Greenhouse Gas Inventory Codebook
Middlebury College

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Middlebury College
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Sustainability Solutions Lab

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GHG Intro For the Website

Greenhouse gasses (GHG) are those which trap heat in the atmosphere, creating a “greenhouse” effect. This both causes and accelerates the global warming and climate change that affects our weather, oceans, ecosystems, and much much more. The main GHGs entering the atmosphere are CO_2 (carbon dioxide), CH_4 (methane), and N_2O (nitrous oxide). These gasses are released through various anthropogenic activities but are mainly released through the burning of biogenic material and fossil fuels. You can learn more about greenhouse gasses here. Institutions have a responsibility to track their GHG emissions and continue to find ways to reduce their carbon footprint. This inventory and codebook were created in order to have a transparent and a comprehensive tool for calculating greenhouse gas emissions at any institution as well as be an instrument of change and further climate initiatives at the college. The inventory tracks all of the sources of greenhouse gasses that Middlebury College considers itself responsible for and calculates the carbon equivalent for all emissions, allowing all sources to be compared as well as represented by one single number.

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Glossary

Σ - A sigma summation notation, representing the sum of multiple numbers or terms.

BBL - One barrel of crude oil.

BTU (British Thermal Unit) - The amount of heat required to increase the temperature of a pint of water (which weighs exactly 16 ounces) by one degree Fahrenheit. For example 3412.14 BTUs = 1 kWh, and 1 BTU = 1,055.06 joules. One Million BTU's can be expressed as MBTU or MMBTU. Middlebury College facilities publications typically use MMBTU to express this quantity.

Carbon Offsets - A reduction in greenhouse gas emissions made in order to counter the production of GHG emissions made somewhere else, measured in MTCDEs.

CCC (Carbon Content Coefficient) – The mass to energy ratio of a fuel source. i.e. the mass of carbon atoms per million BTUs (MMBTU or MBTU).

CH_4 - Methane

CO_2 - Carbon Dioxide

Co-Gen - Cogeneration of electricity as a byproduct of steam generation for heat

Constants - Factors that have a set value in calculations. For the purposes of this codebook, constants are sourced values that are used to calculate total emissions. These values are considered constants, though they have and may continue to change with new information from entities such as the Environmental Protection Agency (EPA), external companies, etc. Thus, any updates to these values over the lifetime of the GHGI are noted.

Conversion Factors - A number used to change one kind of unit to another by either multiplying or dividing. For the purposes of this codebook, this includes both internationally and nationally accepted unit conversions, as well as conversions specific to the EPA, IPCC, WRI, or other external entities and companies.

EF (Emission Factor) – General name for the rate at which an activity releases greenhouse gasses into the atmosphere i.e. how many tonnes of CO2 are released per gallon of gasoline burned. These constants can change over time and need to be updated regularly for the monitoring and reporting system to retain its accuracy.

FY - Fiscal Year

GHG (Greenhouse Gas) - Gasses that trap heat in the atmosphere. These include nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4)

GWP (Global Warming Potential) - A value based on the amount that a given GHG contributes to Global Warming. Multiplying the volume or mass of an emitted gas by its GWP creates a carbon dioxide equivalent for all emissions to be compared to. All GWP's are typically based on a 100 yr time horizon, which is somewhat putative, given the 5-200 yr atmospheric lifespan of a CO2 molecule (IPCC, 2001, "Observed Changes in Globally Well-Mixed Greenhouse Gas Concentrations and Radiative Forcing." http://www.grida.no/climate/ipcc_tar/wg1/016.htm). Learn more about specific GWPs here: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

HC (Heat Content) – The amount of energy (in this case heat) contained in a given mass or volume. Eg. MMBTU/bbl of #6 Fuel oil = 6.287 MMBTU/bbl.

IPCC (Intergovernmental Panel on Climate Change). – Established in 1988 by WMO and UNEP to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation: http://www.ipcc.ch/

kWh - Kilowatt hour

MCF - 1,000 cubic feet. Often used to measure volume of natural gas.

MTCDE (Metric Tons of Carbon Dioxide Equivalent) – A metric measure used to compare the emissions from various greenhouse gasses based upon their global warming potential (GWP). The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP.

MW ratio (kg CO_2/KG C) - Molecular weight ratio

N_2O - Nitrous Oxide

NPCC - Northeast Power Coordinating Council

Scopes - Types of greenhouse gas emissions are broken down into categories created by the World Resource Institute's (WRI) Greenhouse Gas (GHG) Protocol. These categories are labeled as scopes.

Ton (Short Ton) - 2,000 pounds

Tonne (Metric Ton) - 1,000 kilograms (2,200 pounds)

Variables - Sources of GHG emissions the college collects for its annual report.

Acknowledgments

This codebook could not be created without the initial work of Jason Kowolski ‘07 in creating Middlebury College’s Greenhouse Gas Emissions Inventory (GHGI), as well as Billie Borden ‘09 and Chester Harvey ‘09 and their work in creating the Comprehensive Guide to the GHGI, in addition to all those involved in maintaining the inventory since its creation. Additionally, it is important to acknowledge Jack Byrne for his oversight of the project as well as the Sustainability Solutions Lab. The codebook also would not have been possible without the help and insight of Wendy Shook, Jonathan Kemp, Ryan Clement, Mike Moser, and Dean Oullette.

Introduction

Origins of the Inventory

Middlebury College’s Greenhouse Gas Inventory (GHGI) was originally created in 2006 by Jason Kowalski ‘07 with oversight from Jack Byrne, Dean of Sustainability and Environmental Affairs. The project was built under an ambition of political activism, its creators believing in a need for greater transparency and a more comprehensive tool for calculating greenhouse gas emissions. At the time of the creation of the inventory, information on greenhouse gas emissions and inventories in general was lacking. A great portion of consultants at other colleges and institutions only focused on Scope 1 (Stationary and Mobile Combustion sources) and 2 (Purchased electricity, Co-generation, and renewable electricity) emissions, and the actual emission numbers, specific coefficients and calculations were often not readily visible. Few inventories were using publicly available emissions factors from the EPA and IPCC. Kowalski wanted to create a better, more comprehensive and transparent system to track GHG emissions. By using publicly available information, he hoped to create a model which could be used by other people with little to no *a priori* scientific knowledge. In 2006, the Energy Action Coalition, a multi-campus network of activists trying to use similar tools, was first forming. Kowalski believed that using the same math and tools in tracking GHG emissions was important to creating a movement with coherence that could have a real political impact and help with student activism and fundraising. His work provided a basis to help people across the country push climate action and activism at their institutions.

One of the primary reasons for creating Middlebury's inventory is to further climate initiatives at the college. It ultimately played a large role in implementing Middlebury’s 2016 Carbon Neutrality goal. Several trends in the GHGI data show the impacts of the 2016 Neutrality goal, including the reduced and eventual stoppage of of #6 fuel oil use following the introduction of biomass to the institution’s energy mix, as well as the increased introduction of solar initiatives and energy efficiency and conservation expenditures. In 2016, Middlebury College began its Breadloaf Carbon Credit Program (explained in the Carbon offsets section) to quantify carbon credits on its Breadloaf land, and with this the institution could declare itself fully carbon neutral.

Overview of the GHGI

GHG Protocol:

Middlebury College's GHGI is organized according to the World Resource Institute's (WRI) Greenhouse Gas (GHG) Protocol. The GHG Protocol requires the inventory to be divided into three Scopes. Scope 1 includes emissions created from the burning of stationary and mobile combustion sources. Scope 2 includes emissions from purchased or acquired electricity. Scope 3 accounts for emissions from travel associated with the school and methane emissions from institutional landfill waste. More information about the WRI's GHG Protocol and guidance can be found at https://ghgprotocol.org/.

Organization of GHGI:

The Inventory is separated by Scope and subcategories: Scope 1A (Stationary Combustion Sources), Scope 1B (Mobile Combustion Sources), Scope 2 (Electricity), Scope 3A (Travel), and Scope 3B (Landfill Methane). The Inventory spreadsheet also includes tabs for Carbon offsets, Employee Commute, and Normalization Factors, along with several other tabs for various calculations, notes, and edits.

Notes on Source Reproduction:

At the bottom of the Scope tabs in the inventory, there is a section labeled "Notes on Source Reproduction", indicating distinct earlier sources for many of the variables. These earlier sources often came from non-governmental entities, and acted as a back-up to the governmental sources for EFs. The actual values in the inventory often used the EPA's guidance. While there are many different EF values in circulation, Middlebury College has historically tried to choose the values that would lead to the highest emissions in order to remain conservative.

Current GHGI Protocol

The inventory has both a geographic and an operational boundary. It covers emissions from sources on the main campus in Middlebury, the Breadloaf Campus, and the Snow Bowl. Sources owned or controlled by Middlebury within those boundaries are included. The college's GHGI data is reported annually by numerous college sources. This primarily includes Facilities and the Budget office, but also external sources such as utility companies (electricity and solid waste). Scope 1 emissions data are reviewed and approved (and modified if needed) by Director of Facilities Services Mike Moser. Scope 2 data is independently audited by Green Mountain Power and is recorded based on their annual fuel mix report. Scope 3A (Travel) emissions data are calculated using dollars spent on travel, which is reported by the Budget office internally. Scope 3B (Landfill Methane) data comes from the college's Material Recovery Facility that tracks recycling and waste monthly. All data are sent to the Office of Sustainability Integration for preparation for the GHGI.

Overview of Codebook

Description of a Codebook:

Codebooks are predominantly used in data analysis and collection to inform readers of the history of a dataset and to act as an instruction manual for how to interpret the dataset. They are important tools for those using, maintaining, or reporting the data to understand the dataset. Codebooks often consist of a list of variables, which are the primary data in the dataset, and descriptions of what those variables mean, where they come from, and who is responsible for reporting it. They also list information on the history of the dataset, including how many years of data are in the dataset and changes over time. Given that differences from year to year in the dataset make data hard to use and reuse, codebooks are often used to make information consistent and repeatable to simplify and streamline information on the dataset.

Uses and Intentions of the Codebook:

This codebook was created using information from Middlebury College's current GHG Inventory, as well as the Comprehensive Guide to the GHGI, created in 2007 to accompany the inventory. The motivation behind creating a codebook for the current GHGI is twofold: to make the inventory publicly accessible and readable for the general public and to make the inventory transparent and reproducible for other institutions and those continuing to contribute to Middlebury's own inventory. The codebook aims to highlight unique trends and anomalies in the data, as well as historical provenance of the data. Furthermore, the codebook details formulas, conversion factors, and constants sourced from internal and external entities used in order to calculate total emissions. In reviewing the codebook, the intention is to better understand Middlebury's GHGI, how it is created, and how it is and will continue to be used to meet the institution's environmental goals.

For Institutions Similar to Middlebury College:

By highlighting the actions that the college took to reach its 2016 Carbon Neutrality goals, as well as showing the variables and calculations that are sourced and tracked in order to report total emissions, this codebook can serve as a guide to similar institutions that are willing to create or maintain a greenhouse gas inventory with the goal of limiting emissions, minimizing environmental impact, divesting from fossil fuels, and/or becoming carbon neutral. Middlebury chose to report its emissions through the GHGI instead of through an online calculation tool, but other institutions could choose to do this with tools such as SIMAP instead, though this tool does not track methane emissions resulting from the combustion of fossil fuel sources in addition to carbon dioxide emissions. By creating their own inventory, institutions could account for all variables personalized to their institution, track these variables by gathering data from external and internal entities, and calculate emissions.

Codebook Layout:

The codebook tables are laid out according to Scope and subcategories:

- Scope 1

    - Scope 1, Part A: Stationary Combustion Sources
    - Scope 1, Part B: Mobile Combustion Sources
- Scope 2 (Purchased Electricity, Co-generation, and Renewable Electricity)
- Scope 3
    - Scope 3, Part A: Travel
    - Scope 3, Part B: Landfill Methane

Each section includes a description of the category, necessary notes on the data, variables included, the conversion factors and constants used, as well as all associated formulas. Below the Scope data tables, at the bottom of this document, is information on all other tabs other than the Scopes, including carbon offsets, employee commute, and normalization factors.

An example layout of a Scope section is below:

Scope X (example scope)

Scope X: Description of emissions included under scope X

Notes on Scope X

Note A:

This section is for notes that refer specifically to the data in Scope X (i.e. institutional changes in reporting and specific decision-making by Middlebury College).

Variables: Sources of GHG emissions the college collects for its annual report.

Name	*Description*	*Source*	*Trends/Notes*
Name of Variable. These variables are highlighted in yellow in the GHGI.	Description of Variable, including its use at Middlebury.	Source of Variable. Variable data are reported by a combination of Middlebury staff and faculty as well as external parties.	Significant trends/outliers in the data as well as important notes explaining both possible and known causes of trends and general notes about the variable itself.

Conversion Factors and Constants: Data sourced from the EPA or other outside sites, as well as new data calculated from sourced data. This is used to find the MTCDE of each variable, which in turn is all summed up to calculate the ΣMTCDE for the college's GHG outputs.

