Town of Concord Community Greenhouse Gas Emissions Inventory 2008 and 2016

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Customized Solutions for the Community You Want

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Introduction

Concord, Massachusetts has a long history of adopting and promoting sustainable behaviors, actions, and technologies. In 2017, the community voted to align its goals with the Massachusetts Global Warming Solutions Act of 2008 and the Paris Climate Accord to achieve a minimum 25% town-wide reduction in greenhouse gas (GHG) emissions by 2020 and an 80% reduction by 2050 from a 2008 baseline. This GHG inventory report provides the methodologies to calculate community wide emissions in Concord, which can be replicated in subsequent years to track progress on the emission reduction goals. This report also provides the community wide emissions for 2008, the baseline year, as well as emissions from 2016 to show progress to date. The GHG inventory report was prepared by Kim Lundgren Associates, Inc. (KLA), from April 2018 through January 2019. The results of the community GHG inventory will be used for climate action planning for the Town of Concord.

Note: The analysis for this report builds on and replaces a community wide emission inventory for 2008, which was developed for the Town of Concord by a community volunteer. The current GHG inventory report was updated by KLA to be compliant with the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)* and to include emissions results for 2016. Where needed and possible, data for 2008 was obtained directly by KLA. Where data was not available directly from the Town or another primary source, data from the original 2008 inventory was used.

Section 1: Why Greenhouse Gas Emissions Matter?

Greenhouse gases (GHG) are essential to life on Earth as they provide a "blanket" in our atmosphere that traps heat and regulates the Earth's temperature. GHGs are released naturally in our environment for this very reason. However, we increase the level of greenhouse gases when we burn fossil fuels to power our homes, businesses, and automobiles and place material in our landfill to decompose. This increase in GHGs essentially creates a much thicker "blanket," which leads to higher global temperatures.

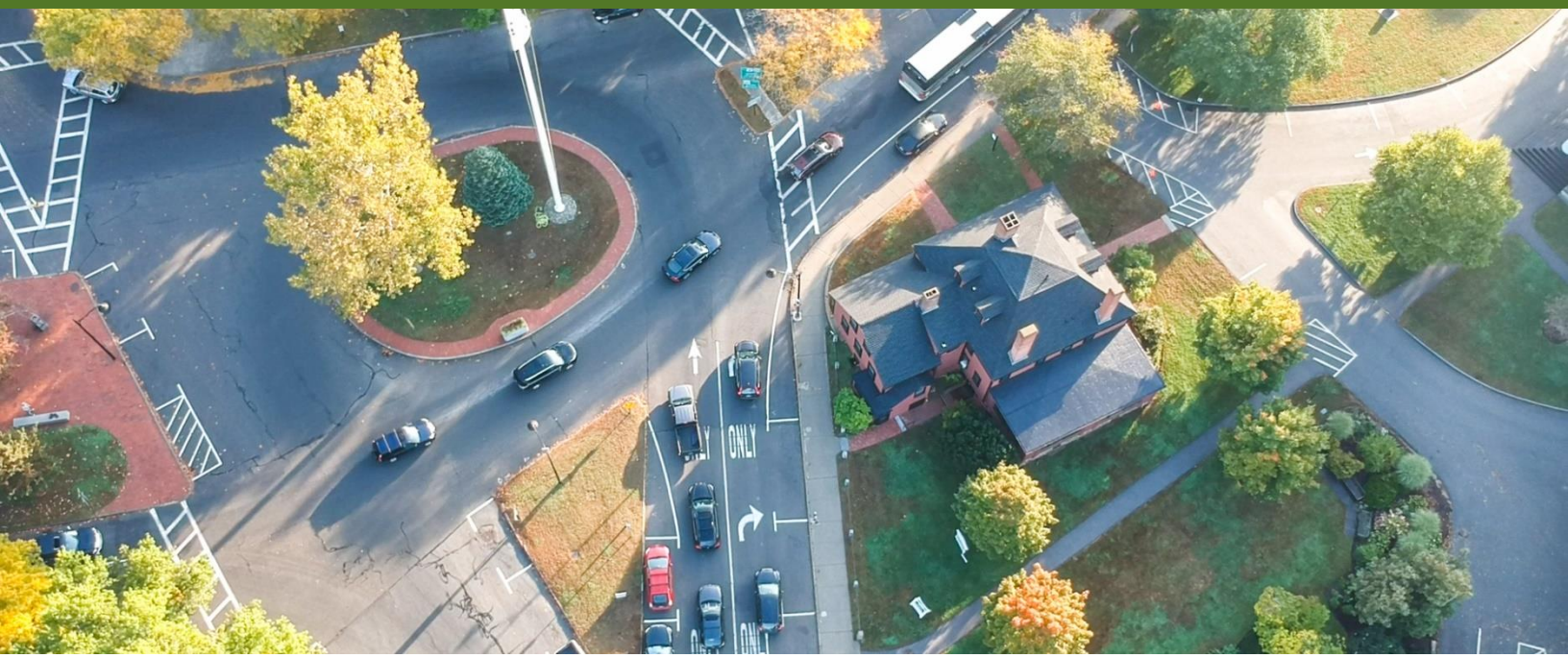
Higher global temperatures change climate patterns, which is evident in the increase in the number and intensity of extreme weather events. Although the change is global, the impacts and actions to address climate change are local. For example, Concord has already experienced an increase in rainfall and flooding, which has resulted in damages to homes and infrastructure. Concord has also experienced higher average temperatures, which can increase heat-related illnesses and drought conditions. This experience has only strengthened Concord's commitment to reducing GHG emissions. By conducting GHG inventories the town's emission sources can be pinpointed and steps can be taken to meet the community's GHG reduction commitments.

There are six different GHGs that are measured to determine the community's total and each GHG traps heat in our atmosphere at different levels. The most significant GHG is carbon dioxide (CO_2) because we produce more CO_2 than any other GHG. Therefore, we measure total emissions based on how each GHG's heat trapping capacity compares to that of CO_2. **Table 1** identifies the comparative warming of each gas to CO_2 (also known as global warming potential, GWP). This allows us to aggregate the total amount of GHGs emitted into what is called the CO_2 equivalent (CO_2e). For example, 1 metric ton of methane released in the atmosphere would be reported as 25 metric tons of CO_2e. Typically, communities and local governments only directly release CO_2, methane, and nitrous oxide.

Table 1. Activities That Release Greenhouse Gases into Our Atmosphere and their Global Warming Potential [1]

Greenhouse Gas	Source Activity	GWP
Carbon dioxide	Burning fossil fuels	1
Methane	Burning fossil fuels Agriculture activities Landfills Wastewater treatment practices	25
Nitrous oxide	Burning fossil fuels Agricultural activities Industrial activities Landfills	298
Perfluorocarbons	Electronics industry	7,390 – 22,800
Hydrofluorocarbons	Air conditioning / refrigeration	124 – 14,800
Sulphur hexafluoride	Switchgear at power installations	22,800

[1] The GWP used in this report is from the IPCC AR4 and is the 100-year time horizon.



Section 2: Concord Community Greenhouse Gas Emissions Inventory

The Concord community greenhouse gas (GHG) emissions inventory was prepared by Kim Lundgren Associates, Inc. (KLA) following the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC).[2] The GPC is adopted by communities around the world to ensure that GHG reports are relevant, complete, consistent, transparent, and accurate. The GPC city-induced Basic reporting level approach was used for this GHG inventory report. The Basic reporting level provides an inventory of the GHGs released as a result of the energy use and waste material generated within the Town of Concord. The GPC provides guidance on what activities need to be included in the inventory and a framework for how to calculate the GHG emissions associated with various activities. There are some activities, like transportation, where the GPC guidance is not specific. In those situations, KLA used guidance provided in ICLEI's U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (Community Protocol)[3] to ensure that the inventory adhered to the GPC principles. The reference to the methodology is included in each of the inventory sector summaries below.

Overall Community Greenhouse Gas Emissions

Activities by residents, visitors and workers in Concord resulted in GHG emissions of 246,890 $MTCO_2e$ in 2008 and 232,951 $MTCO_2e$ in 2016. The 2016 emissions are equivalent to the emissions released by passenger vehicles driving approximately 603 million miles.[4] GHG emissions in Concord decreased 6% from 2008 to 2016 due to lower electricity emissions per kWh from Concord Municipal Light Plant (CMLP) coupled with a decrease in electricity use in the commercial sector of 10%.

