Durham, New Hampshire

UNH Sustainability Institute

2019, 2021 & 2022 Community-Wide Greenhouse Gas Inventories

Completed in Fall 2023 and Spring 2024

Prepared by:
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UNH Sustainability Fellow (2023/2024)

Acknowledgements

I would like to thank the following people who offered their time, expertise, and support throughout this project:

Todd Selig, Town of Durham
Jennifer Andrews, UNH Sustainability Institute
Gail Jablonski, Town of Durham
Karen Edwards, Town of Durham
Nat Balch, Town of Durham
Jim Lawson, Town of Durham
Daniel Peterson, Town of Durham
John Baker, Durham Public Works
David Beaulieu, Unitil
Jeffrey Jackson, Eversource
Jonathan Gagne, Greater Portland Council of Governments
Rachel Dewey, Strafford Regional Planning Commission
Eli Yewdall, ICLEI – Local Governments for Sustainability
Bobby Wenger, ICLEI – Local Governments for Sustainability

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Introduction

In response to rising global temperatures, the Town of Durham (the "Town") is dedicated to fostering a more sustainable and resilient future. Over the past fifteen years, Durham has implemented numerous climate initiatives, including restoring over 300 feet of living shoreline, installing solar arrays, and deploying electric vehicle chargers. In 2021, Durham reaffirmed its commitment to climate action by joining the Global Covenant of Mayors for Climate and Energy (GCoM), an international coalition of cities and local governments committed to advancing a low-emission society. As a GCoM signatory, Durham pledges to monitor and report its emissions through a comprehensive community-wide greenhouse gas (GHG) inventory every few years. This inventory also serves as a benchmark for the Town's progress towards its ambitious goals of reducing GHG emissions by 42.8% by 2030 and achieving net-zero emissions by 2050.

The 2022 GHG inventory was completed in the fall of 2023 and the spring of 2024. Concurrently, the 2019 and 2021 GHG inventories were updated to ensure that the methodologies were consistent across the three inventories, enabling comparison. All necessary data was collected, except data from the Oyster River School District, which has yet to be updated since 2019. Comparison of the three inventories yielded several significant findings, which are detailed below.

Methods

The updated 2019 community-wide inventory as well as the new 2021 and 2022 inventories followed the updated version of the ICLEI US Community Protocol for Accounting and Reporting of Greenhouse Gases (the "Protocol"), which offers a standardized set of methods and a reporting framework recognized by GCoM. This version of the Protocol should be published in late 2024 or early 2025, but advanced copies of updated methodologies were supplied to the UNH Sustainability Fellow by ICLEI staff in 2023 and 2024. Occasionally, tailored strategies were needed to estimate emissions in Durham, particularly in regards to commercial stationary energy emissions. These strategies are explained in more detail in the Durham GHGI Handbook ("the Handbook"). Future inventories should follow the latest version of the Protocol, allowing fellows to access improved methodologies for estimating local emissions.

The Protocol requires participating communities to report five primary emission-generating activities. These required activities are divided into four categories: Built Environment, Transportation, Wastewater, and Solid Waste. An "Agriculture & Livestock" (AFOLU) category is also included, although reporting AFOLU emissions is optional under GCoM. Explanations for what is included in each category are provided in Table 1.

Table 1. Descriptions of Emission Categories

Category	Description
Built Environment	Covers the use of stationary fuel & electricity within the 5 sectors
Transportation	Covers on-road passenger and freight motor vehicles
Wastewater	Covers the treatment of the community's wastewater

Solid Waste	Covers solid waste produced within the Town boundaries
Agriculture and Livestock	Covers fertilizer use & livestock on the UNH campus

All emissions were calculated using the municipal carbon accounting platform, ClearPath, which is the leading online software for completing greenhouse gas inventories. ClearPath is a product of the Local Governments for Sustainability (ICLEI), which is an international non-governmental organization that offers technical support and consulting services to local governments to identify and meet their sustainability goals. All future inventories should use ClearPath software to ensure methodological consistency and enable yearly inventory comparisons.

The emissions factors (EFs) used in the 2022 inventory are from the 2022 factor sets listed in ClearPath, while the 2019 and 2021 inventories use 2019 and 2021 emissions factors, respectively.

The three inventories tracked the three greenhouse gasses that are emitted globally in the highest quantities: carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). The totals of each GHG were weighted using Global Warming Potentials (GWPs) so that the emissions can be presented as one value: Metric Tons of Carbon Dioxide Equivalent (MTCO2e). GWPs are a measure of the potency of the greenhouse gas properties of each gas relative to carbon dioxide and are published by the Intergovernmental Panel on Climate Change (IPCC). All three inventories used the values from a 100-year timescale from the IPCC's Sixth Assessment Report (AR6), published in 2021 (Table 2). Future inventories should adopt the latest IPCC GWPs, and previous inventories should be updated accordingly.

Table 2. Greenhouse Gases and their Global Warming Potential

Greenhouse Gas	GWP (MTCO2e)
CO_2	1
CH_4	27.9
N_2O	273

Detailed explanations of the methodologies used to estimate emissions for each category can be found in Durham's GHGI Handbook (the "Handbook").

Results

<u>Results Summary</u>

Durham’s total community emissions in 2019, 2021, and 2022 were 104,472 MTCO2e, 83,622 MTCO2e, and 97,019 MTCO2e, respectively. As Emily Mello observed in her original 2019 inventory report, Durham’s lower-than-average carbon footprint is likely due to the presence of UNH, which is a dense and low-carbon community.[1] Additionally, the high level of environmental awareness amongst Durham residents, as well as the Town’s own climate efforts, have likely contributed to its lower annual emissions.