Name	*Description*	*Source*	*Trends/Notes*
Name of Conversion Factors/Constants. These are found at the bottom of the Scope tabs (i.e. "Scope3 Travel") and on the sources tabs in the GHGI.	Description of Conversion Factors/Constants.	Source of Conversion Factors/Constants. These come primarily from external entities (i.e. EPA). Some factors are referred to as "Calculated from sourced data" in the GHGI, and these do not have sources, but rather formulas expressing how they are calculated.	Notes containing who found/created the data and when it was last updated.

Formulas for Scope X: Carbon Dioxide emissions are calculated using equations sourced from EPA Climate Leaders publications in 2004. The January 2016 update can be found here: https://www.epa.gov/sites/default/files/2016-03/documents/stationaryemissions_3_2016.pdf.. These equations are used in the GHGI to calculate emissions (in MTCDE) of variables with conversion factors and constants, ending with a total MTCDE number for the entire scope. They can also be found in the Comprehensive Guide to the Greenhouse Gas Inventory.

Source A:

MMBTUs of fuel = (Source A(gal)) * (MMBTU/gal Source A EF)

Metric Tonnes CO_2 = (Source A(gal)) * (Tonnes CO_2/Source A EF)

tonnes CH_4 = (MMBTUs of fuel) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Source A = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Source B:

MMBTUs of fuel = (Source B(gal)) * (MMBTU/gal Source B EF)

Metric Tonnes CO_2 = (Total Source B(gal)) * (Tonnes CO_2/gal Source B EF)

tonnes CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Source B = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Source C:

MMBTUs of fuel = (Source C(gal)) * (MMBTU/gal Source C EF)

Metric Tonnes CO_2 = (Source C(gal)) * (Tonnes CO_2/gal Source C EF)

tonnes CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Source C = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Summary Data for Scope X:

TOTAL MTCDEs = (ΣMTCDE from Source A) + (ΣMTCDE from Source B) + (ΣMTCDE from Source C)

Equation Derivation:

The equations used to calculate the MTCDEs for each scope are derived from the following equations, sourced from 2004 EPA Climate Leaders.

- Scope 1A (Stationary) and Scope 2 (Purchased Electricity, Co-generation, and Renewable Electricty) Carbon Dioxide emissions are calculated using equations sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources" (pg. 5). Scope 1A and Scope 2 Methane and Nitrous Oxide Calculations are calculated using equations sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 7.

Equation 1: Fuel Analysis Approach for Estimating CO_2 Emissions

$$\text{Emissions} = \sum_{i=1}^{n} \text{Fuel}_i \times HC_i \times C_i \times FO_i \times \frac{CO_{2\,(m.w.)}}{C_{(m.w.)}}$$

where:

Fuel_i = Mass or Volume of Fuel Type i Combusted

HC_i = Heat Content of Fuel Type i $\left(\frac{\text{energy}}{\text{mass or volume of fuel}}\right)$

C_i = Carbon Content Coefficient of Fuel Type i $\left(\frac{\text{mass C}}{\text{energy}}\right)$

FO_i = Fraction Oxidized of Fuel Type i

$CO_{2\,(m.w.)}$ = Molecular weight of CO_2

$C_{(m.w.)}$ = Molecular Weight of Carbon

Equation 2: Estimation Method for CH_4 and N_2O Emissions

$$\text{Emissions}_{p,s} = A_s \times EF_{p,s}$$

where,

p = Pollutant (CH_4 or N_2O)

s = Source Category

A = Activity Level

EF = Emission Factor

- Scope 1B (Mobile) and Scope 3A (Travel) Carbon Dioxide emissions are calculated using equations sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources" (pg. 5). Scope 1B and Scope 3A Methane and Nitrous Oxide Calculations are calculated using equations sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 7.

Equation 2: Carbon Content per Unit of Energy Approach for Estimating CO_2 Emissions

$$\text{Emissions} = \sum_{i=1}^{n} \text{Fuel}_i \times HC_i \times C_i \times FO_i \times \frac{CO_{2\,(m.w.)}}{C_{(m.w.)}}$$

where:

Fuel_i = Volume of Fuel Type i Combusted

HC_i = Heat Content of Fuel Type i $\left(\frac{\text{energy}}{\text{volume of fuel}}\right)$

C_i = Carbon Content Coefficient of Fuel Type i $\left(\frac{\text{mass C}}{\text{energy}}\right)$

FO_i = Fraction Oxidized of Fuel Type i

$CO_{2\,(m.w.)}$ = Molecular weight of CO_2

$C_{(m.w.)}$ = Molecular Weight of Carbon

Equation 3: Estimation Method for CH_4 and N_2O Emissions

$$\text{Emissions}_{p,s} = A_s \times EF_{p,s}$$

where,

p = Pollutant (CH_4 or N_2O)

s = Source Category

A = Activity Level

EF = Emission Factor

- Scope 3B (Landfill Methane) emissions calculations are not derived from the EPA Climate Leaders equations. Instead, the calculations done simply involve multiplications of percentages of waste burned as straight methane, with electricity generation, and without electricity generation as well as the total amount of waste taken to the landfill to yield total methane emissions.

Scope 1

Scope 1, Part A: Direct Emissions from Stationary Combustion - This section includes emissions from all stationary combustion of fossil fuels purchased by the institution and combusted within the geographic and control boundaries established in the introduction

Note on Initials:

Some of the trends/notes for the conversion factors and constants indicate that the value was sourced by initials SG. These initials are found next to the sources in the GHGI (i.e. 'SG 08'). However, as of July 2022, the full name of SG is unclear. Thus, only the initials are used.

Variables

Name	*Description*	*Source*	*Trends/Notes*
#6 Fuel Oil (gal)	#6 Fuel Oil was primarily used by Middlebury for steam production to heat buildings on campus. This value also includes Kerosene, since EFs for N2O and CH4 could not be found for Kerosene. Kerosene blends with #2 diesel fuel to maintain low viscosity in order to pump during winter months when it is very cold.	#6 Fuel Oil data is collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collected this data from fuel delivery receipts from Champlain Valley Fuels.	Data show a decline in #6 Fuel Oil usage since 2008, as Middlebury switched from primarily #6 Fuel Oil to mostly gasified wood chips in its Biomass Facility (constructed in 2008). This was a way to help meet its carbon neutrality goals outlined in the Carbon Reduction Initiative. In 2017, there was a significant decline in #6 Fuel Oil usage because of higher usage of natural gas after a pipeline from Burlington to Middlebury was constructed. Middlebury stopped using #6 Fuel Oil fully in 2018.
Straight #2 Fuel Oil (gal)	Straight #2 Fuel Oil is used by Middlebury College in heating oil for small off-campus houses.	Straight #2 Fuel Oil data is collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery	Straight #2 Fuel Oil data increased by over 300% in 2016, as college energy needs necessitated a greater proportion of Straight #2 fuel oil after they stopped usage of B-20 Bioheat.

Name	*Description*	*Source*	*Trends/Notes*
		receipts from Champlain Valley Fuels.	
B-20 Bioheat (gal)	B-20 Bioheat is a type of biofuel and was used for heating purposes at Middlebury. 20% of B-20 Bioheat is straight bioheat, and 80% is #2 Fuel Oil.	B-20 Bioheat data is collected annually by Director of Facilities Service, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Middlebury College stopped used B-20 Biofuel in 2016 due to usability problems with the biofuel and its boilers in cold weather, and instead transitioned to greater proportional usage of Straight #2 Fuel Oil.
Off-Road Diesel (inc. blends)	Off-Road Diesel is used by Middlebury College to heat furnaces and run heavy machinery. It is also used in equipment at the Snow Bowl.	Off-Road Diesel data is collected annually by Director of Facilities Service, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Middlebury's off-Road Diesel usage spiked in the GHGI from FY 09/10 to FY 10/11. This is due to a change in reporting by the institution, in that the college started reporting off-road diesel from larger boundaries (Snow Bowl, Breadloaf, and the main campus) in FY10/11, rather than just the main campus. Since the Snow Bowl uses a significant amount of off-road diesel to fuel its equipment, there was a large increase in the data when this accounting change was made. It has declined since 2017, with more than a 400% decrease between 2016 and 2019. This is because the Snow Bowl transitioned to electric pumps between FY 17/18 and FY 18/19, which led to reduced usage of off-road diesel. 2020 and 2021 saw low off-Road Diesel usage due to Covid-19.
Propane (gal)	Propane is mainly used by college dining hall facilities and for a few building generators.	Propane data is collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Propane usage declined by approximately 40% from 2015 to 2016. Usage was also smaller in 2020 and 2021 due to Covid-19.

Name	*Description*	*Source*	*Trends/Notes*
Natural Gas (MCF)	Natural Gas is used at Middlebury for steam and heat production.	Middlebury College sources its natural gas from a natural gas pipeline that was constructed by Vermont gas systems from Burlington to Middlebury in 2016.	The jump in data from 0 natural gas usage to high usage in 2016 can be explained by the completion of construction of the natural gas pipeline. Higher usage of this natural gas pipeline is associated with the decline in usage of #6 Fuel Oil from 2015 to 2016. Natural gas usage declined by over 50% from 2020 to 2021, as Middlebury College experienced a low energy year across the board in FY21 due to Covid-19.

Conversion Factors and Constants

Name	*Description*	*Source*	*Trends/Notes*
HC (MMBTU/bbl)	The heat content of fuel, also known as HHV (Higher Heating Value), which is expressed as units of energy per quantity of fuel. In the GHGI, units are MMBTU/bbl (Metric Million British Thermal Unit per fuel oil equivalent of one barrel).	Higher heating values (HHV) are used. Values sourced from EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 23. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	HC values sourced by SG in 2008. These values have not been updated since.
CCC (kg C/ MMBTU)	The quantity of carbon found in fuel which is expressed by weight of carbon per quantity of energy. In the GHGI, units are kg C/MMBTU (Kilograms of Carbon per Metric Million British Thermal Units).	Values sourced from EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 23. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	CCC value sourced by SG in 2008. This value has not been updated since.

Name	*Description*	*Source*	*Trends/Notes*
Fraction oxidized	Fraction of Carbon within a fuel type which is Oxidized ie. is held in the form of CO_2 or CO opposed to just C. This affects the emission factor of the GHG source.	Values sourced from EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 23. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	FO value sourced by SG in 2008. This value has not been updated since.
MW ratio (kg CO_2/kg C)	Molecular weight ratio of carbon to carbon dioxide. Value = ((12.011+2*16.000)/12.011) or simplified as 44kg of CO_2/12kg of C.	Internationally accepted chemical standard	Sourced by Billie Borden in 2007. Given this is a chemical standard, value has not been updated since.
CH_4 EF (g gas/MMBTU)	Emission factor of Methane expressed as grams of CH_4 released per MMBTU generated.	Based on HHV and residential/commercial efficiency. EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	CH_4 EF value sourced by SG in 2008. This value has not been updated since.
CH_4 GWP	Global Warming Potential (GWP) of CH_4 based on 100 yr time horizon.	As stated by the EPA in its 2006 publication entitled "Non-CO_2 Gases Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." Emissions Factors are updated continually by the EPA. The EPA's 2022 Emissions Factors update lists CH_4 100-Year GWP as 25 (https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf).	Value sourced by Billie Borden in 2007. This value has not been updated since.
N_2O EF (g gas/MMBTU)	Emission factor of Nitrous Oxide expressed as grams of Nitrous Oxide released per MMBTU generated.	Values based on HHV and industrial efficiency: EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 20. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here:	Values sourced by SG in 2008. These values have not been updated since.

Name	*Description*	*Source*	*Trends/Notes*
		https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	
N_2O GWP	Global Warming Potential (GWP) of N_2O based on 100 yr time horizon.	As stated by the EPA in its 2006 publication entitled “"Non-CO_2 Gases Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." Emissions Factors are updated continually by the EPA. The EPA’s 2022 Emissions Factors update lists N_2O 100-Year GWP as 298 (https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf).	Value sourced by Billie Borden in 2007. This value has not been updated since.
Tonne/kg (1/1,000)	Conversion between tonnes and kilograms.	Internationally accepted unit conversion.	Given this is a unit conversion, value has not been updated throughout inventory’s existence.
barrel/gallon (1/42)	Oil barrels per gallon	Nationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory’s existence.
MMBTU/gal #6 EF	Emission factor of #6 fuel oil expressed as MMBTUs released per gallon of #6 fuel oil.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl))	Nothing of note.
Tonnes CO_2/gal #6 EF	Emission factor of #6 fuel oil expressed as metric tons of CO_2 released per gallon of #6 fuel oil.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl)) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg*1/1,000))	Nothing of note.

