2018 Municipal & Community Greenhouse Gas Inventory

City of Portsmouth, New Hampshire

September 2019

UNH Sustainability Institute

Introduction

In November 2007, the City Council of Portsmouth, New Hampshire unanimously passed a resolution to become an Eco-municipality, confirming a commitment to the principles of sustainability moving forward. This vote signifies Portsmouth's aspirations to develop a socially, economically, and ecologically healthy community for long term growth and development. Four sustainability principles that are used to guide decision making include:

1. Reduce dependence upon fossil fuels and extracted underground metals and minerals;
2. Reduce dependence on chemicals and other manufactured substances that can accumulate in nature;
3. Reduce dependence on activities that harm life-sustaining eco-systems; and
4. Meet the hierarchy of present and future human needs fairly and efficiently.[1]

In addition, the City established a Renewable Energy Committee led by City Councilor Josh Denton that wrote a report which incorporated a number of potential actions the City can take to reduce its greenhouse gas emissions. In addition, at that committee's recommendation, the City Council adopted a Renewable Energy Policy which anticipated use of the actions from the committee's report to accomplish specific reductions in greenhouse gas emissions .[2]

The City also signed a resolution agreeing to prioritize the effort needed to meet the Paris Climate Agreement. As part of the effort to measure sustainable progress, the Portsmouth City government periodically measures its municipal and community greenhouse gas (GHG) emissions. Using the software and guidance documents provided by the International Council for Local Environmental Initiatives (ICLEI), the City of Portsmouth has completed three inventories to date. This report updates Portsmouth's municipal and community greenhouse gas inventory for the 2018 calendar year and provides an assessment of changes in energy usage since 2006 and greenhouse gas emissions since 2012. The municipal inventory includes all emissions and usage resulting from the operation of city government buildings and facilities, municipally operated vehicles, employee commute, street and traffic lights, and water and wastewater facilities. The community analysis portion includes all residential, commercial, industrial, and transportation emissions occurring within the Portsmouth city limits, as well as emissions resulting from waste created within the city and sent to external disposal locations. The inventory results are followed by suggestions on curbing emissions further going forward. Emissions from 2006 are not taken into account for this assessment because this inventory had used global warming potential (GWP) values from the Intergovernmental Panel on Climate Change (IPCC) that have since been revised; meaning these calculations are now outdated. Also to note, when looking at the energy usage data from 2012, some discrepancies were observed when analyzing values for certain sectors. The 2012 energy usage data that remained viable will be analyzed compared to 2018 usage in this report.

References

1. https://www.cityofportsmouth.com/sustainability/eco-municipality

2. http://files.cityofportsmouth.com/files/planning/renewableenergypolicy.pdf

Methodology

The majority of data was collected and processed using the methodologies outlined in ICLEI's Local Government Operations Protocol (LGOP) and the Community Protocol.[3] Methodologies that deviate from either are specified in the respective sections below. Every effort was made to utilize the same methodologies as those used in the 2012 inventory; with deviations made only for improving accuracy or adjusting for differences in the data obtained. The main differences result from changes in the data available for the 2018 inventory. The known differences between the 2012 inventory and the 2018 update are listed within each subsection. Whereas the 2006 inventory was based on the 2006 fiscal year, the 2012 and 2018 inventories were calculated using calendar year, as is the ICLEI recommendation. The government data was collected and processed in various excel spreadsheets and then entered into ICLEI's Clearpath software. The community data was entered directly into this software, with a few exceptions. The Clearpath software calculates greenhouse gas emissions resulting from electricity consumption, fuel use, waste disposal, and other processes and fugitive sources. To simplify the data output, the program converts all of the gases into one value shown as metric tons of CO2 equivalent (tonnes CO2e or MTCDE) utilizing the relative greenhouse equivalent of each gas; specified by the IPCC's GWP values.[4] Once the data was fully entered into the software, a report was generated detailing the energy consumption and greenhouse gas emissions produced by the city government and by the community. The analysis in this inventory is based on the Clearpath software reports.

Emission factors vary depending on the mix of energy-generating fuels used by the electricity provider, or in the case of vehicles, by the gasoline, diesel, or electric mix used. The Clearpath software does not provide electricity emission factors for New Hampshire. Emission factors from the three inventories differ (Table 1). Whereas the emission factors for 2018 are based on the most recent New England Grid factors (NEWE 2018)[5], 2012 values were calculated using local New Hampshire electrical production data. The factors used in the 2006 inventory were based on U.S. Environmental Protection Agency estimates for the New England grid similar to the current inventory. It is likely that if the 2012 emission factors were calculated based on the NEWE grid source mix, the CO2 emissions reported in the 2012 inventory would have been slightly lower; due to the higher use of coal in New Hampshire around 2012 compared to the rest of New England. This is determined by the factor set of electrical production; an evaluation of how many pounds of specific greenhouse gasses are emitted per 1 MWh of electricity. Since then, coal-generated electricity in the state has been reduced, enabling New Hampshire to have a cleaner electrical production factor set than the NEWE consumption grid average. However, the NEWE factor set is used in this inventory due to the inability to track the movement of electrons from source to end use. Furthermore, with Portsmouth's proximity to both Massachusetts and Maine, it is difficult to determine if the NH electrical production factors were truly accurate for the city to begin with.

References

3. http://icleiusa.org/ghg-protocols/

4. https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

5. https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf

The City

The city of Portsmouth makes up the northern-most point of New Hampshire's eighteen mile coastline. The 16.8 square mile city is a cultural and commercial hub for the northeastern coastline; with its crossing of an interstate, two national routes, three state routes, and three rail lines. Settled first in 1630, the city has now grown to an estimated 21,896 (as of 2018) and continues to be a growing regional hub for both commerce and industry as the city upgrades and further enhances its historic downtown.[6]

Image 1: Overview Map of Portsmouth, NH

[https://www.iqboatlifts.com/boat-lifts-portsmouth-nh/]

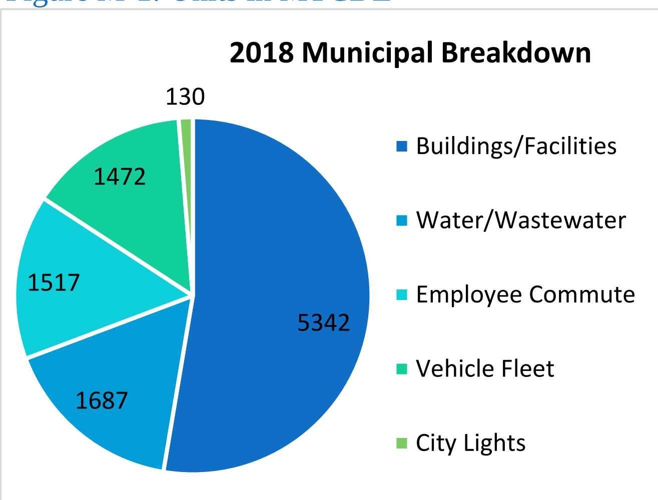
References

6. https://www.census.gov/search-results.html?searchType=web&cssp=SERP&q=Portsmouth%20city,%20NH

Municipal Greenhouse Gas Inventory

The municipal focused portion of the inventory reports total greenhouse gas emissions resulting from the energy consumption from government buildings and facilities, fuel usage from vehicles under the operational control of the city and employee commute of municipal workers, street and traffic lights, and energy usage from water and wastewater locations; all during the 2018 calendar year. City government operations resulted in 10,148 tonnes of CO2 equivalent emissions during the 2018 calendar year. Buildings made up the majority of this amount with 52.64% of emissions, followed by water and wastewater facilities with 16.62%, employee commute accounted for 14.95%, vehicle fleet had 14.51%, and city lights accounted for only 1.28% of emissions (see Figure M-1).

Figure M-1: Units in MTCDE



The City's overall municipal emissions from energy consumption decreased 34.19% percent between 2012 and 2018 (Figure M-2). Although this was partially the result of improvements in energy efficiency, it should be noted the emissions improvements from the electric grid plays an important role in these decreases (see Table 1). The New England grid overall has gotten cleaner by 24.09% since 2006, and 57.66% from the New Hampshire electric production factor set used for 2012.