[1] Emily Mello. 2019 Community-Wide Greenhouse Gas Inventory. UNH Sustainability Institute, Town of Durham, 2021.

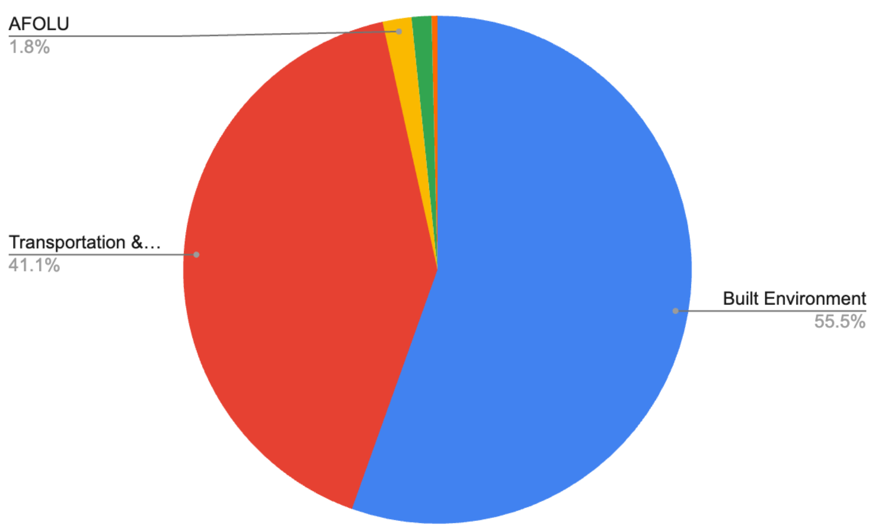
Table 3 and Figure 1 show the breakdown of annual emissions by category. Like most communities, the two largest emitting categories were Built Environment and Transportation, which together accounted for 96.6% of the Town's total emissions.

However, please note that the Built Environment and Solid Waste categories are incomplete due to the missing stationary energy, purchased electricity, and solid waste usage and emissions data from the Oyster River Cooperative School District (ORCSD-D). That is, since ORCSD-D data has not been updated since 2019, ORCSD-D emissions were not included in the 2021 and 2022 inventories as well as the 2019 inventory update to enable comparison across the three inventories. As a result, total emissions in these categories are likely to change if ORCSD-D data is included in future inventories. However, it is worth noting that ORCSD-D emissions amounted to fewer than 1,000 MTCO2e (less than 1% of Durham's community-wide emissions) in the original 2019 inventory, so its absence should not dramatically change the findings in this report. Even so, a solution will need to be developed to ensure that ORCSD-D data is available during Durham's next GHG inventory so that it can be included in the Town's emissions calculations.

Table 3. Durham's 2022 Emissions by Category

Category	Emissions (MTCO2e)	% of Total Emissions
Built Environment	53,812	55.5%
Transportation	39,838	41.1%
Agriculture/Livestock	1,777	1.8%
Solid Waste	1,225	1.3%
Wastewater	367	0.4%
Total	**97,019**	-

Figure 1. Total Emissions Breakdown by Category (2022)



The Town's 2022, 2021, and 2019 emissions can also be divided into different entities (or "sectors") within Durham: Residential, Municipal, Commercial, UNH, and the Durham buildings affiliated with the ORCSD-D. These were the same sectors used in the original 2019 inventory report, and should be used in future inventories for the sake of clarity and consistency. However, as aforementioned, data for the ORCSD-D sector was excluded due to the school district not reporting its emissions since 2019.

<u>Built Environment (BE)</u>

The "Built Environment" category was Durham's largest source of emissions in 2022, emitting 53,812 MTCO2e, or 55.5% of community-wide emissions. It consisted of four sectors: Residential, Commercial, Municipal, and UNH.

This category includes emissions from purchased electricity and the emissions from transmission and distribution losses (T&D). It also includes emissions associated with stationary fuels, which are generally used for heating and cooking and include fuel oil, natural gas, propane, and wood chips.

<u>Stationary Energy</u>

Durham's stationary energy emissions from natural gas, fuel oil, propane, and wood chips across the four sectors totaled 38,792 MTCO2e in 2022. Figure 2 shows the breakdown of stationary fuel emissions by sector, while Table 4 shows each sector's 2022 stationary energy emissions by fuel type.

Figure 2. Stationary Energy Emissions Breakdown by Sector (2022)

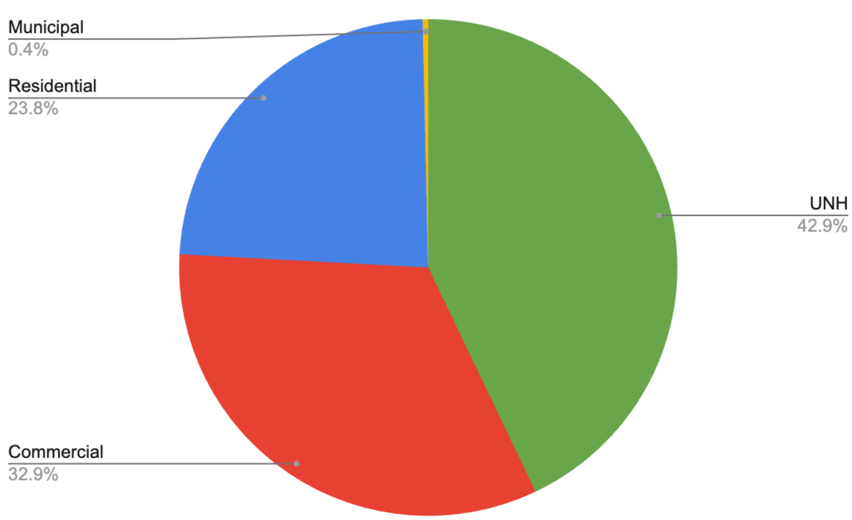


Table 4. Total Stationary Energy Emissions From Each Built Environment Sector (2022)