[2] GHG Protocol. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories.
[3] ICLEI U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions
[4] This assumes 4.71 $MTCO_2e$ per vehicle per year and 11,507 VMT driven per year per vehicle. See EPA Greenhouse Gas Equivalencies Calculator available at: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Emissions are reported below by both the sector (buildings, transportation, waste) and source (electricity, natural gas, etc.). Buildings accounted for the majority of GHG emissions, 65% in 2008 and 60% in 2016. Buildings emit GHGs when fossil fuels are burned to heat, cool, and light the homes, offices, and businesses in the community. The second highest emitting sector is transportation, accounting for 32% of total community emissions in 2008 and 36% in 2016. The transportation sector emissions are released when fuel is combusted while running vehicles. The transportation sector includes all vehicles registered to Concord residents. Finally, emissions from the waste disposal made up approximately 3% of the total emissions in 2008 and 3% in 2016. Overall emissions from the building sector decreased 12% from 2008 to 2016 while transportation emissions increased by 6% and waste emission increased by 16% over the same period. See **Table 2** for GHG totals by sector for each year and **Figure 1** for a visualization of the GHG contribution from each sector.

Table 2. Concord Community Greenhouse Gas Emissions by Sector Over Time

Sector	2008 ($MTCO_2e$)	2016 ($MTCO_2e$)	Percent change	Percent of Total 2008	Percent of Total 2016
Buildings*	159,779	140,072	-12%	65%	60%
Transportation	80,100	84,754	6%	32%	36%
Waste	7,011	8,126	16%	3%	3%
Total	**246,890**	**232,951**	**-6%**	**100%**	**100%**

*Note that installed residential and commercial solar generation is counted as building energy and emissions are calculated using standard emission factors. The benefits from these renewable sources will be quantified in a later Climate Action Plan.

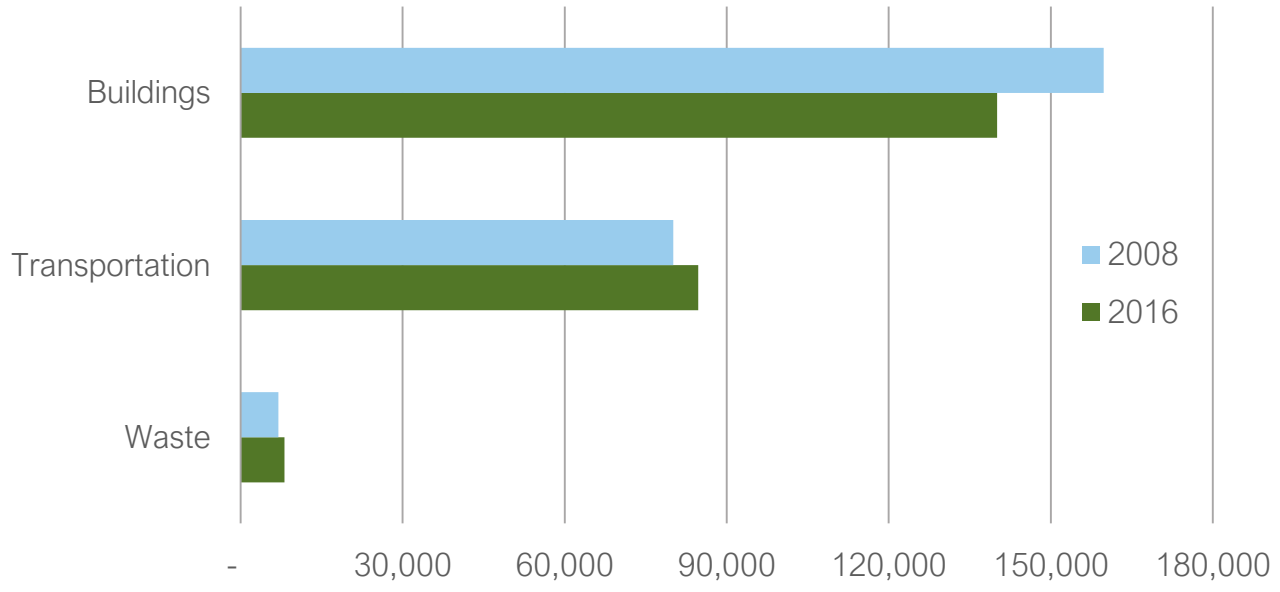


Figure 1. Concord Community GHG Emissions ($MTCO_2e$) by Sector Over Time

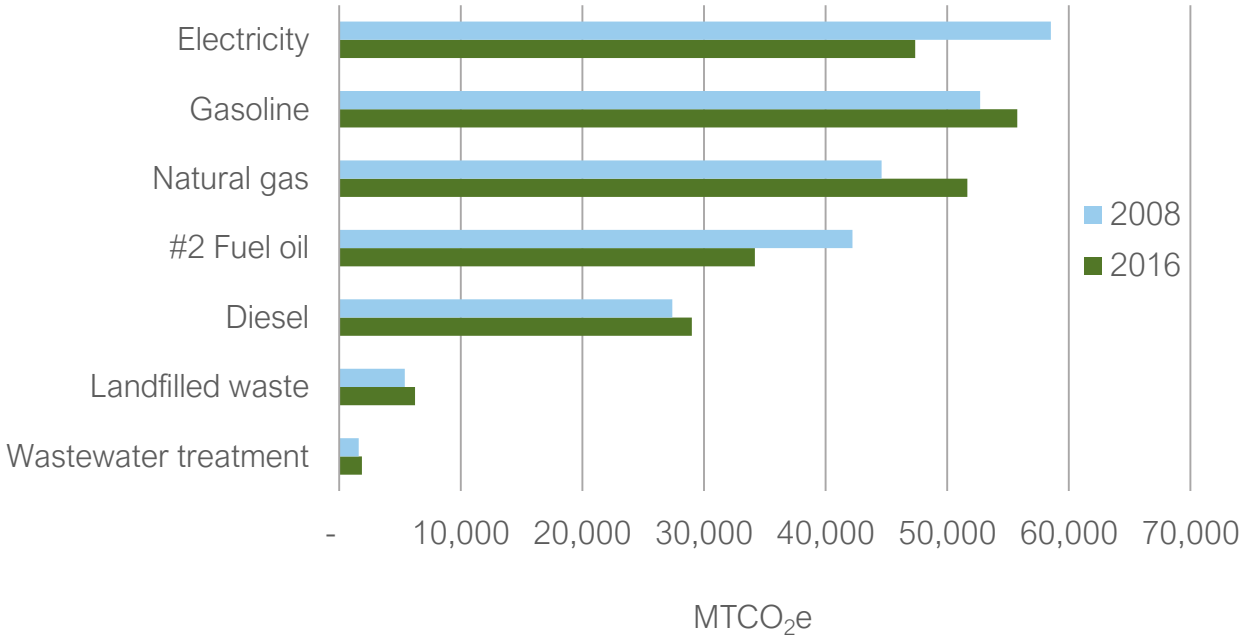


Figure 2. Concord Community GHG Emissions ($MTCO_2e$) by Source Over Time

Figure 2 shows the relative contribution of each source for both 2008 and 2016 and **Table 3** shows emissions by source for both 2008 and 2016.

Table 3. Concord Community Greenhouse Gas Emissions by Source Over Time

Sector	2008 ($MTCO_2e$)	2016 ($MTCO_2e$)	Percent change	Percent of Total 2008	Percent of Total 2016
Electricity	72,993	54,234	-26%	30%	23%
Gasoline	52,696	55,758	6%	21%	24%
Natural Gas	44,590	51,654	16%	18%	22%
#2 Fuel Oil	42,196	34,184	-19%	17%	15%
Diesel	27,404	28,996	6%	11%	12%
Landfilled Waste	5,399	6,244	16%	2%	3%
Wastewater Treatment	1,612	1,881	17%	1%	1%
Total	**246,890**	**232,951**	**-6%**	**100%**	**100%**

Figure 3 shows emissions by source and by year to illustrate how the contribution of each sector has changed relative to total emissions.