Figure M-2: Emissions Compared to 2012 Inventory

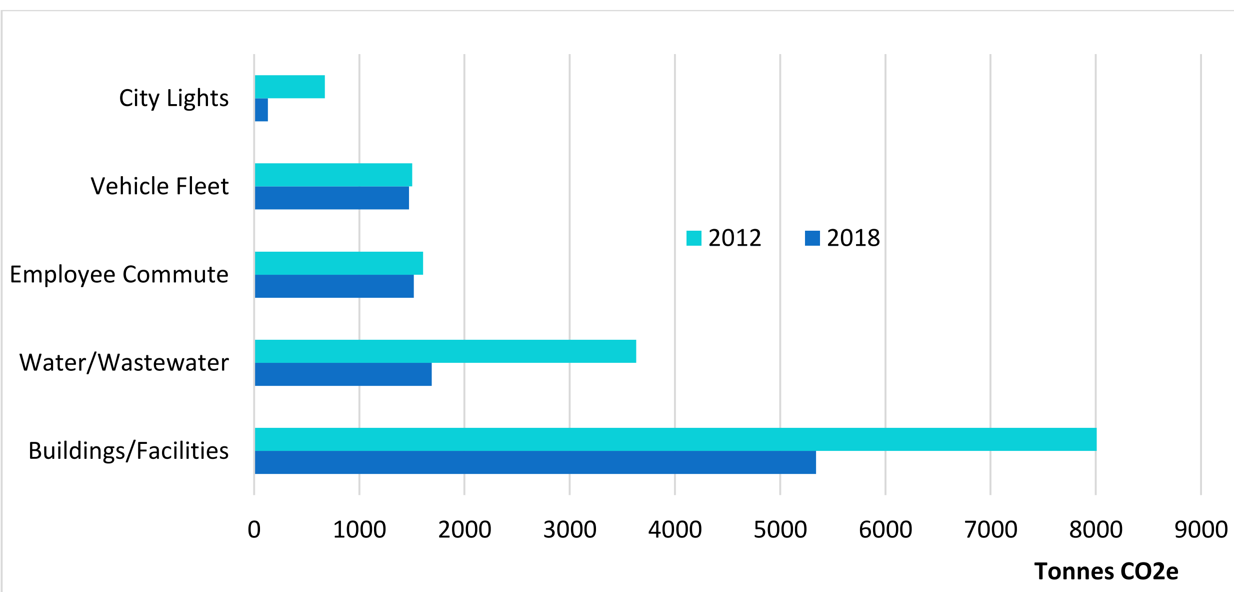
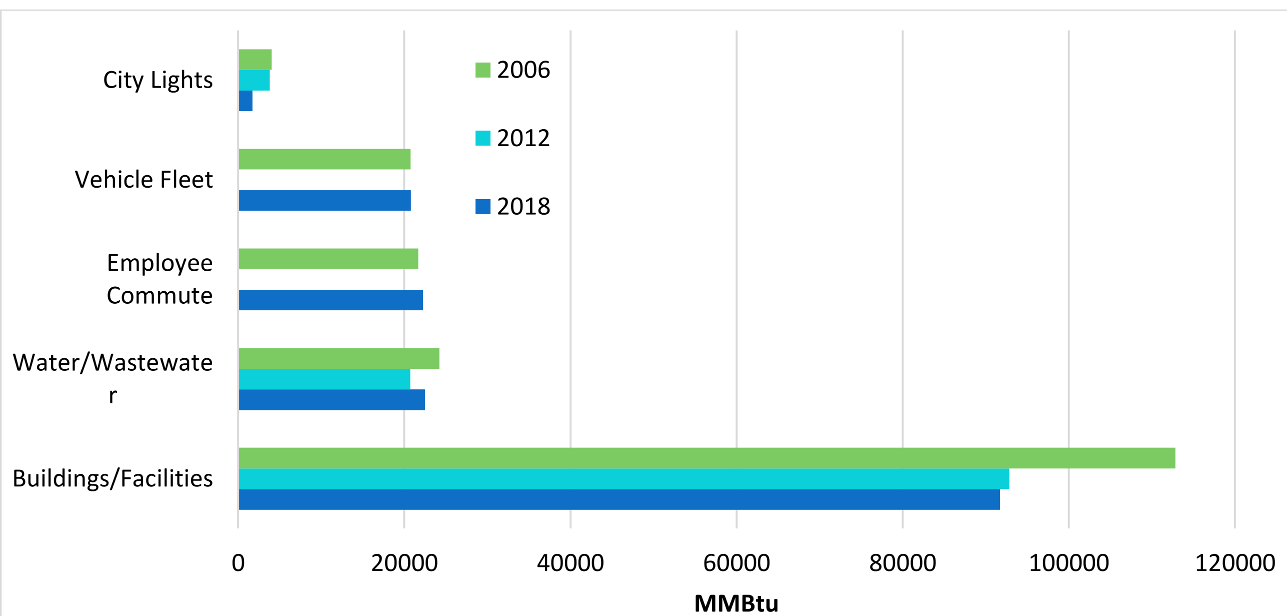


Table 1: Electric Grid Factor Sets (lbs/MWh)

Year	CO_2	CH_4	N2O
2006	709.5	0.113	0.144
2012	1,300.40	0.29	0.088
2018	558.2	0.09	0.012

Significantly, the city has decreased its total energy consumption by 13.3% from 2006, which occurred due to actions taken by the city government (Figure M-3). This energy decrease has been the result of downsizing the overall building square footage operated by the City, the construction of two LEED Silver facilities and a similar accreditation for one of the schools, improvements in energy efficiency, purchasing more efficient vehicles, and upgrades in street and traffic lights around the city. Emissions from stationary combustion of diesel and propane fueled emergency generators, CH4 and N2O emissions from the vehicle fleet and employee commute, and effluent emissions from wastewater treatment were not included in the 2006 inventory, but will be reported in this inventory as it was in 2012. Generator emissions were grouped together for buildings and facilities, and attributed to their billed address for water and wastewater locations. Fugitive emissions from mobile air conditioning units were excluded from this inventory due to the uncertainty of accuracy for 2012 or ability to obtain accurate data for 2018; this provided for 0.065% of total municipal emissions in the 2012 inventory. Overall, the methodology used was to try and recreate the 2012 inventory for the best possible analysis, while not sacrificing accuracy in the data.

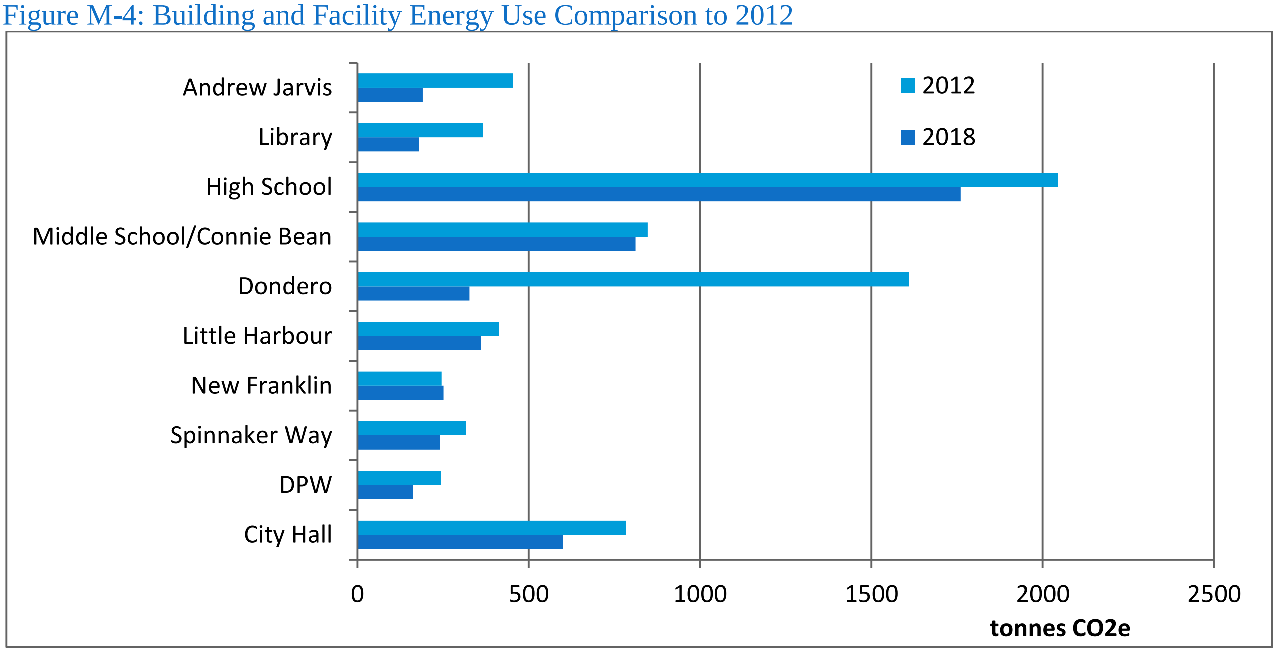
Figure M-3: Energy Usage Comparison to Previous Inventories



