
The Town of Hamilton, NY 2017 Municipal Greenhouse Gas Inventory

A step-by-step guide for completing the Town of Hamilton, NY Greenhouse Gas Inventory

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I. Acknowledgements

Chris Rossi, *Town of Hamilton Council Member*

Sue Reymers, *Town of Hamilton Clerk*

Andy Pattison, *Colgate University Assistant Professor of Environmental Studies*

John Pumilio, *Colgate University Director of Sustainability*

II. Executive Summary

This report provides an update of the Town of Hamilton, NY's 2011 Greenhouse Gas Inventory Report. The 2011 report outlined a comprehensive guide for creating a municipal greenhouse gas inventory, including an explanation of data collection methods and results using the ICLEI software and protocols for local governments (Dolfi, 2012). This 2017 report builds on that guide and uses an Excel greenhouse gas (GHG) emissions calculator modified by Colgate University Assistant Professor of Environmental Studies Andy Pattison and Colgate University Director of Sustainability John Pumilio. The tool stems from a model that was created for the NY State Climate Smart Communities program and is recommended by the New York State Energy Research and Development Authority (NYSERDA) and the Clean Energy Communities Program. It is our recommendation that this tool is used for future greenhouse gas inventories in the Town of Hamilton. This report is outlined as follows.

To begin, we provide an overview of New York's Climate Smart Communities (CSC) Program in section IV. The requirements of this program provide the basis for our report. In section V, we provide an introduction to a greenhouse gas inventory. This section provides information for how a local government can create a greenhouse gas inventory. It explains how different sources of carbon emissions and various sectors of municipal operations are separated within a greenhouse gas inventory. Section VI describes the data collection process for the report and provides an overview of the GHG emissions calculator tool. This section includes the emissions calculations for each sector within the Town of Hamilton's jurisdiction. Section VII contains a holistic view of the Town's GHG emissions, broken down by sector and source, as well as a comparison to the 2011 GHG emissions. Our report, using 2015 as the base year, will provide the baseline for the Town of Hamilton, NY GHG inventories moving forward.

Section VIII goes beyond traditional municipal GHG inventories. This section outlines next steps and recommendations. We model our recommendations for the Town of Hamilton based on what might be included in a future Climate Action Plan (CAP) for the Town. We provide case studies on relevant policies that the Town of Hamilton could adopt to reduce its GHG emissions, including an analysis of converting its lighting districts to LED. Section IX concludes this report.

III. Climate Smart Communities Program Overview

New York State established the Climate Smart Communities program in 2009. The goal of this program is to engage with and provide guidance for local governments on how to reduce their greenhouse gas emissions, save taxpayer dollars, improve operations and infrastructure, and advance community goals for health and safety, energy independence, economic vitality, and quality of life (VHB, 2014). This program includes a partnership of the following six NY State agencies: the New York State Energy Research and Development Authority (NYSERDA), the Department of Environmental Conservation (DEC), the Department of Health (DOH), the Department of Transportation (DOT), the Public Service Commission (PSC), and the Department of State (DOS).

As part of this program, the CSC Regional Coordinator Program developed a guide in 2012 to provide local governments with resources and technical assistance so that they might achieve the program's goals of reducing GHG emissions, adapting to a changing climate, and saving taxpayers money.

Local governments such as the Town of Hamilton can join the CSC program by adopting the voluntary CSC pledge. The pledge framework guides participating communities in the development and implementation of successful local sustainability and climate action programs. The pledge includes these ten pledge elements:

1. Pledge to be a Climate Smart Community
2. Set Goals, Inventory Emissions, Plan for Climate Action
3. Decrease Community Energy Use
4. Increase Community Use of Renewable Energy
5. Realize Benefits of Recycling and Other Climate-Smart Solid Waste Management
6. Reduce GHG Emissions Through Climate-Smart Land-Use Tools
7. Enhance Community Resilience and Prepare for the Effects of Climate Change
8. Support Development of a Green Innovation Economy
9. Inform and Inspire the Public
10. Commit to an Evolving Process of Climate Action

Pledge 1 has been completed by the Town of Hamilton, and pledge 4 is covered by Madison County's solar ordinance along with participation in the Solarize Madison project. Solarize Madison was created in 2011 spearheaded by Jan Myers, a Morrisville State College student with support from the Madison County Department of Planning, the Central New York Regional Planning and Development Board, Colgate University's Office of Sustainability, and dozens of volunteers. The program is a community-based renewable energy program that promoted sustainable energy production to stabilize energy costs in the present and in the future (Myers,

2012). The goal of the program is to help communities save money, generate clean energy, create local jobs, reduce carbon emissions, and promote equity by creating local economic opportunities and career pathways in the region (Myers, 2012). The program helps residents, business owners, and municipalities to overcome financial and logistical barriers to installing solar power through high volume group purchasing.

In order to assist the Town of Hamilton in meeting element 2 of the CSC's program, we have completed this greenhouse gas inventory. Pledge element 2 calls for local governments to develop baseline GHG emissions inventories for their operations and the community (VHB, 2014). In addition to this, the pledge entails establishing a GHG emissions reduction target strategy and developing a local action plan for reducing emissions. The following sections outline how to create a GHG inventory, and provide the Town of Hamilton's 2015 GHG inventory report.

IV. Introduction to a Greenhouse Gas Inventory

The purpose of creating a local government operations greenhouse gas inventory is to obtain a thorough understanding of the GHG emissions sources relevant to the community, establish a baseline for these emissions, and identify opportunities to reduce energy use and GHG emissions. These inventories oftentimes result in several benefits for the community, such as an improved ability to manage energy use, the opportunity to lead by example in the local community, increased transparency and accountability, and cost savings.

This Greenhouse Gas Inventory was created in accordance the Climate Smart Communities (CSC) program and Clean Energy Communities (CEC) program guidelines for local government GHG inventories, as described in the previous section. By following these guidelines, the Town of Hamilton will be one step closer to meeting the requirements for the CSC grant money and potentially obtaining some of the benefits mentioned above. To calculate the GHG emissions, we employed a greenhouse gas inventory tool in Excel that can be used for future inventories for the Town of Hamilton. This tool will be discussed more in depth later in the report.

The 2010 Local Government Operations Protocol explains that GHG inventories must assess six greenhouse gases (Section 2.1). The six greenhouse gases are Carbon Dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF₆). This methodology is consistent with the Greenhouse Gas Protocol developed by the World Resources Institute and World Business Council for Sustainable Development. It is also compatible with the requirements of other reporting programs, such as the Center for Corporate Climate Leadership.

Local governments should include all six of the greenhouse gases mentioned above in a GHG inventory. Figure 1 lists all of these GHGs and their respective global warming potential (GWP). GWP is a relative measure of how much heat a greenhouse gas traps in the atmosphere. The measure compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide over a given period of time (VHB, 2014). For example, each unit of nitrous oxide is 310 times more potent over a 100-year period than an equivalent unit of carbon dioxide. Because of this, it is important to account for the emissions of each GHG separately and to report these emissions in metric tons of each gas and metric tons of carbon dioxide equivalent (MTeCO₂).

Types of GHGs	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	21
Nitrous oxide (N ₂ O)	310
Sulfur hexafluoride (SF ₆)	23,900
Hydrofluorocarbons (HFCs)	12-11,700
Perfluorocarbons (PFCs)	6,500-9,200

Figure 1: GHGs Required in the Inventory and their Global Warming Potential
Source: VHB (2014)

A. Base Year

In order to create a greenhouse gas inventory, a base year must be chosen. This base year should be based on a calendar year, not a fiscal year, and is selected based on data availability and reliability. This report uses 2015 as its base year. 2015 was selected as the baseline year based on the availability of reliable and comparable data. The Town of Hamilton will use this greenhouse gas inventory report moving forward as a baseline for all future inventories. All future inventories can be compared to this one to see how the emissions trend over time. It is recommended that the Town of Hamilton conduct a greenhouse gas inventory report annually.

B. Operational Control

This greenhouse gas inventory follows an operational control approach method based on the CSC and CEC programs. By definition, operational control means that the local government owns a facility, or does not fully own it but has authority over decisions regarding operational, health, safety, and environmental policies concerning the facility at hand. The local government must therefore account for emissions from all facilities, operations, or sources. The Town of Hamilton has the full authority to introduce and implement its operating policies, which in this case means that the Town has operational control over what is accounted for in the inventory.