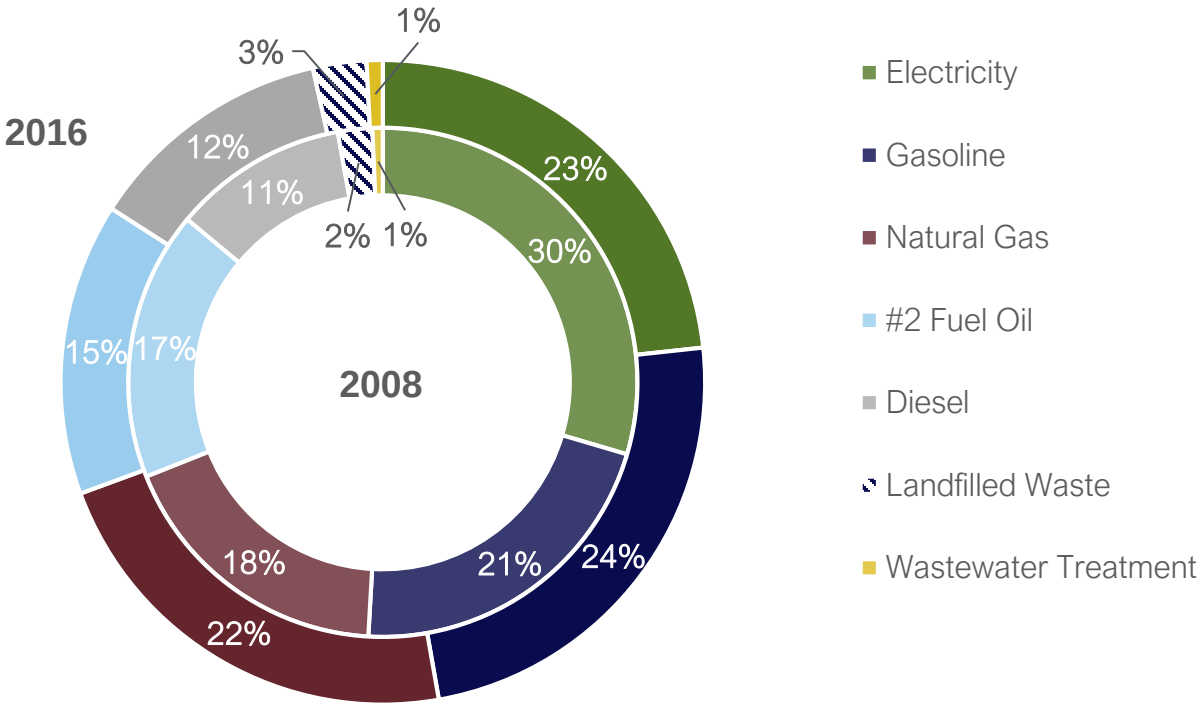


Figure 3. Concord's GHG Emissions by Source, 2008 (inside donut) and 2016 (outside donut)

Community Emissions by Sector

The following section outlines the methods used to calculate emissions for each sector of the community inventory and details fuel use and emissions by source.

Building Energy

The Building Energy sector emissions resulted from energy consumption in the residential, commercial and institutional sub-sectors. Emissions were calculated based off the town's electricity, natural gas, and fuel oil use, following the methodologies in the US Community Protocol. Fugitive emissions from natural gas pipelines within the Concord Town boundary were calculated based off of total natural gas consumption each year. A summary of results and methods for 2008 is provided in **Table 4.** A summary of the results and methodologies used for 2016 is provided in **Table 5**.

Table 4. Summary of Stationary Energy Sector Data and Methodologies 2008

Sub-sector	Source/Activity	Methodology	Activity Data	Units	MTCO2e
Residential Buildings	Electricity	USCP BE 2.1	70,176,556	kWh	28,522
Commercial and Institutional Buildings and Facilities	Electricity	USCP BE 2.1	109,401,979	kWh	44,464
Residential Buildings	Electricity (Solar)	USCP BE 2.1	11,909	kWh	5
Commercial and Institutional Buildings and Facilities	Electricity (Solar)	USCP BE 2.1	6,465	kWh	3
Residential Buildings	Natural Gas	USCP BE 1.1	4,184,866	Therms	22,228
Commercial and Institutional Buildings and Facilities	Natural Gas	USCP BE 1.1	4,087,684	Therms	21,712
Fugitive Emissions from the Natural Gas Sector: Residential	Natural Gas	IPCC Chap. 4.2*	116,127**	Therms	329
Fugitive Emissions from the Natural Gas Sector: Commercial	Natural Gas	IPCC Chap. 4.2*	113,430**	Therms	321
Residential Buildings	Fuel Oil #2	USCP BE 1.2	3,111,934	Gallons	31,879
Commercial and Institutional Buildings and Facilities	Fuel Oil #2	USCP BE 1.2	1,007,137	Gallons	10,317

*No methodology exists in the US Community Protocol for calculating emissions from fugitive natural gas.
** This is the amount of natural gas leaked. Emissions factors for fugitive natural gas are based on total throughput – which includes community usage and the amount leaked each year.

For both 2008 and 2016, electricity use from residential, commercial and industrial customers was provided by email from Laura Scott at the Concord Municipal Light Plant (CMLP). Emissions for 2008 were calculated using a 2008 ISO New England CO_2 factor and 2009 NEWE New England Region CH_4 and N_2O factor.[5] The 2009 eGRID emission factors were used as a proxy for 2008 since eGRID did not list 2008 regional factors. A detailed breakout of power providers contracted by CMLP was not available for 2008.

For 2016 electricity emissions, a custom emissions factor was developed using the list of power providers contracted by CMLP and total energy purchased from each provider for the 2016 GHG inventory year. **Table 6** compares the custom electricity emission factors based on CMLP power purchases to the ISO New England/NEWE emission factor for 2008 and 2016.

[5] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

Table 5. Summary of Stationary Energy Sector Data and Methodologies 2016

Sub-sector	Source/Activity	Methodology	Activity Data	Units	$MTCO_2e$
Residential Buildings	Electricity	USCP BE 2.1	70,078,214	kWh	22,160
Commercial and Institutional Buildings and Facilities	Electricity	USCP BE 2.1	96,954,103	kWh	30,659
Residential Buildings	Electricity (Solar)	USCP BE 2.1	3,004,072	kWh	950
Commercial and Institutional Buildings and Facilities	Electricity (Solar)	USCP BE 2.1	1,472,404	kWh	466
Residential Buildings	Natural Gas	USCP BE 1.1	4,144,564	Therms	22,014
Commercial and Institutional Buildings and Facilities	Natural Gas	USCP BE 1.1	5,438,640	Therms	28,887
Fugitive Emissions from the Natural Gas Sector: Residential	Natural Gas	IPCC Chap. 4.2*	115,008**	Therms	326
Fugitive Emissions from the Natural Gas Sector: Commercial	Natural Gas	IPCC Chap. 4.2*	150,918**	Therms	427
Residential Buildings	Fuel Oil #2	USCP BE 1.2	2,854,169	Gallons	29,238
Commercial and Institutional Buildings and Facilities	Fuel Oil #2	USCP BE 1.2	482,758	Gallons	4,945

*No methodology exists in the US Community Protocol for calculating emissions from fugitive natural gas.
** This is the amount of natural gas leaked. Emissions factors for fugitive natural gas are based on total throughput – which includes community usage and the amount leaked each year.

Electricity generated by residential and commercial solar installations was estimated using kW installed data provided by CMLP and a kWh output per kW for Concord from the National Renewable Laboratory's PV Watts Calculator.[6] According to CMLP, the majority of renewable energy certificates (RECs) produced from solar installations are sold and the town cannot take credit for the GHG benefit from this production. In 2016, emissions from solar electricity produced at residential and commercial installations were calculated using the custom CMLP emissions factor. For 2008, an average ISO New England[7] CO_2 factor as used in conjunction with 2009 NEWE New England Region factors for CH_4 and N_2O.[8] from eGRID. A 2009 eGRID emission factor was used as a proxy for 2008 since eGRID did not list a 2008 regional factor.

The custom electricity emission factor used to calculate 2016 emissions was created by analyzing the origin of each power provider to CMLP in 2016. As CMLP did not retire the RECs associated with their renewable energy purchases in 2016, the ISO New England CO_2 and NEWE New England Region CH_4 and N_2O emission factors were used for all renewable energy purchases except for those from hydro power from the New York Power Authority (NYPA). Emissions from power purchased from the Watson facility were calculated using a factor specific to that generating facility provided by eGRID 2016.

[6] Available at https://pvwatts.nrel.gov/index.php
[7] ISO NE emissions reports available at https://www.iso-ne.com/system-planning/system-plans-studies/emissions
[8] Available at: https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

Table 6. Summary of Electricity Emission Factors

Year	Emission Factor (pounds CO_2e per MWh)		Percent Difference
	CMLP	NEWE eGRID Region	
2016	697.14	715.83	2.7%
2008	N/A	896.02	N/A

Emissions from all other sources, including wholesalers (Constellation, Rise, NextEra) who supply a portion of their power from natural gas generators, were calculated using the ISO New England CO_2 and NEWE New England Region CH_4 and N_2O emission factors. These wholesalers replace natural gas power with grid power when it is more cost effective. The percent of grid power relative to natural gas power from these wholesalers was not available.