Scope 1A Formulas

#6 Fuel Oil:

MMBTUs of fuel = (#6 Fuel Oil(gal)) * (MMBTU/gal #6 EF)

Metric Tonnes CO_2 = (#6 Fuel Oil(gal)) * (Tonnes CO_2/gal #6 EF)

tonnes CH_4 = (MMBTUs of fuel) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from #6 Fuel Oil = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

#2 Fuel Oil/Off Road Diesel:

Total Bioheat = (5% of B-5 Bioheat (gal)) + (20% of B-20 Bioheat (gal))

Total #2 Fuel (gal) = (Straight #2 Fuel Oil(gal)) + (95% of B-5 Bioheat (gal)) + (80% of B-20 Bioheat(gal)) + (Off-Road Diesel(inc. blends))

MMBTUs of fuel = (Total #2 Fuel(gal)) * (MMBTU/gal #2 EF)

Metric Tonnes CO_2 = (Total #2 Fuel(gal)) * (Tonnes CO_2/gal #2 EF)

tonnes CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from #2/diesel = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Propane:

MMBTUs of fuel = (Propane(gal)) * (MMBTU/gal propane EF)

Metric Tonnes CO_2 = (Propane(gal)) * (Tonnes CO_2/gal propane EF)

tonnes CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (MMBTUs of fuel) * (CH_4 EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of fuel) * (N_2O EF(g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from propane = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Summary Data for Scope 1A Stationary Combustion Sources:

TOTAL MTCDEs = (ΣMTCDE from #6 fuel oil) + (ΣMTCDE from #2/Diesel) + (ΣMTCDE from Propane)

Scope 1, Part B: Direct Emissions from Mobile Combustion - This section includes emissions from all mobile combustion of fossil fuels purchased by the institution, combusted within all vehicles owned and controlled by the institution as established in the introduction.

Variables

Name	*Description*	*Source*	*Trends/Notes*
On-campus Gasoline/10% Ethanol (gal)	Gasoline with 10% ethanol used by on-campus vehicles which Middlebury owns or controls more than 50% of.	Gasoline data are collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Middlebury started using ethanol gas in 2010, and usage increased by a factor of 10 in FY 11/12. While the reasoning for this is unclear, this drastic change in usage may be due to the college reporting all gasoline as 10% ethanol gasoline. Usage of 10% Ethanol gasoline has declined since 2018, and was much smaller in 2020 and 2021 because of lower energy usage due to Covid-19. .
On-campus gasoline (gal)	Gasoline used by on-campus vehicles which Middlebury owns or controls more than 50% of.	Gasoline data are collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from	Gasoline usage has declined since 2010. Anomalies in data, including years in which on-campus gasoline usage was 0 or very low, could be attributed to errors in reporting. As stated in the “Trends/Notes” section of 10% ethanol

Name	*Description*	*Source*	*Trends/Notes*
		fuel delivery receipts from Champlain Valley Fuels.	gasoline, another explanation may be that the college reported all on-campus gasoline as 10% ethanol gasoline, at least for the few years in which on-campus gasoline was 0.
Straight on-road diesel (gal)	Straight on-road diesel is used to fuel vehicles which Middlebury owns or controls more than 50% of.	Straight on-road diesel data are collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Straight on-road diesel usage has declined steadily since 2013. Lower energy usage in 2020 and 2021 is due to Covid-19.
B-5 Biodiesel (gal)	B-5 Biodiesel consists of 5% biofuel and 95% diesel. It was used for heating furnaces at Middlebury College.	B-5 Biodiesel data are collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	B-5 Biodiesel data are not quantified in the actual GHGI, but rather reported in the sources. There is no record of when B-5 Biodiesel was used, though it is no longer used at the college.
B-20 Biodiesel (gal)	B-20 Biodiesel consists of 20% biofuel and 80% diesel.	B-20 Biodiesel data are collected annually by Director of Facilities Services, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from fuel delivery receipts from Champlain Valley Fuels.	Middlebury College's total diesel usage has declined steadily since 2010. Biodiesel usage ended in 2012, as the college found issues with the usage of biofuel in its facilities.

Conversion Factors and Constants

Name	*Description*	*Source*	*Trends/Notes*
HC (MMBTU/bbl)	See Scope 1A	Higher heating values (HHV) are used. EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 30.	See Scope 1A

Name	*Description*	*Source*	*Trends/Notes*
		While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	
CCC (kg C/ MMBTU)	See Scope 1A	Based on values sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 30. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	See Scope 1A
Fraction oxidized	See Scope 1A	Based on values sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 30. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	See Scope 1A
MW ratio (kg CO_2/kg C)	See Scope 1A	See Scope 1A	See Scope 1A
CH_4 EF (g gas/MMBTU)	See Scope 1A	Based on 1985-1986 EF's for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 25. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	See Scope 1A
CH_4 GWP	See Scope 1A	As stated by the EPA in its 2006 publication entitled “"Non-CO_2 Gases Economic Analysis and Inventory: Global Warming Potentials and Atmospheric	See Scope 1A

Name	*Description*	*Source*	*Trends/Notes*
		Lifetimes." Emissions Factors are updated continually by the EPA. The EPA's 2022 Emissions Factors update lists CH_4 100-Year GWP as 25 (https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf).	
N_2O EF (g gas/MMBTU)	See Scope 1A	Based on 1996 EF's for heavy duty vehicles (most conservative values). EPA Climate Leaders. 2008. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 25. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	See Scope 1A
N_2O GWP	See Scope 1A	As stated by the EPA in its 2006 publication entitled "Non-CO_2 Gases Economic Analysis and Inventory: Global Warming Potentials and Atmospheric Lifetimes." Emissions Factors are updated continually by the EPA. The EPA's 2022 Emissions Factors update lists N_2O 100-Year GWP as 298 (https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf).	See Scope 1A
Car tank size (gal)	Size (in gallons) of gas tank in school-owned cars.	2005-2008 Toyota Camrys used as case studies (6 cyl 3 L): http://www.fueleconomy.gov/feg/noframes/20932.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used in the original inventory and never deleted.
Car ave miles/gal	Average miles per gallon of gas used for school-owned cars.	2005-2008 Toyota Camrys used as case studies (6 cyl 3 L): http://www.fueleconomy.gov/feg/noframes/20932.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used

Name	*Description*	*Source*	*Trends/Notes*
			in the original inventory and never deleted.
15/11-pass. van tank size (gal)	Gas tank size (in gallons) for school-owned 15- or 11-seat passenger vans.	2005-2008 Chevrolet 15 passenger vans used as case studies (8 cyl 5.3 L 2WD 15/25 conversion - least efficient): http://www.fueleconomy.gov/feg/noframes/21193.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used in the original inventory and never deleted.
15/11-pass. van ave miles/gal	Average miles per gallon of gas used for school-owned 15- or 11-seat passenger vans.	2005-2008 Chevrolet 15 passenger vans used as case studies (8 cyl 5.3 L 2WD 15/25 conversion): http://www.fueleconomy.gov/feg/noframes/21193.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used in the original inventory and never deleted.
Minivan tank size	Gas tank size (in gallons) for school-owned minivans.	2004-2008 Dodge Caravans used as case studies (3.8 L): http://www.fueleconomy.gov/feg/noframes/21230.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used in the original inventory and never deleted.
Minivan ave miles/gal	Average miles per gallon of gas used for school-owned minivans.	2004-2008 Dodge Caravans used as case studies (3.8 L): http://www.fueleconomy.gov/feg/noframes/21230.shtml	Originally sourced by Jason Kowalski in 2006. Value has not been updated since. Value is not used in any calculations in the GHGI, but rather was written to possibly be used

Name	*Description*	*Source*	*Trends/Notes*
			in the original inventory and never deleted.
Putative Vehicle mi/gal (school-owned)	Estimated average miles per gallon for school-owned vehicles.	2005-07 Toyota Camrys used as case studies (6 cyl 3 L): http://www.fueleconomy.gov/feg/noframes/20932.shtml	Originally sourced by Jason Kowalski in 2006. Value updated in FY 10/11, though, as of July 2022, it is unknown who made this change. Value has not been updated since.
MMBTU/gal gas EF	Emission factor of gasoline expressed as MMBTUs released per gallon of gasoline.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl))	Nothing of note.
Tonnes CO_2/gal gas EF	Emission factor of gasoline expressed as metric tons of CO_2 released per gallon of gasoline.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl)) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg*1/1,000))	Nothing of note.
Gas vehicle activity miles (gasoline)	Total miles driven by school-owned vehicles.	Calculated from sourced data: (Σ Scope 1 Gas(gal)) * (Putative Vehicle mi/gal (school owned))	Nothing of note.
MMBTU/gal diesel EF	Emission factor of diesel expressed as MMBTUs released per gallon of diesel.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl))	Nothing of note.
Tonnes CO_2/gal diesel EF	Emission factor of diesel expressed as metric tons of CO_2 released per gallon of diesel.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl)) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg*1/1,000))	Nothing of note.

Name	*Description*	*Source*	*Trends/Notes*
Gas vehicle activity miles (school owned diesel)	Total miles driven by school-owned vehicles.	Calculated from sourced data: (Total diesel(gal)) * (Putative Vehicle mi/gal (school owned))	Nothing of note.

Scope 1B [Formulas]

Gasoline Fueled Vehicles:

Σ Scope 1 Gas(gal) = (Off Campus Gasoline(gal)) + (On-Campus Gasoline(gal))

MMBTUs of fuel = (Σ Scope 1 Gas(gal)) * (MMBTU/gal gas EF)

Metric Tonnes CO_2 = (Σ Scope 1 Gas(gal)) * (Tonnes CO_2/gal gas EF)

Gas Vehicle Activity miles = (Σ Scope 1 Gas(gal)) * (Putative Vehicle mi/gal)

tonnes CH_4 = (Gas Vehicle Activity miles) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/mile))

MTCDE from CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Gas Fueled Vehicles = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Diesel Fueled Vehicles:

Total Biodiesel = (5% of B-5 Biodiesel(gal)) + (20% of B-20 Biodiesel(gal))

Total diesel(gal) = (Straight on-road diesel(gal)) + (95% of B-5 Biodiesel(gal)) + (80% of B-20 Biodiesel(gal))

MMBTUs of fuel = (Total diesel(gal)) * (MMBTU/gal diesel EF)

Metric Tonnes CO_2 = (Total diesel(gal)) * (Tonnes CO_2/gal diesel EF)

Gas Vehicle Activity miles = (Total diesel(gal)) * (Putative Vehicle mi/gal)

tonnes CH_4 = (Gas Vehicle Activity miles) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/mile))

MTCDE from CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Diesel Fueled Vehicles= (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Summary Data for Scope 1 B Mobile Combustion Sources:

TOTAL MTCDE = (ΣMTCDE Gas fueled vehicles) + (ΣMTCDE Diesel fueled vehicles)

Scope 2

Scope 2: Indirect Emissions from Electricity Purchases - This section includes emissions from all stationary combustion of fossil fuels done in direct proportion to an energy source purchased by the institution (i.e. purchased electricity and steam generated outside the geographic/control boundaries set in the introduction, yet consumed within them).

Notes on Scope 2

GMP and ISO-NE Sources:

Middlebury College currently sources its electricity from Green Mountain Power (GMP). In 2012, Central Vermont Public Service (CVPS), from whom the institution had previously sourced its electricity, merged with GMP. When Middlebury's GHG Inventory was first produced, GMP's (then CVPS's) electricity sources were communicated to the college through Dave Dunn (ddunn@cvps.com), the manager of Renewable Project Development at GMP and his colleague Brenda Spafford. Dave can be emailed at. GMP now publishes their annual energy mix, indicating what percentage of their energy comes from each source of power. The latest update details their 2020 energy mix, and can be found here: https://greenmountainpower.com/energy-mix/. Percentages were collected by Director of Facilities Services, Central Heating/Utilities, Mike Moser. GMP's fuel mix for the electricity Middlebury College purchases was 100% carbon neutral and 68% renewable as of 2020. Thus, as of 2020, MTCDEs from Scope 2 emissions is 0.

The college's GHG Inventory also notes that a percentage of GMP's electricity sources is from ISO-New England ('ISO-NE'). This details the energy that GMP purchases on the spot market immediately from different energy plants. To allow for a fully comprehensive emissions inventory, the GHGI includes the energy sources and their corresponding percentages on the ISO-NE market. Occasionally, the ISO-NE grid has to bring energy from another grid into its grid. For the inventory, this category is called 'other', but it is assumed that this is the NPCC grid. The values for the ISO-NE energy source percentages can be found at https://www.iso-ne.com/.

Biomass as a Carbon Neutral Source:

The Intergovernmental Panel on Climate Change (IPCC) states in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 2, Energy) that emissions that result from the combustion of biomass need not be included in greenhouse gas inventories. These emissions are accounted for already in the emissions within the AFOLU (Agriculture, Forestry, and Other Land Use) sector through "estimated changes in carbon stocks through biomass harvest". Thus, any emissions created through the combustion of biomass will be accounted for by national land-use change activities. Furthermore, CO_2 emissions created from the combustion of biomass are often treated differently than those created from burning fossil fuels, because biomass carbon is of biogenic origin, meaning it is contained in living and breathing tissues. GHG Protocol requires that CO_2 emissions from biomass combustion be reported separately from other scopes. However, the combustion of biomass does result in a net addition of N_2O and CH_4 to the atmosphere, which is why these emissions are accounted for in the total emissions inventory, labeled as "anthropogenic emissions". Other perspectives on biomass emissions note that biomass may not be an entirely renewable source of energy, as it takes many years for old trees to sequester a significant amount of carbon. Middlebury College follows the IPCC and WRI guidelines for biomass, in that the institution reports its biomass emissions but does not include them in its emissions total, though it does include anthropogenic emissions from biomass in the total.