C. Scopes

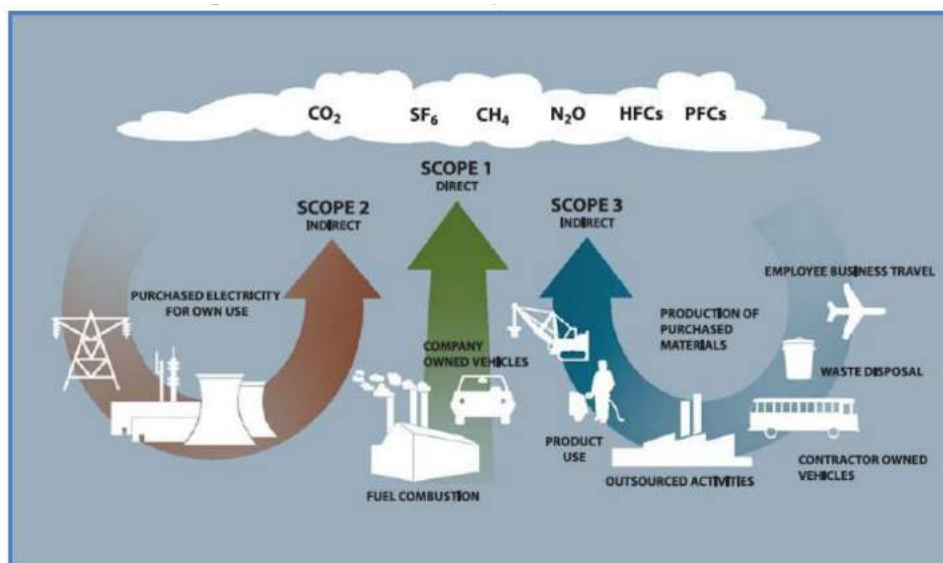
Greenhouse gas emissions are categorized into three different “scopes,” established by the World Resources Institute and described in page 23-26 of the of the Local Government Operations Protocol V1.1. Scopes separate greenhouse gas emissions into direct and indirect emissions. Refer to Figure 2 below for a visual overview of scopes and emissions sources.

Scope 1: All emissions from sources directly owned or operated by the Town of Hamilton. Includes oil to heat the Town garage.

Scope 2: All indirect emissions associated with the consumption of purchased electricity, steam, heating, or cooling. GHG emissions created to generate these utilities are produced outside of Town boundaries.

Scope 3: Emissions related to Town of Hamilton operations; the Town does not hold financial control over their production. Includes emissions from Town employee commute and outsourced activities.

Using the framework of the 3 scopes, local governments are able to best identify the sources of emissions to be measured and organize emissions by degree of control. In this inventory, all emissions will be classified by scope, identifying the Town’s direct and indirect emissions. It is required that Scope 1 and Scope 2 emissions are included in a greenhouse gas report, while reporting Scope 3 emissions is optional. Depending on the extent of operational control, larger municipalities should include air travel, landfill operations and airports within Scope 3. Given the scope of the Town of Hamilton municipal operations this report will include Scope 3 emissions for the Town of Hamilton only in the form of GHG emissions generated by Town employee commute. This is consistent with the Local Government Operations Protocol V1.1.



Source: WRI/WBCSD GHG Protocol Corporate Standard, Chapter 4 (2004)

Figure 2: Overview of Scopes and Emission Sources

D. Government Sectors

This greenhouse gas inventory groups emissions by sector based on the format proposed by the CSC program guide. For the Town of Hamilton, the sectors included are:

- Buildings and Facilities
- Streetlights
- Vehicle Fleet
- Employee Commute

Note: The Town of Hamilton is currently in the process of constructing a new building for its Town Office. This construction began in 2016, which is why this GHG Inventory Report stops at 2015. The year 2016 is an anomaly due to the construction of the new building and the fact that the government operations were shifted mid-year to temporary facility. The Town is expected to be located in their new building by mid-2017.

Additional sectors included in the guide are traffic signals, water delivery facilities, port facilities, airport facilities, transit fleet, power generation facilities, solid waste facilities, and wastewater facilities. While these are listed in the guide, they will not be discussed in this report because they are not relevant to the Town of Hamilton as none of these sectors fall into the operational control of the Town. In other words, the Town's scope of municipal operations do not include these sectors and thus, according to the Local Government Operations Protocol V1.1 should not be included in the municipal inventory of the Town of Hamilton. One potential future sector to include in the Scope 3 section of the Town municipal GHG Inventory might be employee air travel-related emissions (e.g. as a result of traveling for training or a conference).

Using sectors as a framework for organizing emissions provides a more policy-relevant approach to reporting GHG emissions. Under the sectors approach, all types of emissions are summarized and reported for each separate sector. This organization of emissions allows government staff, policymakers, and the public to understand the total GHG emissions impacts as they directly relate to local government operations. Using this framework, policymakers are able to identify key sectors for GHG emissions reductions.

V. Data Collection

The data for the Town of Hamilton's electricity and fuel consumption is documented in Excel spreadsheets for the years 2012 to 2015. This data was primarily provided by Sue Reymers, the Town Clerk. The following subsections summarize the electricity and fuel consumption for the Town of Hamilton, as well as their resulting GHG emissions. More detail about how the spreadsheets were formatted and organized is provided below.

To calculate these GHG emissions, we used a GHG calculator tool, which was modified by Colgate University Assistant Professor of Environmental Studies Andrew Pattison and Colgate University Director of Sustainability John Pumilio. This tool exists in an Excel spreadsheet and is relatively easy to use. It stems from a model tool that was created for the Climate Smart Communities program and is recommended for local governments by the New York State Energy Research and Development Authority (NYSERDA) and the Clean Energy Communities Program¹. The tool is broken up into several tabs in Excel, including a Cover Page; Define Reporting Categories; The GHG Inventory Report; Natural Gas and Electricity; Fuel Oil and Propane; Fleet — Gasoline, Diesel, NG; Landfills and Solid Waste; Reference; and NYSERDA Emission Factors. Each tab contains directions on how to use the tool. Essentially, the tool can be used to organize data and generate emissions calculations all in one place. The tool is still being modified, and the end goal is to make the tool as accessible as possible so that groups in the future will be able to use it for GHG inventories moving forward.

As mentioned in the previous section, the sectors covered in the Town of Hamilton greenhouse gas inventory are:

- Buildings and Facilities
- Streetlights
- Vehicle Fleet
- Employee Commute

Note: The GHG emissions calculations are expressed in metric tons of carbon dioxide equivalents. This measurement is used to compare the emissions from various greenhouse gases based on their GWP, and is derived by multiplying the tons of the relevant gas by its associated GWP. This is an internationally recognized unit that allows for the standardization of all greenhouse gas emissions. This enables the ability to compare emissions between local governments, businesses, and other organizations.

Emissions Factors

According to the Environmental Protection Agency, an emissions factor (EF) “is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per megagram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases,

¹ The tool was originally created by Jim Yienger of Climate Action Associates (CAA). The tool is intended to be a free, easy tool for small town GHG inventories. CAA worked as a NYSERDA contractor for the 2012-2015 CSC regional coordinators pilot and is currently supporting the CEC program as well.

these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average).”²

EFs are used in GHG emissions calculations and are specific to each energy source. For example, the emissions factor for electricity used to light a building is different than the emissions factor for gasoline. These emissions factors are multiplied by the total consumption to yield a final GHG emissions value. The calculations for our report can be found in the Appendix. The emissions factors that we used come from the eGrid NYUP CO2e Emission Factor (note that 2014v2 is the most up to date), as well as the NYSERDA Emissions Factors. These emissions factors are provided in the final tab of the GHG calculator tool, aside from the Emission Factor for the Town of Hamilton’s electrical grid. This EF stems from the eGrid NYUP CO2e report mentioned above and is described more in depth in part A of this report. Note that the Town of Hamilton is located in the NYUP subregion described in the eGrid NYUP report. The EFs are based on the amount of green power generation versus fossil fuel generation that takes place in each region in NY. Consequently, these numbers change often and must be kept up to date.

A. Buildings and Facilities

Scope 1

Data Needed: Heating oil consumption for Town Garage

- *Primary Contact Person:* Sue Reymers, Town Clerk
- *Data Received:* Spreadsheet containing the Town of Hamilton’s electricity usage from 2012-2015 and fuel usage from 2015
 - Spreadsheet includes the heating oil consumption for the Town Garage
 - Under the 2015 Fuel tab, the data was separated by date, gallons, cost, and cost per gallon

Consumption (gal)	Cost (\$)	Cost Per Gallon (\$)	GHG Emissions (MTeCO2)
4166.90	9369.30	2.26	42.53

Table 1: 2015 heating oil consumption for Town Garage (scope 1)

The heating oil used in the Town Garage is categorized as a scope 1 emission, and is provided by the Broedel energy company. The Town of Hamilton consumed 4,166.90 gallons of heating oil in 2015, which produced 42.53 MTeCO2 GHG emissions. See the calculations outlined in the Appendix for a specific guide of how to measure these GHG emissions.