The 2016 custom emission factor calculated for CMLP power was 697.14 lbs CO_2e/MWh is slightly lower than the ISO New England/NEWE emission factor average emission factor of 715.83 lbs CO_2e /MWh.[9] This is because 4% of total energy purchased in Concord was from zero emission sources (NYPA), and emissions from most other sources were assumed to be equivalent to ISO NE grid purchases. Emissions from the Watson facility had a higher emission factor, but this usage accounted for less than 3% of total power purchases.

The GHG reduction benefit of power generated from residential and commercial solar installations was not included in the custom factor. Excluding the GHG reduction benefit of these solar installation projects lessens the chance of double-counting GHG reduction in the inventory. Emissions from residential and commercial users who consumed power generated with rooftop solar were calculated using the ISO New England/NEWE emission factor in 2008 and the custom CMLP factor in 2016. The GHG benefit of these installations can be included in a future Climate Action Plan as a measure the town has taken to achieve its GHG reduction targets.

In 2018, CMLP started retiring the RECs from power it purchases from renewable sources. This will significantly lower the GHG intensity of electric power for future inventories starting in 2018. In 2018, electricity provided by CMLP was 54% carbon-free.

Natural gas activity data for the residential and commercial sectors was obtained from the Town of Concord's original 2008 GHG inventory. Data from this inventory was obtained from the town's natural gas supplier: National Grid. Natural gas emissions factors from EPA Mandatory Reporting Rule,[10] published in November 2015, and last updated in March 2018, were used to calculate natural gas emissions for both 2016 and 2008. The 2008 data came from the Concord Energy Master Plan (edited in 2016) by way of the Concord 2008 Community GHG Inventory. Data from 2016 came from National Grid.

[9] Note that this emission factor takes into account CH4 and N2O from the NEWE eGRID Region. On its own, the ISO NE CO2 emission factor for 2016 is 710 lbs./MWh.
[10] Available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf

The amount of fugitive natural gas from distribution attributable to the Town of Concord was determined using a Harvard University study conducted in 2015 that found that 2.7% of all natural gas distributed in the Boston area is leaked and released into the atmosphere.[11] Total natural gas distributed to Concord (including community consumption and leaked gas) was used to calculate the emissions from natural gas leaked into the atmosphere based on guidance provided in Chapter 4 of the 2006 IPCC Guidelines for Greenhouse Gas Inventories.[12] IPCC emission factors for fugitive natural gas from distribution based on total throughput were used to determine the associated GHG emissions with this source.

Fuel oil used by the community in 2008 was provided by the Town of Concord as published in the Town's original 2008 GHG inventory. Fuel oil use for 2016 was estimated by accounting for the change in community residential and commercial square building square footage as provided by the Town of Concord's Assessor. The Town Assessor provided information on building energy use for 2008 and 2017 (2017 was used as a proxy year for 2016). Emission factors for fuel oil were obtained from the EPA Mandatory Reporting Rule, published in November 2015 and last updated in March 2018. **Figure 4** shows GHG emissions by fuel type in the stationary energy sector.

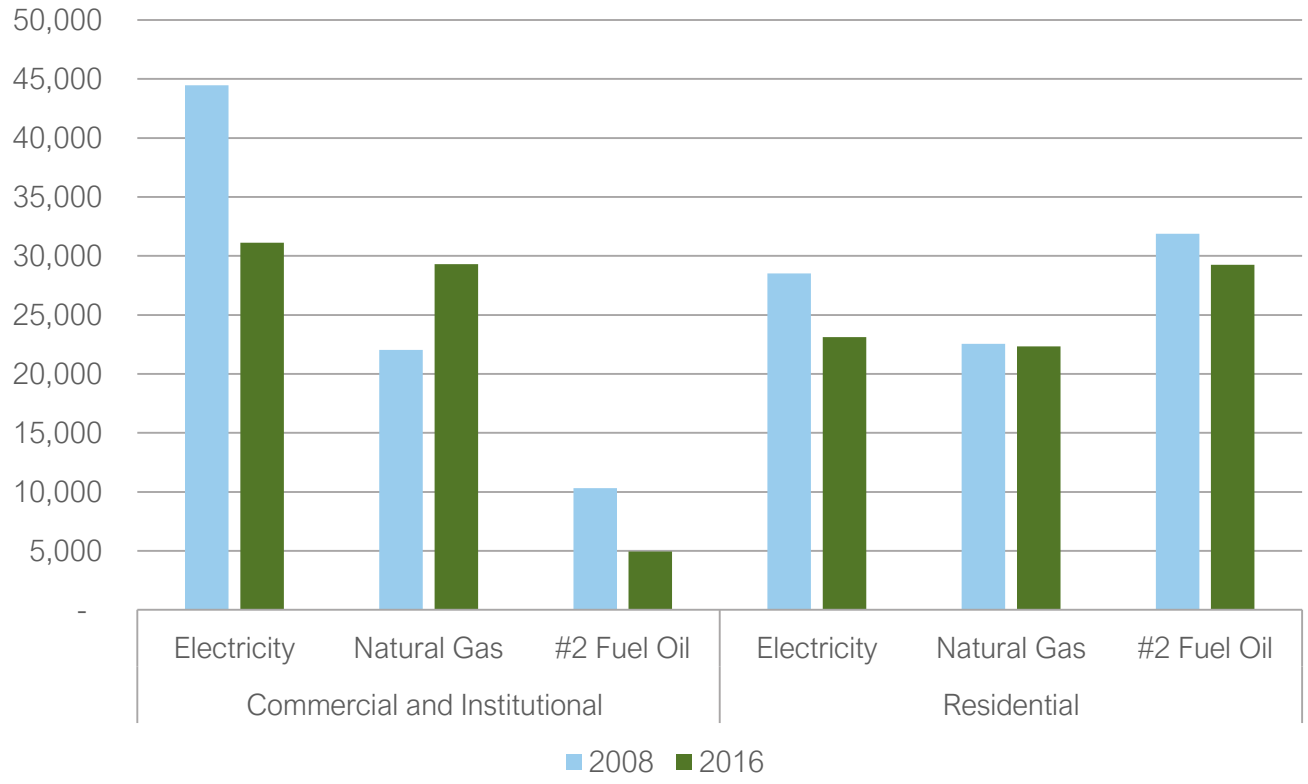


Figure 4. GHG Emissions ($MTCO_2e$) from Concord's Stationary Energy Sector by Building Type and Energy Source Over Time

[11] Summary of study available at https://www.seas.harvard.edu/news/2015/01/boston-s-natural-gas-infrastructure-releases-high-levels-of-heat-trapping-methane
[12] Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/

Transportation

The Transportation sector comprises emissions that result from vehicle miles travelled and fuel consumption by vehicles that are registered within the community boundary. Emissions were calculated based on publicly available reports, following the methodologies in the US Community Protocol. A summary of results and methods for 2008 are provided in **Table 7**. A summary of the results and methodologies used for 2016 are provided in **Table 8**.

Table 7. Summary of Transportation Sector Data and Methodologies 2008

Sub-sector	Source/Activity	Methodology	Activity Data	Units	MTCO2e
On-road transportation	Gasoline Light Trucks	USCP TR.1.B	43,276,290	VMT	22,194
On-road transportation	Gasoline Passenger Vehicles	USCP TR.1.B	80,942,691	VMT	30,502
On-road transportation	Diesel Heavy Trucks	USCP TR.1.B	7,212,715	VMT	26,312
On-road transportation	Diesel Light Trucks	USCP TR.1.B	1,736,394	VMT	934
On-road transportation	Diesel Passenger Vehicles	USCP TR.1.B	400,706	VMT	158

Table 8. Summary of Transportation Sector Data and Methodologies 2016

Sub-sector	Source/Activity	Methodology	Activity Data	Units	MTCO2e
On-road transportation	Gasoline Light Trucks	USCP TR.1.B	45,790,676	VMT	23,483
On-road transportation	Gasoline Passenger Vehicles	USCP TR.1.B	85,645,523	VMT	32,275
On-road transportation	Diesel Heavy Trucks	USCP TR.1.B	7,631,779	VMT	27,841
On-road transportation	Diesel Light Trucks	USCP TR.1.B	1,837,280	VMT	988
On-road transportation	Diesel Passenger Vehicles	USCP TR.1.B	423,988	VMT	167

Activity data in the form of daily Vehicle Miles Travelled (VMT) for 2009 and 2014 were obtained from the Metropolitan Area Planning Council's (MAPC) Massachusetts Vehicle Census: Municipal Summary 2009-2014.[13] Data for 2009 was used as a proxy for 2008 and 2014 data was used as a proxy for 2016. The MAPC reports total daily vehicle miles by quarter for vehicles registered in the Town of Concord. As a result, this VMT accounts for miles travelled both inside the community boundary and travelled outside of the community boundary – making transportation emissions a mix of Scope 1 and Scope 3 according to the GPC. Daily VMT for each quarter was multiplied by the number of days per quarter to get yearly VMT.