One tab in the GHGI is labeled "Biomass Accounting", and refers to the work done by Gabe Desmond '20.5 in the summer of 2020 to determine if Middlebury's biomass production is truly carbon neutral. While hesitant to make conclusions about how sustainable biomass truly is, he determined that biomass gasification was a reasonable alternative to fossil fuels. In Desmond's paper, "Tracking Campus Emissions from Biomass Gasification", he notes "because there is net sequestration in the larger Vermont bioenergy system, many people consider biomass sustainable, although this would be entirely different if there was higher demand for wood products in the state and there was not net sequestration, as is seen in many parts of the world." This ties into an ongoing discussion about the way in which Middlebury's biomass plant fits into the school's definition of sustainability, given the college's unique opportunity to be able to burn wood chips, and whether or not Middlebury can claim the net growth of Vermont's lands. Currently the college tracks forest growth according to the US Forest Service National Forest Inventory and Analysis program and reporting by the Vermont Department of Forest, Parks and Recreation (https://fpr.vermont.gov/forest/vermonts-forests). During the time the biomass system has operated Vermont has had a steady increase in net forest growth though this fluctuates from year to year. This allows Middlebury to label its biomass energy production as carbon neutral, though it is recognized that there is no agreed-upon methodology for assigning net growth to specific biomass users. Discussion over issues like this serve as a reminder that Middlebury must constantly question and rethink how it is defining sustainability and if the practices of the college today fit the goals of tomorrow. The college must continue to reevaluate if it is doing its best at "helping to create a more sustainable world." (Middlebury's Sustainability in Action)

Variables

Name	*Description*	*Source*	*Trends/Notes*
Total kWh from GMP	Electricity purchased from Green Mountain Power.	Collected annually by director of Facilities Service, Central Heating/Utilities, Mike Moser and Customer Service Coordinator, Jen Pottinger. Moser and Pottinger collect this data from energy purchase receipts from GMP.	There is much smaller energy usage in pandemic years (2020 and 2021). GMP changed its energy sourcing to all carbon-neutral sources in 2020. This is why the scope 2 MTCDEs declined in FY19/20 and were zero in FY 20/21.

GMP kWh excluded	The electricity used by renters who reimburse the college for their electricity bill (not included in the campus' energy total).	Based on documentation composed by Director of Facilities Services, Central Heating/Utilities, Mike Moser (rental properties excluded from the total kWh purchased). Moser collects this data from energy purchase receipts from GMP.	From FY06/07 to FY10/11, data are calculated by the college. In FY 11/12, the college began using an estimate of 300,000 kWh based on a survey of which units reimbursed the college for their power. These estimates dropped significantly from around 300,000 to 100,000 in FY 18/19, as this excludes kWh from renters who reimburse the college for electricity billed to the college for their units.
GMP kWh from CH_4 dig.	For cow power, GMP contracts with outside farmers who have generators on their own properties. GMP buys electricity from these farmers, subsidized by entities such as Middlebury College who want to use renewable power. The college is then allowed to credit the electricity that powers Weybridge House (28 Weybridge St.) and the President's house (3 South Street). Power is supplied to Weybridge in order for the Franklin Environmental Center at Hillcrest to meet its LEED certification. This works because Weybridge, being a similar size with similar energy use, acts as a proxy, and because it is off-campus and not connected to the Middlebury grid, its electricity use is independent, unlike Hillcrest.	David Dunn, Cow Power Program Manager, GMP via Associate Vice President, Middlebury College Facilities Services, Susan Personnette. Data are reported through energy purchase receipts from GMP.	There was a sharp decline in data in FY16/17 and FY17/18. Reasons are unexplained, though this may have been due to a human reporting error. Further variations from year to year in the amount of electricity purchased are unknown.
On-campus co-gen kWH	On-campus cogeneration kWH includes electricity generated from steam created in the biofuel plant. This electricity is	Collected annually by Director of Facilities Services, Central Heating/Utilities: Mike Moser and Customer	On-campus co-generation had significant drops in FY 15/16 and FY 17/18. Fluctuating data results from the differing amounts of steam

	co-generated in that it serves two purposes, as it is the same steam used to heat buildings.	Service Coordinator: Jen Pottinger.	produced in a given year, as less steam usage results in less electricity production. Mild summers and winters, for example, may require less steam production and thus less electricity. Additionally, all three chp turbines were offline for a portion of August 2016, which can explain the drop in data in FY 17/18.
On-campus wind kWH	On-campus wind includes one wind turbine near the Recycling Center.	Collected annually by College Electrician, Dean Ouellette.	Nothing of note.
On-campus solar kWH	Middlebury College's on-campus solar generation comes from the Franklin Environmental Center at Hillcrest, the solar farm on Rt. 125, Self-reliance/InSite houses, and Farrell House. There are also 2 solar hot water systems: 107 Shannon St. System 1 and 107 Shannon St. System 2. The school-owned solar generation goes directly to its grid.	Collected annually from College Electrician, Dean Ouellette.	There was an increase in on-campus solar production in FY 07/08 due to the addition of solar PV panels during the renovation of the Franklin Environmental Center at Hillcrest, completed in 2008. Additionally, there was a significant increase in FY11/12 with addition of Rt.125 solar farm, which was offline for unexplained reasons in FY14/15.
Off-campus solar kWH	The college's off-campus solar generation comes from South Ridge Solar Project and Wilber Farm Solar Project. The school purchases solar energy from these projects independent from GMP.	Collected annually from College Electrician, Dean Ouellette.	South Ridge Solar Project went online in FY 13/14 (December 2013) and Wilber Farm Solar Project went online in FY 16/17 (December 2016). There is missing data for the total kWH from South Ridge Solar Project in FY 14/15.
Wood chips (tons)	The college's biomass facility was built in 2008 (FY 08/09) in order to achieve carbon neutrality. The facility gasifies wood chips and burns the gas to heat up water and create steam to heat buildings on campus and also generate	Collected annually by Director of Facilities Services, Central Heating/Utilities: Mike Moser and Customer Service Coordinator: Jen Pottinger. When the biomass facility was first built, Middlebury bought its	Emissions from biomass combustion were much higher in 2010 because the biomass facility only partially came online in 2009, and was fully online in 2010. More knowledge about how to operate facility explains the increased proportion of biomass to #6 fuel oil in 2011.

	electricity (see On-campus co-gen kWH). Wood chips come from a combination of mill residue and whole tree chips.	woodchips through Cousineau Forest Products, which sourced their wood chips from a 75 mile radius. The college currently sources woodchips through Lathrop Forest Products (located in Bristol, VT), which also source their wood from a 75-mile radius.	

Conversion Factors and Constants

Name	*Description*	*Source*	*Trends/Notes*
CCC (kg C/ MMBTU)	See Scope 1A	Values sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Stationary Combustion Sources." pp 22. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	See Scope 1A
Fraction Oxidized	See Scope 1A	See Scope 2 "CCC (kg C/MMBTU)"	See Scope 1A
MW ratio (kg CO_2/kg C)	See Scope 1A	See Scope 1A	See Scope 1A
CH_4 EF (g gas/MMBTU)	See Scope 1A	See Scope 2 "CCC (kg C/MMBTU)"	See Scope 1A
CH_4 GWP	See Scope 1A	See Scope 1A	See Scope 1A

N_2O EF (g gas/MMBTU)	See Scope 1A	See Scope 1A	See Scope 1A
N_2O GWP	See Scope 1A	See Scope 1A	See Scope 1A
MWh/kWh (1/1000)	Conversion between Megawatt-hours and kilowatt-hours.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
MMBTU/kWh	Conversion between MMBTUs (Metric Million British Thermal Units) and kilowatt-hours.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
tonne/gram (1/1x106)	Conversion between tonnes and grams.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
Tonne/lb (1/2,204.6)	Conversion between tonnes and pounds.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
Tonne/kg (1/1,000)	See scope 1A	See Scope 1A	See Scope 1A
Tonnes CO_2/kWh Natural Gas EF	Emission factor of natural gas expressed as metric tonnes of CO_2 emitted per kWh of electricity generated by natural gas.	Calculated from sourced data: (barrels/gallon(1/42)) * (HC(MMBTU/bbl)) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg*1/1,000))	Nothing of note.
Tonnes CO_2/kWh Coal EF	Emission factor of coal expressed as metric tonnes of CO_2 emitted per kWh of electricity generated by coal.	Calculated from sourced data: (MMBTU/kWh) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))	Nothing of note.

Tonnes CO_2/kWh Dis #1,2 & 4 Fuel Oil EF	Emission factor of #1, 2, 3, and 4 distillate oil expressed as metric tonnes of CO_2 emitted per kWh of electricity generated by #1, 2, 3, and 4 distillate oil.	Calculated from sourced data: (MMBTU/kWh) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))	Nothing of note.
Tonnes CO_2/kWh res #5 & 6 Fuel Oil EF	Emission factor of #5 and 6 residual oil expressed as metric tonnes of CO_2 emitted per kWh of electricity generated by #5 and 6 residual oil.	Calculated from sourced data: (MMBTU/kWh) * (CCC(kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))	Nothing of note.
Yr. 2000 EF (lbs CO_2/MWh)	Emission factor the NPCC electrical grid for the year 2000. Expressed as lbs of CO_2 per MWh (Megawatt Hour) of electricity generated.	EPA Climate Leaders. 2004. "Core Module Guidance: Indirect Emissions from Purchases/Sales of Electricity and Steam." pp 22.	Nothing of note.
Tonnes CO_2/kWh Res Oil EF (NPCC grid)	Emission factor of residual oil expressed as metric tonnes of CO_2 emitted per kWh of electricity generated by residual oil in the NPCC powergrid.	Calculated from sourced data: (mWh/kWh(1/1000)) * (Yr. 2000 EF(lbs CO_2/mWh)) * (Tonne/lb(1/2,204.6))	Nothing of note.

Scope 2 Formulas

Calculating kWh of Carbon Emitting Electricity:

kWh used w/in boundaries = (Total kWh from CVPS – CVPS kWh excluded) + (on-campus go-gen kWh) + (on-campus wind kWh) + (on-campus solar kWh)

on-campus renewable kWh = (on-campus go-gen kWh) + (on-campus wind kWh) + (on-campus solar kWh)

off-campus renewable kWh = CVPS kWh from CH_4 dig.

in bounds kWh from CVPS grid = kWh used w/in boundaries – (on-campus renewable kWh + off-campus renewable kWh)

Adjusted Sources as Percents:

% Biomass = (“CVPS Sources as Percents” % Biomass) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Biomass)/100)]

% Hydro = (“CVPS Sources as Percents” % Hydro) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Hydro)/100)]

% Nuclear = (“CVPS Sources as Percents” % Nuclear) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Nuclear)/100)]

% Natural Gas = (“CVPS Sources as Percents” % Natural Gas) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Natural Gas)/100)]

% Coal = (“CVPS Sources as Percents” % Coal) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Coal)/100)]

% #1, 2, & 4 Fuel Oil = (“CVPS Sources as Percents” % #1, 2, & 4 Fuel Oil) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % #1, 2, & 4 Fuel Oil)/100)]

% #5 & 6 Fuel Oil = (“CVPS Sources as Percents” % #5 & 6 Fuel Oil) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % #5 & 6 Fuel Oil)/100)]

% Other (assume NPCC grid) = (“CVPS Sources as Percents” % Other(assume NPCC grid)) + [(“CVPS Sources as Percents” %ISO-NE)*((“ISO-NE Sources as Percents” % Other(assume NPCC grid))/100)]

Should be 100: (“Adjusted Sources as Percents” %Biomass) + (“Adjusted Sources as Percents” %Hydro) + (“Adjusted Sources as Percents” %Nuclear) + (“Adjusted Sources as Percents” %Natural Gas) + (“Adjusted Sources as Percents” %Coal) + (“Adjusted Sources as Percents” %#1, 2, & 4 Fuel Oil) + (“Adjusted Sources as Percents” %#5 & 6 Fuel Oil) + (“Adjusted Sources as Percents” %Other(assume NPCC Grid))s

Net kWh by Source:

Co-Gen = on-campus co-gen kWh

Wind = on-campus wind kWh

Solar = on-campus solar kWh

CH_4 digestion = CVPS kWh from CH_4 dig.

