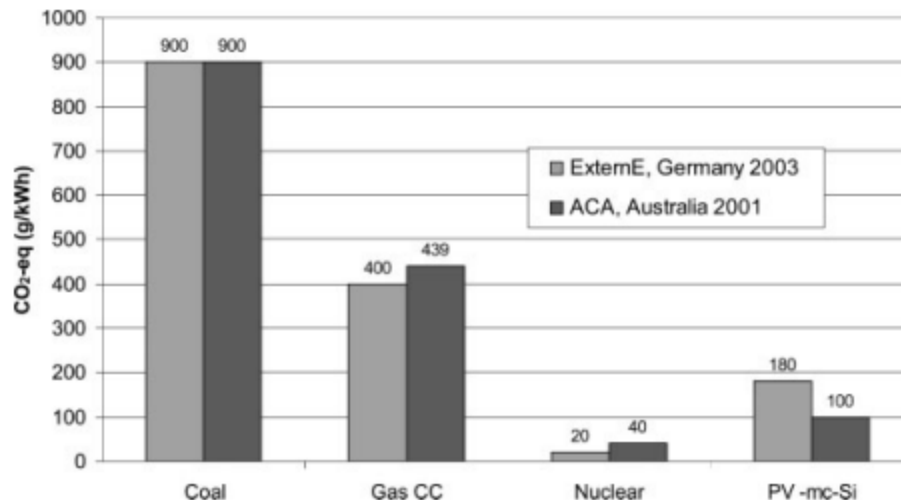
Figure 28 - GHG emissions from energy production

Switching to Natural Gas

The town of Auburn could switch all utilities over from gasoline to natural gas, then the utility price and GHGs emitted will both decrease significantly due to the fact that natural gas is more environmentally friendly and costs a lot less. Since October 2011 the price of gasoline is at $3.499 per gallon while natural gas is only at $1.056 per therm. While the price of gasoline keeps increasing the price of natural gas stays very constant from year to year. 'Therm' is the standard unit of measurement for natural gas. One gallon is equal to roughly 1.25 therms. With this in mind, the equivalent therm cost would be 1.32, still considerably lower than that of gasoline, saving of $2.179. Over the past couple years since approximately January 2007 the cost of natural gas has on average been decreasing while the cost of heating oil has been fluctuating slightly but has and still is significantly higher than natural gas (epa.gov, n.d.). This shows that natural gas is a safe bet to save money because over about the last 4 years the price of heating oil has always been more expensive then natural gas and sometimes substantially more expensive. Natural gas is also more environmentally friendly than oil and coal (eia.gov, n.d.). In the table Natural gas gets compared to oil and coal for pollutants released when burned and it is evident that natural gas is much less harmful to the environment than the other two. The Berkshire Gas Company promotes the installation of high-efficiency natural gas heating systems through the offers of rebates and discounts for those who switch to natural gas. They offer their customers incentives of $400-800 discount on furnaces equipped with an ECM or equivalent.

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The Berkshire Gas Company also promotes the installation of high-efficiency natural gas heating systems.   For this type of installation they offer their customers incentives of $500-1,500 on natural gas boilers for forced hot water systems. Furthermore they offer incentives of $1,000-1,600 on high-efficiency Combined Boiler and Water Heating Units. By switching the furnaces and boilers over from gasoline to natural gas, not only does the town of Auburn incur an annual savings on buying natural gas but there are also additional rebates for purchasing these systems. Since natural gas emits less GHGs switching over to natural gas will also help achieve a reduction target. Purchasing and installing the natural gas furnaces and water heaters can initially be very expensive, however in the long run they will pay off and overall benefit the town through the reduction of GHGs. Using the BTU requirement table and the cost tables below it is possible to see how the initial price of the furnaces and heaters can be very expensive up to around $5,000. Although that price is initially expensive it is worth it to drastically reduce GHG emissions and fuel cost in the long run.
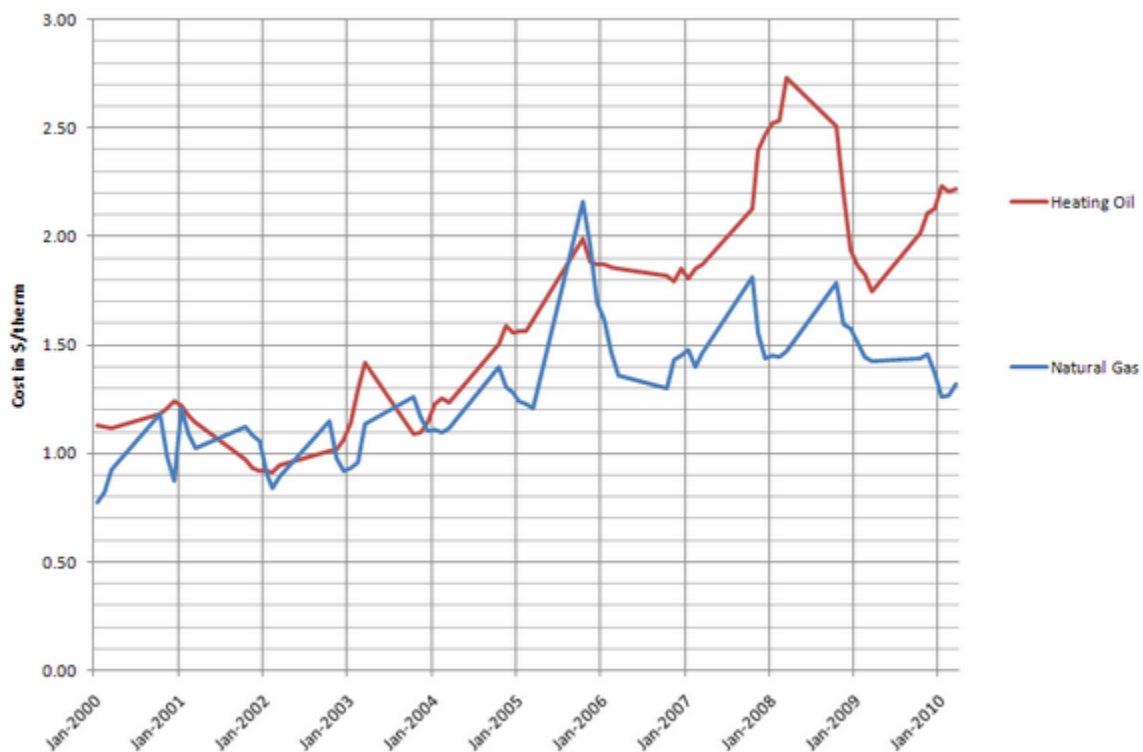

Figure 29 - Natural gas vs. heating oil prices from January 2000 to January 2010

Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Figure 30 - Fossil fuel emission levels

Installed Costs	BTU				
	50 k	75 k	100 k	125 k	140 k
FORCED AIR FURNACES					
High Efficiency	$2,400	$2,900	$3,200	$3,600	$4,000
Mid Efficiency	$2,100	$2,500	$2,800	$3,200	$3,500
BOILERS					
Mid Efficiency	$2,500	$2,500	$2,500	$3,000	$3,000
High Efficiency	–	–	$4,200	–	–
COMBINATION SPACE/ WATER HEATING	$2,600 rent $20.95/mo	$2,800 $31.70/mon.	$3,000 $33.65/mo	$3,000 $33.65/mo	–
WATER HEATER	Rent	Standard	$8.35	Buy and Install	$450
–		Power Vent	$13.45	Buy and Install	$800
POSSIBLE ADDITIONAL COSTS					
Power Vent Kit		$700			
Metal Chimney		$450			
IF HOME IS ELECTRIC BASEBOARD HEATED		1 story house		2 story house	
Ductwork Costs		$3,000 - 5,000		$4,000 - 7,000	
Plans and Permits		$500		$500	

Figure 31 - Prices of purchasing and installing natural gas furnaces and water heaters

House Size	BTU/HR
< 1,200 sq. ft.	50,000
1,200 - 1,600 sq. ft.	75,000
1,600 - 2,000 sq. ft.	100,000
2,000 - 3,000 sq. ft.	125,000
3,000 - 4,000 sq. ft.	140,000

Figure 32 - The recommended BTU for natural gas furnaces and heaters based on building size

5.2 Future Survey Design

A new survey is designed in order to make data collection for Auburn more efficient than the original survey used. This section will outline the new survey that can be distributed and bring back even more beneficial results for the project. The proposed survey is broken down into four sections which form the foundation of the survey and subsequent data analysis. These four sections are:

- Commuting Method
- The type of transportation (i.e. bus, car, bicycle, etc.)
- The type of fuel (petroleum diesel, bio diesel, gasoline, etc)
- Number of days commuted
- Distance commuted
- Fuel efficiency

There are a variety of ways for which most individuals take to get to and from work. For each type of commuting method there is an associated fuel type. The fuel type will have an associated fuel efficiency that needs to be recorded. Not all individuals will commute with the same commuting method each day.