Buildings and Facilities

Buildings and facilities had the largest amount of curbed emissions by sector. These emissions were calculated from usage of electricity, natural gas, and propane from each location. Electric emissions were based on the factor set of the NEWE grid and emissions for propane and natural gas were attributed by the amount of emissions resulting from combustion of each. It should be noted that the Connie Bean Recreational Center was built on to the middle school building since the last inventory, therefore they are entered as one unit and are to be compared to the sum of the previous middle school data and the data from the old center's location; 135 Daniel St. Compared to 2012, municipal buildings and facilities decreased emissions 33.29%; a reduction of 2,666 tonnes CO2e. With both the largest quantitative and percentage drop in emissions, the Dondero school was able to decrease its 2012 emissions by 1,283 tonnes CO2e; nearly an 80% reduction. Other notable reductions include Andrew Jarvis Drive pool with nearly 58% less emissions, the library with a 50.82% decrease, the Public Works building with a 33.61% reduction, City hall with 23.24% decrease and Spinnaker Way with just under a 24% of curbed emissions. The high school remains the largest emitter at 1,761 tonnes CO2e, even with a 13.89% reduction from 2012. This number would be further decreased by 86 tonnes CO2e, if the school retained the renewable energy credits (RECs) from the 335 MWh of electricity it received from its new rooftop solar installation. Projects like this would have a greater impact on emissions if these RECs were retained. While there have definitely been improvements made in energy efficiency, it should be noted that the improvements to the grid also play a large part in these reductions. Since 2006, energy usage for buildings and facilities has dropped by 18.69%, but there has only been a 1.2% reduction from 2012. Therefore, given all the improvements made since the last inventory, grid improvements had a greater impact on the reduction of emissions, rather than overall consumption. Further reductions could be realized if the City were to increase its focus on energy efficiency for these buildings. Although a number of sites have shown solid improvements, there is a fairly small amount of overall efficiency through energy reductions since 2012.

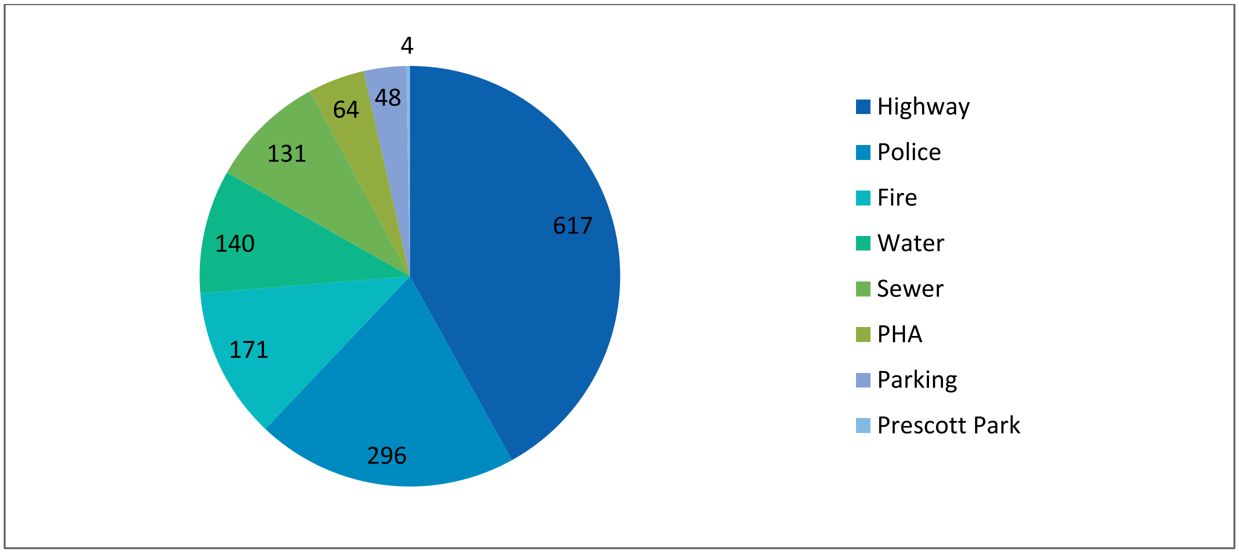
Figure M-4: Building and Facility Energy Use Comparison to 2012



Vehicle Fleet

Vehicle fleet emissions decreased marginally compared to the previous inventory. This was determined by obtaining fuel usage data from the municipal pump located at the Public Works building. This data was categorized by department and added up based on the total fuel usage of each type of fuel; E10 gasoline, B5 diesel, and B20 diesel. Once these totals were obtained, emissions were calculated based on the amount of CO_2, CH_4, and N_2O emitted from each fuel blend.[6] The sections for fleet data were categorized as received from the gas pump tracking system and do not necessarily correlate with the categorization done previously. Additionally, all emissions were input together per each fuel type by department. Previously, this had been separated by emissions and new/old vehicles as well, which had given possibly inaccurate total energy usage amounts, due to redundancies. Overall, since 2012, emissions for vehicle fleet in this inventory were decreased by 2%. Highway department vehicles account for 41.9% of vehicle fleet emissions, followed by police vehicles with 20.1% and the fire department with 11.6%; adding up to over 70% of all vehicle emissions. The combined Water and Sewer categories contributed another 18.4% of vehicle fleet emissions. It may be difficult to cut down on driving time for municipal operations but as vehicle efficiency improves these reductions will increase. Overall, vehicle fleet emissions did not decrease a substantial amount compared to the other sectors of this inventory.

Figure M-5: Vehicle Fleet Breakdown (MTCDE)