Biomass = ((“Adjusted Sources as Percents” %Biomass)/100) * (in bounds kWh from CVPS grid)

Hydro = ((“Adjusted Sources as Percents” %Hydro)/100) * (in bounds kWh from CVPS grid)

Nuclear = ((“Adjusted Sources as Percents” %Nuclear)/100) * (in bounds kWh from CVPS grid)

Natural Gas = ((“Adjusted Sources as Percents” %Natural Gas)/100) * (in bounds kWh from CVPS grid)

Coal = ((“Adjusted Sources as Percents” %Coal)/100) * (in bounds kWh from CVPS grid)

#1, 2, & 4 Fuel Oil = ((“Adjusted Sources as Percents” %#1, 2, & 4 Fuel Oil)/100) * (in bounds kWh from CVPS grid)

#5 & 6 Fuel Oil = ((“Adjusted Sources as Percents” %#5 & 6 Fuel Oil)/100) * (in bounds kWh from CVPS grid)

Other (assume NPCC grid) = ((“Adjusted Sources as Percents” %Other(assume NPCC grid))/100) * (in bounds kWh from CVPS grid)

Total kWh = (“Net kWh by Source” Co-Gen) + (“Net kWh by Source” Wind) + (“Net kWh by Source” Solar) + (“Net kWh by Source” CH_4 digestion) + (“Net kWh by Source” Biomass) + (“Net kWh by Source” Hydro) + (“Net kWh by Source” Nuclear) + (“Net kWh by Source” Natural Gas) + (“Net kWh by Source” Coal) + (“Net kWh by Source” #1, 2, & 4 Fuel Oil) + (“Net kWh by Source” #5 & 6 Fuel Oil) + (“Net kWh by Source” Other(assume NPCC grid))

Electricity Sources by Percent:

Co-Gen = (“Net kWh by Source” Co-Gen)/(“Net kWh by Source” Total kWh)

Wind = (“Net kWh by Source” Wind)/(“Net kWh by Source” Total kWh)

Solar = (“Net kWh by Source” Solar)/(“Net kWh by Source” Total kWh)

CH_4 digestion = (“Net kWh by Source” CH4 digestion)/(“Net kWh by Source” Total kWh)

Biomass = (“Net kWh by Source” Biomass)/(“Net kWh by Source” Total kWh)

Hydro = (“Net kWh by Source” Hydro)/(“Net kWh by Source” Total kWh)

Nuclear = (“Net kWh by Source” Nuclear)/(“Net kWh by Source” Total kWh)

Natural Gas = (“Net kWh by Source” Natural Gas)/(“Net kWh by Source” Total kWh)

Coal = (“Net kWh by Source” Coal)/(“Net kWh by Source” Total kWh)

#1, 2, & 4 Fuel Oil = (“Net kWh by Source” #1, 2, & 4 Fuel Oil)/(“Net kWh by Source” Total kWh)

#5 & 6 Fuel Oil = (“Net kWh by Source” #5 & 6 Fuel Oil)/(“Net kWh by Source” Total kWh)

Other (assume NPCC grid) = (“Net kWh by Source” Other(assume NPCC grid))/(“Net kWh by Source” Total kWh)

Total kWh = (“Electricity Sources by Percent” Co-Gen) + (“Electricity Sources by Percent” Wind) + (“Electricity Sources by Percent” Solar) + (“Electricity Sources by Percent” CH_4 digestion) + (“Electricity Sources by Percent” Biomass) + (“Electricity Sources by Percent” Hydro) + (“Electricity Sources by Percent” Nuclear) + (“Electricity Sources by Percent” Natural Gas) + (“Electricity Sources by Percent” Coal) + (“Electricity Sources by Percent” #1, 2, & 4 Fuel Oil) + (“Electricity Sources by Percent” #5 & 6 Fuel Oil) + (“Electricity Sources by Percent” Other(assume NPCC grid))

Natural Gas:

kWh from Natural Gas = (“Net kWh by Source” Natural Gas)

MMBTUs of fuel = (kWh from Natural Gas) * (MMBTU/kWh)

Metric Tonnes CO_2 =(kWh from Natural Gas) * (Tonnes CO_2/kWh NG EF)
tonnes CH_4 = (MMBTUs of electricity) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of electricity) * (CH_4 EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Natural Gas = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Coal:

kWh from Coal = (“Net kWh by Source” Coal)

MMBTUs of electricity = (kWh from Coal) * (MMBTU/kWh)

Metric Tonnes CO_2 =(kWh from Coal) * (Tonnes CO_2/kWh Coal EF)

tonnes CH_4 = (MMBTUs of electricity) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of electricity) * (CH_4 EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Coal = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

#1, 2, & 4 Fuel Oil:

kWh from Fuel Oil = ("Net kWh by Source" #1, 2, & 4 Fuel Oil)

MMBTUs of electricity = (kWh from Fuel Oil) * (MMBTU/kWh)

Metric Tonnes CO_2 =(kWh from Fuel Oil) * (Tonnes CO_2/kWh Dis Oil EF)

tonnes CH_4 = (MMBTUs of electricity) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of electricity) * (CH_4 EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from #1, 2, & 4 Fuel Oil = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

#5 & 6 Fuel Oil:

kWh from Fuel Oil = ("Net kWh by Source" #5 & 6 Fuel Oil)

MMBTUs of electricity = (kWh from Fuel Oil) * (MMBTU/kWh)

Metric Tonnes CO_2 =(kWh from Fuel Oil) * (Tonnes CO_2/kWh Res Oil EF)

tonnes CH_4 = (MMBTUs of electricity) * (tonne/gram ($1/1x10^6$)) * (CH_4 EF (g gas/MMBTU))

MTCDE from CH_4 = (MMBTUs of electricity) * (CH_4 EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from #5 & 6 Fuel Oil = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Other – NPCC New England Grid Assumed:

kWh from NPCC = ("Net kWh by Source" Other(assume NPCC grid))

MMBTUs of electricity = (kWh from NPCC) * (MMBTU/kWh)

Metric Tonnes CO_2 =(kWh from NPCC) * (Tonnes CO_2/kWh Res Oil EF)

tonnes CH_4 = (MMBTUs of electricity) * (Tonne/lb(1/2,204.6)) * (CH_4 EF (lbs gas/mWh)

MTCDE from CH_4 = (MMBTUs of electricity) * (CH_4 EF (lbs gas/mWh)) * (Tonne/lb(1/2,204.6)) * (CH_4 GWP)

tonnes N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (Tonne/lb(1/2,204.6))

MTCDE from N_2O = (MMBTUs of electricity) * (N_2O EF (g gas/MMBTU)) * (Tonne/lb(1/2,204.6)) * (N_2O GWP)

ΣMTCDE from Other = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

MTCDEs by Electricity Source:

Co-Gen = 0

Wind = 0

Solar = 0

CH_4 digestion = 0

Biomass = 0

Hydro = 0

Nuclear = 0

Natural Gas = ΣMTCDE from Natural Gas

Coal = ΣMTCDE from Coal

#1, 2, & 4 Fuel Oil = ΣMTCDE from #1, 2, & 4 Fuel Oil

#5 & 6 Fuel Oil = ΣMTCDE from #5 & 6 Fuel Oil

Other (assume NPCC grid) = ΣMTCDE from NPCC-NE

ΣMTCDE from Electricity = ("MTCDEs by Electricity Source" Co-Gen) + ("MTCDEs by Electricity Source" Wind) + ("MTCDEs by Electricity Source" Solar) + ("MTCDEs by Electricity Source" CH_4 digestion) + ("MTCDEs by Electricity Source" Biomass) + ("MTCDEs by Electricity Source" Hydro) + ("MTCDEs by Electricity Source" Nuclear) + ("MTCDEs by Electricity Source" Natural Gas) + ("MTCDEs by Electricity Source" Coal) + ("MTCDEs by Electricity Source" #1, 2, & 4 Fuel Oil) + ("MTCDEs by Electricity Source" #5 & 6 Fuel Oil) + ("MTCDEs by Electricity Source" Other(assume NPCC grid))

MTCDE Sources by Percent:

Co-Gen = 0

Wind = 0

Solar = 0

CH_4 digestion = 0

Biomass = 0

Hydro = 0

Nuclear = 0

Natural Gas = ("MTCDEs by Electricity Source" Natural Gas) / (ΣMTCDE from Electricity)

Coal = (“MTCDEs by Electricity Source” Coal) / (ΣMTCDE from Electricity)

#1, 2, & 4 Fuel Oil = (“MTCDEs by Electricity Source” #1, 2, & 4 Fuel Oil) / (ΣMTCDE from Electricity)

#5 & 6 Fuel Oil = (“MTCDEs by Electricity Source” #5 & 6 Fuel Oil) / (ΣMTCDE from Electricity)

Other (assume NPCC grid) = (“MTCDEs by Electricity Source” Other(assume NPCC grid)) / (ΣMTCDE from Electricity)

Should be 100% = (“MTCDE Sources by Percent” Co-Gen) + (“MTCDE Sources by Percent” Wind) + (“MTCDE Sources by Percent” Solar) + (“MTCDE Sources by Percent” CH_4 digestion) + (“MTCDE Sources by Percent” Biomass) + (“MTCDE Sources by Percent” Hydro) + (“MTCDE Sources by Percent” Nuclear) + (“MTCDE Sources by Percent” Natural Gas) + (“MTCDE Sources by Percent” Coal) + (“MTCDE Sources by Percent” #1, 2, & 4 Fuel Oil) + (“MTCDE Sources by Percent” #5 & 6 Fuel Oil) + (“MTCDE Sources by Percent” Other(assume NPCC grid))

Scope 3

Scope 3, Part A: Indirect Emissions from Outsourced Travel - This section includes all emissions from the mobile combustion of fossil fuels used in vehicles not owned by Middlebury College, but whose services are directly solicited by the institution.

Notes on Scope 3A

Travel Accounting:

Travel emissions are split into five categories: personal vehicle mileage, bus, air, train, and taxi. In 2019, Middlebury College switched accounting systems from Banner to Oracle, which limited the categories of travel itemization to only personal mileage and air travel. Therefore, half of the FY 18/19 numbers are generated from reliable Banner data and half are from Oracle data, which was an estimate as it only included mileage and airfare. Due to this system change, all of the FY 19/20 and FY 20/21 numbers are estimates generated from 18/19 and are further complicated because of how Covid-19 affected travel (travel expenditures estimated to have decreased by half starting in FY19).

Variables

Name	*Description*	*Source*	*Trends/Notes*

Total reimbursement $	Total reimbursement ($) details the total mileage reimbursement for the use of personal and rental cars (gasoline).	Mileage reimbursement data were annually collected by Budget Director Kristen Anderson and Budget Analyst Sue Lalumiere.	Adjustments were made in FY14 and retroactively in FY06/07 in order to credit gas as only being ⅓ of expenditure to account for vehicle wear and tear.
% of $ spent on dom travel	Percentage of total reimbursement $ spent on travel within the United States.	Number posited by Jason Kowalski and confirmed as "close" by Kristen Anderson and Budget Analyst, Sue Lalumiere, Middlebury College Budget Director.	Value has not been updated since FY 08/09.
Total taxi $	Total taxi ($) includes the amount of dollars spent on reimbursement for the use of taxi vehicles or hired rides by employees traveling on business.	Taxi reimbursement data were collected annually by Budget Director Kristen Anderson and Budget Analyst Sue Lalumiere until FY 18/19.	See Note on Travel Accounting
Total bus $	Total bus ($) includes the amount of dollars spent on reimbursement for the use of buses by employees traveling on business.	Bus reimbursement data were collected annually by Budget Director Kristen Anderson and Budget Analyst Sue Lalumiere until FY 18/19.	See Note on Travel Accounting
Total airline $	Total airline ($) includes the amount of dollars spent on reimbursement for the use of planes by employees traveling on business.	Airline reimbursement data were collected annually by Budget Director Kristen Anderson and Budget Analyst Sue Lalumiere.	See Note on Travel Accounting
Total train $	Total train ($) includes the amount of dollars spent on reimbursement for the use of trains by those associated with the school traveling on business.	Train reimbursement data were collected annually by Budget Director Kristen Anderson and Budget Analyst Sue Lalumiere until FY18/19.	See Note on Travel Accounting

Conversion Factors and Constants

Name	*Description*	*Source*	*Trends/Notes*
HC (MMBTU/bbl)	See scope 1A	Higher heating values (HHV) are used. Values sourced from EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from	Values originally sourced by Jason Kowalski in 2006. These

		Stationary Combustion Sources." pp 22. While values used in Middlebury College's GHGI have always remained the same, the EPA has continually published updated values. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/stationaryemissions.pdf.	values have not been updated since.
CCC (kg C/MMBTU)	See scope 1A	See Scope 1B	Values originally sourced by Jason Kowalski in 2006. These values have not been updated since.
Fraction oxidized	See scope 1A	See Scope 1B	Values originally sourced by Billie Borden '09 in 2007. These values have not been updated since.
MW ratio (kg CO_2/kg C)	See Scope 1A	See Scope 1A	See Scope 1A
CH_4 EF (g gas/MMBTU)	See Scope 1A	Based on 1987-1993 EF's for vans, pickups and SUVs (most conservative light-duty values),1985-1986 EF's for heavy duty vehicles (most conservative values), 1966-1982 EF's for heavy duty vehicles (most conservative values), values for locomotive diesel fuel. EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." p 9 and 25., and Jet Fuel Specific EFs. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (April 2003) EPA 430-R-03-004; Annex E. The latest report was published in April 2022 and can be found here: https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf.	Values originally sourced by Jason Kowalski in 2006. They have not been updated since.
CH_4 GWP	See scope 1A	See scope 1A	See scope 1A

N_2O EF (g gas/MMBTU)	See scope 1A	See Scope 3 A "CH_4 EF"	See Scope 3 A "CH_4 EF"
N_2O GWP	See scope 1A	See scope 1A	See scope 1A
US dollars/cent (1/100)	Conversion between US dollars and cents.	Nationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
tonne/kg (1/1,1000)	See Scope 1A	See Scope 1A	See Scope 1A
barrels/gallon (1/42)	See Scope 1A	See Scope 1A	See Scope 1A
tonne/gram (1/1x10^6)	See Scope 2	See Scope 2	See Scope 2
Bus miles/gal	Bus mileage per gallon of diesel.	Calculated from sourced data: 1 / (Gallons per mile (diesel))	Nothing of note.
MMBTU/BTU (1/1 million)	Conversion between MMBTUs and BTUs.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
Annual ave cents/gal	U.S. annual average cents per gallon of gasoline.	Values calculated according to the Energy Information Association (EIA) at https://www.eia.gov/petroleum/gasdiesel/. Values calculated by adding "US change from a year ago" to previous year's average.	Values originally sourced by CN in 2009. Updated annually from 2009-2014 by various people working on the GHGI. Values last updated in FY 14/15 by Vir Chachra.
Total reimbursement gas (gal)	Total gallons of gas used by Middlebury employees on trips reimbursed by the college.	Calculated from sourced data: (Total Reimbursement $) / ((US Dollars/cent(1/100))	Nothing of note.