The structure of the survey is intuitive and is distributable to a broader audience, which means a higher return rate of the surveys and more data is collected. The survey is attached as Appendix H. The first part of the survey asks the respondent the type of transport he/she uses to get to work, and what percentage of the year do they use this method. This information allows the survey issuer to be able calculate the total yearly emissions based on the data collected from

the second part of the survey. The responder is in the second part to fill in the information about the mileage they commute and the fuel efficiency of their vehicle. Knowing this, the survey issuer can obtain the emissions for transportation type. Depending on the transport type, the respondent can answer how many other individuals used that transport type with them as well, i.e. carpooling.

Respondents are not offered many "self-response" answer choices, rather, they are asked mainly to choose from a list of provided answers, which allows for easier data collection and entry. This method of survey question design provides the survey issuer with more directly comparable data. If for example, each respondent had put their own exact "miles commuted to work daily", there would have been a large number of varied results that may not be able to lead to conclusive data. After the data is analyzed, the survey issuer is able to create graphs to show the data in a easier to view format, as opposed to a table. Having graphical displays enables an individual to either quickly identify the differences amongst responses, or someone not trained in data analysis to visualize the meaning of the results.

5.3 Energy and Fuel Emission Database

The reason why it was so important for our group to create a database was so that Auburn would be able to have all data needed in one area and to easily keep track of that data. Initially our group was given the task of creating a climate action plan, which we soon found out wouldn't be feasible due to the lack of an efficient record keeping system. Our recommendation to the town of Auburn is to use the database that we are going to be giving to them. This database will be crucial for them to create their climate action plan because the database has all the fields required for the climate action plan so the data just has to be gathered and input into the database. Although this database is going to be essential in completing the climate action it is also going to be very helpful for every day record keeping. Many of the fields that are in the database are items that could be useful for the town to use for the annual town report or other activities. The database will be divided into specific buildings and departments for ease of data entry and retrieval. By having each building and department separated it will be very easy to track individual departments for energy, fuel use or any data that is entered into the software. Any building or department can be targeted for emissions reductions or simply just to look up specific data for buildings or departments. This database is going to be very adaptable for the

use of the climate action plan and for later uses. Fields that are in the software or aren't in the

software to date will be able to be included or taken out as seen fit and will be able to be

customized in whatever means best suits the job at hand.

Part II – The Database

When doing the emissions inventory for the Town of Auburn, it was not possible to obtain a complete inventory because the town does not have a systematic data collection and data recording method. Unfortunately, due to this issue some of the departments did not have the capacity of providing the data that we needed to collect. The recommendations given in this report cover only the areas that the team was able to gather the data for. In order for the Town of Auburn to get the green community designation and to establish a Climate Action Plan (CAP) approved by ICLEI, a complete emissions inventory will be needed. A CAP requires, as describes by the ICLEI Protocol, municipal governments to conduct an annual emissions inventory. Therefore, it is important for the town to implement a methodical data collection system. The objectives of part II on this project are to:

- Establish the need for a database system to help the Town of Auburn to better manage and organize its data for future emissions inventories.
- Design a database system that will meet the needs of the town.

CHAPTER 6 – BACKGROUND RESEARCH

Regardless of the type of organization, collecting and recording is very important. This is why proper organization and management of data is necessary to run organizations efficiently. For instance, data management and data organization are found in places such as bookstores where it is important to keep track of all the available books (ITL Education Solutions, 2010). Additional areas where data management and data organization are important include planning, banking, marketing, payroll, production control, etc. The Town of Auburn is no exception because to implement a CAP the town will need to collect and record the data for an emissions inventory. Therefore it is important for the town to have a more efficient data management and data organization system.

Data comes in many forms for different types of information. Figure 33 shows a summary of the different types of data (Singh, 2006). Depending on the type of organization or field, a data type may be preferable to use than the others. Although in the case of Auburn there is no need to record data such as customer's name and customer's number, the data to be recorded is similar. For instance department-names and department-account numbers are needed for the emissions inventory.

Salesperson	Electricity supplier	Employer
Customer-name	Customer-name	Employee-name
Customer-account	Consumer-number	Identification-number
Address	Address	Department
Telephone numbers	Telephone numbers	Date-of-birth
	Unit consumed	Qualification
	Amount-payable	Skill-type

Figure 33 - Example of data

With the growing importance of organization and management of data, a system called a database was developed. Databases can either be computerized or non-computerized (Singh, 2006). A non-computerized database is a database that is not accessed via a computer. Examples of non-computerized databases are phonebooks, TV guides, etc. (ITL Education Solutions, 2010). It is important to design a computerized database for the Town of Auburn because the data to be recorded have to be imported into other programs such as the CACP software that translate data into eCO2 emissions.

The implementation of a computerized database requires other technologies such as database management systems. Database management systems are the liaison between the database-users and the database itself (Sumathi & Esakkirajan, 2007). The design of a database that meets the need of the town requires the comparison of several database management systems. In this process we consider the database-users for the town.

6.1 Advantages of Database Systems

In addition to providing reliable data storage, computerized database systems also provide other important features that are necessary for the implementation of good databases. In the book called an *Introduction to Database Systems* by ITL Education Solutions, it is stated that in a database approach data are all stored at one main location and they are accessible by multiple users. Therefore "The centralized nature of database system provides several advantages, which overcome the limitations of the conventional file processing system" (ITL Education Solutions, 2010). In other words having all the data at one location provides advantages that are beyond traditional data management techniques such as non-computerized databases. In fact, the principal advantages provided by database management systems are data availability, data integrity, data security, and data independence (Sumathi & Esakkirajan, 2007). To this list one can also add controlled data redundancy, data sharing, simplicity of application development, multi user interfaces, and backup and recovery (ITL Education Solutions, 2010).

As discussed above, database management systems provide a lot of advantages for data organization and data management. Most of these advantages will be relevant for designing a database that is suitable for the need of Auburn. Therefore, it is necessary to have an in-depth understanding of each of the relevant advantages.

6.1.1 Data Integrity

Most DBMSs such as relational database management system have the capacity of maintaining data integrity (Petersen, 2002). Data integrity simply refers to the reliability of the data in the database (Sumathi & Esakkirajan, 2007). It will be important to enter reliable data in the database because those data is used to calculate the eCO2 emissions of the town.

6.1.2 Data Security

In some cases, data security is of high importance. Thus, database management systems have the advantage of controlling access to the data in the database by only allowing usage to the authorized users. Data security can be imposed by password (Sumathi & Esakkirajan, 2007). Although not of high priority, it is important to have some form of security so that non-authorized users cannot disrupt the data integrity.