Sector	Energy Source	Emissions (MTCO2e)	Sector Total (MTCO2e)
Residential	Natural Gas	2,025	9,229
	Fuel Oil	5,612	
	Propane	1,531	
	Wood Chips	61	
Municipal	Natural Gas	103	138
	Fuel Oil	15	
	Propane	20	
Commercial	Natural Gas	11,008	12,777
	Fuel Oil	157	
	Propane	1,612	
UNH	Natural Gas	13,666	16,648
	Fuel Oil	1,402	
	Propane	311	
	Wood Chips	73	
	Landfill Gas	1,196	

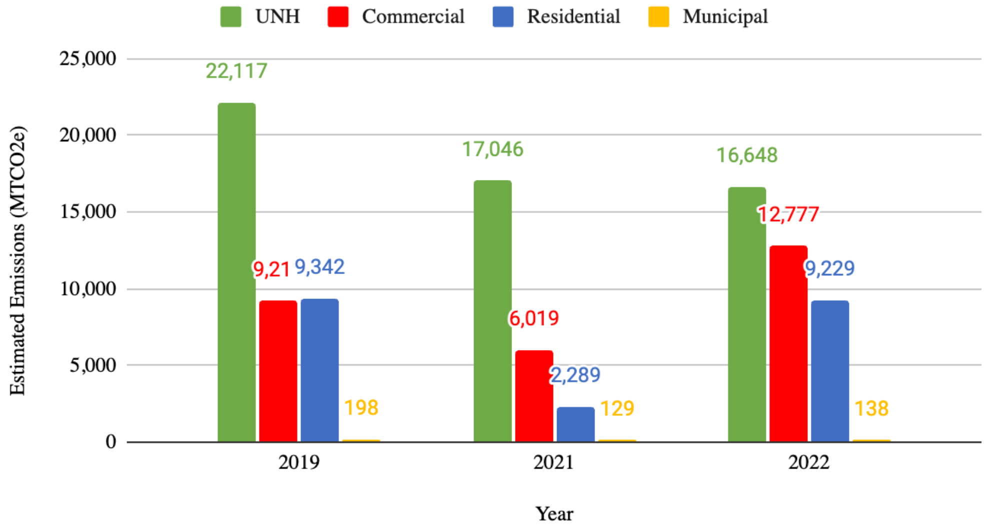
ICLEI typically does not include stationary fuels unless the fuel is used by at least 5% of residences in a community. In Durham, natural gas, fuel oil, and propane meet the 5% of residences threshold, while wood chips do not. However, since the original 2019 inventory included wood chips, it was also included in the 2019 inventory update and the 2021 and 2022 inventories for the sake of consistency.

Natural gas data was provided by Unitil, Durham’s natural gas utility. Additionally, fuel oil and propane data for the municipal sector was provided by Durham Public Works. The remaining stationary energy emissions were calculated using updated Protocol methodologies and tailored approaches designed by ICLEI technical support staff. For more information on the methodologies used to calculate Durham’s stationary energy emissions, refer to the natural gas, fuel oil, propane, and wood chips entries in the "Residential Energy" and "Commercial Energy" sections of the Handbook.

Comparisons to Previous GHG Inventories

The difference in estimated annual stationary energy emissions by sector (between the updated 2019, 2021, and 2022 inventories) can be found in Figure 3. Later sections explore these differences in greater detail.

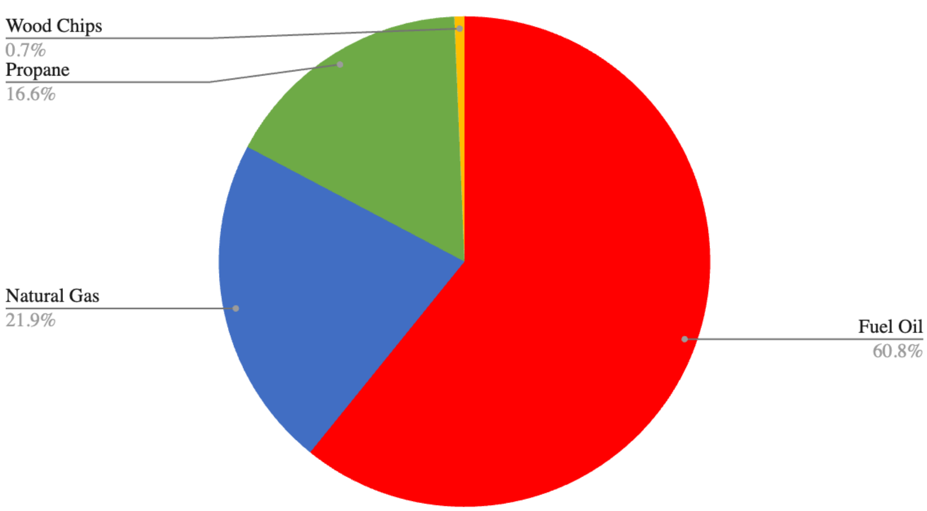
Figure 3. Yearly Stationary Energy Emissions By Sector (2019-2022)



Residential Sector

Durham residents used an estimated 144,346 MMBtu of stationary energy in 2022, resulting in approximately 9,229 MTCO2e in annual emissions. Residential stationary energy emissions accounted for 23.8% of the annual stationary energy footprint and 9.5% of the Town's community-wide emissions. Of this sector's stationary energy emissions, over half (60.8%) came from fuel oil, followed by natural gas and propane, which accounted for 21.9% and 16.6% of emissions, respectively (Figure 4).