MMBTU/gal gas EF	See Scope 1B	See Scope 1B	See Scope 1B
Tonnes CO_2/gal gas EF	See Scope 1B	See Scope 1B	See Scope 1B
Putative vehicle mi/gal (personal vehicles)	Mileage rate used by Middlebury College in determining $ reimbursements.	Taken From Middlebury College Campus Activities and Leadership (CCAL) Gas Mileage Chart by Charlotte Chase.	Originally sourced by Jason Kowalski in 2006. Values last updated in FY 16/17, though as of July 2022, it is unclear by whom.
Gas vehicle activity miles (personal vehicles)	Total mileage of vehicles used by Middlebury employees on reimbursed business trips.	Calculated from sourced data**:** (Total Reimbursement Gas (gal)) * (Putative Vehicle mi/gal (personal vehicles))	Nothing of note.
Average $/person (taxi)	Average amount of U.S. dollars spent per person on a taxi trip from Middlebury, VT to Burlington, VT.	Middlebury Transit, Inc. Owner, Bill Fuller.	Last updated in 2006 by Jason Kowalski. Note that Middlebury Transit has permanently closed down.
Average people/trip (taxi)	Average number of people on a trip using a taxi.	Middlebury Transit, Inc. Owner, Bill Fuller.	Last updated in 2006 by Jason Kowalski. Note that Middlebury Transit has permanently closed down.
Average $/trip (taxi)	Average U.S. dollars spent per taxi trip.	Middlebury Transit, Inc. Owner, Bill Fuller.	Last updated in 2006 by Jason Kowalski. Note that Middlebury Transit has permanently closed down.
Mode trip distance (mi) (taxi)	Mileage of trip distance via taxi, assuming case study from	Middlebury to Burlington International Airport, mileage found on www.mapquest.com.	Originally sourced by Jason Kowalski in 2008. Updated periodically in FY 10/11 and FY 16/17, though as of July 2022, it is unclear by whom.

	Middlebury to Burlington.		
Total taxi miles	Total taxi miles driven reimbursed by the school.	Calculated from sourced data: ((Total Taxi $) /(Average $/trip))*(Mode trip distance (mi))	Nothing of note.
Van mi/gal	Gas Mileage of Middlebury Transit vans.	Middlebury Transit, Inc, Owner, Bill Fuller.	Originally sourced by Jason Kowalski in 2008. Updated periodically in FY 10/11 and FY 16/17, though as of July 2022, it is unclear by whom.
Total taxi gas (gal)	Gallons of gas used by taxi rides reimbursed by the school.	Calculated from sourced data: (Total Taxi Miles) / (Van mi/gal)	Nothing of note.
Mode bus size (by capacity)	Capacity of Premier Travel bus.	Premiere Travel	Originally sourced by Jason Kowalski in 2006. Last updated in FY 16/17, though as of July 2022, it is unclear by whom.
Base hourly fee ($/hr) (bus)	Base fee per hour for usage of Premier Travel bus.	Premiere Travel	Last updated by Jason Kowalski in 2006.
Live mile charge/mile ($/mi) (bus)	Premier Travel bus rate while carrying passengers.	Premiere Travel	Last updated by Jason Kowalski in 2006.
Dead mile charge/mile ($/mi) (bus)	Premier Travel bus rate while not carrying. passengers, but traveling to pick up passengers.	Premiere Travel.	Last updated by Jason Kowalski in 2006.

Gallons per mile (diesel) (bus)	Gallons of diesel fuel combusted per mile driven by bus.	Based on values published in EPA Climate Leaders. 2004. "Core Module Guidance: Direct Emissions from Mobile Combustion Sources." pp 12. The December 2020 update can be found here: https://www.epa.gov/sites/default/files/2020-12/documents/mobileemissions.pdf.	Originally sourced by Billie Borden '09 in 2007. Values have not been updated since.
Live RT distance (mi) (bus)	Distance in miles bus travels while carrying passengers.	Middlebury to Colby College, with endpoint at 326 College St, Middlebury, VT, mileage found on www.mapquest.com.	Last updated in 2006 by Jason Kowolski.
Dead RT distance (mi) (bus)	Distance in miles bus travels to pick up passengers.	Middlebury to Colby College, with endpoint at 326 College St, Middlebury, VT, mileage found on www.mapquest.com.	Last updated in 2006 by Jason Kowolski.
Live time (hr) (bus)	Time in hours of bus travel while carrying passengers.	Middlebury to Colby College, with endpoint at 326 College St, Middlebury, VT, mileage found on www.mapquest.com.	Last updated in 2006 by Jason Kowolski.
Dead time (hr) (bus)	Time in hours of bus travel while traveling to pick up passengers.	Middlebury to Colby College, with endpoint at 326 College St, Middlebury, VT, mileage found on www.mapquest.com.	Last updated in 2006 by Jason Kowolski.
Stationary time (hr) (bus)	Time when bus is not actively driving but still being paid. Putatively small in order to remain conservative.	Middlebury to Colby College, with endpoint at 326 College St, Middlebury, VT, mileage found on www.mapquest.com.	Last updated in 2006 by Jason Kowolski.
Live speed (bus)	Speed of bus while actively carrying passengers.	Calculated from sourced data: (Live RT Distance (mi)) / (Live Time (hr))	Nothing of note.
Dead speed (bus)	Speed of bus while traveling to pick up passengers.	Calculated from sourced data: (Dead RT Distance (mi)) / (Dead Time (hr))	Nothing of note.

Total cost (bus)	Total cost of a bus trip.	Calculated from sourced data: ((Live Time(hr)) + (Dead Time (hr)) + (Stationary Time (hr))) * (Base hourly fee ($/hr)) + ((Live RT Distance (mi)) * (Live Mile charge/mile ($/mi))) + ((Dead RT Distance (mi)) * (Dead Mile charge/mile ($/mi)))	Nothing of note.
Total gal diesel combusted (bus)	Total gallons of diesel combusted by bus on a reimbursed Middlebury trip.	Calculated from sourced data: ((Live RT Distance (mi)) + (Dead RT Distance (mi))) * (Gallons per Mile (diesel))	Nothing of note.
Gal/$ given the high em. Scenario (bus)	Gallons per dollar for a high emissions bus travel scenario (assuming Middlebury College to Colby College).	Calculated from sourced data: (Total Gal Diesel Combusted) / (Total Cost)	Nothing of note.
MMBTU/gal diesel EF (bus)	See Scope 1B	See Scope 1B	See Scope 1B
Tonnes CO_2/gal diesel EF (bus)	See Scope 1B	See Scope 1B	See Scope 1B
Gas vehicle activity miles (bus)	Total miles driven by buses.	Calculated from sourced data: (Total diesel (gal)) * (Bus Miles per Gal)	Nothing of note.
Burlington to NYC RT price (air)	Price of non-weekend air travel from Burlington International Airport (BTV) to LaGuardia Airport (LGA) 2 months from booking date.	http://www.orbitz.com	Originally sourced by Jason Kowalski in 2006. Updated annually from 2006-2010, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in FY 14/15.

Burlington to NYC RT mileage (air)	Mileage from Burlington International Airport (BTV) to LaGuardia Airport (LGA).	Mileage data collected via mapquest at http://www.mapquest.com. While this is an air travel scenario, mileage is on-ground.	Originally sourced by Jason Kowolski in 2006.
Burlington to Phoenix via DC RT price (air)	Price of non-weekend air travel from Burlington International Airport (BTV) to Phoenix International Airport (PHX) via DC 2 months from booking date.	http://www.orbitz.com	Originally sourced by Jason Kowolski in 2006. Updated annually from 2006-2010, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in FY 14/15.
Burlington to Phoenix via DC RT mileage (air)	Mileage from Burlington International Airport (BTV) to Phoenix International Airport (PHX) via DC.	Mileage data collected via mapquest at http://www.mapquest.com. While this is an air travel scenario, mileage is on-ground.	Originally sourced by Jason Kowolski in 2006.
Burl to London via DC RT price (air)	Price of non-weekend air travel from Burlington International Airport (BTV) to London via DC 2 months from booking date.	http://www.orbitz.com	Originally sourced by Jason Kowolski in 2006. Updated annually from 2006-2010, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in 2015.
Burl to London via DC RT mileage (air)	Mileage from Burlington International Airport (BTV) to London via DC.	Mileage data collected via mapquest at http://www.mapquest.com. While this is an air travel scenario, mileage is on-ground.	Originally sourced by Jason Kowolski in 2006.

Dom BTU jet fuel/pass. Mi (air)	Energy intensity of passenger modes for Domestic flights in British Thermal Units (BTUs) per passenger-mile.	Originally sourced from the Bureau of Transportation Statistics (BTS) 2009 publication, National Transportation Statistics: Energy Intensity of Passenger Modes (BTU per passenger mile), Table 4-21) (https://rosap.ntl.bts.gov/view/dot/35474).	Updated annually from 2006-2010, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in FY 14/15 with the BTS' 2013 Domestic BTUs per passenger mile values in order to more accurately calculate FY 14/15 GHGs. The BTS' 2020 update can be found here: https://www.bts.gov/content/energy-intensity-passenger-modes.
Int BTU jet fuel/pass. Mi (air)	Energy intensity of passenger modes for Domestic flights in British Thermal Units (BTUs) per passenger-mile.	Originally sourced from the Bureau of Transportation Statistics (BTS) 2009 publication, National Transportation Statistics: Energy Intensity of Passenger Modes (BTU per passenger mile), Table 4-21) (https://rosap.ntl.bts.gov/view/dot/35474).	Updated annually from 2006-2010, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in FY 14/15 with the BTS' 2013 International BTUs per passenger mile values in order to more accurately calculate FY 14/15 GHGs. The BTS' last update was in 2020, and data can be found here: https://www.bts.gov/content/energy-intensity-passenger-modes.
MMBTU/airfare $ EF (air)	Emission factor of airfare dollars expressed as MMBTUs emitted by each dollar spent on air travel.	Calculated from sourced data: [((Domestic passenger mi) * (Dom BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million))) + ((International passenger mi) * (Int BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million)))] / (Total Airline $)	Nothing of note.
Tonnes CO_2/airfare $ EF (air)	Emission factor of airfare dollars expressed as tonnes of CO_2 emitted by each dollar spent on air travel.	Calculated from sourced data: ((MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))) / (Total Airline $)	Nothing of note.

Radiative forcing index	Radiative forcing index (RFI) accounts for the greater impact of CO_2 emissions from planes at high altitudes rather than on-ground emissions.	Based on the 1992 Global RFI as set by the IPCC. This is one of the more concrete RFI numbers in circulation, and is higher than that used by Native Energy and the Carbon Exchange. http://www.grida.no/climate/ipcc/aviation/064.htm. Source states, "In 1992, the RFI for aircraft is 2.7; it evolves to 2.6 in 2050 for the Fa1 scenario."	Last updated by Billie Borden in 2007.
Burlington to st. albans RT price (train)	Price of non-weekend train travel, assuming diesel-fueled trains, from Burlington, VT to St. Albans, VT 2 months from booking date.	www.amtrak.com	Originally sourced by Jason Kowolski in 2006. Last updated by Vir Chachra in FY 14/15.
Burlington to st. albans RT mileage (train)	Mileage from Burlington, VT to St. Albans, VT.	Mileage data collected via mapquest at http://www.mapquest.com.	Originally sourced by Jason Kowolski in 2006.
Burlington to NYC RT price (train)	Price of non-weekend train travel, assuming diesel-fueled trains, from Burlington, VT to NYC 2 months from booking date.	www.amtrak.com	Originally sourced by Jason Kowolski in 2006. Updated from FY 06/07 to FY 07/08, though as of July 2022, it is unclear by whom.
Burlington to NYC mileage	Mileage from Burlington, VT to NYC.	Mileage data collected via mapquest at http://www.mapquest.com.	Originally sourced by Jason Kowolski in 2006.