6.1.3. Data Availability

Data availability simply refers to the fact that the database-user can easily access the data in the database at any desired time. The database-users from the Town of Auburn do not need to have high computer skills to access the database. Therefore it is important to design a database that is simple to access and will be available when needed.

6.1.4. Data Independence

By offering data independence, the database management system allows the user to store, update, and retrieve data in an efficient way. This is important because the town will be entering and retrieving data that will be collected from energy and fuel inventory into and from the database for processing and decision making.

6.1.5. Multiple-user interface

The multiple-user interface will enable multiple users to access the database at the same time. With this advantage each department can access the database to add new data anytime without having to wait.

6.1.6 Who interacts with databases?

To design a database system specific to a situation it is imperative to consider those who will be interacting with the database. This will help choosing the right models and implementing the database with the appropriate technology. In general, many people interact with a database and are involved in the design process.. Among those one can cite database-users (naïve, sophisticated, and specialized users), system analysts, application programmers, database administrators (ITL Education Solutions, 2010), and data administrators (Singh, 2006).

This list provides a large number of people involved in the design process of a database, as well as its usage. In the case of the Town of Auburn, it is not important to have many people involved with the design process of the database. Nor it is important to have a database that will meet the needs of users with different computer skills. Also, due to the limited time the team has, it is not possible to gather a complete database design team. Instead, the database design will only include the project team taking the responsibilities of system analysts and of the data administrators; which mean the team will be gathering the information regarding the database-users to understand their needs. An employee of the town Information Technology (IT) department will take the responsibilities of the application programmer and the of database administrator (DBA). The employee will be responsible for the technical aspects of the database, which involves developing the specification for the users, initially the application programmer's job. Some of the database administrator jobs that will be done by the IT employee will be

- New software installation if necessary
- Security enforcement and administration
- Preliminary database design
- Routine maintenance

The data administrator (DA) will be an employee of the finance office. The role of a data administrator is data control. In other words, the responsibility of a DA is to decide what data to store in the database and to institute policies for maintaining and dealing with that data (Singh, 2006). However the town DA will not have such responsibilities because the team has already defined what data to collect and have established policies for maintaining and dealing with the data based on the ICLEI protocol. The job of the DA will be only to make sure that each data is entered at the right place. It is important to design the database for naïve users and not to care about other users because the people who will be using the database will be from departments such as police, fire, etc.

6.2 Database Models

Data manipulation and organization have become a focus point for researchers since the early days of computers. "Due to the needs and demands of organizations, database technology has developed from the primitive file-based methods of the fifties to the powerful integrated

database systems of today" (Singh, 2006). This need for organization of data has led to the development of several data models. The figure below shows the evolution of database system technology.
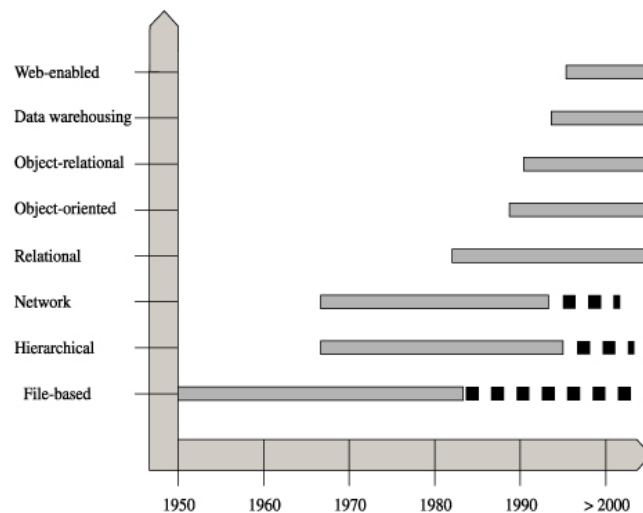

Figure 34 - Evolution of data model

The main purpose of a database system is to only present the end-user with essential features. Thus, it is important to develop a database that meets the need of the user. Therefore, one database model might be appropriate for one application and not the other.

Data models are divided into three types, namely, conceptual data models, representational data models, and physical data models (ITL Education Solutions, 2010).

- The conceptual data model is independent of any implementation, thus independent of any hardware and software constraints.
- The representational data model is divided into several other models, namely, hierarchical data models, network data models, relational data models, object-based data models, and semi-structured data models. This data model is good at only showing the user with the necessary information by hiding storage details. An advantage of this model is that it can be directly implemented on a computer system.
- The physical data model only describes data as a collection of files, indices, etc. However, the file system has many separate and unreliable files (Singh, 2006).

Understanding each of these data model will help pick a convenient data model for the design and the implementation of a database system for the town of Auburn. This data model picking process will be done by examining the type of data that will be needed, and the type data representation will be more appropriate for the user of the database.

6.3 Classification of Database Management Systems

As stated in previous sections, the design of a database requires using a database management system. The database management system serves as a contact link between the user and the data available in the database. However, each database management system has its own classifications that must be taken into account when designing a database. There are four main classifications for DBMSs that is, data models, number of users, number of sites, and purpose (ITL Education Solutions, 2010).

- As discussed in the previous section, database management systems have various models. A DBMS can be hierarchical, relational, object-based, etc.
- The number of users is also very important. Will the database be single-user system or multi-user system? A single-user database supports one user at the time, and the database runs a personal computer. A single-user database is called a desktop database (Rob & Coronel, 2009). On the other hand, a multi-user database supports several users at the same time. This is called a workgroup database or an enterprise database, depending on the size of the users (Rob & Coronel, 2009).
- A database can either be centralized or distributed. A centralized database is when the database runs on one computer system as a network. And a distributed database is when the database runs on multiple networks (ITL Education Solutions, 2010).
- Each database management system represents and stores data using a different structure. Therefore, knowing the purpose for which the data is be used and which representation is easier to store the data into is relevant (ITL Education Solutions, 2010).

The importance of understanding the classifications of data is to help in choosing the appropriate DBMS for the Town of Auburn so that the data will be easily to interpret.

6.4 Cost and Risk of Database Systems

Although database systems have improved data organization and data management, there are some disadvantages ranging from social disadvantages to technical disadvantages.

- High cost: training, licensing, and regulation fulfillment tend to be overlooked when databases are implemented. Database systems require advanced hardware, software, and high skilled personnel (Rob & Coronel, 2009).
- Management complexity: "Database systems interface with many different technologies and have a significant impact on a company's resources and culture (Rob & Coronel, 2009). Given the fact that database systems hold important data, the changes to the introduction of a database must be well managed.
- Upgrades and replacement cycle: this could be the software or the hardware. This is due to the rapid development of new technologies.
- System failure: a system failure can damage the data and also can prevent users to access the database (ITL Education Solutions, 2010).

Before implementing a database system to keep track of its energy use and fuel consumption, the Town of Auburn must be aware that there some risks and expenses associated with it.

When conducting an emissions inventory for the Town of Auburn, the team was not able to collect all the necessary data for the municipal sector. Therefore it was decided to design and implement a database system to solve this problem of lack of organized data collection. This chapter is a background research on the design and implementation of database systems. It explores different data models and several database technologies to enable the team understand the design steps, the important requirements, and the advantages of a database. It is also important to note that database systems are not risk free. Therefore, certain precautions need to be taken to minimize the dangers of using a database to store data.

Chapter 7 – Design and Implementation of a Database for the Town of Auburn

As it was previously stated, the Town of Auburn would like to develop a Climate Action Plan. Initially the purpose of this project was to deliver a draft of a climate action plan following the ICLEI protocol. The ICLEI protocol requires conducting a complete emissions inventory for both the municipal and the community sectors. However, it was not possible to obtain a complete inventory due to the fact that Town of Auburn does not have an organized data collection method for the municipal sector. This issue made it impossible to make more concrete recommendations for mitigating GHG emissions. However, it drafts the steps needed for the Town of Auburn to complete a Climate Action Plan. To solve this problem of lack of systematic data collection methods, the team has designed a Microsoft Access database system. This chapter elaborates on all the different steps that were taken to design and implement this database system specific to the Town of Auburn.