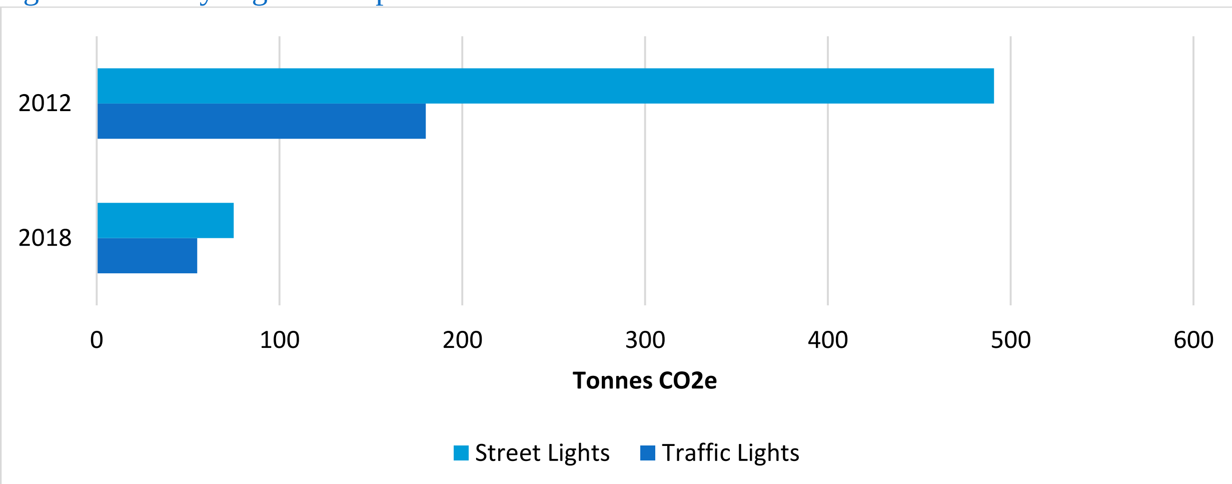
Employee Commute

Employees driving to and from their place of work leads to considerable amounts of carbon equivalent emissions for the municipality. To gather this information, a survey was created and distributed among municipal employees. This survey asked participants a number of questions in order to precisely obtain data on how far employees live from work, how they get to work throughout the week, and the fuel efficiency of their vehicles (SEE APPENDIX). Just over 300 employees responded with usable answers. This number was extrapolated to 970 employees; based on email accounts and values estimated per department. Previously, this had also been separated by emissions and new/old vehicles as well, which had given possibly inaccurate total energy usage amounts due to redundancies. Based on the survey, 98.66% of employees drove gasoline vehicles, 1.01% drove diesel, and 0.34% drove electric vehicles. These percentages were extrapolated for the whole municipal workforce based on average commute distances and fuel efficiencies to get the yearly consumption of each fuel type. This data was transferred to emissions by using normal fuel blends and combustion ratios determined by the EPA.[6] Overall, emissions from employee commute were decreased by a total of 5.54% from 2012. There are different programs to encourage carpooling and greater participation would be beneficial however it is still subject to personal preference and not something that is enforceable. It should be noted that over 75% of people that filled out the survey noted that they drive a car alone to work every single day. The region has limited public transportation and given that many people live in rural areas this is not likely to improve to allow commuting by public transportation in the near future. However, even with a higher number of employees, emissions from employee commuting still experienced a marginal decrease from 2012.

City Lights

City lights exhibited a dramatic decrease in energy consumption and emissions which is reflected in the 2018 data. This data was separated into two inputs. Traffic lights were considered any of the city lights that were paid for on meters, and owned by the city. These emissions values were gathered from Eversource utility statements and evaluated based on the NEWE grid factor set. Streetlights were defined as the lights owned and operated by Eversource. The city of Portsmouth is billed for this using the quantity and types of fixtures, each type's energy consumption rate, and the average total hours of darkness per year. The electrical energy equivalent for total city lights in 2018 was 1,735 MMBtu. This value shows a 56.8% decrease in energy consumption since 2006, and a 54.3% decrease from 2012. In 2018, traffic lights alone used 730.5 MMBtu and emitted 55 MTCDE. Compared to 2012, this was a 69.4% decrease in carbon equivalent emissions and a 28.2% decrease in energy consumption. Although traffic light LED upgrades were already taking place before the 2012 inventory, these lights were only upgraded as needed, meaning that the consumption decrease is likely the result of continued upgrades. Streetlights consumed 1,004.5 MMBtu in 2018, emitting 75 MTCDE. The entire streetlight system was upgraded to LEDs at the end of 2016 and the beginning of 2017. This explains how since 2012, streetlights experience a 62.7% decrease in consumption and a 84.7% decrease in carbon equivalent emissions. The combined upgrades enabled city lights to reduce carbon equivalent emissions 80.6% from 2018; to a value of only 130 MTCDE. While this decrease can be attributed to greater energy efficiency, it should also be noted that the grid emissions have changed as well, and have gotten cleaner as a result. Although city light emissions remains the least impactful sector, some suggestions could be made to drive this down further. The most viable of these could be turning on fewer lights or for less time driving down consumption itself. Management of the street lights would enable the lights to run cleaner at their current capacity. Considering this is the most dramatic decrease in both energy consumption and carbon equivalent emissions, efficiency efforts would likely be hard to achieve in this sector at the current time. Overall, the upgrades completed on city lights since 2012 can be attributed to the dramatic 80.6% decrease in carbon equivalent emissions and 54.3% decrease in consumption; the largest proportional decrease experienced in the municipal inventory.

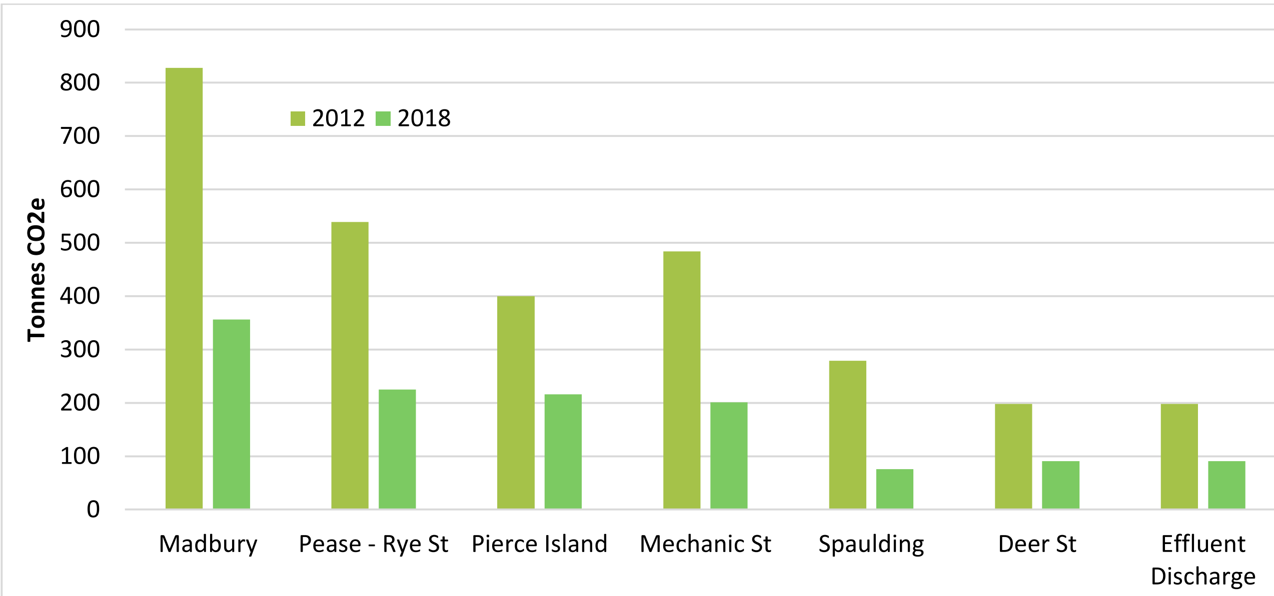
Figure M-6: City Lights Comparison to 2012



Water and Wastewater

Water and Wastewater locations decreased emissions considerably compared to 2012. The 2012 inventory had separated both water delivery and wastewater management locations. However, due the change in software, these two sectors have been bundled together. These emissions were calculated from usage of electricity, natural gas, and propane from each location. Electric emissions were based on the factor set of the NEWE grid and emissions for propane and natural gas were attributed by the amount of emissions resulting from combustion of each. Effluent nitrogen emissions were calculated and given by the sewer department. It should be noted that effluent emissions were lowered in this inventory due to Pierce Island being under construction with reduced operations and not experiencing nitrification processes. Therefore the Pease wastewater plant is the only plant where nitrification is calculated. When compared to 2012, emissions from water and wastewater sites were decreased by 53.6%. The highest emitting locations from 2012 all were able to decrease emissions by drastic amounts. The Madbury water treatment plant had the largest quantitative decrease in emissions with a 472 tonnes CO_2e averted; a 57% drop. The Madbury plant would experience an even further reduction, however, they do not retain the renewable energy credits (RECs) from the recently constructed solar field on the property; per the power purchase agreement made. For the 2018 calendar year, this accounted for nearly 327 MWh of electricity for the water delivery plant and would have decreased emissions a further 84 tonnes CO2e if RECs were retained. The Spaulding Turnpike station experienced a 72.76% decrease in emissions from 2012; the largest decrease percentage-wise. Including both Madbury and Spaulding, Mechanic St and Pease (Rye St) locations all had decreases of over 200 tonnes CO2e; each accounting for a 57% decrease since 2012 or greater. Of the seven largest emitting sources from 2012, all but one was able to decrease their emissions by over 50%.

Figure M-7: Water and Wastewater Emissions Comparison



These numbers are quite astounding, but in addition to some efficiency upgrades made, it should be noted that the improvements in the grid also account for a large portion of averted emissions. When looking at energy efficiency, water and wastewater locations actually increased energy consumption 8.51% since 2012, but still experienced drastically decreased emissions. Since 2006 however, water and wastewater locations have decreased consumption overall by 7.22%. Although water and wastewater locations experienced such drastically decreased emissions, there is still room for improvement as far as energy efficiency is concerned. Initiatives like the Madbury solar field will show themselves as greater impacts if the panels are purchased by the City and the RECs are no longer sold. Overall, the decrease in emissions experienced by water and wastewater locations is certainly a great improvement. Being that it is one of two municipal sectors to decrease emissions over 50%, these results are noteworthy.