² <https://www.epa.gov/air-emissions-factors-and-quantification/basic-information-air-emissions-factors-and-quantification>

Scope 2

Data Needed: Electricity consumption for Town Garage and Town Office

- *Primary Contact Person:* Sue Reymers, Town Clerk
- *Data Received:* Spreadsheet containing the Town of Hamilton’s electricity usage from 2012-2015 and fuel usage from 2015
 - Under the 2015 Electric tab, data was divided into four sections, one for each location: Town Garage, Hubbardsville, Poolville, and the Town Office
 - Data was further separated by company, meeting (month paid), service dates, kilowatt hours, and cost

Location	Consumption (kWh)	GHG Emissions (MTeCO2)
Garage	20,475	3.43
Office	23,810	3.99
Total	44,285	7.42

Table 2: 2015 electricity consumption for Town Garage & Town Office (scope 2)

The total electricity consumption for the Town Garage and the Town Office is shown in Table 2. It is important to note that, in 2015, the Town Office was located in the Village of Hamilton and was therefore connected to the Village of Hamilton’s electricity grid. The Town Garage was connected to the Town of Hamilton’s electricity grid. The two grids have different emissions factors based on the fuel profile and purchasing agreements of the two entities. However, for the ease of calculation, we used one EF, the Town of Hamilton’s EF, for both the Town Garage and the Town Office. This can be seen in the calculations in the Appendix.

Also important to note is that the Town of Hamilton owns a solar panel, which is located on the Town Garage. This solar panel generated 17,917 kWh in 2015, which offset some of the Town’s GHG emissions. This offset is included in Table 3 below for a more holistic view of the Town of Hamilton’s electricity consumption and GHG emissions. A visual representation of the impact of the solar panel is provided in Figure 3 below. The electricity generated by the solar panel decreases the Town’s GHG emissions by 3.01 MTeCO₂, reducing their total GHG emissions resulting from electricity consumption from 7.42 MTeCO₂ to 4.41 MTeCO₂.

Location	Consumption (kWh)	GHG Emissions (MTeCO2)
Garage	20,475	3.43
Office	23,810	3.99
Solar Panel (On Town Garage)	- 17,917	- 3.01
Total	26,368	4.41

Table 3: 2015 Town of Hamilton, Holistic Energy Consumption and GHG Emissions (scope 2)

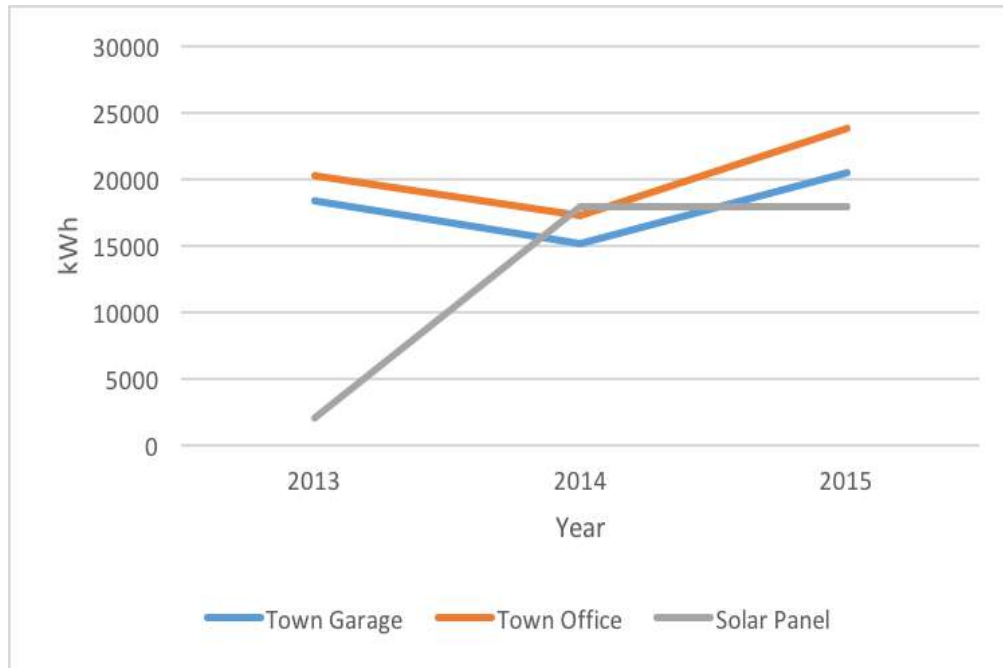


Figure 3: Total Energy Consumption and Production from 2013 to 2015 (scope 2)

It is important to note that, while the solar panel did offset some of the Town of Hamilton’s GHG emissions, it only made a small dent in the total emissions produced by the Town due to the majority of the total emission resulting from the vehicle sector. Therefore, while solar panels may not be the master solution to reducing all of the Town’s GHG emissions, solar panels (or other renewables such as geothermal) could provide enough energy to offset all electric use of the Town if sized large enough, the existing system was just not built to do this. Other areas provide an opportunity for more significant reductions. This will be discussed a bit more in section VII below, which presents an overall summary of the Town’s greenhouse gas emissions in 2015.

B. Streetlights

Scope 2

Data Needed: Electricity consumption for lighting districts in Hubbardsville, NY and Poolville, NY

- *Primary Contact Person:* Sue Reymers, Town Clerk
- *Data Received:* Spreadsheet containing the Town of Hamilton’s electricity usage from 2012-2015 and fuel usage from 2015
 - Under the 2015 Electric tab, data was divided into four sections, one for each location: Town Garage, Hubbardsville, Poolville, and the Town Office
 - Data was further separated by company, meeting (month paid), service dates, kilowatt hours, and cost

Location	Consumption (kWh)	GHG Emissions (MTeCO2)
Poolville	9,245	2.62
Hubbardsville	11,575	3.28
Total	20,820	5.9

Table 4: 2015 electricity consumption for lighting districts in the Town of Hamilton (scope 2)

Table 4 contains the electricity consumption for the two lighting districts, Poolville and Hubbardsville, in the Town of Hamilton. Total combined electricity consumption in 2015 was 20,820 kWh, which produced 5.9 MTeCO2 GHG emissions. Converting these lighting districts to LED would decrease the number of GHG emissions, as outlined in Section VIII below³.

C. Vehicle Fleet

Scope 1

Data Needed: Gasoline and diesel consumption for Town-owned vehicles

- *Primary Contact Person:* Sue Reymers, Town Clerk
- *Data Received:* Spreadsheet containing the Town of Hamilton’s electricity usage from 2012-2015 and fuel usage from 2015; email containing information regarding the Town fleet from Sue
 - Data separated into three categories: gasoline, diesel, and heating oil
 - Further divided by invoice date, gallons, cost, and cost per gallon for each fuel

The fuel usage by the Town fleet is divided into gasoline consumption and diesel consumption. The Town fleet is comprised of the following vehicles:

- 5 plow trucks
- 1 small dump truck
- 1 pick-up truck, ¾ ton
- 1 loader
- 1 backhoe
- 1 mowing tractor
- 1 grader

All of the vehicles in the Town fleet use diesel except for the pickup truck, which uses gasoline. Diesel engines and gasoline engines are fairly similar, but there are some key differences. Both diesel and gasoline engines convert fuel into energy through a series of small explosions, but

³ Amanda Mazzoni, Senior Planner, Central New York Regional Planning & Development Board has indicated she could provide technical assistance on this proposal

how these explosions happen differentiate the two fuels. Due to this difference, diesel fuel is one of the most efficient and energy dense fuels available today. It contains much more usable energy than gasoline, and thus delivers better fuel economy and emits less pollution. However, diesel fuel still emits greenhouse gases, and is the largest contributor to the Town of Hamilton’s emissions.

Fuel Type	Total Consumption (gal)	Cost (\$)	Cost Per Gallon (\$)	GHG Emissions (MTeCO2)
Gasoline	2,693.3	5,081.04	1.932	23.50
Diesel	12,821.1	29,451.34	2.21	130.86
Total	15,514.4	34,532.38	4.142	154.36

Table 5: 2015 data for Town of Hamilton-owned vehicles (scope 1)

Table 5 depicts the fuel consumption for the Town fleet. As described in the paragraph above, all of the vehicles consume diesel aside from the pickup truck, which consumes gasoline. The total gasoline consumption for the Town fleet in 2015 was 2,693.3 gallons, which produced 23.50 MTeCO2 GHG emissions. The diesel consumption was 12,821.1 gallons in 2015, which produced 130.86 MTeCO2 GHG emissions. It is evident from the table that diesel consumption and resulting emissions contributed much more to the Town of Hamilton’s GHG emissions. In fact, diesel usage is the single largest contributor to GHG emissions in the Town of Hamilton. Therefore, the Town of Hamilton should target diesel fuel consumption as the main area in which they should try to reduce emissions. Recommendations for how to achieve this can be found in Section VIII.

D. Employee Commute

Scope 3

Data Needed: Measurement of mobile combustion concerning Town employees who drive to work

- *Primary Contact Person:* Sue Reymers, relaying information from Town employees
- *Data Received:* Survey responses from all 6 of the full-time employees

Below is the survey that was given to each employee of the Town:

Please fill out the following survey regarding the vehicle you used to drive to work from Jan 2015-Jan 2016. Please fill out and return to the Town Office ASAP.

Year, Make & Model of Vehicle:

This will be used in determining the “carbon footprint” of the Town of Hamilton.

Fuel Type (circle one): Gasoline, Diesel, Other

Average MPG:

Distance of commute (one way):

Number of days per week on average you commute to work:

Note: The survey was collected from employees in 2017, though the energy data for the Town is from 2015. It is assumed that the results of the survey are similar enough to those that would have been found if the survey was conducted in 2015 due to the fact that there are the same number of full-time and part-time employees now as was in 2015.