7.1 Database Design Process

To help understand the necessary steps in designing a database system, we looked into several database design processes. By analysis, we decided that the following steps were more complete because it ensures that all the requirements for designing a database specific to Auburn are met. This design process was obtained from the book called *Introduction to Database Systems* by the ITL Education Solutions. The steps for an effective database design are:

1. Requirement collection and analysis: this first step includes gathering all the important information that is essential to design a database specific to the Town of Auburn. Such information includes the type of data, how the data is represented, etc.

2. Conceptual database design: after collecting all the essential information for the design, the conceptual database design compares the different types of data model to determine the appropriate one that will meet the requirement established after the first step.

3. Choice of DBMS: the choice of a DBMS takes into consideration factors such as costs of implementation and hardware requirement. In the case of Auburn it was important to implement a database at lower cost without having to change the hardware.

4. Logical database design: this step is completed after the first three steps. It basically connects all the information gathered from those three steps and translates that information into an implementation model.

5. Physical database design: under the physical database design storage structures are taken into consideration. It is important to determine whether the data is stored in a network or if it is shared through the web. And so forth.

6. Database system implement: this phase is the database implementation. The implementation is done based on the implementation model previously designed and the information regarding the storage structure.

7. Testing and evaluation: in this last step the database is tested to make sure that all the requirements are met and there are no discrepancies.

7.2 Determining the requirements

As discussed chapter 6, the design of a database requires that one understands the purpose of the database and the need of the database users, as well as the costs of the database. To help think through the analysis process, the guidelines from the book called *Beginning Database Design: From Novice to Professional* (Churcher, 2007) were used. The guidelines include the following useful set of questions important to understand the requirements of the database to be designed:

1. What does the user do?
2. What data is involved?
3. What is the main objective of the system?
4. What data is needed to satisfy this objective?
5. What are the input cases?
6. What is the first data model?
7. What are the output cases?

We added the following additional questions because although the preceding questions were appropriate, they were not specific to the Town of Auburn.

1) How often will the data be modified? Who will make these modifications?
2) Who will be providing IT support for the database?

3) What hardware is available? Is there a budget for purchasing additional hardware?

4) Who will be responsible for maintaining the data?

Based on the questions the team determined that the database to design must be multi-user. Considering the fact that the Town of Auburn has a small staff, it was necessary to design a workgroup database. A workgroup database does not exceed 50 users at the same time. The data administrator will be a current town employee because there is no budget to hire a new employee. It was decided that the town employee must work in the financial department because most data entries will be energy expenses. There will be no need to purchase sophisticated hardware. Instead the database will be shared on the current town network where department heads can easily access it. Therefore, no additional hardware is needed. And lastly, the IT department will be responsible for maintaining the database.

7.3 Comparing Database Models and Database Management Systems

We saw in chapter 6 that data models depend on the type of data to be collected and the form storage is desired. Database models are divided into three models. These are conceptual data models, representational data models, and physical data models.

The data to be collected by the Town of Auburn are both numerical and alphabetic data types. These data must be recorded in a representational form so that they can be easily analyzed. Also, the user of the database does not need to know the details of the storage medium and the database must be directly implemented on a computer system. Therefore, a representational model was selected for the implementation of the database.

The representational data model has several other sub-categories. (ITL Education Solutions, 2010). By examining the data model, the team would like to have a data model that represents data in form of tables. The description of each of the data models is as follows:

1) Hierarchical data model: a hierarchical data model is made of a set of data connected to one another through links. Although in this model the retrieval and the update of data are optimized, it does not represent the data in the desired form.

2) Network data model: the network data model is quite similar to the hierarchical data model in the sense that data are also represented as sets of data linked together. Without any further analysis this model was taken out of the potential list.

3) Relational data model: in the relational data model the data are maintained in the form of relations, or tables, consisting of row and columns. This representation of data makes querying easier and the programming of database much simpler.

4) Object-based data model: this data model uses more complex programming languages such as C, and C++. It was important to choose a system that will not require a complex programming language due to the time constraints and the size of the project.

5) Semi-structured data model: the way this data model represents data is more complex and also requires advanced programming language.

The comparison process of the different data model has resulted in choosing a relational data model to implement the database for the Town of Auburn. This model meets the requirements of representing the data in table forms, and it is easily accessible.

After choosing a data model for the database, it was vital to select a database management system that could handle the data model while providing the desired requirements. The team decided to use a relational data model to implement the database. However, several database management systems can be used to implement a relational data model. The popular ones are: Oracle, Microsoft Access, Microsoft SQL Server, and DB2 IBM.

It is essential to notice that these DBMSs use different programming languages although they all can be used to represent data in table forms. As stated previously, due to the size of the project, it was imperative to choose a database that uses a simple programming language and therefore easy to design. By looking into all these DBMSs, some of them use programming languages such as C, and C++. This process of elimination left us with Microsoft Access and Microsoft SQL Server. These two DBMSs do not require a high level of programming language. Microsoft Access uses a graphical user interface. It means that one can design the very simple database by only using the tools provided by the software. The table below shows a comparison of Access and SQL server (fmsinc.com).

	Access	SQL Server
Description	A database development environment that supports tables, queries, forms, reports, and programming logic	A scalable, reliable, and secure client/server database engine
Maximum Database Size	2 gigabytes	1 terabyte
Maximum Concurrent Users	5-15	Unlimited
Security	Basic desktop security	Robust enterprise level security
Performance	Limited by fileshare model	Limited only by hardware
Reliability	Fairly reliable	Very reliable

Figure 35 - Comparison between Microsoft Access and Microsoft SQL Server

As shown on the table above (FMS Professional Solutions Group, n.d.), Access supports tables, queries, forms, and reports while SQL Server is a lot more secure, scalable, and reliable. Due to the simplicity of the database system to be designed Access seemed to be more suitable for the design. Although the number of concurrent users is limited to $5 - 15$ with Microsoft Access, this is more than sufficient enough because the database system will only be accessed by a few users at any time. Also, the possibility to import the data from Microsoft Access to other programs such excel, and outlook makes Access appropriate to use for the implementation of the database because it gives the possibility to send out the data in the form of a report for analysis.

7.4 Microsoft Access Town of Auburn's Database Tutorial

Following the steps for the design and the implementation of a database system, it was concluded that Microsoft Access was more suitable to use to design and implement a database that is most appropriate for the needs of the Town of Auburn. This section gives a quick tutorial of the database system that was designed and tested for this project.

a. *Home screen*

When the Microsoft Access icon is clicked on the desktop screen, the database's home screen looks like the figure below
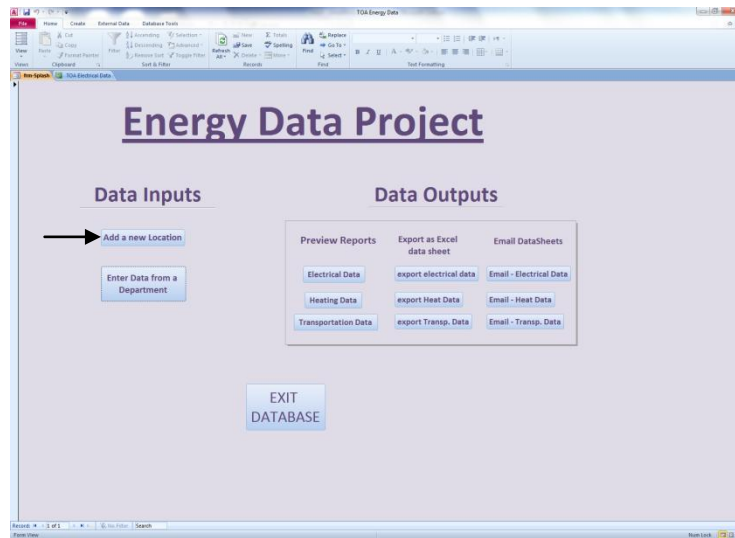
a. *Adding a new department*