Figure 4. Residential Stationary Energy Emissions by Fuel Type (2022)



Comparisons to Previous GHG Inventories

The Town's residential stationary energy emissions decreased slightly from 9,342 MTCO2e in 2019 to 9,229 MTCO2e in 2022, representing a 1.2% decrease. Differences in annual residential stationary energy emissions were the most significant between pandemic and non-pandemic years; for instance, residential fuel oil emissions fell from 5,683 MTCO2e in 2019 to 1,354 MTCO2e in 2021 (a 76.2% decrease). This significant reduction is likely due to the closure of the

UNH Main Campus, resulting in fewer off-campus students living in Durham during the school year. However, comparisons between 2019 and 2022 emissions suggest a return to normalcy, as the residential stationary energy estimates were similar in these non-pandemic years. For example, residential fuel oil emissions decreased by roughly 1.2% between 2019 and 2022 (from 5,683 MTCO2e to 5,612 MTCO2e). Differences in estimated yearly stationary energy emissions from 2019-2022 in the residential sector are depicted below in Figure 5 and Table 5.

Figure 5. Yearly Residential Stationary Energy Emissions By Fuel Type (2019-2022)

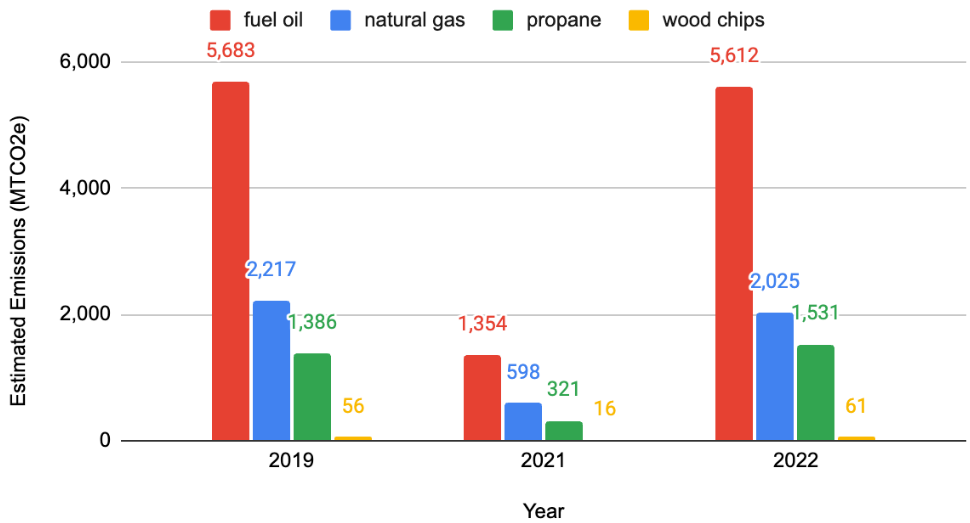


Table 5. Percent Change in Yearly Residential Stationary Fuel Emissions by Fuel Type (2019-2022)

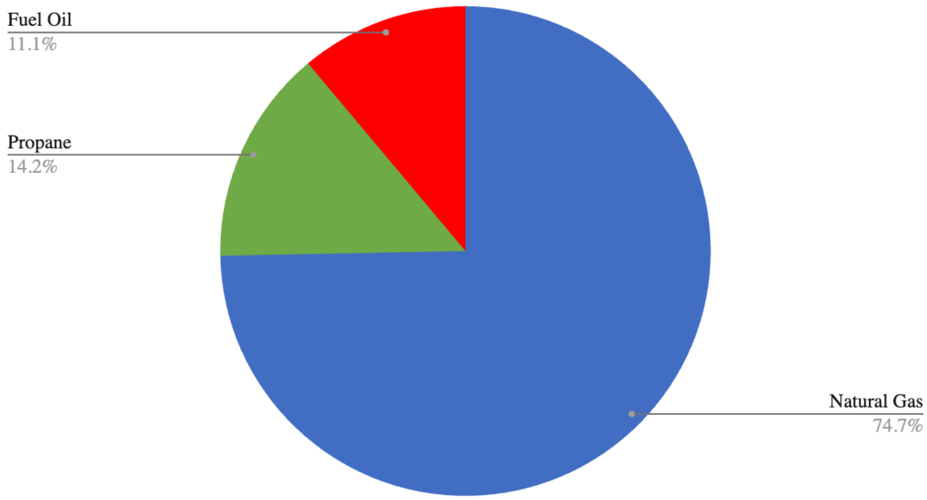
Fuel Type	% Change in Stationary Fuel Emissions (2019-2022)
Natural Gas	-8.7%
Fuel Oil	-1.2%
Propane	+10.5%
Wood Chips	+8.9%

All residential stationary energy emissions were estimated using ICLEI's updated methodology entitled "Module 3c: Stationary Energy Non-Utility Stationary Fuel (Recommended) Method 1." For more information about this approach, refer to the residential fuel oil, propane, and wood chips entries in the Handbook (pg. 4-6).

Municipal Sector

The Town emitted 138 MTCO2e from its municipal stationary energy use in 2022, accounting for approximately 0.4% of the annual stationary energy footprint and 0.1% of the total community-wide emissions. Of this sector's stationary energy emissions, nearly three-quarters (74.7%) came from natural gas, followed by propane and fuel oil, which accounted for 14.2% and 11.1%, respectively (Figure 6).

Figure 6. Municipal Stationary Energy Emissions by Fuel Type (2022)



All municipal stationary energy emissions were calculated using the Town's measured usage data compiled by Durham Public Works and Unitil. For more information about this approach, refer to the municipal natural gas, fuel oil, and propane entries in the Handbook (pgs. 10 & 18).