There are 6 full-time employees (FTE) for the Town of Hamilton, 3 part-time employees, and 3 salaried employees who do not have regular hours. We grouped the salaried employees without regular hours with the 3 part-time employees to equal 6 part-time employees. Each part-time employee is measured as 0.5 FTE. Therefore, the total number of employees is measured as 9 FTE. There are also 5 board members that are paid by the Town of Hamilton but do not have regular hours, and they are also separated from employees for tax and legal reasons. Thus, they were left out of our survey and analysis.

We did not receive information for the part-time employees, so we took the average of the responses for the 6 FTE and extrapolated to create data for the additional 3 FTE. These calculations are provided in the Appendix. This data only captures commuting from home to work. Potential future GHG emissions could include commuting resulting from town business-related travel.

Miles to Work	Number of Employees
0-5	9
6-10	0
11-15	0

Table 6: 2015 length of commute for Town of Hamilton employees (scope 3)

To calculate the numbers in Table 7, we scaled up the responses from per one-way commute to per year. These calculations can be found in the Appendix along with the others. We did this so that all of the data and results provided in this report are annual numbers for 2015.

Type of Fuel	Gasoline Consumption (gal)	GHG Emissions (MTeCO₂)
Diesel	0	0
Gasoline	931.57	8.13
Total	931.57	8.13

Table 7: 2015 fuel consumption used in commute of Town of Hamilton employees per week (scope 3)

Note: None of the respondents' vehicles consumed diesel fuel.

In total, the Town of Hamilton employees consume 931.57 gallons of gasoline per year in their commute to work. This amounts to greenhouse gas emissions of 8.13 MTeCO₂. This is for the 9 FTE, so averaging just under 1 MTeCO₂ per employee. A significant component of this came from the different mpg per car. Some cars were much more polluting than others, with a wide

range of gallons consumed per year. These numbers and calculations can be found in the Appendix.

VI. Gross Greenhouse Gas Emissions

This section provides a holistic view of the Town of Hamilton’s electricity and fuel consumption, as well as the resulting GHG emissions.

Overall, the Town’s electricity usage has increased from 2012 to 2015, as seen in Figure 4 below. The Town Office used 23,810 kWh in 2015, the most of any building in 2015. The Town Garage had the second highest electricity consumption in 2015 with 20,475 kWh. Electricity consumption for Poolville and Hubbardsville has stayed relatively constant across all four years.

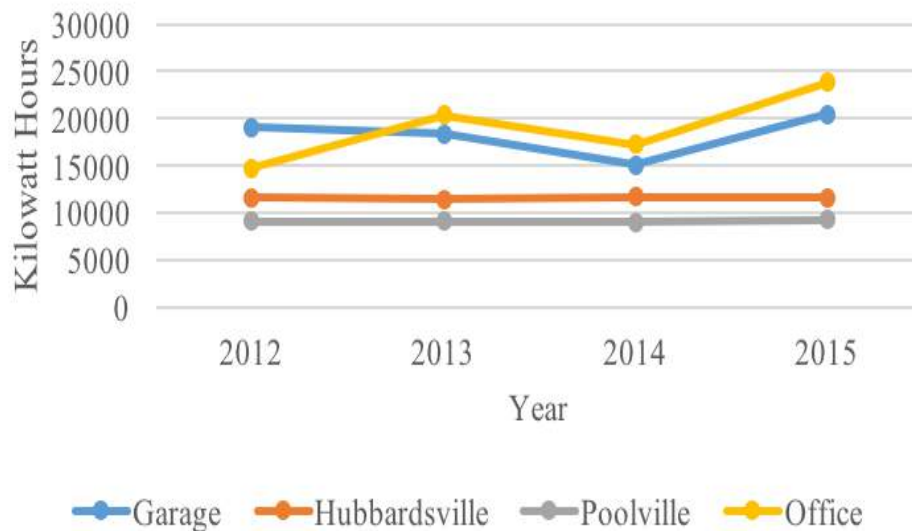


Figure 4: Town of Hamilton annual electricity consumption by location (scope 2 emissions) In terms of annual fuel usage, diesel comprises the largest component with 12,821 gallons used during 2015. This can be seen in Figure 5 below. Overall diesel fuel consumption has generally increased over the past four years, with gasoline and heating oil following the same trends.

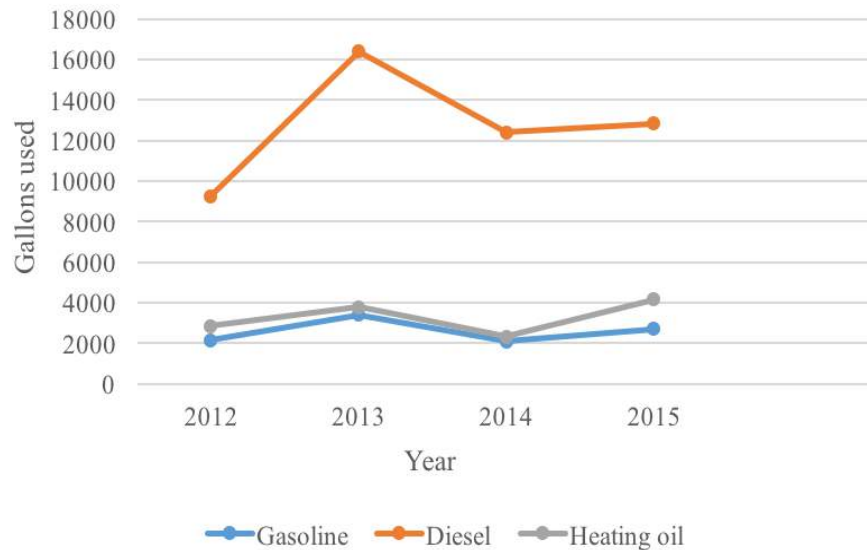


Figure 5: Town of Hamilton annual fuel usage by fuel type (scope 1 emissions)

Given the magnitude of diesel use for the Town of Hamilton, we recommend that the Town target diesel consumption as an area for reduction. This provides the most significant opportunity for greenhouse gas emission reductions. Potential ways in which to achieve this goal are provided in section VIII of this report.

A. GHG Emissions Summary by Sector

The Town of Hamilton’s vehicle fleet produced the largest number of GHG emissions compared to the other sectors. These greenhouse gas emissions amounted to 154.36 MTeCO₂, which accounts for 71.7 percent of the Town of Hamilton’s 2015 GHG emissions. The main contributor to this total was diesel usage, which accounts for 84.8 percent of the GHG emissions from mobile fuel usage in the Town of Hamilton. In terms of the other sectors, Buildings & Facilities accounts for 21.8 percent of the Town’s 2015 GHG emissions, Streetlights account for 2.7 percent, and the Employee Commute accounts for 3.8 percent. A holistic summary of these numbers can be found in Table 8 below.

Sector	GHG Emissions Count (MTeCO ₂)
Buildings & Facilities	46.94
Streetlights	5.9
Vehicle Fleet	154.36
Employee Commute	8.13
Total	215.3

Table 8: 2015 GHG Emissions Summary by Sector

Note: This total includes the reduction from the solar panel on the Town Garage. This reduction is calculated in the Buildings & Facilities total.

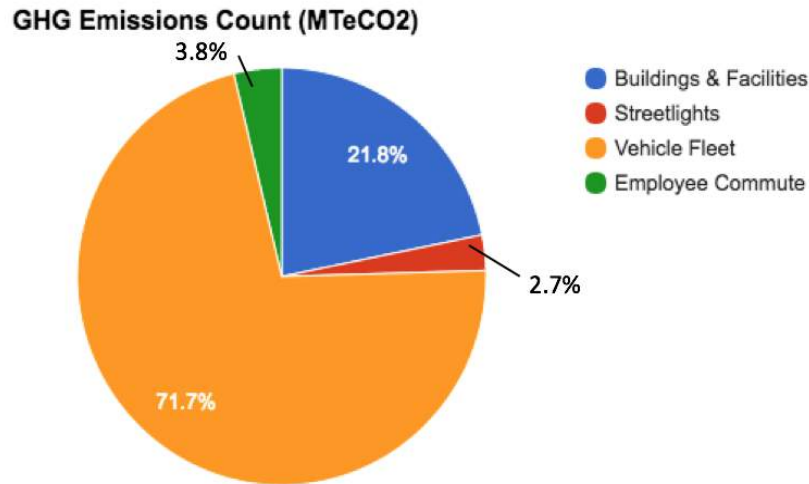


Figure 6: Graph of GHG Emissions Count by sector

Figure 6 provides a visual representation of the Town of Hamilton’s GHG emissions broken down by sector. It is very apparent from this pie chart that the Town’s vehicle fleet contributed the most to the Town’s emissions in 2015.