Burl to DC RT price	Price of non-weekend train travel, assuming diesel-fueled trains, from Burlington, VT to Washington DC 2 months from booking date.	www.amtrak.com	Originally sourced by Jason Kowolski in 2006. Updated periodically from FY 06/07 to FY 14/15, though as of July 2022, it is unclear by whom. Last updated by Vir Chachra in FY 14/15.
Burl to DC RT mileage	Mileage from Burlington, VT to Washington DC.	Mileage data collected via mapquest at http://www.mapquest.com.	Originally sourced by Jason Kowolski in 2006. Value has not been updated since.
Amtrak BTU/pass. Mi	Energy intensity of passenger modes for Amtrak in British Thermal Units (BTUs) per passenger-mile.	Originally sourced from the Bureau of Transportation Statistics (BTS) 2009 publication, National Transportation Statistics: Energy Intensity of Passenger Modes (BTU per passenger mile), Table 4-20, pp. 286) (https://rosap.ntl.bts.gov/view/dot/35474).	Originally sourced by Billie Borden ‘09 in 2007.. Last updated by Vir Chachra in FY 14/15 with the BTS’ 2013 Amtrak BTUs per passenger mile values in order to more accurately calculate FY 14/15 GHGs. The BTS’ last update was in 2020, and data can be found here: https://www.bts.gov/content/energy-intensity-passenger-modes.
MMBTU/train $ EF	Emission factor of train dollars expressed as MMBTUs emitted by each dollar spent on train travel.	Calculated from sourced data: ((Total train passenger-miles) * (Amtrak BTU/pass. mi) * (MMBTU/BTU(1/1million))) / (Total Train $)	Nothing of note.
Tonnes CO_2/train $ EF	Emission factor of train dollars expressed as tonnes of CO_2 emitted by each dollar spent on train travel.	Calculated from sourced data: ((MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))) / (Total Train $)	Nothing of note.

Scope 3A - Formulas

Mileage Reimbursement for use of Personal and Rental Cars (Gasoline):

Total Reimbursement Gas (gal) = (Total Reimbursement $) / ((US Dollars/cent(1/100)) * (Annual ave cents/gal))

MMBTUs of fuel = (Total Reimbursement Gas (gal)) * (MMBTU/gal gas EF)

Metric Tonnes CO_2 = (Total Reimbursement Gas (gal)) * (Tonnes CO_2/gal gas EF)

Gas Vehicle Activity miles = (Total Reimbursement Gas (gal)) * (Putative Vehicle mi/gal)

tonnes CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Mileage Gasoline = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Taxi Emissions (Gasoline):

Average $/trip = (Average $/person) * (Average people/trip)

Total Taxi Miles = ((Total Taxi $) /(Average $/trip))*(Mode trip distance (mi))

Total Taxi Gas (gal) = (Total Taxi Miles) / (Van mi/gal)

MMBTUs of fuel = (Total Taxi Gas (gal)) * (MMBTU/gal gas EF)

Metric Tonnes CO_2 = (Total Taxi Gas (gal)) * (Tonnes CO_2/gal gas EF)

tonnes CH_4 = (Total Taxi Miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (Total Taxi Miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (Total Taxi Miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (Total Taxi Miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Taxi Gasoline = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Bus Emissions (Diesel):

High Emissions/$ Scenario: Midd=>Colby for a 4 Hour Event:

Live Speed = (Live RT Distance (mi)) / (Live Time (hr))

Dead Speed = (Dead RT Distance (mi)) / (Dead Time (hr))

Total Cost = ((Live Time(hr)) + (Dead Time (hr)) + (Stationary Time (hr))) * (Base hourly fee ($/hr)) + ((Live RT Distance (mi)) * (Live Mile charge/mile ($/mi))) + ((Dead RT Distance (mi)) * (Dead Mile charge/mile ($/mi)))

Total Gal Diesel Combusted = ((Live RT Distance (mi)) + (Dead RT Distance (mi))) * (Gallons per Mile (diesel))

Gal/$ Given the High Em. Scenario = (Total Gal Diesel Combusted) / (Total Cost)

Total diesel (gal) = (Total Bus $) * (Gal/$ Given the High Em. Scenario)

MMBTUs of fuel = (Total diesel (gal)) * (MMBTU/gal diesel EF)

Metric Tonnes CO_2 = (Total diesel (gal)) * (Tonnes CO_2/gal diesel EF)

Gas Vehicle Activity miles = (Total diesel (gal)) * (Bus Miles per Gal)

tonnes CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from CH_4 = (Gas Vehicle Activity miles) * (CH_4 EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (Total Taxi Miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$))

MTCDE from N_2O = (Gas Vehicle Activity miles) * (N_2O EF (g gas/mile)) * (tonne/gram ($1/1x10^6$)) * (N_2O GWP)

ΣMTCDE from Bus Travel = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Air Travel Emissions:

Burlington => NY $/pass-mi = (Burlington=> NY RT price) / (Burlington => NY RT mileage)

Burl to Phoenix via DC $/pass-mi = (Burl. to Phoenix via DC RT price) / (Burl to Phoenix via DC RT mileage)

Burl to London via DC $/pass-mi = (Burl. to London via DC RT price) / (Burl to London via DC RT mileage)

Domestic $/passenger mi = ((Burlington=> NY $/pass-mi) + (Burl to Phoenix via DC $/pass-mi))/2

International $/passenger mi = Burl to London via DV $/pass-mi

Domestic passenger mi = ((% of $ spend on dom travel) * (Total Airline $)) / (Domestic $/passenger mi)

International passenger mi = ((Total Airline $) * (1-(% of $ spent on dom travel)) / (International $/passenger mi)

Total Passenger mi = (Domestic passenger mi) + (International passenger mi)

MMBTU/airfare $ EF = [((Domestic passenger mi) * (Dom BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million))) + ((International passenger mi) * (Int BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million)))] / (Total Airline $)

Tonnes CO_2/airfare $ EF = ((MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))) / (Total Airline $)

MMBTUs of fuel =((Domestic passenger mi) * (Dom BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million))) + ((International passenger mi) * (Int BTU jet fuel/pass. mi.) * (MMBTU/BTU(1/1million)))

Metric Tonnes CO_2 = (MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO2/kg C)) * (Tonne/kg(1/1,000))

MTCDEs Adj. for RFI = (Metric Tonnes CO_2) * (Radiative Forcing Index (RFI))

Gallons of Jet Fuel Consumed = ((MMBTUs of fuel) / (HC (MMBTU/bbll))) / (barrels/gallon(1/42))

tonnes CH_4 = ((MMBTUs of fuel) / (HC (MMBTU/bbll))) * (Jet Fuel Density (tonne/bbll)) * (kg/tonne(1,000/1)) * (CH_4 EF (g gas/kg fuel)) * (tonne/gram($1/1x10^6$))

MTCDE from CH_4 = (CH_4 GWP) * (tonnes CH_4)

tonnes N_2O = ((MMBTUs of fuel) / (HC (MMBTU/bbll))) * (Jet Fuel Density (tonne/bbll)) * (kg/tonne(1,000/1)) * (N_2O EF (g gas/kg fuel)) * (tonne/gram($1/1x10^6$))

MTCDE from N_2O = (N_2O GWP) * (tonnes N_2O)

ΣMTCDE from Air Travel = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Train Travel Emissions:

Burlington => St. Albans $/pass-mi = (Burlington=> St. Albans RT price) / (Burlington => St. Albans RT mileage)

Burlington => NYC $/pass-mi = (Burlington to NYC RT price) / (Burlington to NYC RT mileage)

Burlington => Wa. DC $/pass-mi = (Burlington => Wa. DC RT price) / (Burlington => Wa. DC mileage)

Average $/passenger-mile = ((Burlington => St. Albans $/pass-mi) + (Burlington => NYC $/pass-mi) + (Burlington => Wa. DC $/pass-mi))/3

Total train passenger-miles = (Total Train $) / (Average $/passenger-mile)

MMBTU/train $ EF = ((Total train passenger-miles) * (Amtrak BTU/pass. mi) * (MMBTU/BTU(1/1million))) / (Total Train $)

Tonnes CO_2/airfare $ EF = ((MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO_2/kg C)) * (Tonne/kg(1/1,000))) / (Total Airline $)

MMBTUs of fuel =(Total train passenger-miles) * (Amtrak BTU/pass. mi) * (MMBTU/BTU(1/1million))

Metric Tonnes CO_2 = (MMBTUs of fuel) * (CCC (kg C/MMBTU)) * (Fraction Oxidized) * (MW ratio (kg CO2/kg C)) * (Tonne/kg(1/1,000))

Gallons of Jet Fuel Consumed = ((MMBTUs of fuel) / (HC (MMBTU/bbl))) / (barrels/gallon(1/42))

tonnes CH_4 = (CH_4 EF (g gas/kg fuel)) * (Fuel Density(kg/gal)) * (Gallons of Jet Fuel Consumed) * (tonne/gram($1/1x10^6$))

MTCDE from CH_4 = (Gallons of Jet Fuel Consumed) * (Fuel Density(kg/gal)) * (CH_4 EF (g gas/kg fuel)) * (tonne/gram($1/1x10^6$)) * (CH_4 GWP)

tonnes N_2O = (N_2O EF (g gas/kg fuel)) * (Fuel Density (kg/gal)) * (Gallons of Jet Fuel Consumed) * (tonne/gram($1/1x10^6$))

MTCDE from N_2O = (Gallons of Jet Fuel Consumed) * (N_2O EF (g gas/kg fuel)) * (tonne/gram($1/1x10^6$)) * ((N_2O GWP)

ΣMTCDE from Train Travel = (Metric Tonnes CO_2) + (MTCDE from CH_4) + (MTCDE from N_2O)

Summary Data for Indirect Emissions from Outsourced Travel:

TOTAL MTCDE= (ΣMTCDE Mileage) + (ΣMTCDE Taxis) + (ΣMTCDE Bus) + (ΣMTCDE Airplanes) + (ΣMTCDE Trains)

Scope 3, Part B: Indirect Emissions from Landfill Waste - This section includes all emissions from methane produced by the institutional waste stream.

Notes on Scope 3B

Landfill Methane Recapture:

There are three different potential ways that the landfills receiving middlebury's waste deal with the release of methane associated with waste decomposition. First there is the release of untouched methane (Straight LF). This enters the atmosphere as CH_4 gas. Another method is to burn the methane before it enters the atmosphere, turning it into carbon dioxide (CH_4 Recovery/Flaring). This reduces the emission factor associated with waste because methane's GWP is higher than carbon dioxide's. Lastly, the burning of methane to create CO_2 can also be harnessed to produce electricity. This is referred to as landfill gas to energy (LFGE). LFGE uses the burning of the methane produced by waste to power generators producing electricity. While this does not reduce the amount of carbon dioxide entering the atmosphere from the landfill itself, it prevents the need for burning other gas or fuel to produce electricity. In the GHGI the increased sustainability of recapture and electricity generation is noted by a lower emission factor than that of both straight LF and CH_4 Recovery.

Sourcing for Conversion Factors and Constants:

Scope 3 is the least supported by the EPA and the GHG protocol, making past equations and numbers difficult to track down as well as update. There is an error in the reporting of sources in the GHGI for Scope 3 Landfill Methane. The coefficients for CH_4 EF w/out Recovery (MTCE/ton), CH_4 EF w/ Recovery (MTCE/ton), and CH_4 EF w/ LFGE (MTCE/ton) are all input to the spreadsheet as specific values, meaning it was not calculated from existing data. This means the number must have been sourced from an outside entity such as the EPA. In the "Scope3 Travel Sources" tab, these specific constants are not listed, so it is impossible to know where the values were sourced from. Additionally, these constants are cited in the "Scope3 Travel" tab as used to calculate the coefficients of CH_4 EF w/o Recovery (tonne gas/ton waste), CH_4 EF w/ Recovery (tonne gas/ton waste), and CH_4 EF w/ LFGE (tonne gas/ton waste).

These (tonne gas/ton waste) constants are what are actually used in the formulas for scope 3B. Confusion arises in that, according to the sources tab, the (tonne gas/ton waste) number is sourced from the EPA when this source should be where the (MTCE/ton) values came from. This means that there are two sources (a calculated result and an EPA number) for the (tonne gas/ton waste) values while there are no sources for the (MTCE/ton) values. Much additional research has been done without any ability to find where these numbers could have come from or what this mistake may be. As a way to understand the data, we have decided to assume that the EPA sourced data was actually the (MTCE/ton) and that the (tonne gas/ton waste) is calculated from sourced data, because the Scope 3 formulas would make more sense under this consideration.