When you are going to input a new piece of data there are two options. The first option is to add a new location button under the Data Inputs area. If the department of the data you are entering is not already in the database then you have to add a new location. When you click on the add a new location button it will bring you to a screen which looks like the following
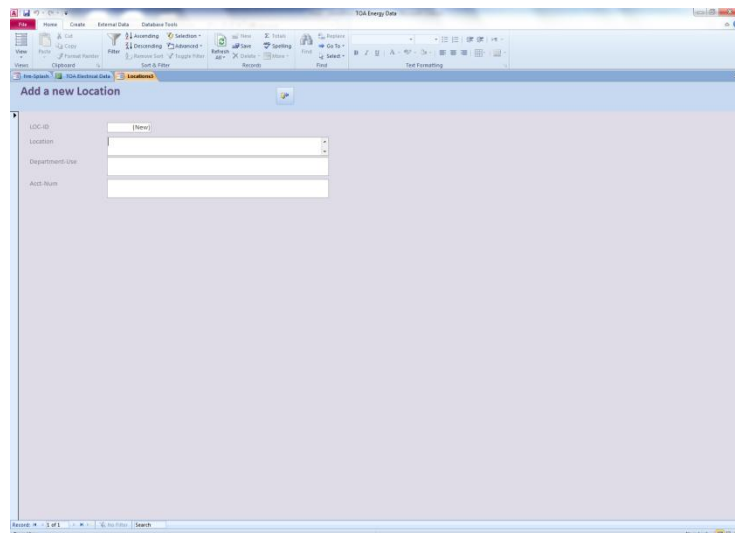
From this screen you are able to input the location of the building, the department that uses that building and the account number of the data if you have it. When you are done inputting the location information you can hit the back button to go back to the main screen. The

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second option at the home screen is the Enter Data from a Department button. If the department is already entered into the database you choose this option to input data.

a. **Entering data**

From the home screen select Data Inputs as indicated by the arrow
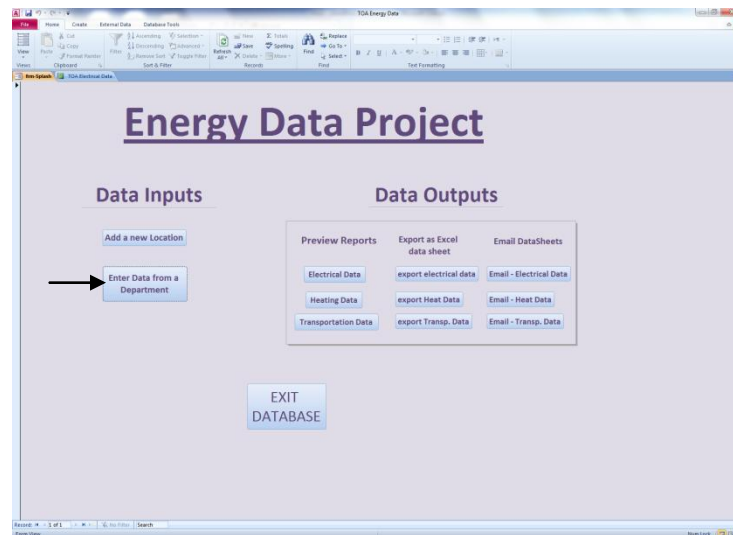
Once you click on the enter data from a department button it will bring you to a screen that looks like this.
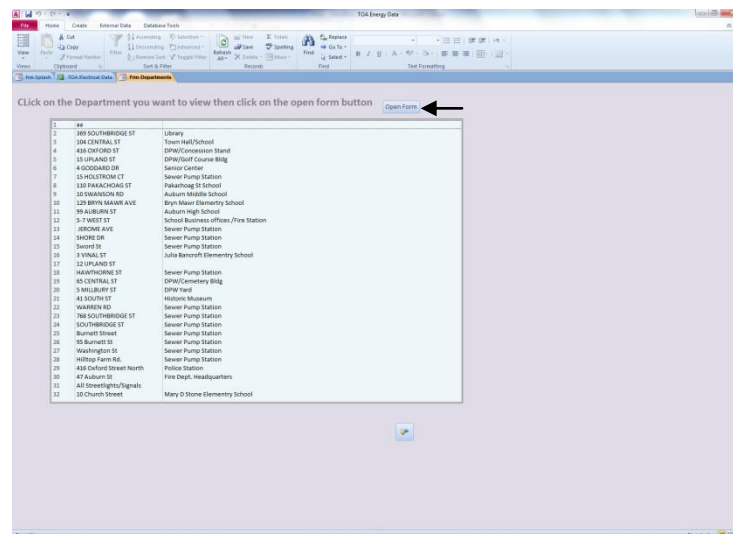
When you are on this screen you are able to click on the location and the department that you want to input data for. Then you click on the location you want. Click on the open form

button, indicated by the arrow, located at the top of the database. Click on the open form button and it will bring you to a screen that looks like the one below.

From this screen you are able to put in the electricity, heating and transportation data. For electricity you are able to input the month and year for the data, the monthly usage and the monthly cost. For heating you are able to input the type of fuel being used, the month and year for the data, the monthly usage and the monthly cost. For transportation you are able to input the vehicle use, the make, model, model year, the type of fuel it uses, the month and year for the data and the monthly miles traveled for that vehicle. Once you have entered all the data you hit the button indicated by the arrow located at the top of the database which will bring you back to the screen where you can choose the location.
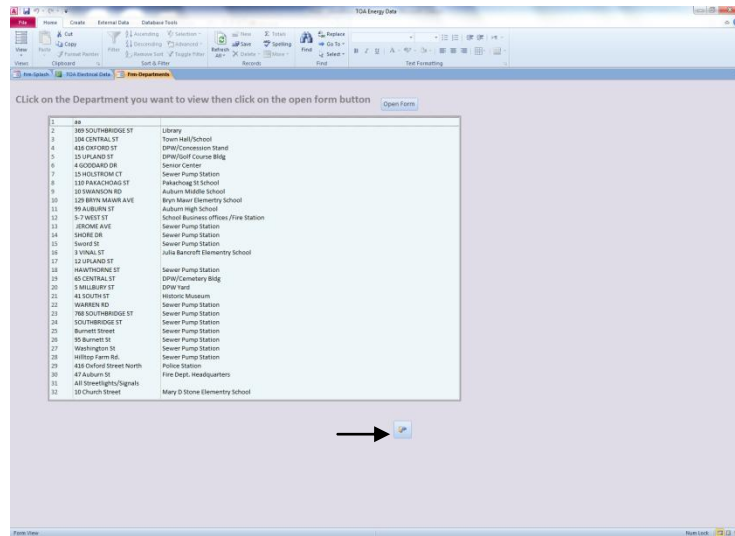
At this screen you can either choose a new location to input data for or you can hit the back button to go back to the main screen located at the bottom of the database.