Comparisons to Previous GHG Inventories

The Town's municipal stationary energy emissions decreased from 198 MTCO2e in 2019 to 138 MTCO2e in 2022, representing a 30.3% decrease (Figure 7). This decrease is attributed to a reduction in municipal stationary energy use across all three fuel types between 2019 and 2022 (Table 6). However, the Public Works department was unable to provide 2021 usage data for fuel oil and propane, so 2022 data was used instead. As a result, emissions for these two fuel types were likely overestimated in 2021 due to the COVID-19 lockdown and subsequent closure of many municipal buildings in the first half of the year.

Figure 7. Yearly Municipal Stationary Energy Emissions By Fuel Type (2019-2022)

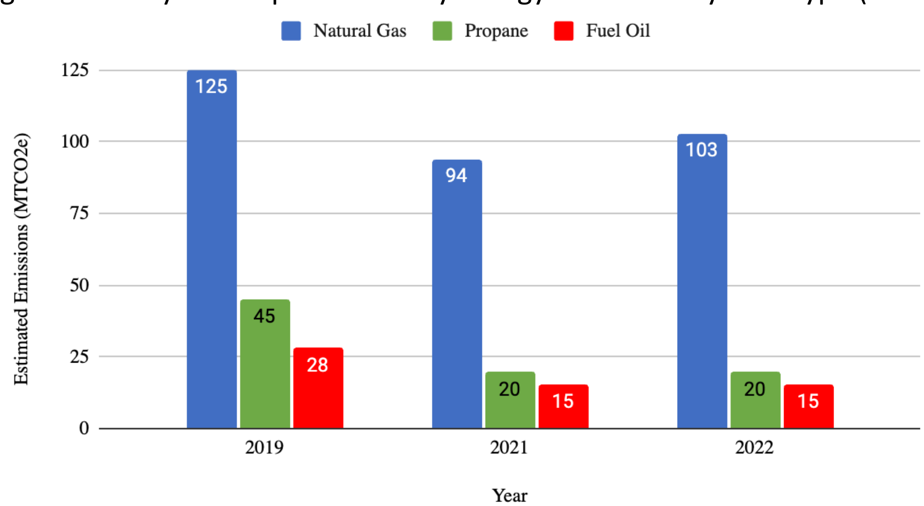


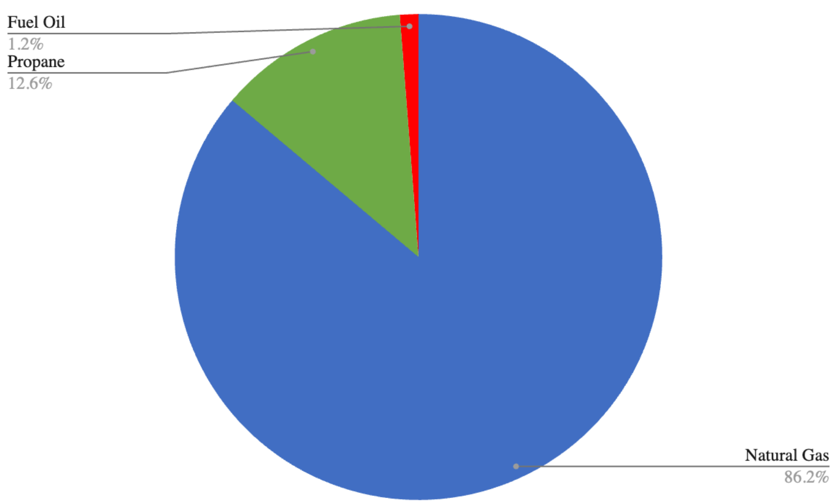
Table 6. Percent Change in Yearly Municipal Stationary Fuel Emissions by Fuel Type (2019-2022)

Fuel Type	% Change in Stationary Fuel Emissions (2019-2022)
Natural Gas	-17.6%
Fuel Oil	-46.4%
Propane	-55.6%

Commercial Sector

Durham's commercial sector produced 12,777 MTCO2e from its stationary energy use in 2022, accounting for 32.9% of the annual stationary energy footprint and 13.2% of the Town's community-wide emissions. Approximately 86.2% of commercial stationary energy emissions came from natural gas, while 12.6% of emissions were attributed to commercial propane use (Figure 8).

Figure 8. Commercial Stationary Energy Emissions by Fuel Type (2022)



Comparisons to Previous GHG Inventories

Commercial natural gas usage data was provided by Unitil, allowing for more precise estimates to be made. However, emission estimates from commercial fuel oil and propane usage remained constant between 2019 and 2022 due to the fact that measured usage of these fuel types was unavailable for Durham's commercial sector. Therefore, ICLEI staff advised Durham to use the same tailored methodology and estimates across the three inventories for commercial fuel oil and propane emissions.