B. GHG Emissions Summary by Source

Scope 1 emissions account for 91.4 percent of the Town of Hamilton’s total GHG emissions in 2015. Scope 1 includes both fuel oil (fuel oil #2) used to heat the Town Garage and diesel and gasoline used for the Town Fleet. Scope 2 emissions account for 4.8 percent of GHG emissions in 2015. These emissions include the electricity purchased for streetlights in the two lighting districts, as well as the electricity consumed by the Town Garage and Town Office. Scope 3 emissions from employee commute accounts for 3.8 percent of GHG emissions in 2015.

Source of Emissions	Scope	GHG Emissions Count (MTeCO2)
Fuel Oil	1	42.53
Vehicle Fleet	1	154.36
Purchased Electricity	2	10.31
Employee Commute	3	8.13
Total		215.3

Table 9: GHG Emissions in the Town of Hamilton by Source and Scope

Note: This total includes the reduction from the solar panel on the Town Garage. This reduction is calculated in the purchased electricity total.

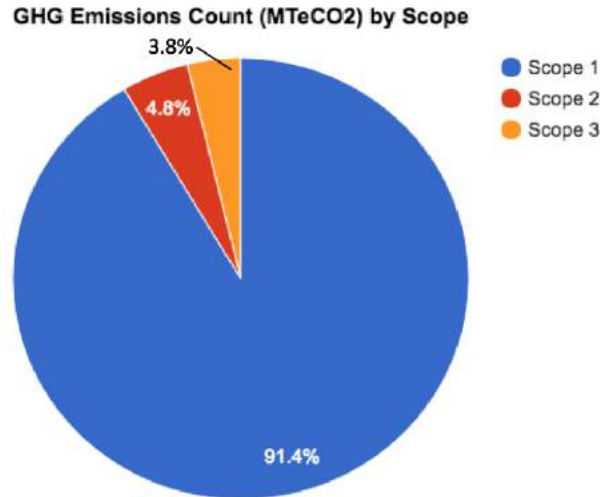


Figure 7: 2015 GHG emissions by scope.

Figure 7 provides a visual representation of GHG emissions in the Town of Hamilton in 2015 divided by scope. As is evident from the graph, the majority of emissions are scope 1 emissions.

C. GHG Inventory Report Comparison to 2011

Compared to the 237 MTeCO₂ that the Town of Hamilton produced in 2011, GHG emissions in totals in 2015 were lower, with only 215.3 MTeCO₂ produced. Figure 8 shows emissions from each year broken down by sector. There were very small increases in emissions from 2011 to 2015 in the Buildings & Facilities and Employee Commute sectors likely due to season variations and temperature control needs. There was also a negligible decrease (near zero) in emissions from the Streetlight sector from 2011 to 2015. The largest change in emissions from 2011 to 2015 was in the vehicle fleet sector, with a decrease of 27 MTeCO₂. This may have been due to reductions in vehicle use.

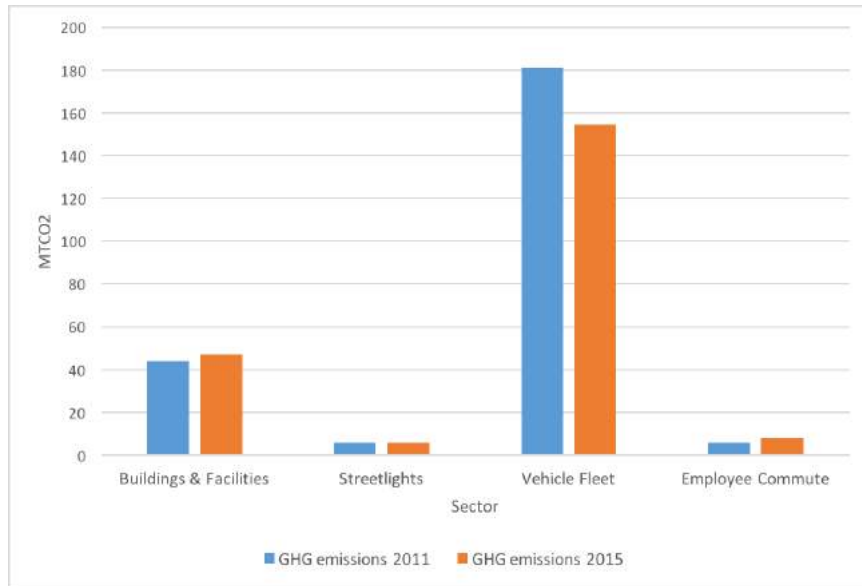


Figure 8: Comparison of 2011 and 2015 GHG emissions by sector
 Scope 1 and 2 GHG emissions decreased from 2011 to 2015, as shown in Figure 9 below. Scope 3 emissions only slightly increased from 2011 to 2015. These emissions are comprised of those produced in the employee commute. Data for 7 employees was included in the employee commute sector of the 2011 GHG inventory, while 9 employees were accounted for in the employee commute sector for the 2015 GHG inventory. This increase in scope 3 emissions was likely due to the increase in number of town employees from 2011 to 2015.



Figure 9: Comparison of 2011 and 2015 GHG emissions by scope

VII. Next Steps and Recommendations

This section includes recommendations for the Town of Hamilton for future work and ways to achieve reductions targets based on the emissions described above. These recommendations come from the model of a Climate Action Plan, which is described below.

A. Climate Action Plan

The Town of Hamilton Greenhouse Gas Inventory can be used to inform policy decisions for the Town moving forward. One method used by local municipalities to organize and implement sustainability-related policy is the creation of a Climate Action Plan (CAP). A CAP describes the policies and measures that a local government will enact to reduce greenhouse gas emissions and increase the community's resilience to unavoidable climate change (NY State DEC, 2017). Below, we propose various policy recommendations that the Town may consider. These recommendations are organized by sector. This section also includes case studies highlighting the effects of proposed policies in municipalities similar to the Town of Hamilton.

B. Sample Case Studies and Policies

Case studies are a vital aspect of the recommendations section of this document because they validate the specific policies we put forth below. They provide us with the data and evidence we need to confidently recommend what we believe will reduce emissions in the Town of Hamilton. The various case studies provide evidence for the effectiveness of these recommendations since local governments have implemented them in the past. The selection of these case study locations was based on a set of criteria that allows us to justifiably make comparisons between those towns and the Town of Hamilton. If the towns are too dissimilar, the links will not be as strong. As such, we believe the most important factors are population size, town layout, and environment (urban, rural, suburban). These criteria do not have to be identical to Hamilton, but they should be within a close enough range so we can reasonably compare the two effectively. However, there is one instance where we will diverge from one aspect of our criteria (population) in making a case study comparison. For that city, San Mateo, we will further explain why we do so and why we believe it is still a valid case study to use.

Below is the formal layout of our recommendations for each sector of the GHG inventory. These recommendations are not for a community CAP, but rather for a municipal CAP for the Town of Hamilton.

Buildings & Facilities

Potential policies to reduce electricity use in Town-owned buildings

- Retrofit existing building appliances
 - Note: retrofitting is the process of replacing older building appliances with new, more energy efficient ones (Roseland, 2012)

- Appliances may include Town office and garage space heaters, water heaters, refrigeration, lighting, air conditioners
 - May include replacing lights with LED light bulbs, insulating buildings, and using energy efficient power strips, among others
- “Rightsizing” fan circulation systems
 - “Rightsizing” a fan system involves better matching fan capacity to the requirements of the load (ie for air circulation systems)
 - Excellent way to save energy
 - EPA study found that almost 60 percent of building fan systems were oversized by at least 10 percent, with an average oversizing of 60 percent (Practice Greenhealth, 2017)
- Install solar panels on Town Office
 - Town solar panel saved 17.917 kWh of electricity, or 3.01 MTeCO₂ GHG emissions in 2015
 - Installing a similar solar panel on the Town Office would help to reduce these GHG emissions even further
- Draft a Green Buildings Standard for the Town
 - Align all future Town construction and renovation with a Green Building Certification program
 - Certification programs include LEED, Green Globes
 - Green Building Standard document considers lifetime of the building, from inception to implementation (Roseland, 2012)
- Review building codes to ensure new projects comply with existing regulation
 - Include compliance costs in development budget

Sample Case Study - Town of Cazenovia (NY)

- Population: 2,933
- Rural environment
- Buildings and Facilities of Town Municipal Operations account for 21 percent of GHG emissions (97 MTeCO₂)

The Town of Cazenovia breaks its Climate Action Plan⁴ into two parts, one that provides a Municipal Operations Analysis and the other that provides a Community Analysis. For the purposes of this case study, we focus on the municipal operations, since it is most similar to the report that we provide for the Town of Hamilton. In 2010, the Town of Cazenovia’s municipal emissions were 703 MTeCO₂. The total estimated municipal emissions by 2025 from their strategy implementation are projected to be 317 MTeCO₂ (a 55%, or 386 MTeCO₂ in reductions). The total estimated cost of implementation is \$760,810, and the total estimated

⁴ Town of Cazenovia Climate Action Plan Executive Summary:
<http://townofcazenovia.org/content/Generic/View/102:field=documents;/content/Documents/File/1004.pdf>

annual cost savings are \$139,018. Therefore, they estimate that the payback period for their plan will be 5.47 years (Town of Cazenovia, 2015).