a. **Import to other programs**

Once you are back at the home screen of the database you can either preview the reports of the data that you just entered by clicking on one of the buttons located under preview reports under the data outputs section. It is also possible to export the data right to a Microsoft Excel spreadsheet by clicking on one of the buttons located under export an excel data sheet under the data outputs section. Finally you can directly email the data sheets by clicking on one of the buttons located under email datasheets under the data outputs section.
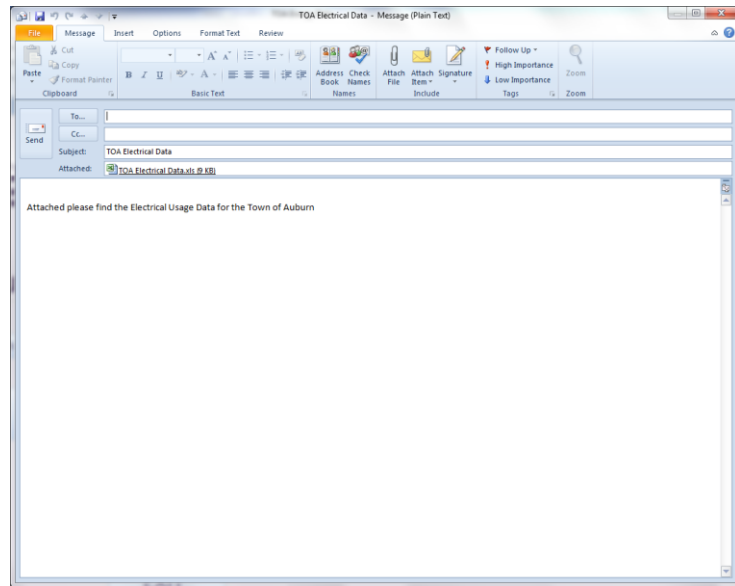
7.4 Summary

Following the design process from section 7.1, we designed a Microsoft Access based database system for the Town of Auburn. With the help of the town IT department, a database was successfully designed and implemented. This database will be shared through the town network and will only be accessed by the authorized users. Authorized users include the town manager, the town planner, and the persons who will be responsible for entering data for each department. The town will be responsible for choosing the people who must have access to the database for each department. Accessing the database is fairly simple and it is just one click away on the personal computer desktop. The database is a workgroup database system, which means that multiple users can access the database at the same time.

CHAPTER 8 - CONCLUSION

The Town of Auburn would like to reduce its energy and fuel expenses and in the same process mitigate its greenhouse gas emissions to better the quality of life of its citizens. In order to reach its goals, the town has decided to implement a Climate Action Plan (CAP) and to earn the green community designation. This report explores the different options and possibilities about designing a CAP and presents the town with some recommendations so that it can successfully reach its goals.

ICLEI – Local Governments for Sustainability is an organization that helps local governments to implement a Climate Action Plan by providing certain guidelines and protocols. The team has looked into the different ICLEI Protocols and has identified the sectors that are more relevant to the Town of Auburn. One important part of the protocol is to conduct an emissions inventory for both the municipal and the community sectors. However during the emissions inventory process, the team was not able to obtain all the data that are needed to get a complete inventory. This problem was due to the fact that the Town of Auburn does not have a systematic data collection system. In order to resolve this issue a database system was designed. Therefore, this report consists of two parts.

The first part discusses the steps taken to conduct an emissions inventory and makes certain recommendations for the Town of Auburn. In this part the methods of collection of data are discussed using the ICLEI Protocol as a guideline. Data collection was divided into two sectors: the municipal and the community sectors. Most of the data were obtained and analyzed using the CACP software. The information acquired from the data collected is provided and some recommendations are given to the town for further data collection techniques, and also methods to reduce air pollution and mitigate the concentration of greenhouse gases.

The second part focuses on a database design and implementation for the town. It discusses the design process of a database system specific to the need of Auburn. Different data models and several data technologies are compared to each other to determine the suitable technology to use for the design of the database, based on certain requirements that were established in order to meet the need of the town. After analysis it was determined that a

Microsoft Access database is suitable to implement. This part of the report also includes a quick tutorial about how to use the database.

The Town of Auburn still has a long way to go to complete a Climate Action Plan. However, this project is an important stage to help the town accomplish its goal. All the information presented and discussed in this report will be important to use by the next committee that will be working on moving the project forward.

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APPENDIX A – CACP 2009 Software Guide

This Appendix outlines the methods used to enter the raw data collected for each sector into the Clean Air and Climate Protection Software.

Custom Fuel Efficiency Coefficients

When entering data for the emissions sources from transportation, it is advised to enter custom fuel efficiencies for the records when the data is available in order to create a more accurate report of the emissions. In order to do this, click the Settings tab on the top bar, open Emissions Factors, and then open the Transportation Average window. In this window, click Add Coefficient Set and appropriately label the coefficient set. .Click the Fuel Efficiencies box and then under the appropriate fuel type for the vehicle the set is being created for (gasoline, diesel, biofuel, etc.) enter the custom mpg in the same category that the vehicle miles will be entered into in the record. In cases where coefficient sets are being created for specific vehicles (such as for the Fire Department) enter the custom mpg under the Passenger Cars Alt. Method row, even if the vehicle is a truck in order to create consistency and lessen the chance of errors. Remember to always enter this information for the base year and not the vehicle's model year since this is the spot that the software will look for the information.

Fire Department

The Auburn Fire Department has fifteen vehicles that need to be entered into the CACP 2009 software separately. There are two different methods for entering the vehicles. The following vehicles need to be entered in a similar manner: Cars 1,2,3,11,12 and the Dive Truck. This is because the fuel efficiencies of these vehicles were available from the website fueleconomy.gov and therefore were used when calculating the emissions. For each of these vehicles, separate transport average coefficient sets are created following the steps outlined in previously. Each car is entered as a separate record so that each customized coefficient set can be applied to each vehicle. To enter one car, insert a new record and label it as so: the year of the vehicle, the make and model, followed by a dash, the label FD, and which car it is. For example if Car 1 were to be input into the software, the label would look like this: 2007 Ford Taurus – FD Car 1. This labeling enables easy identification of which car caused which emissions in the final report.

For each vehicle, and therefore each record entered, enter the vehicle miles traveled under the appropriate fuel type (diesel or gas in the case of the Fire Department) and subsequently under the corresponding vehicle type where the custom mpg was entered (Passenger Car Alt. Method according to the steps outlined previously.) After entering the vehicle miles traveled, the coefficient sets need to be set. Under the Transport Average Coefficient Set, select the custom set created for the car being entered and then select Defaults for the Fuel CO2 Coefficient Set.

The remaining vehicles in this department, Engines 1, 2, 3, Tower 1, Rescue 1, Forestry 1, and Ambulances 1, 2, 3, need to be entered in a slightly different manner. Since the fuel efficiencies for these vehicles are unavailable, custom coefficient sets cannot be created for them. With the exception of the Forestry 1 vehicle, all of the vehicle miles entered into these records will be entered under the correct fuel type under the Heavy Duty Vehicle All MYs designation. The Forestry 1 vehicle will be entered under the Light Trucks MYs 1983-1995 designation due to the fact that it is a pickup. For all of these vehicles, the coefficient sets used will be the Defaults for both the Transport Average Set as well as the Fuel CO2 set.

Public Transportation

Unlike most of the other vehicles, the record for the public transportation vehicles is entered under the Transit Fleet tab under the Government Analysis instead of the Vehicle Fleet tab. To enter the data, insert a new record into the Transit Fleet sector and label it WRTA Fleet – Scope 3. The Scope 3 designation is due to the fact that it is not directly under operational control by the town of Auburn. The reason for including it in the record title is so that it is easy to distinguish it from scope 1 or scope 2 items in the final report. In this record, enter the vehicle miles traveled under the Heavy Duty Vehicles All MYs in the Diesel fuel category. The coefficient sets used for this record are the Defaults for both the Transport Average and Fuel CO2.

School Transportation

The school transportation vehicles will be entered as two different records – one for the Regular Education buses and one for the Pupil Services mini-buses. The record for the buses is entered as School Transportation – Buses Scope 3, and the mini-buses are labeled in a similar manner.

Again, the scope 3 designation is to distinguish in the final report which emissions sources the town of Auburn does not have direct influence over. The vehicle miles are entered under the Heavy Duty Vehicles All MYs under the Diesel fuel section. Default emissions factors are chosen.