[13] MAPC Vehicle Census Municipal Summary 2009-2014 Excel file available at: https://www.mapc.org/learn/data/

Total VMT was attributed to diesel and gasoline burning vehicles according to national averages for on-road vehicles as provided by the US Community Protocol. Similarly, the types of vehicles on the road in Concord (heavy duty, light duty, passenger vehicles) were assumed to conform to national averages as provided by the US Community Protocol. VMT was used to calculate emissions from methane and nitrous oxide with emission factors obtained from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories[14] last published in November 2015 and updated in March 2018.

To estimate emissions from carbon dioxide, VMT was converted to fuel use using fuel efficiencies for each vehicle type obtained from the U.S Department of Energy's Alternative Fuel Data Center.[15] Carbon dioxide emission factors for each fuel were obtained from the U.S. EPA's Emission Factors for Greenhouse Gas Inventories last published in November 2015 and updated in March 2018.

Emissions resulting from train travel, such as from MBTA were assumed to be negligible. The authors were not able to obtain any information on freight deliveries made by rail.

Waste

The Waste sector comprises methane emissions that result from the decomposition of residential and commercial waste generated in the inventory year that is deposited in a landfill. While these emissions occur over time, they are attributed to the year in which the waste was generated and deposited. Waste emissions were calculated based off residential deposition data contained in the Town of Concord's publicly available Annual Reports, following the methodologies in the US Community Protocol and average deposition per square foot of commercial space from a study of New York City's waste generation. A summary of results and methods for 2008 are provided in **Table 9.** A summary of the results and methodologies used for 2016 are provided in **Table 10**.

Table 9. Summary of Waste Sector Data and Methodologies 2008

Sub-sector	Source/Activity	Methodology	Activity Data	Units	$MTCO_2e$
Solid Waste Disposal	Waste Deposited	USCP SW.4	20,505	Tons	5,298
Solid Waste Disposal	Alternative Daily Cover (ADC)	USCP SW.4	1,432	Tons	101

[14] Available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf
[15] Available at: https://www.afdc.energy.gov/data/categories/fuel-consumption-and-efficiency

Table 10. Summary of Waste Sector Data and Methodologies 2016

Sub-sector	Source/Activity	Methodology	Activity Data	Units	$MTCO_2e$
Solid Waste Disposal	Waste Deposited	USCP SW.4	21,933	Tons	6,102
Solid Waste Disposal	Alternative Daily Cover (ADC)	USCP SW.4	2,020	Tons	142

Yearly waste deposition for the residential sector was calculated based on total residential waste generated for 2008 and 2016 from the Town of Concord's 2016 Annual Report.[16] In 2016, Concord had 3,608 residential subscribers (households) to the municipal curbside collection program and 2,581 tons of waste was collected from these residents. In 2008, there were 3,305 subscribers and a total of 2,467 tons of waste collected. An intensity value (tons/household) was calculated for each year and then multiplied by the total number of households existing in Concord each year (as identified by the Assessors Data). This resulted in the total tons of waste generated by Concord's residential sector.

The Town of Concord was not able to provide any real data on waste from the commercial sector. Therefore, it was estimated using total square feet of commercial space in the Town of Concord and an estimate of waste tonnage produced per square foot.[17] The characterization of waste from the commercial sector was estimated using MassDEP's Solid Waste Master Plan's Summary of Waste Combustor Class II Recycling Program Waste Characterization Studies (Includes 2010, 2013 and 2016 Data) document. Waste characterization was assumed to be the same for 2008 and 2016. Emissions were determined using emission factors from the California Air Resources Board's Landfill Tool v1.3[18] and methodologies adapted from the US Community Protocol.

Alternative daily cover (ADC) used at landfills was estimated using state averages for ratios of ADC/MSW calculated from MassDEP's 2011 Solid Waste Master Plan.[19] Emissions from ADC were determined using emission factors from the California Air Resources Board's Landfill Tool v1.3 [20] and methodologies adapted from the US Community Protocol.

Water Treatment and Delivery

The Water Treatment sector comprises emissions that result from electricity used to treat and convey water throughout the community during the inventory year. However, it is expected that this consumption was included in the aggregate electricity consumption numbers provided by Concord Municipal Light Plant and so are not itemized separately here to avoid double counting.

Electricity was assumed to be the only source of energy used to treat and move water.
For more detail on estimated emissions from water treatment related to electricity use, see the Concord Community GHG Emissions Inventory.xlsx Excel workbook.

[16] Available at: http://concordma.gov/754/Annual-Reports
[17] Available at: https://www1.nyc.gov/assets/planning/download/pdf/applicants/env-review/evles/14_feis.pdf
[18] Available at: https://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_3_2011-11-14.xls
[19] Available at: https://www.mass.gov/files/documents/2016/08/rr/11swdata.pdf
[20] Available at: https://www.arb.ca.gov/cc/protocols/localgov/pubs/landfill_emissions_tool_v1_3_2011-11-14.xls

Wastewater Treatment

The Wastewater Treatment sector comprises emissions that result from electricity used to treat and convey wastewater throughout the community during the inventory year as well as process and fugitive emissions and biosolid incineration that result from the treatment of organic materials in the wastewater. Electricity use from the Wastewater Treatment sector was available in the Mass Energy Insight tool. However, this value was also included in the aggregate electricity consumption data provided by Concord Municipal Light Plant. Therefore, to avoid double counting, this sum was not included in the GHG inventory. Process and fugitive emissions were estimated based on per capita emissions rates contained within the US Community Protocol. Emissions from biosolid incineration were calculated based on biosolid production provided by the Town of Concord and calculation methodologies adapted from the US Community Protocol. A summary of results and methods for 2008 are provided in **Table 11**. A summary of the results and methodologies used for 2016 are provided in **Table 12**.

Table 11. Summary of Water Treatment Sector Data and Methodologies 2008

Sub-sector	Source/Activity	Methodology	Activity Data	Units	$MTCO_2e$
Wastewater Treatment and Discharge	Process and Fugitive Emissions	USCP WW.6 (alt), WW.7, WW.12	5,742	Population served	947
Wastewater Treatment and Discharge	Fugitive Septic	USCP WW.11	9,558	Population served	611
Wastewater Treatment and Discharge	Biosolid Incineration	USCP WW.4, WW.5*	185	Tons	55

*Calculation methodologies from the US Community Protocol were adapted to use dry weight factors from the IPCC and BEAM.

Table 12. Summary of Water Treatment Sector Data and Methodologies 2016

Sub-sector	Source/Activity	Methodology	Activity Data	Units	$MTCO_2e$
Wastewater Treatment and Discharge	Process and Fugitive Emissions	USCP WW.6 (alt), WW.7, WW.12	6,000	Population served	1,106
Wastewater Treatment and Discharge	Fugitive Septic	USCP WW.11	9,987	Population served	718
Wastewater Treatment and Discharge	Biosolid Incineration	USCP WW.4, WW.5*	194	Tons	57