Municipal Summary

Municipal operations in 2018 experienced a 34.19% reduction of greenhouse gas emissions, compared to 2012. Buildings and facilities contributed to just over half of all emissions, as it did in 2012; but this sector also experienced the largest quantitative decrease since 2012. Buildings and facilities reduced emissions 2,666 tonnes, or nearly a third of the 2012 value. Water and wastewater facilities composed the second most emissions, with 16.62% of the total; a much smaller component than the 23.56% from 2012. This sector's emissions were reduced by a whopping 53.6%; with all of the largest facilities experiencing dramatic reductions to help make this possible. Employee commute and vehicle fleet emissions each comprised of 14.95% and 14.51% of government emissions; each accounting for 10% in 2012. Both of these categories did not see much notable progress since 2012. City lights may have only accounted for 1.28% of total municipal emissions in 2018, but it was also able to achieve an emissions reduction of 80.6% since 2012; the largest percentage decrease experienced. Although city infrastructure upgrades helped contribute to this decrease, the improvement in the grid also plays a very large role in making many of these reductions feasible. Since 2006, municipal energy consumption has decreased 13.3%; completely attributed to city infrastructure improvements. Looking forward, further upgrading building and facilities for greater efficiency should be the top priority. Because this still makes up a vast amount of the emissions and consumption, there is certainly more that can be done. Although this may be a very large undertaking, it would be an important focus if the city wishes do continue driving down emissions. The same thing can be said for the water and wastewater facilities. This could be considered slightly less of a priority, due to the great improvements from 2012, as well as this being a much smaller portion of the total. However, if the city hopes to move towards carbon neutrality this would be another huge project that would have to be addressed. Municipal vehicle fleet improvements could be achieved through the use of more fuel efficient vehicles. Employee commute may be the most difficult to address due to the inaccessibility of public transportation in the region, as well as inability to control how employees choose to get to and from work. Even though the city has done much to reduce municipal emissions, it is important for the city to look forward to what the next steps are. Because the city cannot control the grid itself, municipal improvements should be focused on energy efficiency, reducing fossil fuel use, and further implementing renewable energy solutions as needed.

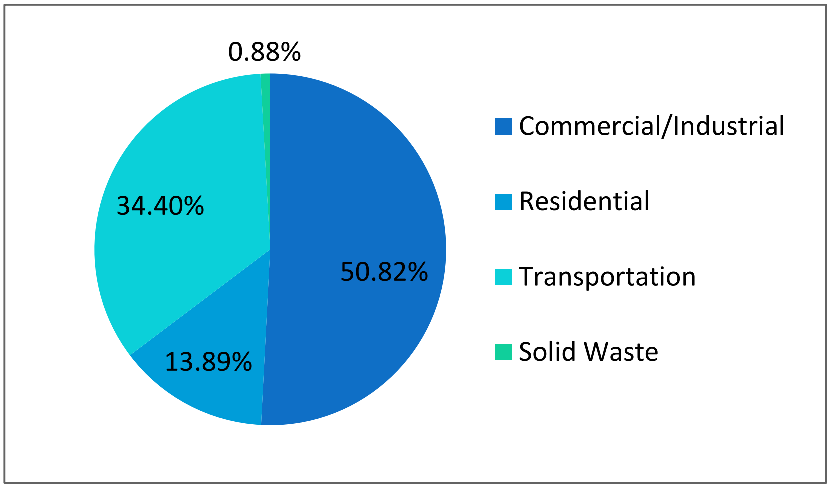
Table M-1: Municipal Emissions and Energy Use Overview

	MTCDE			MMBtu		
Sector	**2018**	**2012**	**Change**	**2018**	**2006**	**Change**
Buildings/Facilities	5,342	8,008	-33.29%	91,742	112,827	-18.69%
Water/Wastewater	1,687	3,632	-53.55%	22,475	24,223	-7.22%
Employee Commute	1,517	1,606	-5.54%	22,273	21,659	2.83%
Vehicle Fleet	1,472	1,502	-2.00%	20,777	20,748	0.14%
City Lights	130	671	-80.63%	1,735	4,018	-56.82%
Total	**10,148**	**15,419**	**-34.19%**	**159,002**	**183,475**	**-13.34%**

Community Greenhouse Gas Inventory

The community portion of this inventory includes emissions from the whole city. This is composed of emissions from residential, commercial, industrial, transportation, and waste sources within the city. Commercial and industrial emissions combined for about half of all community emissions and vehicle transportation attributed to over a third. The remainder consisted of primarily residential emissions; with less that 1% coming from waste production.

Figure C-1: Breakdown of Community Emissions



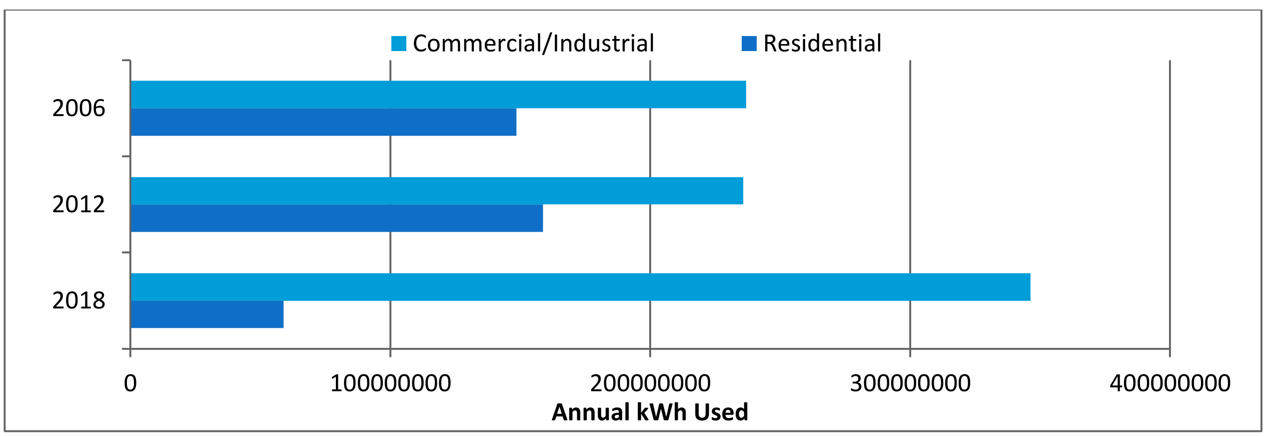
Pease Tradeport was excluded from this inventory, as it was in the previous two inventories. This was not only for the purpose of maintaining an accurate evaluation, but also due to the difficulty in trying to get accurate data of the emissions specifically pertaining to areas within the city limits. The same can be said for boats coming and going from the city's harbor. Waste and transportation data for this inventory were also not compared to 2012 values; due to observed inaccuracies in the data reported then, compared to what was gathered for this inventory. Therefore, an overall breakdown comparison to 2012 and total emissions comparison to 2012 will not be exhibited.

However, breakdowns for individual sectors that were determined to be viable will be exhibited in this report. As part of the electrical data received, the commercial and industrial sectors were combined into one category, therefore this was used when referring to heating fuel usage as well. Because municipal emissions were counted within the commercial sector for 2012, it will remain as part of the commercial and industrial sector in this inventory. Estimations were made when specific data could not be obtained. This includes estimations regarding breakdowns and usage of natural gas and heating fuels, as well as vehicle type breakdowns for transportation. Overall, the city of Portsmouth, as a community, accounted for a total of 429,378 MTCDE, with 2.36% of these emissions being accounted for by municipal operations.