The Town of Cazenovia outlines several municipal operations strategies for reducing emissions, below we highlight the strategies for vehicles and buildings. These include:

Municipal Operations Estimate Emission Reduction Strategies for Vehicles

- Conversion to biodiesel → *49 MTeCO₂ annual reductions*
- Conversion to electric and hybrid vehicles → *75 MTeCO₂ annual reductions*

Municipal Operations Estimate Emission Reduction Strategies for Buildings

- Energy efficient retrofits to existing facilities → *40 MTeCO₂ annual reductions*
- Installing lighting occupancy sensors → *18 MTeCO₂ annual reductions*
 - Assumes that half of the municipal buildings install sensors
- Power-down at night policy → *18 MTeCO₂ annual reductions*
 - Assumes that half of the municipal buildings participate
- Indoor lighting retrofits → *15 MTeCO₂ annual reductions*
 - Assumes that half of the municipal buildings undergo lighting retrofits
- Equipment retrofits (buy EnergyStar appliances) → *2 MTeCO₂ annual reductions*
- Install solar PV → *71 MTeCO₂ annual reductions*
 - Assumes that 285 kW of solar PV is installed
- Install geothermal heating at Town Garage → *98 MTeCO₂ annual reductions*
 - Rather than propane heating system

The estimated annual GHG emissions reductions for the Town of Cazenovia are provided next to each recommendation (Town of Cazenovia, 2015). The Town of Cazenovia's CAP does not include specific details on the implementation of each of these policies, but it does provide ideas of recommendations that could be considered and adapted for the Town of Hamilton. Some of these programs may seem to have initial high costs, but that is a topic that Cazenovia's CAP addresses. They describe the various funds and state programs that are available to assist with the implementation of these programs. For example, the CAP states that the initial cost of retrofitting heating units may seem daunting, but that NYSERDA and the Central New York Regional Planning and Development Board (CNY RPDB) can offer assistance by providing educational materials, low-interest loans, and guidance on where to find potential grants or incentives to help cover costs (Town of Cazenovia, 2015). Given that Cazenovia is only a few towns over from the Town of Hamilton, it is reasonable to assume that the Town of Hamilton would have access to these resources as well. The CAP also touches upon the Solarize Madison program and the benefits that stem from participating in the program, which are mentioned earlier in this report. Overall, the CAP for the Town of Cazenovia includes some helpful big picture ideas for ways in which the Town of Hamilton might be able to reduce its GHG emissions. These are especially relevant for the Town of Hamilton since Cazenovia is located only 30-40 minutes away and is thus similar both geographically and demographically.

Streetlights

For this section, we provide one thorough recommendation, which is to convert the Town of Hamilton's lighting districts to LED. Many communities of a similar size have had success with LED retrofitting programs, and we believe that these benefits would be no different for the Town of Hamilton. An analysis of this policy is provided below in part C of this section, with additional case studies outlined in the Appendix.

Vehicle Fleet

Potential policies to reduce gasoline/diesel consumption and emissions

- Consider purchasing energy efficient vehicles such as hybrid or electric cars for the vehicle fleet
 - Can help reduce emissions from gasoline and diesel consumption
 - Curtailing diesel fuel use is of paramount importance, investing in a vehicle fleet made up of electric vehicles is the best place to begin mitigating diesel emissions
- Implement an ordinance that requires all future Town-owned vehicles to be fuel-efficient
- Replace Town vehicles with electric or hybrid vehicles
- Offset emissions from Town vehicles
 - Purchase carbon offsets
- Adopt stricter fuels standards/requirements
 - Require a percentage of diesel to contain biodiesel
 - Red Hook, NY regulation→ 5% (Mayer, 2012)
 - Require a percentage of gasoline to contain ethanol
 - Red Hook, NY regulation→ 10% (Mayer, 2012)

Sample Case Study-Town of Tiburon (CA)

- Population: 8,962
- Suburban/coastal environment
- Vehicle fleet accounted for 33 percent of carbon emissions (128 MTeCO₂)

The Town of Tiburon combines its CAP into a municipal and community CAP. However, it discusses each independently. For the purposes of this case study, we focus only on the municipal operations regarding the town vehicle fleet, and the subsequent recommendations provided by the Town for emissions reductions.

Mitigation Measures for Government Operations				
Measure		Cost to Implement	Annual Savings	GHG Reductions (Metric Tons)
3.2.G1	Replace Town Vehicles with Hybrid or Electric Vehicles	As replaced	\$2,200	6.0
3.2.G2	Encourage Town Employees to Commute by Alternative Means of Transportation	Variable	n/a	11.0
3.2.G3	Replace Police Patrol Cars with More Fuel-Efficient Vehicles	As replaced	\$6,000	15.2
3.2.G4	Offset Emissions from Town Vehicles	\$1,200/year	n/a	92.1
TOTAL				124.3
% Reduced from 2005 Levels				32.0%

Figure 10: Town of Tiburon’s Mitigation Measures for Government Operations (2011)
Source: Town of Tiburon (2011)

The Town of Tiburon outlines several potential strategies for reducing emissions from its vehicle fleet in the table provided in Figure 10 above. The strategies relevant to the Town of Hamilton are to replace town vehicles with hybrid or electric vehicles and offset emissions from town vehicles (Town of Tiburon, 2011). The cost to implement and annual savings give an idea of what these sorts of programs would cost. The anticipated GHG reductions are also helpful in providing a holistic picture of the sorts of benefits that would result from implementing these strategies. Measure 3.2.G3 could also be adapted to the vehicle fleet. Rather than replacing police patrol cars with more fuel-efficient vehicles, the Town of Hamilton could replace vehicles in its fleet with more fuel-efficient alternatives.

Employee Commute

Potential policies to reduce the total number of VMT per day and per person:

- Encourage flexible employee work schedules
 - Telecommuting a few days per week when appropriate
 - Implement better web conferencing technology to allow for productive telecommuting
 - Ensure telecommuting employees have sufficient means to communicate with other employees
 - Create schedules and plan around which days of the week work best to have employees telecommute
- Incent town employees to drive more fuel-efficient vehicles
 - Subsidies for electric or hybrid cars
 - Provide charging stations in the parkings lots free of charge to employees
- Parking Cash-Out
 - Employees who receive free parking would be offered the cash equivalent for the value of their parking spot if they choose to commute by alternative methods as opposed to driving, the town can determine payment sums

- Host events/competitions for commuters dedicated to encouraging cleaner, environmentally-friendly transportation
 - Example: Calgary Commuter Challenge: annual week-long event (Roseland, 2012)

Sample Case Study- Town of La Conner (WA)

- Population: 891
- Rural coastal environment
- Employee Commute comprised 9 percent of the GHG emissions in 2005 (550 MTeCO₂)

The Town of La Conner also combines its municipal and community CAPs, but discusses each individually. For this case study, we focus only on the municipal operations regarding employee commute, and the subsequent recommendations provided. The Town of La Conner has similar employee characteristics to the Town of Hamilton. La Conner has 8 full time employees and 3 part-time employees (Town of La Conner, 2010). Similar to the Town of Hamilton, the employee commute figure only includes the travel of the Town’s direct employees – contract employees were not included in this figure. It’s interesting to note that the municipal commute is equal to almost one half of the municipal fleet’s emissions, as seen in Table 10 below.

Municipal Sectors	Equiv CO₂ (Tons)	Energy (Million Btu)	Cost (\$)
Buildings	120	1,317	17,676
Vehicle Fleet	47	550	11,023
Employee Commute	23	268	
Streetlights	50	323	11,578
Water/Sewage	289	1,858	38,931
Waste	-9		20,093
TOTAL	520	4,315	99,302

Table 10: Town of La Conner Municipal Emissions Summary (2005)

Source: Town of La Conner (2010)

The Town of La Conner’s main recommendation for reducing emissions from the employee commute is compressed work schedules for Town employees. By allowing for compressed work schedules, the Town would be able to reduce the annual vehicle miles traveled in the employee commute sector. The Town of La Conner suggests that the Town Administrator or other employees could work from home one day per week, providing that the work is conducive to that. The Town of La Conner’s CAP notes that telecommuting one-day per week during a year reduces greenhouse gas emissions by 1 MTeCO₂ (Town of La Conner, 2010).

Whether or not this is feasible for the Town of Hamilton depends upon the roles of each employee and the potential for telecommuting. If this could be done, however, it could save the Town at least 1 MTeCO₂ of GHG emissions per year, as mentioned above.

C. Converting Lighting Districts to LED

We recommend that the Town of Hamilton look to convert its two lighting districts to LED lights. LED lights, formally known as light-emitting diodes, are a technological alternative to incandescent or halogen light bulbs. LED lights are more efficient, durable, versatile, and longer lasting than standard bulb alternatives (Energy Star, 2017). There are many benefits to LED lights, such as energy cost-savings, maintenance cost-savings, an extended lifecycle, reduced carbon emissions, reduced light pollution at night, increased lighting quality, and greater perceived security (Northeast Energy Efficiency Partnerships, 2015).