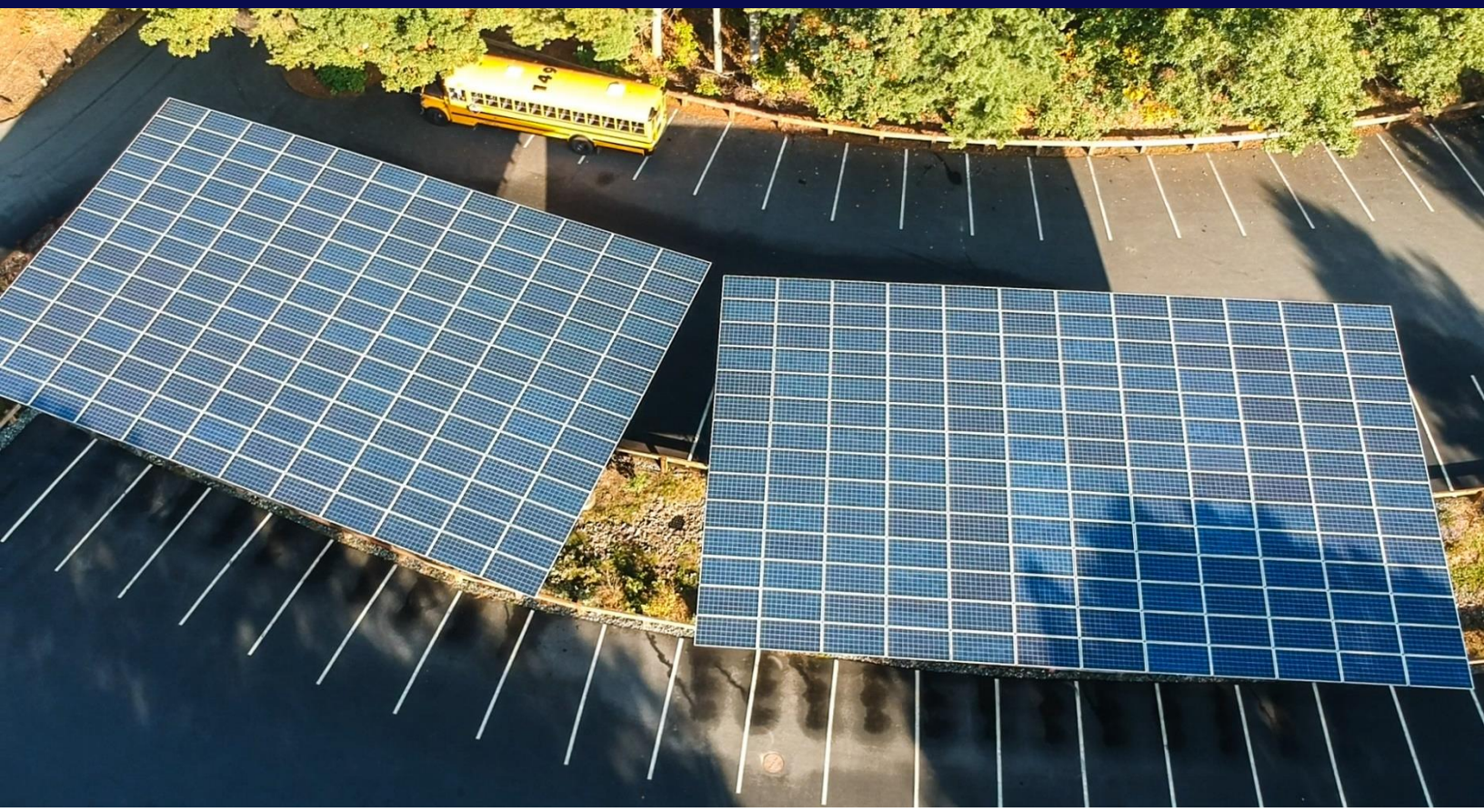
*Calculation methodologies from the US Community Protocol were adapted to use dry weight factors from the IPCC and BEAM.

Total electricity used to pump wastewater within the Town of Concord was obtained from Mass Energy Insight, but was not included in the total GHG emissions inventory as it was included in the aggregate electricity consumption value provided by Concord Municipal Light Plant.

Process, fugitive and septic emissions from wastewater treatment were calculated using Town of Concord population estimates for 2008 and 2016 and standard methodologies in the US Community Protocol. The US Community Protocol calculations were additionally refined by substituting local values for biochemical oxygen demand (BOD5) provided by Valerie Doerrer from the Town of Concord. Water usage per person per day was provided by Melissa Simoncini from the Town of Concord.

Emissions from biosolid incineration were estimated using data on the total amount of sludge produced in 2016 provided by Melissa Simoncini from the Town of Concord. Emissions were calculated using methods from the US Community Protocol that were adapted to calculate emissions from dry weight of biosolids rather than wet weight. Dry weight emission factors for methane were obtained from the Biosolids Emissions Assessment Model (BEAM).[21] Dry weight emission factors for nitrous oxide were obtained from the IPCC 2006 Chapter 5: Incineration and Open Burning of Waste.[22] Sludge produced in 2008 was estimated based on changes in population served by wastewater treatment between 2016 and 2008.

[21] Available at https://www.ccme.ca/files/Resources/waste/biosolids/beam_final_report_1432.pdf
[22] Available at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf



Section 3: Concord GHG Emissions and Energy Analysis

This section provides an analysis of why the Town's GHG emissions changed between 2008 and 2016 and insight into how energy is being used by Concord's community.

Per Square Foot Analysis

While it is useful to know that overall emissions from buildings decreased since 2008, it is important to know where this change took place. According to Concord's assessor's database, the number of buildings in Concord decreased by 1% between 2008 and 2016 (228 commercial/institutional buildings in 2016 and 230 in 2008; 4,839 residential buildings in 2016 and 4,878 in 2008). However, the square footage for commercial building types increased 8% and the square footage for residential buildings increased 13% between 2008 and 2016. This could mean that additions were put onto existing buildings and/or old structures were torn down and replaced with larger buildings. The fuel used to heat buildings shifted between 2008 and 2016.

The bars in **Figure 5**, below, show how the town's buildings were heated based on size (square feet) in 2008 and 2016. The dots show the number of residential buildings by heating fuel for 2008 and 2016. There was a shift from using oil heat to natural gas heating, and to a smaller extent, electric heating, during this time. Residences heated by fuel oil decreased by 480 (-17%) while those heated by natural gas increased by 406 (+20%) and those heated by electricity rose by 37 (+37%).

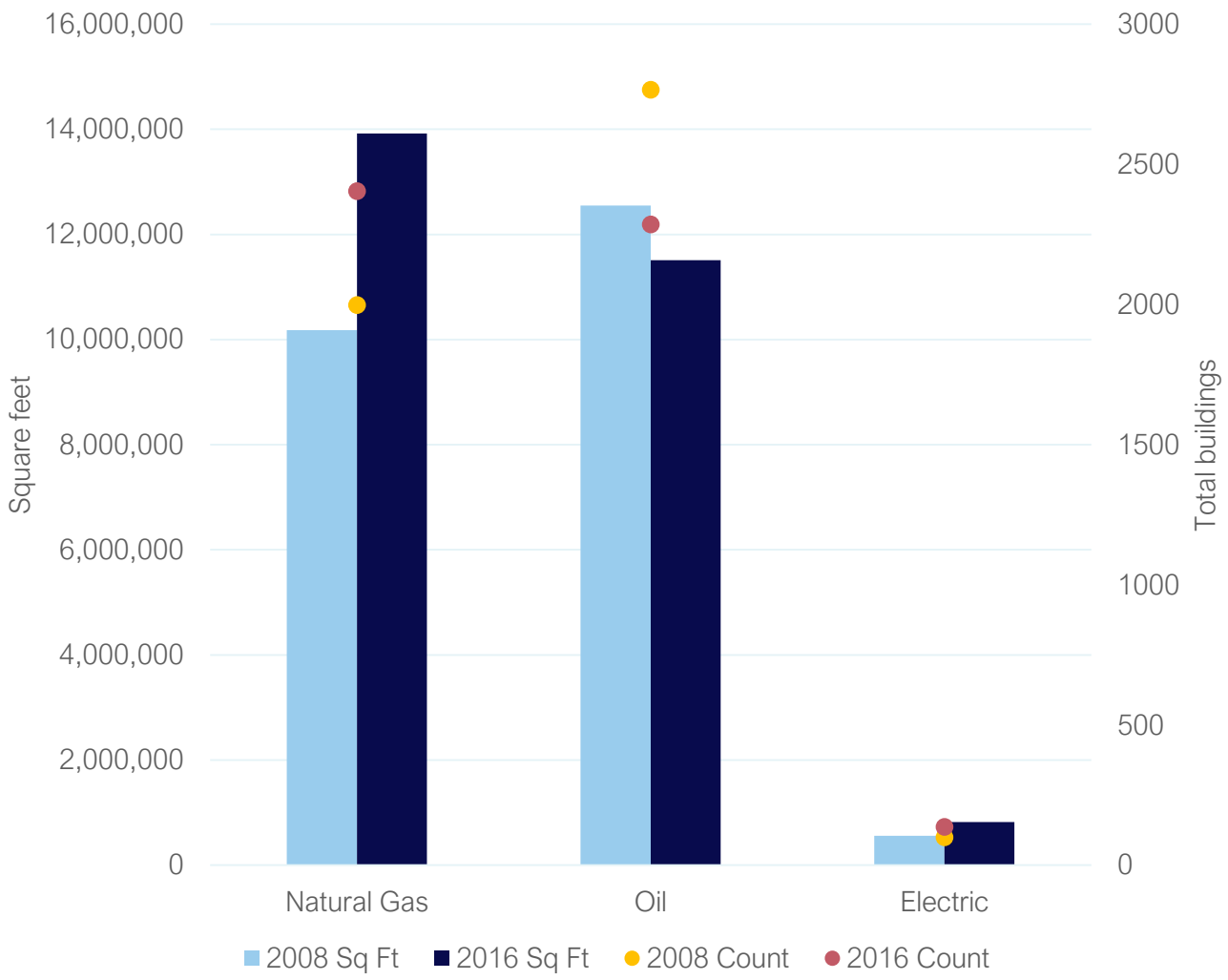


Figure 5. Primary Fuel used to Heat Concord's Residential Building Stock by Source and Count Over Time