Electric Usage

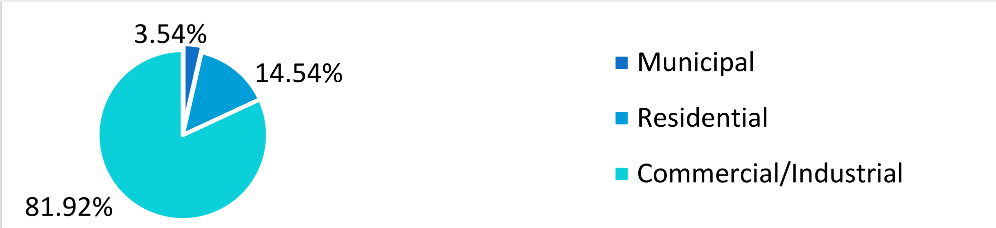
Electrical data was given directly by Eversource. This included a breakdown of usage by residential, municipal, and commercial/industrial sources. Residential electricity usage decreased 62.89% since 2012; attributed to an emissions reduction of 84.1%, or over an 80,000 MTCDE decrease. It is quite remarkable as to how residential electricity usage was able to be decreased by such a large amount, especially considering the more widespread use of technology. While it is difficult to determine what exactly was the cause for this, things like upgrading light bulbs and water heaters, as well the growing use of home solar panels, could be likely conclusions. An alternative explanation could be that the way Eversource chose to distinguish residential and commercial and industrial activities changed from 2012 to 2018. Given the difficulty in acquiring the electrical data from Eversource and the lack of transparency in how the data was calculated, questions remain unanswered on this point. Other than the data provided there was little explanation of how the numbers were arrived at by the utility company. While it is very helpful that the electrical utility provided the information for the community usage it is a process that could be vastly improved. More background and resolution on how the electrical utility information is collected and provided would make the community section much more valuable understandable and useful and increase confidence for making recommendations on future improvements. Commercial and Industrial sources used 40.8% more electricity than in 2012. This is most likely due to an increase in commercial development in the city, bringing more business along with it. However, even with this usage increase, emissions attributed to electrical usage were still able to be dropped by 39.68%; due to improvements in the grid. Based on the fact that the commercial and industrial sector accounted for nearly 82% of total electrical usage, as well as that electrical consumption actually increased; the city should look for ways to make these businesses more responsible for their emissions.

Figure C-2: Electrical Usage Since 2006



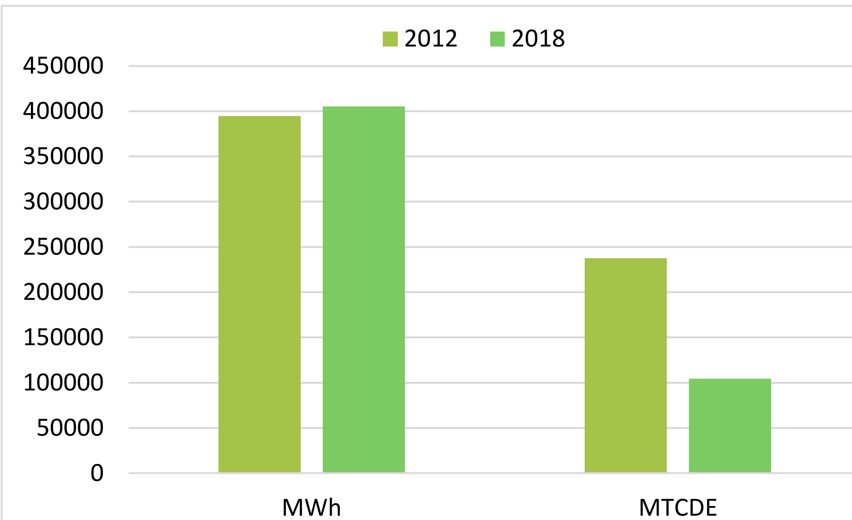
Municipal electrical usage as a whole was not given separately by the utility in 2012, instead being added into the commercial category. Municipal electrical usage only made up 3.54% of the 2018 total. This is included with the commercial and industrial sector for comparisons.

Figure C-3: Electrical Usage Breakdown



Overall, electricity usage in the city increased 2.71% since 2012 to a total of 405,169,638 kWh. However, emissions from this usage was decreased 133,088 MTCDE; or 56%.

Figure C-4: Comparison of Electrical Usage and Emissions to 2012



Because city electrical usage actually increased, all emissions reductions are solely attributed to a cleaner grid (see Table 1).

Table 1: Electric Grid Factor Sets (lbs/MWh)

Year	CO_2	CH_4	N2O
2006	709.5	0.113	0.144
2012	1,300.40	0.29	0.088
2018	558.2	0.09	0.012

The electrical usage as a whole accounted for 24.68% of city emissions; a total of 104,576 MTCDE.

Table C-1: Electrical Usage and Emissions Overview

Sector	2018		2012	
	kWh	MTCDE	kWh	MTCDE
Residential	58,909,338	15,205	158,735,693	95,639

Commercial/Industrial	346,260,300	89,371	235,726,044	142,025
Total	**405,169,638**	**104,576**	**394,461,737**	**237,664**

Natural Gas, Propane, and Fuel Oil

The bulk natural gas data was given by Unitil; a total of 23,975,310 therms of natural gas. It should be noted that to get any data from Unitil it took many requests. They were very reluctant to provide natural gas information for the municipality as a whole and would not provide any breakdown of the overall total usage for 2018. Considering a breakdown was not included in what was provided, it was assumed that the natural gas usage percentages from 2012 remained unchanged. Based on the 2012 natural gas breakdown, 17.46% of total natural gas was used by city residents and the remaining 82.54% was used by the commercial and industrial centers. Because the electrical breakdown given by Eversource combined both the commercial and industrial sectors, they have been combined here as well to establish a more accurate comparison. These percentages were then used to estimate how much natural gas both of these sectors used in 2018. Residential use accounted for over 4 million therms, and the commercial and industrial sectors accounted for almost 20 million therms.

Fuel oil and propane usage for the commercial and industrial sector were estimated in roughly the same way as the natural gas breakdown. Based on the 2012 usage percentages for different types of fuel used in the commercial and industrial sector (including natural gas) from that inventory, fuel oil and propane usage were able to be estimated. This is obviously based on the assumption that 2012 fuel usage breakdowns remained unchanged as well. Of the total fuel used by this sector in 2012, 84.82% consisted of natural gas, 12.41% came from propane, and 2.77% was from fuel oil. Because fuel oil and propane are not measured in therms, as natural gas often is, these values were all converted to million British thermal units (MMBtu).

Residential fuel oil and propane usage were estimated a bit differently using the American Community Survey. This is a multi-faceted survey ran by the United States Census that reveals a plethora of data for a number of different specifications. Based on housing data gathered for Portsmouth, the usage breakdowns of different fuels were able to be calculated within the residential sector. 48.4% of Portsmouth homes use natural gas for heating, while 26.4% use residential fuel oil and 4.4% use liquid propane. 18.8% of homes are electrically heated; which is already accounted for, and the remainder use wood or solar.[7] Assuming that this data is an accurate representation, usage amounts for different fuels used can be accurately estimated.

Table C-2: Fuel Usage By Type and Sector (in MMBtu)

Fuel Type	Residential	Commercial/Industrial	Total
Natural Gas	418,549	1,978,410	2,396,959
Fuel Oil	228,299	64,575	292,874
Propane	38,050	289,422	327,471
Fossil Fuel Total	**684,898**	**2,332,407**	**3,017,304**
Total	**864,770**	**2,332,407**	**3,197,177**

References

7. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

2012. The overall increase from 2006 was 29.04%, and 36.02% from 2012.

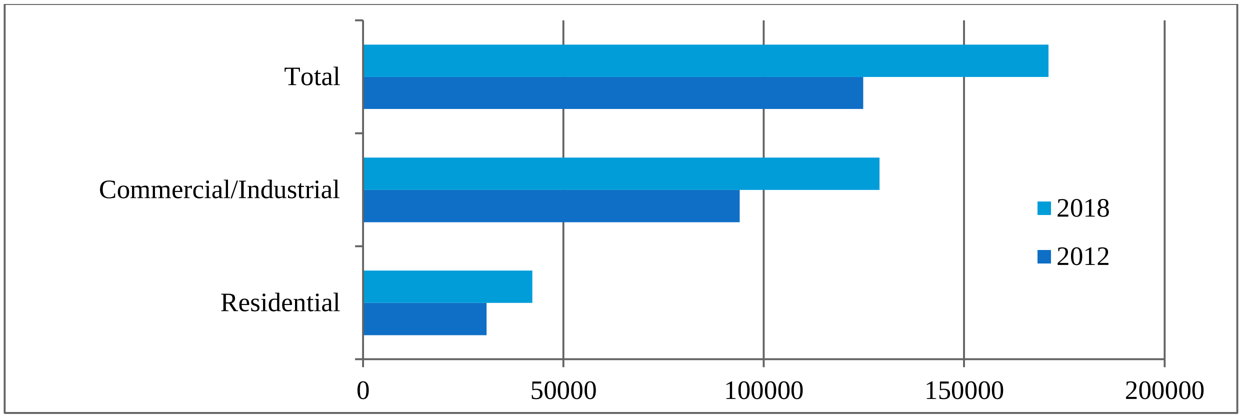
Residential fuel usage accounted for 42,227 MTCDE and the commercial and industrial sectors accounted for 128,853 MTCDE; a total of 171,080 MTCDE. This value is over 60% more than what was emitted from electrical usage and just about 40% of total community emissions. Natural gas usage was attributed approximately 75% of all fossil fuel emissions from these sectors. Fuel oil and propane emissions contributed to approximately 13% and 12% of that as well.