Community Transportation

The community transportation information is entered under the Transportation tab of the Community Analysis module of the CACP 2009 software. For this record, a custom coefficient set must be created according to the steps outlined previously. Label the record Community Transportation. Then, in the Gasoline tab under the Passenger Vehicles Alt. Method, enter the annual vehicle miles traveled by Auburn's community. The coefficient set selected for this record is the custom set created for the community vehicles under the Transport Average Coefficient Set and the Defaults set for the Fuel CO_2 coefficients.

Curbside Trash Pickup Fleet

This information is entered under the Vehicle Fleet tab under the Government Analysis module of the software. The label for the record used is Curbside Pickup – Scope 3 in order to distinguish it from other emissions sources that are under direct control of the government. The vehicle miles for this vehicle group are entered under the Heavy Duty Vehicles All MYs row in the Diesel fuel section. The Defaults coefficient sets are used for both the Transport Average and Fuel CO_2 sets.

Police Department

The raw data collected for each police vehicle is entered under the Vehicle Fleet tab of the software. A custom coefficient set is created for each vehicle following the steps outlined previously. The fuel efficiencies of the vehicles can be found at fueleconomy.gov. Each vehicle is entered as a separate record into the software and the custom coefficient sets for the Transport Average are applied. For all vehicles the Defaults set is used for the Fuel CO2 category. When Fuel efficiency information is unavailable, the Defaults set is used for the Transport Average coefficients. The vehicle miles traveled should be entered into their respective car types under the fuel type used and not just in Passenger Vehicles Alt. Method as is done when using custom coefficients.

Department of Public Works

The raw data collected for the DPW vehicles is entered into the Vehicle Fleet tab in the software. For each vehicle where fuel efficiencies are available, a custom coefficient set is created using the method outlined previously. Each vehicle is entered as a separate record and labeled in a similar manner as the Fire and Police Department vehicles. The vehicle miles traveled for each vehicle is entered into the appropriate fuel type and under the correct vehicle designation (Passenger Car Alt. Method for vehicles with custom Transport Average coefficient sets and under the corresponding vehicle category for the remaining.) The Defaults set should be chosen as the Fuel CO2 coefficient set for all vehicles.

Government Facilities and Buildings

Once the necessary data is obtained it is entered in the Buildings and Facilities tab under the Government Analysis Module in the CACP 2009 software. When inputting the data into the software each building should be entered as a separate record. This allows particularly inefficient buildings to be targeted when the reports are generated. The electricity information is entered in the Electricity (Grid Average) row in the table, the heating oil in the Fuel Oil (#1 2 4) row, and natural gas in the Natural Gas row. Coefficient sets used for each of these records are EPA EGrid (entered from LGOP) for the Average Grid Electricity and Marginal Grid Electricity sets, and the Defaults set for the RCI Average and Fuel CO2 categories

Solid Waste Facilities

This section follows the same method as for the Government Facilities and Buildings. The only difference is that the information is entered under the Solid Waste Facilities under the Government Analysis tab.

Wastewater Facilities

Wastewater Facilities data is entered in the same way as Government Facilities and Buildings. The only difference is that the information is entered under the Wastewater Facilities tab under the Government Analysis Module.

Water Delivery Facilities

The data obtained regarding the water delivery facilities – kWh of electricity, therms of natural gas, and gallons of other fuels, is entered in the Government Analysis module under the Water Delivery Facilities tab. Each water district should be entered as a separate record. The records should be labeled as the water district followed by Scope 3 in order to more easily distinguish these sources from other scopes in the final report. In the case of the Auburn Water District, which operates three different buildings, all facility data should be aggregated into one record. In each record, the data is entered in its respective rows. The coefficient sets used are the EPA eGrid (entered from LGOP) for both the Average and Marginal Grid Electricity sets while the Defaults group should be used for the remaining coefficient categories.

Mobile Fugitive Emissions

Once the necessary information is obtained regarding the air conditioning equipment, some calculation independent of the CACP 2009 software is needed.

Equation 7.13, provided by ICLEI, is used to calculate the total metric tons of emissions of each type of refrigerant.

Equation 7.13	Estimating Emissions of Each Type of Refrigerant

For each type of refrigerant:

$$\text{Total Annual Emissions (metric tons)} = [\,(C_N \times k) + (C \times x \times T) + (C_D \times y \times (1-z))\,] \div 1{,}000$$

$$\quad\;\; \text{(kg) (\%)} \;\; \text{(kg) (\%) (years)} \;\; \text{(kg) (\%) (\%)} \qquad \text{(kg/metric ton)}$$

Where:
C_N = quantity of refrigerant charged into the new equipment [1]
C = total full charge (capacity) of the equipment
T = time in years equipment was in use (e.g., 0.5 if used only during half the year and then disposed)
C_D = total full charge (capacity) of equipment being disposed of [2]
k = installation emission factor [1]
x = operating emission factor
y = refrigerant remaining at disposal [2]
z = recovery efficiency [2]

[1] Omitted if no equipment was installed during the reporting year or the installed equipment was pre-charged by the manufacturer
[2] Omitted if no equipment was disposed of during the reporting year

Although the equation may seem complicated, many of the terms are omitted if equipment was not installed or disposed of during the year (which is a rare occurrence.) Once the total annual emissions are found for each refrigerant blend, the appropriate global warming potential factors from Appendix F are applied. This converts the tonnage of refrigerant emissions into eCO2 emissions for each blend The eCO2 tonnage for each blend is summed together to obtain a single eCO2 amount for all mobile fugitive emissions.

The eCO2 amount for the whole sector is entered in the Government Analysis module under the Mobile Source Refrigerants tab. The value is input into the Carbon Dioxide row. The sector has no coefficient sets to apply to it since the eCO2 emissions are already calculated using the above equation.

Community Energy Use

Community energy information is entered into the CACP 2009 software under the Residential tab of the Community Analysis Module. The total kWh of electricity for the community is entered into the Electricity (Grid Average) row, the total number of Therms of natural gas in the

Natural Gas row, and the total gallons of heating oil in the Fuel Oil (#1 2 4) row. The coefficient sets used are the EPA eGRID (entered from LGOP) for the Average Grid Electricity and Marginal Grid Electricity Sets, and the Defaults for the RCI Average and the Fuel CO2 set.

Appendix B– Fire Department Vehicle Spreadsheet

This is the spreadsheet sent to the Fire Chief in order to acquire data for the transportation vehicle inventory.

Vehicle	Make	Model	Year	Vehicle Use/Function	Fuel Type	Average mileage traveled per year or month (which ever is available)
Car 1	Ford	Taurus	2007			
Car 2	Chevy	Tahoe	2008			
Car 3	Chevy	Tahoe	2002			
Car 11	Ford	Pickup	1999			
Car 12	Dodge	Ram/Van	1990			
Engine 1	American Motors		2004			
Engine 2	KME	Excel	2000			
Engine 3	Pierce	Contender	2009			
Tower 1	Mack	Custom	1995			
Rescue 1	KME	Excel	1999			
Forestry 1	Ford	Pickup	1993			
Dive Truck	Ford	E350	1991			
Ambulance 1	Ford	E450	2005			
Ambulance 2	Ford	F450	2006			
Ambulance 3	Chevy	C4500	2007			

Appendix C – CMRPC Travel Demand Model

This is an excerpt from the Central Massachusetts Regional Planning Commissions website detailing the travel demand model used in estimating community vehicle use. It can be found at the following web address: http://www.cmrpc.org/travel-demand-modeling.

The Regional Travel Demand Forecast Model is an important planning tool both for the evaluation of proposed regional transportation improvements and the projection of mobile source air emissions for significant regional projects. The model is the most effective and comprehensive way to project transportation needs within a twenty-year planning horizon as required by Federal regulation.