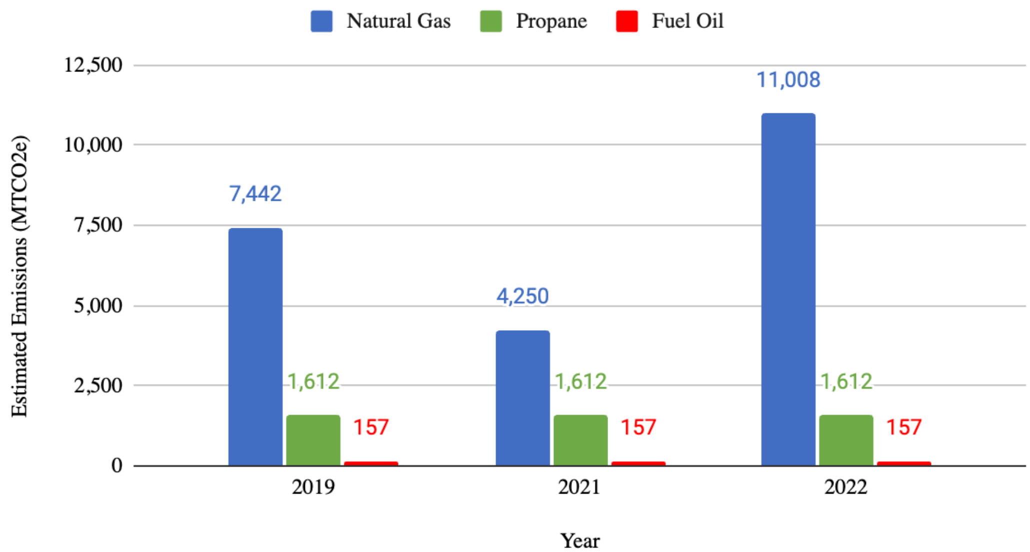
The tailored methodology involves using Google maps and a town-supplied list of commercial spaces and their fuel types to estimate commercial square footage in Durham by fuel type. However, since the list does not distinguish between natural gas and propane usage, a map of

Unitil natural gas pipelines was used to estimate which properties use natural gas or propane based on access to a natural gas pipeline.[2]

Commercial emissions from stationary energy use increased from 9,211 MTCO2e in 2019 to 12,777 MTCO2e in 2022, representing a 38.7% increase (Figure 9). The increase in commercial stationary energy use can be attributed to the 47.9% increase in natural gas usage between 2019 and 2022 (from 1,399,335 therms to 2,069,898 therms) according to Unitil.

However, between 2019 and 2021, commercial natural gas emissions decreased by 42.9%. This decrease can be attributed to the closure of non-essential commercial establishments during the COVID-19 lockdown in the first half of the year. Therefore, the comparison between emissions in non-pandemic years (2019 and 2022) is likely more reflective of the commercial sector's natural gas usage and its associated emissions.

Figure 9. Yearly Commercial Stationary Energy Emissions by Fuel Type (2019-2022)

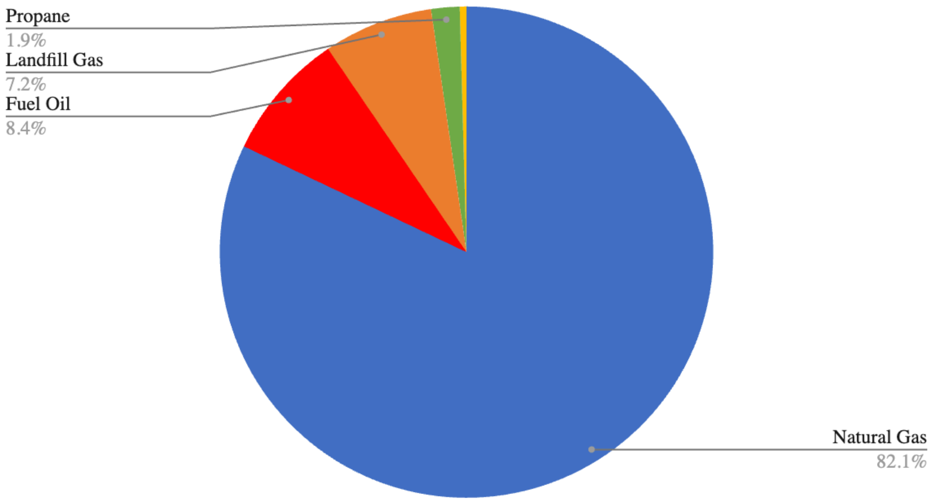


UNH Sector

UNH's stationary energy emissions accounted for 42.9% of the Town's stationary energy emissions and 17.2% of community-wide emissions in 2022. All of UNH's usage data was reported in SIMAP for the given inventory year. Of UNH's total stationary energy emissions, 82.1% was from natural gas, with the remaining 17.9% of emissions split between fuel oil (8.4%), landfill gas (7.2%), propane (1.9%), and wood chips (0.4%) (Figure 10).

[2] For more information on the tailored methodology used to calculate commercial fuel oil and propane emissions, refer to the "Commercial Energy" section of the Handbook in the shared "GHGI Instructions" folder.

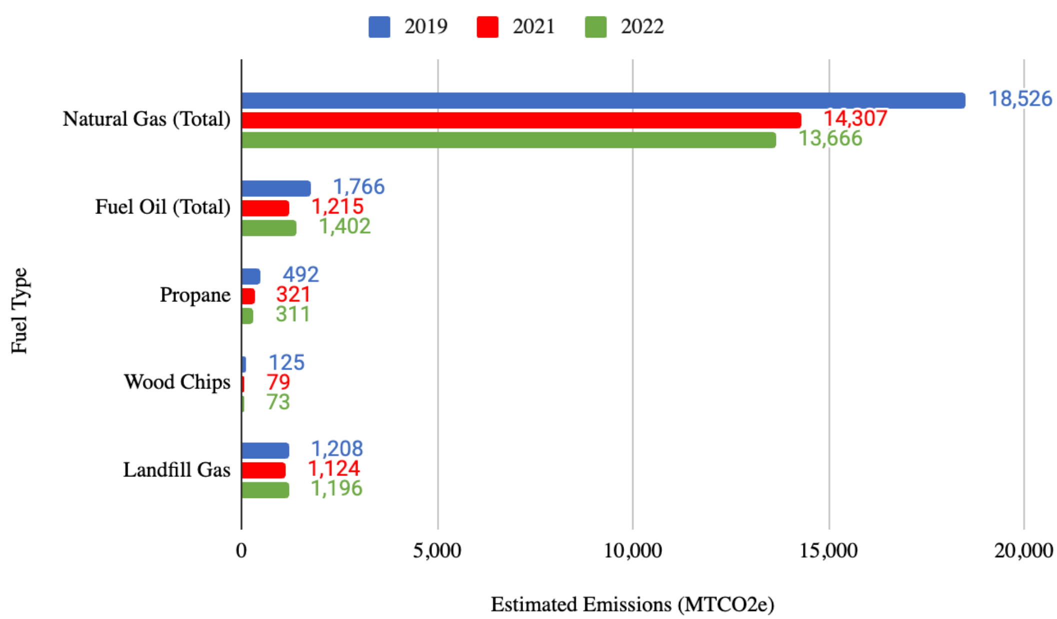
Figure 10. UNH Stationary Energy Emissions by Fuel Type (2022)