Table C-3: Emissions by Fuel Usage and Sector (MTCDE)

Fuel Type	Residential	Commercial/Industrial	Total
Natural Gas	22,380	105,788	128,168
Fuel Oil	17,405	4,923	22,328
Propane	2,442	18,142	20,584
Fossil Fuel Total	**42,227**	**128,853**	**171,080**

Emissions from fossil fuel usage increased quite uniformly. Since 2012, emissions from these sectors, as well as the overall total, increased approximately 37.1%.

Figure C-5: Fossil Fuel Emissions Comparison



To try and curb this amount, it would be useful if the city held businesses responsible for their emissions. Another idea could be incentivizing the switch away from fossil fuels for certain applications. Nonetheless, considering that such a large part of city-wide emissions is derived directly from the combustion of fossil fuels, the reduction of these types of energy use should be among the city's top priorities.

Transportation

Transportation values were given from models created by the Rockingham Planning Commission for the 2017 year. The models used did not pertain to every road in the city, but was meant to determine the vast majority of vehicle miles traveled (VMT) throughout the city; and its data is not meant for extrapolation. According to their data, a total of 322,049,171 vehicle miles were traveled within city limits in that year. Due to the fact that the values given contained only VMT data, as well as a rudimentary vehicle type breakdown; other data was needed to determine how this translated into emissions. Because the breakdown by vehicle type from Rockingham Planning Commission only included basic values for cars and freight trucks, more complex ratios would be needed for accurate computation of emissions. Therefore, it was assumed that the vehicle type breakdown from the 2012 inventory was still accurate enough to represent 2018. This breakdown attributed 68.50% of total vehicle miles traveled to passenger cars, 24.45% to light trucks, and 7.05% to heavy trucks. From these breakdowns, and the data from the models, the miles each vehicle type traveled was able to be estimated.

Although the breakdown from 2012 was used to extrapolate this data; total 2012 values still will not be used for comparison. This is due to the excessively high values displayed in the previous inventory that would not make much sense compared to this data. Using the EPA's emissions factor estimates, these mileage values were able to be translated to emissions from carbon dioxide, methane, and nitrous oxide.[6]

Table C-4: EPA Emission Factors for Greenhouse Gas Inventories[6] - Data from Table 9

Vehicle Type	CO2 Factor (kg/VMT)	CH4 Factor (g/VMT)	N2O Factor (g/VMT)

Passenger Vehicle	0.343	0.019	0.011
Light Truck	0.472	0.019	0.018
Medium/Heavy Truck	1.467	0.014	0.01

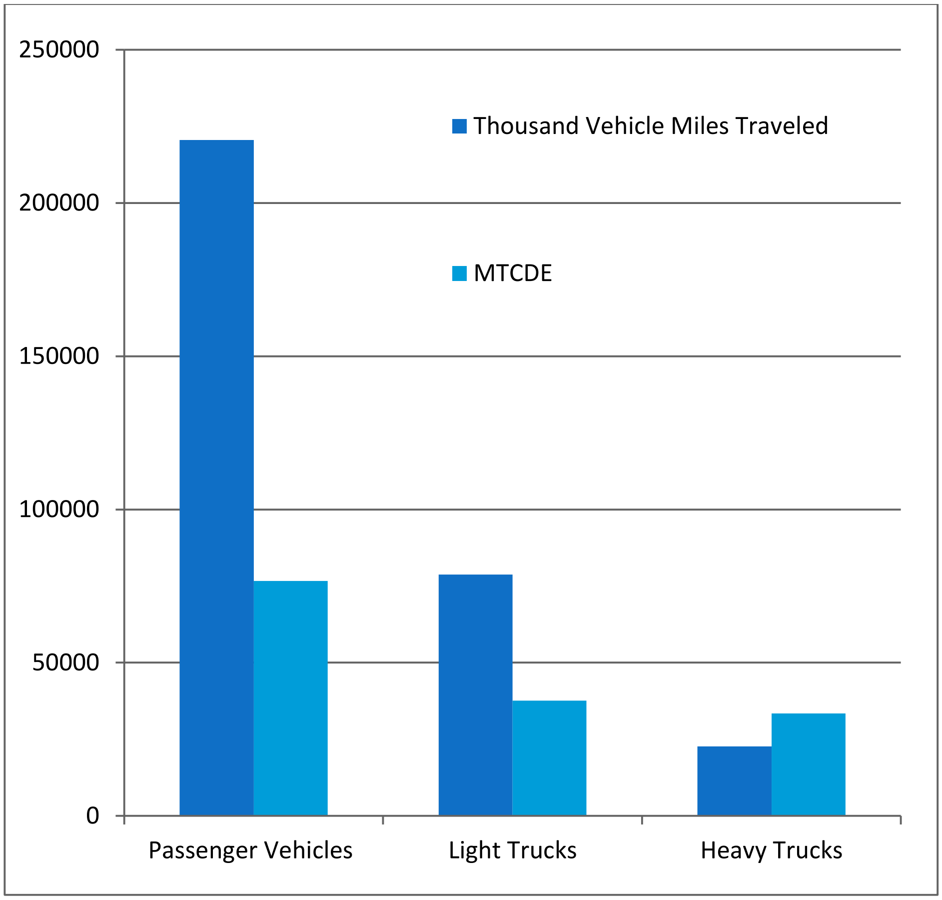
Overall, this accounted for 147,725 MTCDE, 34.86% of total emissions. Although passenger vehicles covered almost 70% of total vehicle miles traveled, this accounted for just about 52% of emissions from vehicles. Light trucks accounted for 25.50% of those emissions, while heavy trucks accounted for 22.61%; with just 7.05% of the traffic.

Table C-5: Vehicle Miles Traveled and Carbon Equivalent Emissions per Vehicle Type

Vehicle Type	Vehicle Miles Traveled	MTCDE
Passenger Vehicles	220,603,682	76,664
Light Trucks	78,741,022	37,667
Heavy Trucks	22,704,467	33,394
Total	**322,049,171**	**147,725**

Due the importance of the main roadways in Portsmouth for regional commerce, it would be a very large undertaking to try and curb transportation emissions. Any effective means of reducing emissions from this would certainly involve some form of regulation at the county, state, regional, or national level; and would not be something city government could tackle on its own. Improvements to pedestrian, bike, and public transportation are ongoing within the city and hopefully will decrease emissions in this sector. Even with municipal improvements it is unlikely that this will create drastic changes however, due to the daily through traffic from state and interstate highways traversing the City. Considering that this is the second biggest sector of community emissions, it would be useful to try and come up with a regional action plan to help curb these emissions.