The Northeast Energy Efficiency Partnerships (NEEP) highlight three potential barriers to implementation: technical, regulatory, and financial barriers. These barriers are described in depth on pages 4-5 of the LED Street Lighting Assessment and Strategies for the Northeast and Mid-Atlantic report created in 2015 (Northeast Energy Efficiency Partnerships, 2015). While these barriers are mentioned in the report, they are not difficult to overcome if a plan is created and implemented correctly.

We do not have the data or information to perform a cost-benefit analysis of converting the Town of Hamilton's lighting districts to LED. More information would be needed to do so⁵. We recommend that, once the data is available, the information be plugged into the LED Savings Calculator from LED Waves: <https://www.ledwaves.com/pages/led-calc> (LED Waves, 2017). The calculator is very simple and easy to use, and would provide a sense of how much the Town might save through converting its lighting districts to LED. It requires the user to answer a few questions on current lighting usage, plus the LED replacement, in order to calculate savings from switching to LED lights. The information is fairly basic and should not be difficult to obtain. Other calculators exist as well, so if this is not the Town of Hamilton's preferred calculator, it would be easy to find another based on the desired company.

Since we could not calculate this on the behalf of the Town of Hamilton, we have conducted several case studies on similar towns and their retrofitting projects. We did so in order to determine the effects of a LED conversion program, which would presumably be similar to the effects that we would see from such a program in the Town of Hamilton. These case studies can be found in the Appendix. It is evident from these case studies that communities of all sizes can

⁵ From Amanda Mazzoni, Senior Planner, Central New York Regional Planning & Development Board: "I am happy to work with the Town to do this. Since the Town is in NYSEG territory, there are a few options they can pursue, one of which is currently available and one of which will become available September 1, 2017."

benefit from converting their streetlights to LED. While the specific numerical costs and benefits will vary by community, these benefits are evident in all locations. Therefore, we recommend that the Town of Hamilton convert its lighting districts to LED.

VIII. Conclusion

In 2015, the Town of Hamilton's total greenhouse gas emissions were 207.2 MTeCO₂, down from the 2011 emissions of 237 MTeCO₂. While this indicates progress, the Town of Hamilton still has many areas in which it could improve to reduce emissions. These steps not only reduce emissions and help the environment, but oftentimes they save time, effort, and money. This report should provide a foundation from which to measure progress in reducing emissions, as well as to determine areas for improvement.

One such area that had the largest impact on the Town of Hamilton's GHG emissions is the vehicle fleet. The fleet accounted for 71.7 percent of the Town of Hamilton's 2015 GHG emissions, most of which came from diesel fuel. In fact, of the emissions from the Town fleet, 84.8 percent of them came from diesel fuel usage. Therefore, we recommend that the Town of Hamilton prioritize reductions in diesel consumption to reduce its overall greenhouse gas emissions. Potential programs and policies to reduce diesel consumption are provided in section VIII of this report.

The first part of this report outlines a greenhouse gas inventory and can serve as a foundation for future reports. We hope that our work might be used as a benchmark for comparison moving forward, and that it helps highlight areas in which the Town of Hamilton should prioritize energy and fuel consumption reductions. Furthermore, we hope that this report might be used in the creation of a Climate Action Plan for the Town of Hamilton. This type of plan can be incorporated into the Town's general plan to create a more sustainable community. The recommendations provided in section VIII can be used as a foundation to begin this work and inform policies moving forward. Such policies would not only reduce the Town of Hamilton's GHG emissions, but they would also lead to cost savings and health benefits for the community members.

IX. Appendix

A. Greenhouse Gas Emissions Calculations

Heating Oil Consumptions: Table 1

(total heating oil consumption) x (conversion of 1 gallon of diesel to MMBtus) x (emission factor for diesel) / (1,000 because want Btus rather than MMBtus)

$$(4,166.90 \text{ gallons}) \times (0.1380 \text{ MMBtu/gallon}) \times (73.96 \text{ kg/MMBtu}) / 1,000 = 42.53 \text{ MTeCO}_2$$

Electricity Consumption: Tables 2-4

Town of Hamilton Electric Grid Emission Factor

The emissions factor that we used for the Town of Hamilton's electric grid comes from the eGrid NYUP CO₂e Emission Factor (note that 2014v2 is the most up to date). This number is 367.6 lb/mwh. To convert into the same units used in the GHG calculator tool, perform the following conversion:

$$\begin{aligned} (367.6 \text{ lb/mwh}) \times (1\text{kg}/2.2\text{lb}) &= 167.09 \text{ kg/mwh} \\ (167.09 \text{ kg/mwh}) \times (1 \text{ mwh}/1000 \text{ kwh}) &= 0.16709 \text{ kg/kwh} \\ (0.16709 \text{ kg/kwh}) \times (1 \text{ kwh}/0.0034 \text{ MMBTU}) &= 49.144 \text{ kg/MMBtu} \end{aligned}$$

The emission factor for the Town of Hamilton's electric grid is therefore 49.144 kg/MMBtu. This emission factor can be used for the following electricity calculations.

-- Tables 2 and 3:

Town Garage:

(total electricity consumption) x (conversion of 1 kwh to MMBtus) x (emission factor for Town of Hamilton electric grid) / (1,000 because want Btus rather than MMBtus)

$$(20,475 \text{ kwh}) \times (0.0034 \text{ MMBtu/kwh}) \times (49.144 \text{ kg/MMBtu}) / 1,000 = 3.43 \text{ MTeCO}_2$$

Town Office:

(total electricity consumption) x (conversion of 1 kwh to MMBtus) x (emission factor for Town of Hamilton electric grid) / (1,000 because want Btus rather than MMBtus)

$$(23,810 \text{ kwh}) \times (0.0034 \text{ MMBtu/kwh}) \times (49.144 \text{ kg/MMBtu}) / 1,000 = 3.99 \text{ MTeCO}_2$$

Solar Panel:

Take total electricity produced, and subtract from total electricity consumption for Town of Hamilton Garage and Office, to generate a new total. Then, do the following calculation for the new total:

(total electricity consumption) x (conversion of 1 kwh to MMBtus) x (emission factor for Town of Hamilton electric grid) / (1,000 because want Btus rather than MMBtus)

$$(26,368 \text{ kwh}) \times (0.0034 \text{ MMBtu/kwh}) \times (49.144 \text{ kg/MMBtu}) / 1,000 = 4.41 \text{ MTeCO}_2$$

To find the number of GHG emissions saved by the solar panel, subtract 4.41 MTeCO₂ from the

previous total of 7.42 MTeCO₂ to get 3.01 MTeCO₂.

--Table 4:

Poolville:

(total electricity consumption) x (conversion of 1 kwh to MMBtus) x (emission factor for Town of Hamilton electric grid) / (1,000 because want Btus rather than MMBtus)

$(9,245 \text{ kwh}) \times (0.0034 \text{ MMBtu/kwh}) \times (83.06345397 \text{ kg/MMBtu}) / 1,000 = 2.62 \text{ MTeCO}_2$

Hubbardsville:

(total electricity consumption) x (conversion of 1 kwh to MMBtus) x (emission factor for Town of Hamilton electric grid) / (1,000 because want Btus rather than MMBtus)

$(11,575 \text{ kWh}) \times (0.0034 \text{ MMBtu/kwh}) \times (83.06345397 \text{ kg/MMBtu}) / 1,000 = 3.28 \text{ MTeCO}_2$

Fuel Consumption: Table 5

Gasoline:

(total gasoline consumption) x (conversion of 1 gallon of gasoline to MMBtus) x (emission factor for gasoline) / (1,000 because want Btus rather than MMBtus)

$(2,693.3 \text{ gallons}) \times (0.1243 \text{ MMBtu/gallon}) \times (70.22 \text{ kg/MMBtu}) / 1,000 = 23.50 \text{ MTeCO}_2$

Diesel:

(total diesel consumption) x (conversion of 1 gallon of diesel to MMBtus) x (emission factor for diesel) / (1,000 because want Btus rather than MMBtus)

$(12,821.1 \text{ gallons}) \times (0.1380 \text{ MMBtu/gallon}) \times (73.96 \text{ kg/MMBtu}) / 1,000 = 130.86 \text{ MTeCO}_2$

B. Employee Commute Data Calculations

To calculate the emissions of each survey response, per year, we performed the following calculations. The details of the calculations are provided in the first conversion, and are not listed for the others since the logic is the same.