Comparisons to Previous GHG Inventories

UNH's total stationary energy emissions decreased by 24.7% between 2019 to 2022 (from 22,117 MTCO2e to 16,648 MTCO2e) (Figure 11). In fact, between 2019 and 2022, there were emissions reductions in all five of UNH's stationary energy sources (Table 7).[3]

Figure 11. Yearly UNH Stationary Energy Emissions By Fuel Type (2019-2022)



[3] Natural Gas (total) and Fuel Oil (total) in Figure 11 and Table 8 refer to total emissions from natural gas and fuel oil associated with UNH's Main Campus and its Cogeneration Plant.

Table 7. Percent Change in Yearly UNH Stationary Fuel Emissions by Fuel Type (2019-2022)

Fuel Type	% Change in Stationary Fuel Emissions (2019-2022)
Natural Gas (Total)	-26.2%
Fuel Oil (Total)	-20.6%
Landfill Gas	-1.0%
Propane	-36.8%
Wood Chips	-41.6%

Purchased Electricity

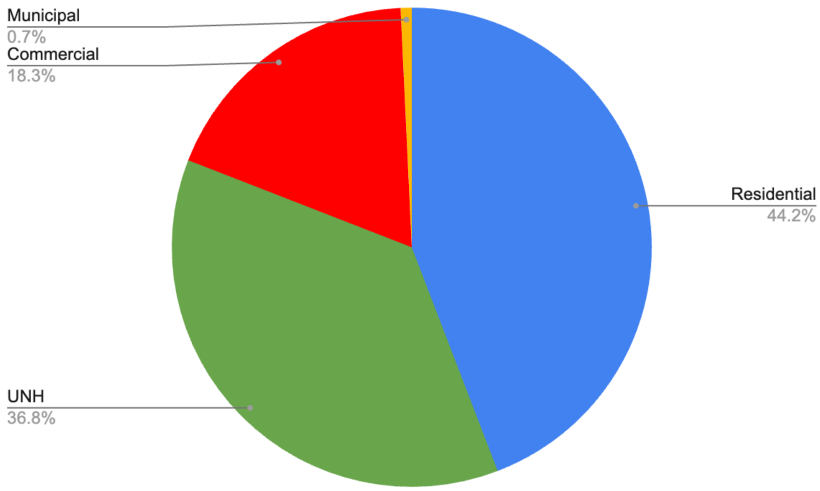
Electricity data for the residential, commercial, and municipal sectors were provided by Eversource, while UNH reported its electricity use in SIMAP. Total electricity emissions include emissions from purchased electricity and transmission and distribution losses (T&D).

Purchased electricity emissions across the four sectors totaled 14,291 MTCO2e in 2022. When upstream transmission and distribution (T&D) losses are included, the total rises to 15,020 MTCO2e. T&D losses are the total losses that occur when electricity is transmitted between sources of supply and points of distribution. Emissions from T&D losses in 2022 were approximately 729 MTCO2e. A breakdown of these emissions is provided in Table 8 and Figure 12.

Table 8. Total Electricity Emissions by Sector and Energy Source (2022)

Sector	Energy Source	Emissions (MTCO2e)	Sector Total (MTCO2e)
Residential	Purchased Electricity	6,312	6,634
	T&D Losses	322	
Municipal	Purchased Electricity	107	112
	T&D Losses	5	
Commercial	Purchased Electricity	2,620	2,754
	T&D Losses	134	
UNH	Purchased Electricity	5,252	5,520
	T&D Losses	268	

Figure 12. Total Electricity Emissions Breakdown by Sector (2022)



Comparisons to Previous GHG Inventories

Durham's total electricity emissions (including T&D losses) slightly increased from 14,828 MTCO2e in 2019 to 15,020 MTCO2e in 2022, representing a 1.3% increase. Over 95% of these emissions were attributed to purchased electricity usage. While purchased electricity emissions increased by 16.3% in the residential sector between 2019 and 2022 (from 5,427 MTCO2e in 2019 to 6,312 MTCO2e in 2022), they decreased in the commercial, municipal, and UNH sectors. Figure 13 depicts the differences in estimated yearly purchased electricity emissions (excluding T&D loss emissions) by sector from 2019-2022.