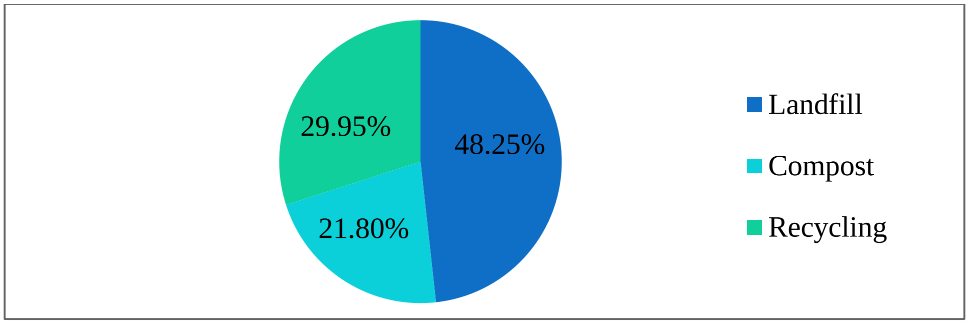
Figure C-6: Thousand VMT and Emissions Comparison



Waste

Waste data was tracked by the Department of Public Works. This included breakdowns of municipal solid and bulky waste going to landfills, types of green waste to be sent out for composting, and types of recyclables picked up as part of the city's single-stream recycling system. These amounts do not include city dumpsters, which are picked up by one of a number of private companies; making this data difficult to track. Of the 11,235.31 tons of annual waste created in the city, 51.75% is diverted from the landfill; through composting and recycling.

Figure C-7: Waste Breakdown



Landfill waste from the city is transported to the Turnkey Landfill, in Rochester, NH. Of the waste sent to the landfill, 79.25% consists of municipal solid waste, while the remaining 20.75% is bulky waste. Of what is sent to compost, 50.45% is composed of yard or leaf waste, 49.32% is brush or wood waste, and the small remainder is food waste. Although recycling isn't included within emissions data for this inventory, it should be noted that the 3,364.53 tons recycled prevents a considerable amount of emissions.

This data will not be compared to the waste data in previous inventories due to inherent inconsistencies. Waste data from the previous inventories reports emissions far lower than what should have been feasible.

The Turnkey Landfill reported an 82% methane capture, meaning that only 18% of the methane created at the landfill will enter the atmosphere as emissions. Therefore, even though Portsmouth sent 5,421.02 tons of waste to the landfill in 2018, the methane capture makes the emissions impact equal to 975.78 tons of waste without methane capture. In 2018 the city's emissions from landfill waste were 3,549 MTCDE. Emissions from the 2,450 tons of compost from the city accounted for an additional 248 MTCDE. Together, this made up 3,797 MTCDE; or 0.88% of the total community emissions. Although it would be difficult to implement waste restrictions or a system to pick up compostable food waste; this is done in other cities and countries and would not necessarily be impossible. The city could also ban all forms of packaging that are either not recyclable or not compostable, as a more feasible option. Overall, it would be difficult to implement large-scale waste reduction programs, however sending landfill waste to a location with methane capture is certainly a step in the right direction.

Community Summary

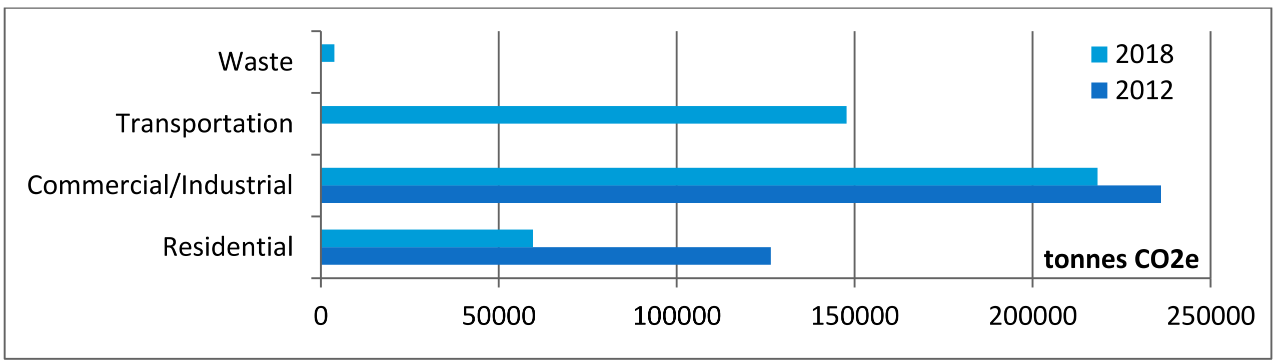
Due to the data collected in this inventory compared to those previous, the community emissions breakdown is quite different from previous years. The residential, commercial, and industrial sectors accounted for 64.71% of total community emissions. Natural gas and fuel usage accounted for 61.57% of emissions from these sectors, or 39.84% of the total. Electrical usage accounted for the remaining 38.43% from these sectors, or 24.86% of total community emissions. While the city can only do so much to clean the electric grid further or reduce fuel use, it could focus on renewable energy infrastructure to increase clean energy independence.

Table C-6: Residential, Commercial, and Industrial Emissions (MTCDE)

	Residential	Commercial/Industrial	Total
Fossil Fuel Total	42,227	128,853	**171,080**
Electricity	17,405	89,371	**106,776**
Total	**59,632**	**218,224**	**277,856**

Commercial and industrial sectors accounted for 50.82% of total emissions. Sector-wise, this should be the city's top priority of where to reduce. Even with a 7.53% decrease in emissions from 2012, it is important that the city holds these businesses accountable for their emissions, or at the very least incentivizes sustainable upgrades. With 34.40% of community emissions, reducing the transportation sector's impact by any significant amount would require immense regional cooperation for upgrading public transportation in the area. Compared to 2012, residential emissions were decreased 52.84%, or 66,815 MTCDE. Attributing to 13.89% of community emissions, this sector could further be reduced by incentivizing solar or the transition from fuel-powered appliances to electric substitutes. While waste should be the last priority, with 0.88% of total community emissions, implementing initiatives to reduce waste still allows for reductions in emissions and helps create a cleaner city overall. Emissions were reduced in the residential, commercial, and industrial sectors; with transportation and waste having incomparable data to previous inventories. Even with the 37.1% increase in fuel emissions, every comparable sector experienced decreases from 2012.

Figure C-8: Community Emissions Comparison



Conclusion

Municipal emissions were reduced by over a third from the 2012 amount, but still accounted for 2.36% of total community emissions. Every municipal sector experienced emissions decreases from 2012 and all comparable community sectors experienced reductions as well. Natural gas and fuel usage increased considerably on the community scale, however the residential, commercial, and industrial sectors all experienced emissions reductions overall. While the electrical emissions decreases particularly pertain to upgrades in the grid infrastructure, other reductions can be accounted for due to increases in energy efficiency and municipal reductions is fossil fuel use. However, the city is now faced with needing to reduce emissions further by tackling their largest emitting sources head on. Overall, reducing the reliance on fossil fuels, increasing renewable energy use, and upgrading transportation infrastructure would be the most effective factors in decreasing much of the city's municipal and community emissions. While this would be an enormous challenge, the city of Portsmouth is resilient and proving to be prioritizing sustainable initiatives; solidifying themselves as a regional leader in the fight against climate change.

Going forward, there are a number of tactics that could make this inventory process more effective, more efficient, and more accurate. First and foremost, completing this inventory more often would allow a simpler data collection process. Because of the 6 year interval between inventories, many of the contacts for data collection have either moved positions or do not completely recall what data is needed. If this process is conducted more often, this would allow for a more seamless data collection process as well as an increase in accuracy from year to year; as these contacts would know what data is needed and when. While needing to report the data more often would not be as necessary, the data collection component would be to ensure more accurate methods and comparisons from year to year. For more accurate totals, it should be noted that the inclusion of Pease Tradeport and emissions from boats entering and exiting the harbor would help gather a more complete account for all of the emissions pertaining to the community. Furthermore, getting a hold of data from private waste collection of dumpsters would also help increase the accuracy of the reporting as a whole. Although these would be important in gaining a full perspective of community emissions, they would be very difficult components to gather the data for and calculate accurately. Future inventories should focus on maintaining preexisting methods and increasing the frequency of data collection. Overall, as the process of inventorying greenhouse gas emissions progresses in the city, inventories should become more accurate and more comparable. Continuing these inventories and improving the methods and tactics used is crucial for maintaining an accurate representation of greenhouse gas emissions in the city of Portsmouth and evaluating how effectively they are being reduced.

This report was prepared by Griffin Brown, 2019 UNH Sustainability Fellow with support from the City of Portsmouth and Peter Britz, City of Portsmouth Environmental Planner and Sustainability Coordinator.