While the home size in Concord has grown, homes are using less energy overall for heat and power. **Figure 6** shows that natural gas use per square foot has dropped 28% since 2008, and electricity consumption has gone down 8% per square foot. Fuel oil use per square foot in the residential sector has remained constant.

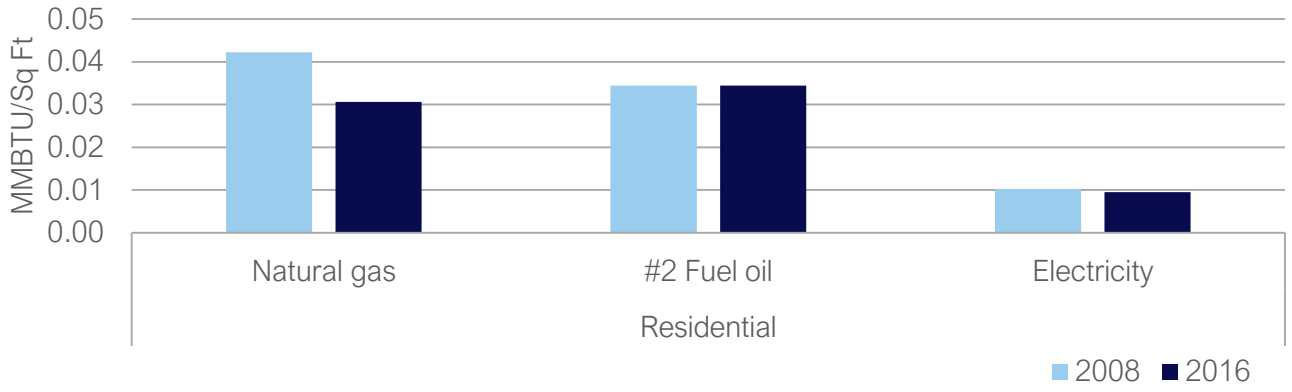


Figure 6. Concord's Residential Building Energy Use by Square Foot (MMBTU/Sq ft) and Fuel Source Over Time

Figure 7 identifies how each Concord resident used energy in 2008 and 2016. Residential electricity use per person stayed constant while fuel oil per person went down 12%. Residential natural gas use per person went down 5%.

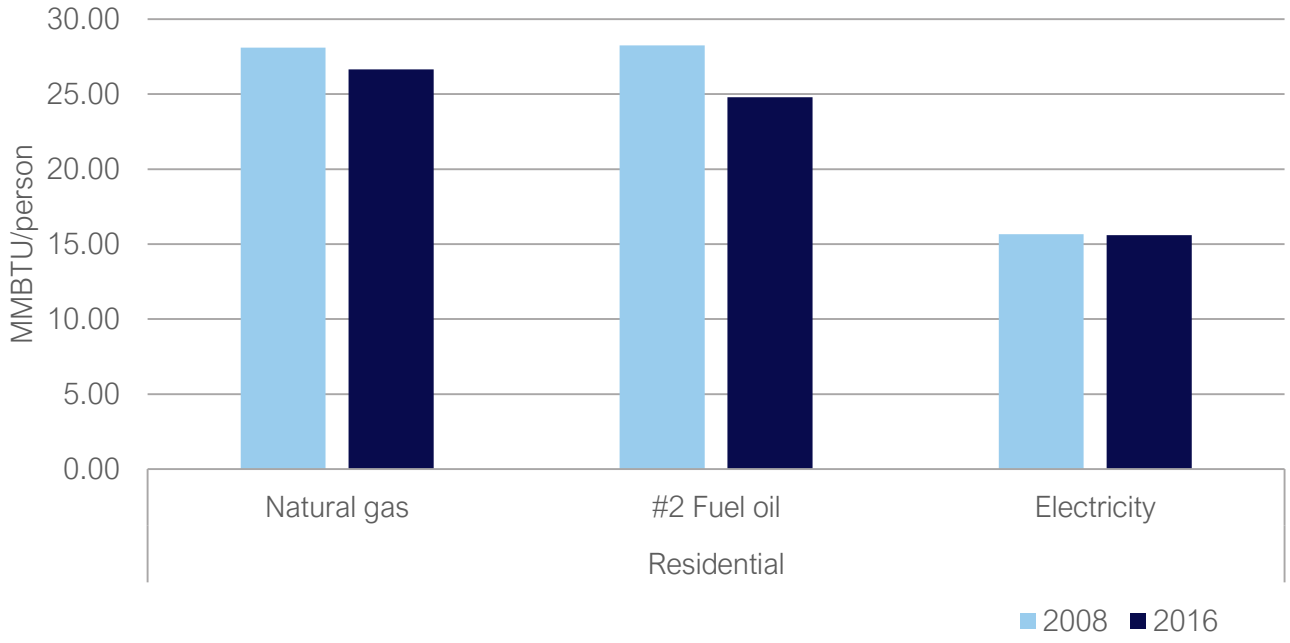


Figure 7. Concord Energy Use in Homes per Capita (MMBTU/capita) by Fuel Type Over Time

The commercial sector saw an overall decrease of 5% in MMBTU per square foot from 2008 to 2016. By fuel type, however, MMBTU per square foot was highly variable. **Figure 8** shows that MMBTU from buildings heated by fuel oil increased 12% per square foot while MMBTU from electricity decreased by 17% per square foot. MMBTU per square foot for commercial buildings heated by natural gas decreased by 27% from 2008 to 2016.

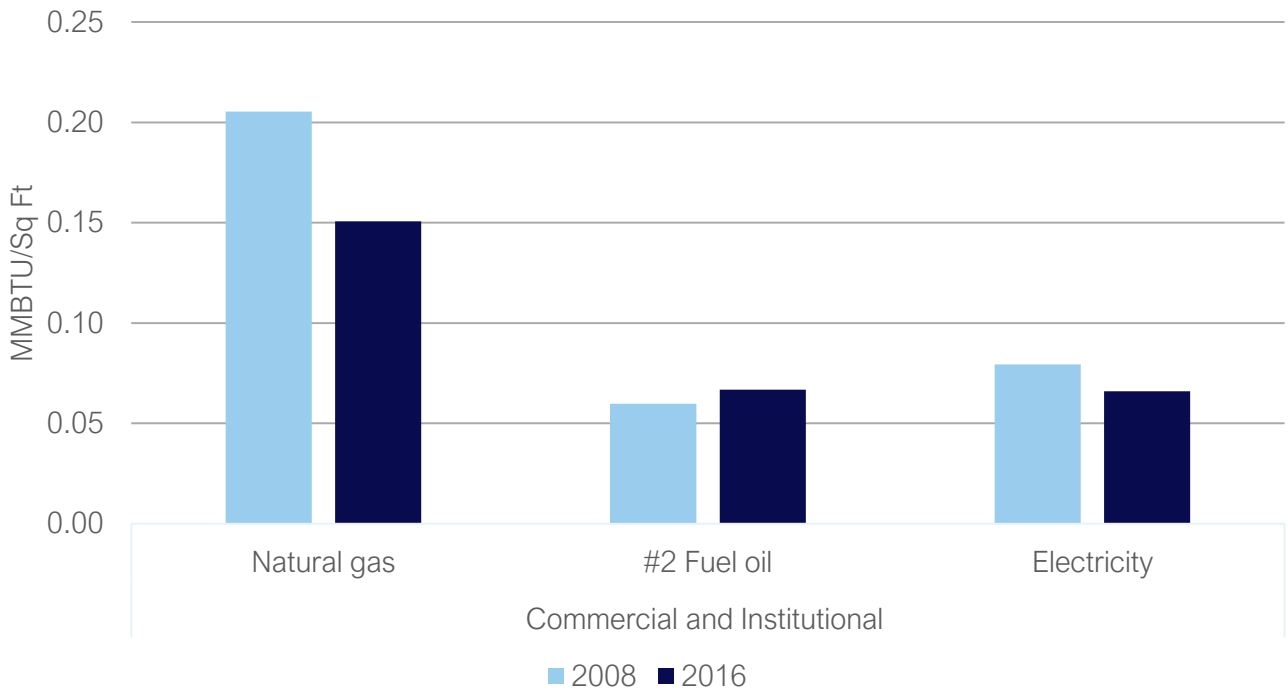


Figure 8. Concord's Commercial and Institutional Building Energy Use by Square Foot (MMBTU/Sq ft) and Fuel Source Over Time