Note: m/mpg=gallons

To calculate individual totals per year:

(miles in commute)/(car mpg) = gallons used, one way

5 miles/32 mpg= 0.156 gallons, one way

(gallons used in commute one-way) x 2 = gallons used per day

(0.156 gallons) x 2 = 0.313 gal, per day

(gallons used per day) x (number of days employee commutes to work) = gallons used per week

(0.313 gallons) x 5 = 1.56 gallons per week — gasoline

(gallons used per week) x 52 weeks = gallons used per year

(1.56 gallons) x 52 = 81.25 gallons of gasoline per year

2 miles/21 mpg = 0.095 gallons, one way
(0.095 gallons) x 2 = 0.19 gallons, per day
(0.19 gallons) x 5 = 0.952 gallons per week — gasoline
(0.952 gallons) x 52 = 49.504 gallons of gasoline per year

5 miles/12 mpg = 0.4167 gal, one way
(0.4167 gallons) x 2 = 0.8334 gal per day
(0.8334 gallons) x 6 = 5.0004 gallons per week — gasoline
(5.0004 gallons) x 52 = 260.02 gallons of gasoline per year

3 miles/21 mpg = 0.1428 gal, one way
(0.1428 gallons) x 2 = 0.2857 gal, per day
(0.2857 gallons) x 5 = 1.428 gallons per week — gasoline
(1.428 gallons) x 52 = 74.2857 gallons of gasoline per year

3 miles/15 mpg = 0.2 gal, one way
(0.2 gallons) x 2 = 0.4 gal per day
(0.4 gallons) x 5 = 2 gallons per week — gasoline
(2 gallons) x 52 = 104 gallons of gasoline per year

3.5 miles/18 mpg = 0.194 gal, one way
(0.194 gallons) x 2 = 0.388 gal per day
(0.388 gallons) x 4 = 1.56 gal per week — gasoline
(1.56 gallons) x 52 = 80.89 gallons of gasoline per year

To find the total for all 6 FTE:

81.25 gallons + 49.504 gallons + 260.02 gallons + 74.28 gallons + 104 gallons + 80.89 gallons =
649.94 gallons of gasoline per year

^ per 6 FTE

Calculate average of 6 FTE to extrapolate for 6 part-time employees (3 FTE):

Average miles per employee = (5 miles + 2 miles + 5 miles + 3 miles + 3 miles + 3.5 miles)/6 =
3.58 miles

Average mpg per employee = (32 mpg + 21 mpg + 12 mpg + 21 mpg + 15 mpg + 18 mpg)/6 =
19.83 mpg

Based on this, calculate gallons used for one person. Then, multiply this by 3 to get the total additional gallons used for the 6 part-time employees.

3.58 miles/19.83 mpg = 0.181 gal, one way
(0.181 gallons) x 2 = 0.361 gal per day

$(0.361 \text{ gallons}) \times 5 = 1.805 \text{ gal per week}$
 $(1.805 \text{ gallons}) \times 52 = 93.88 \text{ gallons of gasoline per year}$

6 PTE = 3FTE
 $3 (93.88 \text{ gallons}) = 281.63 \text{ gallons}$

Add the two totals together to obtain the total for the 9 FTE:
 $649.94 \text{ gallons} + 281.63 \text{ gallons} = 931.57 \text{ gallons of gasoline per year}$

Calculate the GHG emissions:

(total gasoline consumption) x (conversion of 1 gallon of gasoline to MMBtus) x (emission factor for gasoline) / (1,000 because want Btus rather than MMBtus)

$(931.57 \text{ gallons}) \times (0.1243 \text{ MMBtu/gallon}) \times (70.22 \text{ kg/MMBtu}) / 1,000 = 8.13 \text{ MTeCO}_2$

B. LED Lighting District Conversion Case Studies

Tarentum, PA

- Geographic and demographic background
 - Borough in Allegheny County, PA
 - Total area of 1.4 square miles
 - 22 miles northeast of Downtown Pittsburgh, along the Allegheny River
 - Old industrial manufacturing town
 - Population in 2010 census was 4,530
- Program details
 - General Electric (GE) conducted an audit of Tarentum's high-pressure sodium-vapor street lighting (General Electric, 2017)
 - The street lighting was comprised of 310 100-watt fixtures and 120 250-watt fixtures
 - Old street lighting consumed 335,771 kWhs of electricity annually
 - Estimated that GE's Evolve LED Roadway fixtures would only consume 112,517 kWhs annually
 - Retrofitted 430 street lights with dimmable and programmable new LED lighting fixtures (General Electric, 2017)
 - GE's Monitor Stand-Alone Controllers → allow the borough to dim the lights to a prefixed percentage during the evening
 - Dims the streetlights to a 30-percent reduction in light output from 12-5am
 - Saves the city ~66 percent annually in energy and maintenance costs (~\$40,000)
 - Based on a \$0.10 kWh rate and 4,000 hours of operation per year

Various Towns in Iowa

Many towns in Iowa with characteristics similar to those of the Town of Hamilton have implemented programs to retrofit their streetlights to LED. The following figures provide background on these programs, which will also be discussed in more depth below.

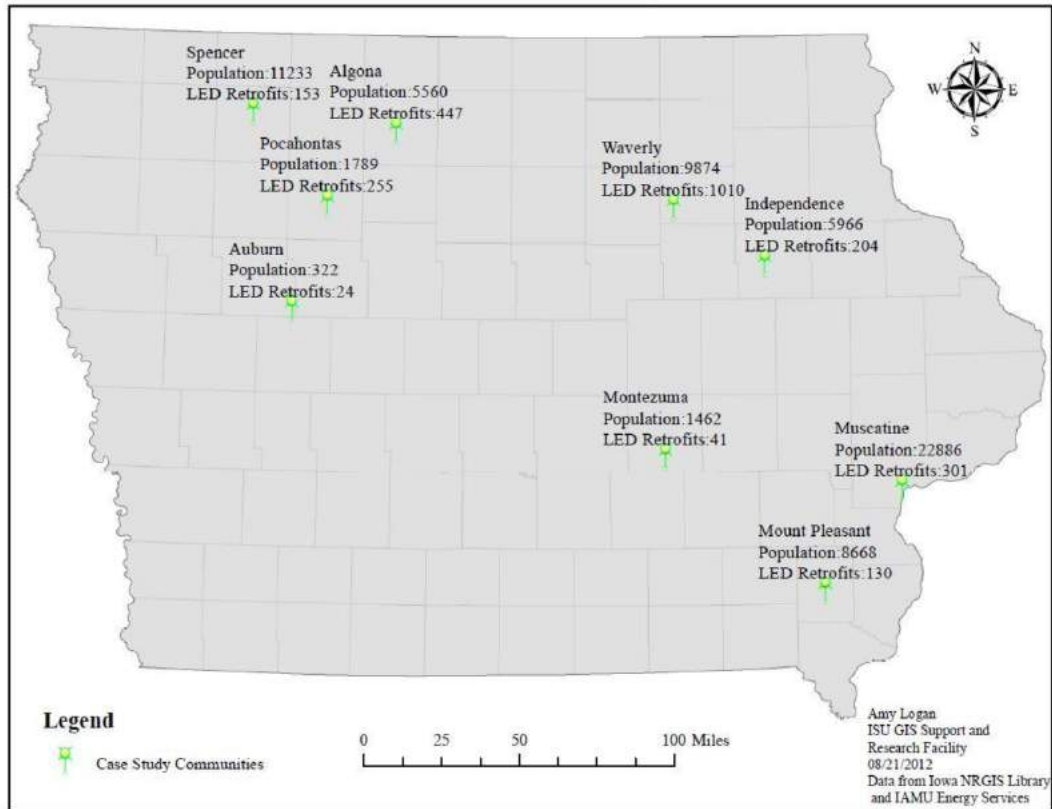


Figure 11: Iowa Case Study Communities

Source: Kimber (2013)

Figure 11 depicts the nine Iowa communities in which these LED conversion programs took place, as well as a bit of information about them. More detail about each community is described in Table 11, which provides a sense of which towns might be the most similar to the demographics of the Town of Hamilton.

Community	County in Iowa	Area (square miles)	Population (in 2010 census)
Algona	Kossuth	4.51	5,560
Auburn	Sac	0.50	322
Independence	Buchanan	6.22	5,966
Montezuma	Poweshiek	2.49	1,462
Mount Pleasant	Henry	8.53	8,668
Muscatine	Muscatine	18.35	22,886
Pocahontas	Pocahontas	2.02	1,789
Spencer	Clay	11.18	11,233
Waverley	Bremer	11.51	9,874

Table 11: Geographic and Demographic Characteristics of Iowa Case Study Locations

While Table 11 summarizes geographic and demographic characteristics of the nine case study location in Iowa, Table 12 describes information about each LED street light retrofit project.

Case Study Community	Total Number of Retrofits	Estimated Annual Energy Savings from LED Retrofits (kWh)	Energy Savings as Percentage of Original Energy Usage Pre-Retrofit
Algona	447	234,254	46%
Auburn	24	37,864	78%
Independence	204	99,154	45%
Montezuma	41	21,460	41%
Mount Pleasant	130	70,378	57%
Muscatine	301	155,534	51%
Pocahontas	255	105,639	43%
Spencer	153	57,632	29%
Waverly	1010	403,805	63%
Totals	2565	1,185,720	50%

Table 12: Summary of Energy Savings from LED Street Light Retrofit Projects Featured in Iowa Case Studies

Source: Kimber (2013)

As shown in Table 12, the average energy savings as a percentage of the original energy usage pre-retrofit is 50 percent. Some communities experienced higher cost savings than others, which is likely due to factors unique to each town.

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