In the regional travel demand model, traffic volumes are forecast through the interaction of transportation demand and supply. Traffic zones are defined to encompass areas of development that represent the demand, while the actual road network represents the supply. A network is developed consisting of a series of points, or nodes, that graphically show locations of roadway intersections and other elements of the network. Connections between nodes are called links. Links represent highway segments and contain information such as speed and road capacity. Traffic zones contain demographic and employment information, and are represented by special nodes called centroids. Each zone is attached, or "loaded," onto the network by specialized links called centroid connectors.

Appendix D– Government Employee Commute Survey

This was the Government Employee Commute Survey handed out to town employees regarding daily work commute habits.

Employee Commuter Survey

The purpose of this survey is to gather information on the Town of Auburn's employees' commute to work to aid in the creation of a Climate Action Plan to reduce the town's greenhouse gas (GHG) emissions.

Please answer as many questions as possible.

1. What department do you work in? _____

2. Are you a full-time employee? ☐ Yes   ☐ No

3. How many days per week do you commute to work? 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4. How much time does your one-way commute to work take? _____

How many miles is your one-way commute to work? _____

5. What type of vehicle do you drive to work? Passenger Car ☐ Light Truck/SUV/Pickup/Van ☐
Heavy Truck ☐ Motorcycle/Scooter ☐

What model year is your vehicle? _____

What is the make and model of your vehicle? _____

What type of fuel does your vehicle use? Gasoline ☐ Diesel ☐

Appendix 3.5– Police Department Vehicle Spreadsheet

Appendix E– Police Department Vehicle Spreadsheet

This is the survey sent to the Police Chief at the Auburn Police Department to gather information regarding vehicles operated by the department.

Model	# of Vehicle	Vehicle Function	Fuel Type	Average mileage traveled per year or month (which ever is available)
Crown Victoria	14	Patrol		
Crown Victoria	1	Chief		
Crown Victoria	1	Detectives		
F-350	1	Patrol/ Inclement weather		
Econoline Van	1	SWAT		
Expedition	1	Patrol/ Inclement weather		
Expedition	1	K-9		
318IS	1	Detectives		
CLK320	1	Detectives		
Civic	1	Detectives		
Camry	1	Detectives		

Appendix F– Refrigerant Blends to be Reported and Global Warming Potentials

This table shows the refrigerant blends to be reported in Auburn's emission inventory. The global warming potentials (GWP) refers to the ability of each blend to trap heat in the atmosphere compared against carbon dioxide. CO2 has a GWP of one. If a blend has a GWP of 1300, this means that it is 1300 times more efficient at trapping heat than the same amount of CO2.

Hydrofluorocarbons (HFCs)			
HFC-23	CHF_3	trifluoromethane	11,700
HFC-32	CH_2F_2	difluoromethane	650
HFC-41	CH_3F	fluoromethane	150
HFC-43-10mee	$C_5H_2F_{10}$	1,1,1,2,3,4,4,5,5,5-decafluoropentane	1,300
HFC-125	C_2HF_5	pentafluoroethane	2,800
HFC-134	$C_2H_2F_4$	1,1,2,2-tetrafluoroethane	1,000
HFC-134a	$C_2H_2F_4$	1,1,1,2-tetrafluoroethane	1,300
HFC-143	$C_2H_3F_3$	1,1,2-trifluoroethane	300
HFC-143a	$C_2H_3F_3$	1,1,1-trifluoroethane	3,800
HFC-152	$C_2H_4F_2$	1,2-difluoroethane	43*
HFC-152a	$C_2H_4F_2$	1,1-difluoroethane	140
HFC-161	C_2H_5F	fluoroethane	12*
HFC-227ea	C_3HF_7	1,1,1,2,3,3,3-heptafluoropropane	2,900
HFC-236cb	$C_3H_2F_8$	1,1,1,2,2,3-hexafluoropropane	1,300*
HFC-236ea	$C_3H_2F_8$	1,1,1,2,3,3-hexafluoropropane	1,200*
HFC-236fa	$C_3H_2F_8$	1,1,1,3,3,3-hexafluoropropane	6,300
HFC-245ca	$C_3H_3F_5$	1,1,2,2,3-pentafluoropropane	560
HFC-245fa	$C_3H_3F_5$	1,1,1,3,3-pentafluoropropane	950*
HFC-365mfc	$C_4H_5F_5$	1,1,1,3,3-pentafluorobutane	890*
Perfluorocarbons (PFCs)			
Perfluoromethane	CF_4	tetrafluoromethane	6,500
Perfluoroethane	C_2F_8	hexafluoroethane	9,200
Perfluoropropane	C_3F_8	octafluoropropane	7,000
Perfluorobutane	C_4F_{10}	decafluorobutane	7,000
Perfluorocyclobutane	c-C_4F_8	octafluorocyclobutane	8,700
Perfluoropentane	C_5F_{12}	dodecafluoropentane	7,500
Perfluorohexane	C_6F_{14}	tetradecafluorohexane	7,400

Source: Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report published in 1995, unless no value was assigned in the document. In that case, the GWP values are from the IPCC Third Assessment Report published in 2001 (those marked with *). GWP values are from the Second Assessment Report (unless otherwise noted) to be consistent with international practices. Values are 100-year GWP values.

Appendix G – Department of Public Works Vehicle Spreadsheet

This is the spreadsheet sent to the Department of Public Works regarding vehicle data needed for the transportation inventory.

Vehicle	Make	Model	Year	Vehicle Use/Function	Fuel Type	Average mileage traveled per year or month (which ever is available)

APPENDIX H - COMMUTER SAMPLE SURVEY

Employee Commuter Survey

The purpose of this survey is to gather information on the (City/Town name) employees' commute to and from work. The information obtained from the survey will aid in understanding the potential sources of Greenhouse Gas Emissions.

Please answer as many questions as possible

Indicate the total number of days worked during the last year? _____

What is your method of commuting to and from work (more than one may be applicable)? Indicate, to the closest estiamte, the percentage or number of days commuted with each communting method used.

	Percentage		Percentage		Percentage
☐ Drive Alone	_____	☐ Carpool	_____	☐ Bus	_____
☐ Train/Subway	_____	☐ Motorcycle	_____	☐ Bicycle	_____
☐ Walk	_____	☐ No commute	_____	☐ Other	_____

Based on the information provided above, fill in the necessary and applicable information below.

Drive Alone

Miles commuted (per day): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ Other:_____

Fuel type: ☐ Gasoline ☐ Diesel ☐ Biodiesel ☐ Electricity

Fuel efficiency (Mpg or kWh): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ 30-35
☐ 36-41 ☐ 42-47 ☐ Other:_____

_____

Carpool

Miles commuted (per day): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ Other:_____

Fuel type: ☐ Gasoline ☐ Diesel ☐ Biodiesel ☐ Electricity

Fuel efficiency (Mpg or kWh): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ 30-35
☐ 36-41 ☐ 42-47 ☐ Other:_____

Average persons per vehicle: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

_____

Bus

Miles commuted (per day): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ Other:_____

Fuel type: ☐ Gasoline ☐ Diesel ☐ Biodiesel ☐ Electricity ☐ Not known

_____

Train

Miles commuted (per day): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ Other:_____

_____

Motorcycle

Miles commuted (per day): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ Other:_____

Fuel type: ☐ Gasoline ☐ Diesel ☐ Biodiesel ☐ Electricity

Fuel efficiency (Mpg or kWh): ☐ 0-5 ☐ 6-11 ☐ 12-17 ☐ 18-23 ☐ 24-29 ☐ 30-35

☐ 36-41 ☐ 42-47 ☐ Other:_____

_____

Bicycle

Miles commuted (per day): ☐ 1 ☐ 2 ☐ 3 ☐ Other:_____

_____

Walk

Miles commuted (per day): ☐ 0.25 ☐ 0.5 ☐ 0.75 ☐ 1 ☐ Other:_____

_____

If there are any additional comments or concerns that may be beneficial, list them below.

_____
_____
_____
_____
_____

Thank you