Variables

Name	*Description*	*Source*	*Trends/Notes*
Total solid waste (lbs)	Total solid waste (lbs) that Middlebury College produces annually.	Waste data were collected annually by Supervisor of Waste Management and Custodial, Melissa Beckwith.	There has been a gradual decrease in solid waste going to landfills, likely due to increased diversion rate because of increased recycling/composting efforts in recent years.
% Taken to coventry LF, VT	Coventry Landfill is the only landfill in Vermont. "% Taken to Coventry LF, VT" details the percentage of Middlebury College's waste sent to this landfill annually.	As of 2008, data were collected annually by Katie at the transfer station at Casella Waste Management. Last name is unknown as of July 2022. Since 2010, this percentage is somewhat irrelevant and it is unclear if this value is still sought out annually, given that this is the only landfill Middlebury uses.	Since 2010, 100% of Middlebury's waste has gone to Coventry Landfill.
% Taken to Clinton Co. LF. NY	Clinton County Landfill is a landfill in New York state. "% Taken to Clinton Co. LF. NY" details the percentage of Middlebury College's waste sent to this landfill annually.	Data collected annually by Katie at the transfer station at Casella Waste Management. Last name is unknown as of July 2022. Since 2010, this percentage is somewhat irrelevant and it is unclear if this value is still sought out annually, given that Middlebury does not send waste here anymore.	Middlebury College stopped sending its waste to Clinton County Landfill in FY 10/11. This is likely because Clinton County stopped accepting waste from outside of New York.

Coventry - Straight LF	Percent of waste at Coventry Landfill released as straight methane.	Coventry Landfill waste data collected annually by Janet Shatney, Permits & Compliance Administrator at the Montpelier office of Casella Waste Management. Personal communication through Abbie Webb, Senior Environmental Analyst at Casella Waste Systems.	Percentage declined from FY 07-12 and has remained 24% since FY 12/13.
Coventry - CH_4 Recovery/Flaring w/o LFGE (%)	Percent of waste at Coventry Landfill burned with methane recapture but without LFGE (landfill electricity generation).	Coventry Landfill waste data collected annually by Janet Shatney, Permits & Compliance Administrator at the Montpelier office of Casella Waste Management. Personal communication through Abbie Webb, Senior Environmental Analyst at Casella Waste Systems.	Percentage declined from FY 06-10 and was 0% starting in FY 10/11.
Coventry - Electricity Generation (%)	Percent of waste at Coventry Landfill burned with methane recapture and landfill electricity generation.	Coventry Landfill waste data collected annually by Janet Shatney, Permits & Compliance Administrator at the Montpelier office of Casella Waste Management. Personal communication through Abbie Webb, Senior Environmental Analyst at Casella Waste Systems.	Percentage has remained at 76% since FY 12/13.
Clinton Co. - Straight LF	Percent of waste at Clinton County Landfill released as straight methane.	Personal communication, Lisa, Coventry Landfill. Washington Electric Cooperative, Landfill Gas to Energy Project, Coventry Landfill. Opening Ceremony Brochure.	Percentage is 0% starting in FY 10/11, as Middlebury College stopped sending their waste to Clinton County Landfill in this year.
Clinton Co. - CH_4 Recovery/Flaring w/o LFGE (%)	Percent of waste at Clinton County Landfill burned with methane recapture but without landfill electricity generation.	Personal communication, Lisa, Coventry Landfill. Washington Electric Cooperative, Landfill Gas to Energy Project, Coventry Landfill. Opening Ceremony Brochure.	Percentage is 0% starting in FY 10/11, as Middlebury College stopped sending their waste to Clinton County Landfill in this year.

Clinton Co. - Electricity Generation (%)	Percent of waste at Clinton County Landfill burned with methane recapture and landfill electricity generation.	Personal communication, Lisa, Coventry Landfill. Washington Electric Cooperative, Landfill Gas to Energy Project, Coventry Landfill. Opening Ceremony Brochure.	Percentage is 0% starting in FY 10/11, as Middlebury College stopped sending their waste to Clinton County Landfill in this year.

Conversion Factors and Constants

Name	*Description*	*Source*	*Trends/Notes*
Short tons/lb (1/2000)	Conversion between short tons and lbs.	Internationally accepted unit conversion	Given this is a unit conversion, value has not been updated throughout inventory's existence.
CH_4 EF w/out Recovery (MTCE/ton)	Emission factor of CH4 w/out recovery expressed as metric tons of carbon equivalent emitted per metric ton of waste.	Value based on data from EPA Climate Leaders 2006. "Solid Waste Management and Greenhouse Gas" pp. 168.	See note on sourcing for conversion factors and constants.
CH_4 EF w/ Recovery (MTCE/ton)	Emission factor of CH4 w/recovery expressed as metric tons of carbon equivalent emitted per metric ton of waste.	See "CH_4 EF w/out Recovery"	See note on sourcing for conversion factors and constants.
CH_4 EF w/ LFGE (MTCE/ton)	Emission factor of CH4 w/LFGE expressed as metric tons of carbon equivalent emitted per metric ton of waste.	See "CH_4 EF w/out Recovery"	See note on sourcing for conversion factors and constants.
MTCDE/MTCE (tonne CO_2/tonne C)	Molecular weight ratio of MTCDE to MTCE. Value = ((12.011+2*16.000)/12.011) or simplified as 3.664 tonne CO_2/tonne C.	Internationally accepted chemical standard	Given this is a chemical standard, value has not been updated throughout inventory's existence.
CH_4 GWP	See scope 1A	See scope 1A	See scope 1A

CH_4 EF w/o Recovery (tonne gas/ton waste)	Emission factor of CH4 w/out recovery expressed as tonnes of CH_4 emitted per metric ton of waste.	Calculated from sourced data: (CH_4 w/out Recovery (MTCE/ton)) * (MTCDE/MTCE (tonne CO_2/tonne C)) / (CH_4 GWP)	See note on sourcing for conversion factors and constants.
CH_4 EF w/ Recovery (tonne gas/ton waste)	Emission factor of CH4 w/recovery expressed as tonnes of CH_4 emitted per metric ton of waste.	Calculated from sourced data: (CH_4 w/ Recovery (MTCE/ton)) * (MTCDE/MTCE (tonne CO_2/tonne C)) / (CH_4 GWP)	See note on sourcing for conversion factors and constants.
CH_4 EF w/ LFGE (tonne gas/ton waste)	Emission factor of CH4 w/out recovery expressed as tonnes of CH_4 emitted per metric ton of waste.	Calculated from sourced data: (CH_4 w/LFGE (MTCE/ton)) * (MTCDE/MTCE (tonne CO_2/tonne C)) / (CH_4 GWP)	See note on sourcing for conversion factors and constants.

Scope 3B - Formulas

Assessing the Split Between Landfills:

Coventry Landfill Emissions:

CH_4 Recovery/Flaring w/o LFGE? (%) = 1 - (Electricity Generation? (%))

Short Tons Solid Waste = (Total Solid Waste (lbs)) * (% Taken to Coventry LF, VT) * (Short tons/lb(1/2000))

CH_4 EF (tonnes gas/ton waste) = (Tonnes Coventry LF CH_4) / (Coventry Landfill Emissions: Short Tons Solid Waste)

Tonnes Coventry LF CH_4 = (Total Solid Waste (lbs)) * (% Taken to Coventry LF, VT) * ((Coventry Landfill Emissions: Straight LF) * (CH_4 EF w/out Recovery (tonne gas/ton)) + (Coventry Landfill Emissions: CH_4 Recovery/Flaring w/o LFGE? (%)) * (CH4 EF w/ Recovery (tonne gas/ton)) + (Coventry Landfill Emissions: Electricity Generation? (%)) * (CH_4 EF w/ LFGE (tonne gas/ton)) * (Short tons/lb (1/2000))

Clinton Co Landfill Emissions:

Short Tons Solid Waste = (Total Solid Waste (lbs)) * (% Taken to Clinton Co. LF, NY) * (Short tons/lb(1/2000))

CH_4 EF (tonnes gas/ton waste) = (Tonnes Clinton Co. LF CH_4) / (Clinton Co Landfill Emissions: Short Tons Solid Waste)

Tonnes Clinton Co LF CH_4 = (Total Solid Waste (lbs)) * (% Taken to Clinton Co. LF, NY) * ((Clinton Co. Landfill Emissions: Straight LF) * (CH_4 EF w/out Recovery (tonne gas/ton)) + (Clinton Co. Landfill Emissions: CH_4 Recovery/Flaring w/o LFGE? (%)) * (CH4 EF w/ Recovery (tonne gas/ton)) + (Clinton Co. Landfill Emissions: Electricity Generation? (%)) * (CH_4 EF w/ LFGE (tonne gas/ton)) * (Short tons/lb (1/2000))

Net Methane + Emissions Factor Calculations:

Short Tons Solid Waste = (Coventry Landfill Emissions: Short Tons Solid Waste) + (Clinton Co Landfill Emissions: Short Tons Solid Waste)

Tonnes CH_4 = (Tonnes Coventry LF CH_4) + (Tonnes Clinton Co LF CH_4)

ΣMTCDE from Landfill CH_4 = (Tonnes CH_4) * (CH_4 GWP)

Carbon Offsets

Middlebury College's GHG inventory splits the college's offsets into external and internal offsets. External offsets consist of the offsets that the college buys from the Snow Bowl (located in Ripton, VT). The Snow Bowl buys its offsets from Native Energy (https://native.eco/), a company based in Burlington, VT that has many projects they sell carbon credits for. Middlebury College's internal offsets come from its Breadloaf Carbon Credit Program. The college hires Bluesource (https://www.bluesource.com/), formerly Anew, to develop the Breadloaf carbon credits. They do this by estimating how much carbon the land at Breadloaf stores and sequesters through five year field studies and annual "desktop" evaluations. Bluesource also compares the way carbon has been stored in the forests at Breadloaf and the way forests are managed in the area in general. Most forests in this area are harvested periodically, but the college harvests very little of its Breadloaf land. Thus, Bluesource determined that there was much more carbon stored in these forests than if the college had managed them in similar ways to others in the area, which has led to a surplus of carbon storage. Also factored into these offsets is the net growth of these forests every year. Bluesource uses the Improved Forestry Management Protocol of the American Carbon Registry as its methodology.

The carbon credits that Bluesource determines the college should receive as part of the Breadloaf Carbon Credit Program are put on the American Carbon Registry, which facilitates the voluntary sale and purchase of carbon credits. The college has been selling credits since 2016, and has had around 20,000 to 25,0000 credits a year to sell or buy back. The institution buys back a number of these same carbon credits they need each year to achieve carbon neutrality. They are free to sell the rest of their carbon credits, and this money is partially used to pay the costs of the project. Starting in 2023, the amount of carbon credits available to sell on the American Carbon Registry will drop significantly to around 7,000 or 8,000, as the college will have sold off its accumulated carbon established at the beginning of the project, so the amount of credits available will only be determined by the yearly net growth of the Breadloaf forests.

In the GHGI, a tab is dedicated to tracking offsets data; however, data is infrequent and often missing. The total contributing internal and external offsets (located at the top of the offsets tab) are subtracted from total emissions to get 0 net carbon emissions. The introduction of carbon offsets and the Breadloaf Carbon Credit Program was the primary method in which the college was able to reach carbon neutrality by 2016.

Other GHGI Tabs

From 2007 to 2009, Middlebury College also tracked total emissions from all mobile combustion of fossil fuels used in vehicles not owned by the institution but whose operations are indirectly solicited by the institution. This primarily includes regular employee and off-campus student housing. In order to calculate these emissions, the college sent out a survey to Middlebury employees inquiring about which modes of transportation they take on their commute. 463 employees responded to the survey, and using this information as well as a distribution of where employees live, provided by Human Resources, the college estimated employee commute emissions for all employees. These emissions were not required to be counted in the total emissions for the institution, and Middlebury stopped keeping track of employee commute emissions after 2009. In the GHGI, this tab is labeled “EmployeeCommute”.

Middlebury College’s GHGI dedicates one tab to “Normalization factors”, which includes information related to institutional growth between reporting periods, in an effort to normalize emissions data to more easily view trends. In this tab, the college made calculations of MTCDEs per full time equivalent (FTE) student or per square foot of building space. Given that Middlebury College also hosts part-time Language School students in the summer, these calculations were more complicated. The college also attempted to calculate MTCDEs for heating and cooling, given that window air conditioning units are installed in the summer for Language School students and faculty. Furthermore, degree-days are used to normalize annual climate differences. Every day above 65° Fahrenheit (F) is recognized as a cooling degree-day, and days below this temperature are heating degree-days. The institution recognizes and records how many total degree-days are in a given year (with units in degrees Fahrenheit) because this will require more steam production by the college, and thus more electricity usage. For example, according to the latest Middlebury College STARS Report, in Fiscal Year 2021 (July 1, 2020 to June 30, 2021), the college reported 6,514.20 heating Degree-Days (°F) and 1,015.30 cooling Degree-Days (°F). Mild winters and summers result in less degree-days, and generally require less steam production and thus less electricity production. This can account for fluctuations in usage of fuels associated with steam production (i.e. #6 fuel oil) as well as co-generation of electricity.

In addition to GHGI tabs dedicated to offsets, employee commute, and normalization factors, the inventory also includes tabs with various calculations, notes, and edits. These include a tab on “Biomass Accounting”, the summary of biomass accounting work done by Gabe Desmond ‘20.5, with accounting ending in FY 18/19. Another tab, labeled “Edits Log”, notes changes made in the inventory, though has not thoroughly been kept up since 2011. A “FY 02-06 reference” tab notes emissions calculated retroactively from 2002-2006, before the inventory's creation. Final tabs in the inventory were used to experiment with other ways data in the GHGI could be organized.