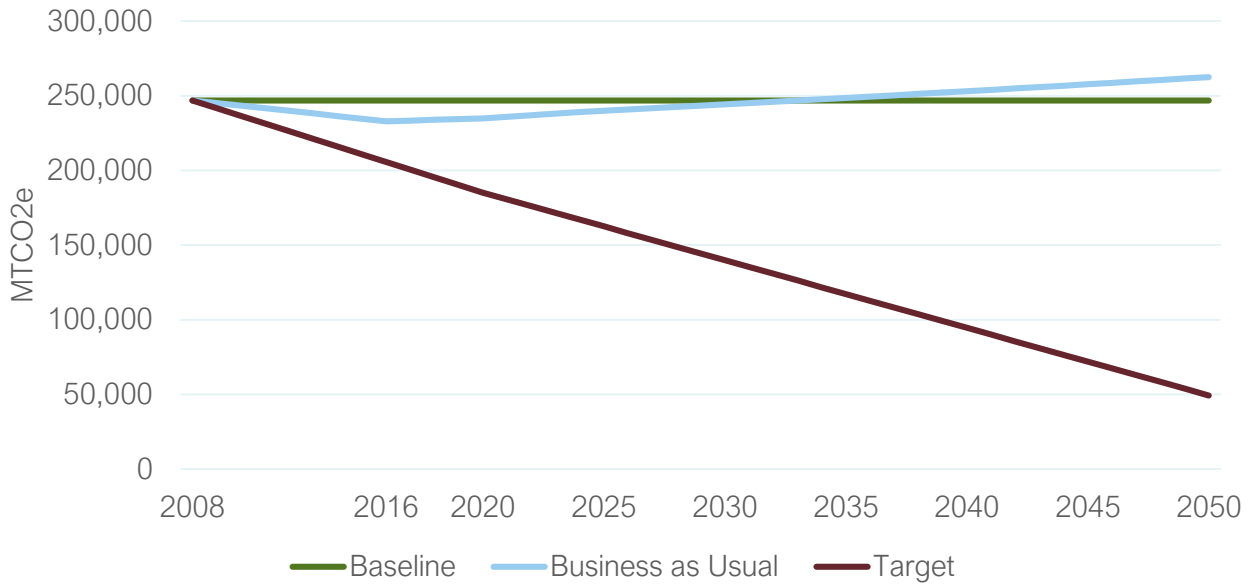
Section 4: Concord GHG Projections

The Town has set targets to reduce emissions 25% below 2008 levels by 2020 and 80% below 2008 levels by 2050. In order to accurately assess the amount of GHGs to be reduced, the town will need to estimate future emissions and account for any changes that would have otherwise occurred under a business as usual scenario. The two most common drivers of emissions under a business as usual scenario are population and employment, where emissions per person are held constant. The projection below assumes that population will decrease between 2010 and 2020 by 0.09% per year and then begins to increase in 2020 at a rate of 0.1% per year between 2020 and 2050. Forecasted population changes for the Town of Concord were obtained from the Metropolitan Area Planning Council (MAPC) Population Forecasts website.[23] Population trends forecasted by the MAPC out to 2030 were assumed to carry forward to 2050. Changes in employment modeled by the Executive Office of Labor and Workforce Development for 2016-2026 in the Metro North region of Massachusetts[24] have been carried forward through 2050. The projection below forecasts future emissions based on the 2016 inventory and emissions per capita and per job from 2016.

[23] Municipal population projections completed in 2014 for each jurisdiction in MAPC territory are available at https://www.mapc.org/learn/projections/
[24] Available at: http://lmi2.detma.org/Lmi/Occupation_Projection.asp?Area=15000009long

Business as Usual Emission Forecast

Under the business as usual scenario, emissions are forecast to be 262,488 $MTCO_2e$ in 2050. The Town's target for 2050 is 49,378 $MTCO_2e$. See **Figure 9**.



* BAU is forecasted from 2016.
** Target is based on 2008 baseline.

Figure 9. Concord GHG Emissions ($MTCO_2e$) Projections to 2050

Table 13 shows the current baseline emissions and the towns future GHG targets.

Table 13. GHG Targets and Reductions Needed

	2008 (Baseline)	2016	2020	2050
Business as usual (BAU) $MTCO_2e$	246,890	232,951	234,873	262,488
Target $MTCO_2e$	-	-	185,168	49,378
Target Percent below 2008	-	-	25%	80%
Difference between BAU and Target	-	-	49,705	213,110

Emissions projections for 2020, 2030, 2040 and 2050 were estimated by sector from the 2008 GHG baseline inventory. The rate of change in GHG for each sector was determined by one of three indicators: population, employment and average of population and employment.

Emission rates per person and per job from 2016 were assumed to be constant through 2050. The rate of population change was calculated using a compound growth rate based on forecasted population changes between 2010 and 2020, and 2020 and 2030 from the MAPC's 2014 Municipal Projection for Concord.[25] The employment forecast for the Metro North region of Massachusetts was obtained from the Executive Office of Labor and Workforce Development (EOLWD). The EOLWD published employment forecasts for 2016-2026.[26] A compound growth rate was estimated based on the forecasted total change in employment for the region. Sectors such as waste generation are dependent on both people living and working in the town. Employment forecasts for the Town of Concord were not available so the average of the population and employment rates was used.

Changes that occurred to emission rates, including to the emission factor from CMLP electric power in 2016, were not included in the business as usual forecast. 2016 emission rates per person and per job were carried forward to 2050. **Table 14** contains the indicators used for each sector.

Table 14. Forecast Indicators

Sector and Sub-sector	Source/Activity	Indicator	Growth Rate 2016 - 2020	Growth Rate 2020 - 2050
Residential Buildings	Electricity, natural gas, fuel oil, fugitive natural gas	Population	0.09%	0.10%
Commercial Buildings	Electricity, natural gas, fuel oil, fugitive natural gas	Employment	0.88%	0.88%
Transportation On-road	Gasoline, diesel, VMT	Population	-0.09%	0.10%
Solid Waste	Waste deposited in landfills	Average of population & employment	0.40%	0.49%
Wastewater	Wastewater treatment, biosolid incineration	Average of population & employment	0.40%	0.49%

[25] Available at: https://www.mapc.org/learn/projections/
[26] Available at: http://lmi2.detma.org/Lmi/Occupation_Projection.asp?Area=15000009long

Section 5: Conclusion

The Town of Concord's total GHG emissions from 2008 to 2016 decreased 6%. The emissions decrease was largely driven by increased renewable generation and lower emitting sources being added to the ISO New England grid. Concord's commercial sector electricity emissions also decreased. Emissions for transportation increased as did emissions from waste disposed. Concord's population grew by 4%, while per capita $MTCO_2e$ emissions fell by 10%. Total building energy use per square foot (primarily from natural gas and electricity use) decreased by 11%, which suggests that Concord residents are adopting energy efficient technologies and behaviors. GHG emissions from the transportation and waste sectors rose 1% and 11% per capita, respectively, indicating a need for improvement in these areas.

If the Town of Concord's residential population grows according to MAPC projections, employment grows according to regional expectations, and no new technology or behavior changes are adopted, total emissions may reach 262,488 $MTCO_2e$ in 2050. Given the Town's ongoing commitment to addressing climate change, it is anticipated that the community will continue to drive action to achieve its GHG reduction goals of 25% below 2008 levels (target emissions of 185,168 $MTCO_2e$) by 2020 and 80% below 2008 levels (target emissions of 49,378 $MTCO_2e$) by 2050.

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