Figure 13. Yearly Purchased Electricity Emissions By Sector (2019-2022)

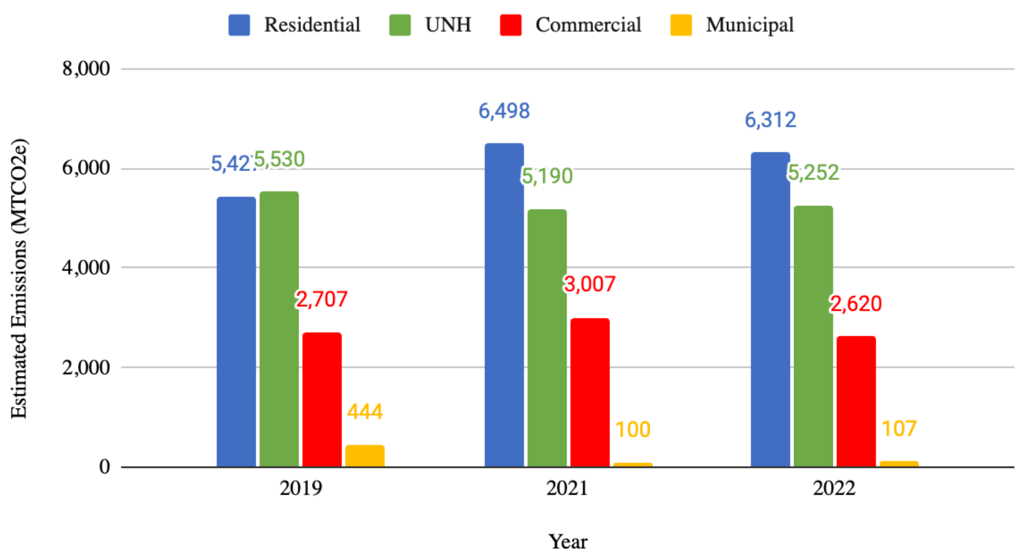
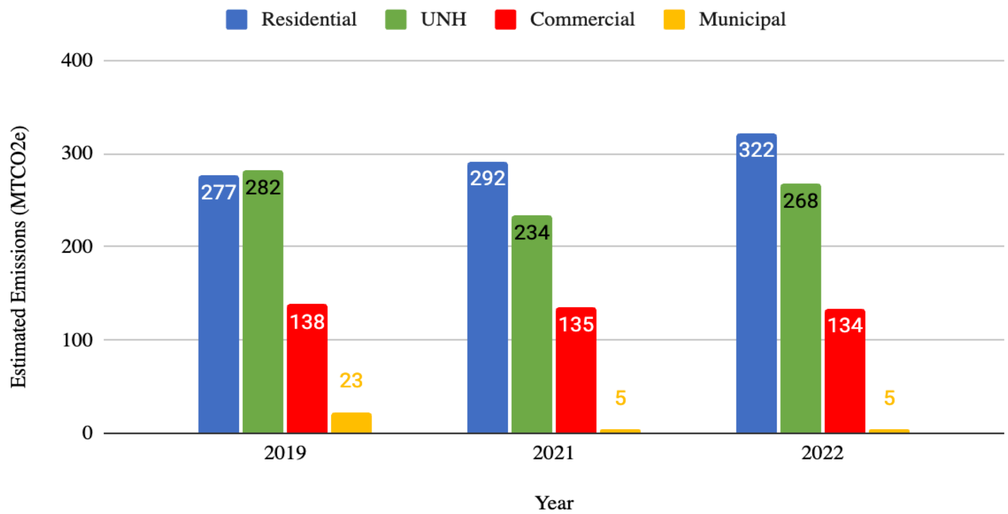


Figure 14, which depicts yearly emissions from T&D losses by sector, mirrors the trends seen in Figure 13 (since T&D losses are directly related to the amount of electricity purchased). Later sections explore these differences in greater detail.

Figure 14. Yearly T&D Loss Emissions By Sector (2019-2022)



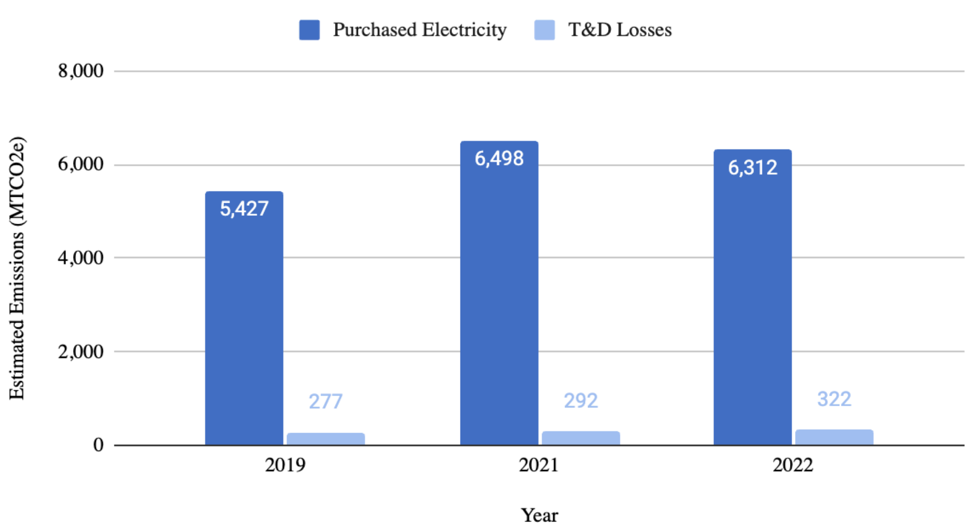
Residential Sector

Durham residents used 25,755,966 kWh of purchased electricity in 2022, resulting in approximately 6,312 MTCO2e in annual emissions (excluding T&D losses). Residential purchased electricity usage accounted for 42% of the 2022 electricity footprint and 6.5% of the total community-wide emissions. Residential T&D losses generated 322 MTCO2e in emissions and represented 2.1% of the 2022 electricity footprint and 0.3% of Durham's total emissions.

Comparisons to Previous GHG Inventories

The residential sector's total electricity emissions (including T&D losses) increased from 5,704 MTCO2e in 2019 to 6,634 MTCO2e in 2022, representing a 16.3% increase (Figure 15). This increase is due to the 6.3% increase in the amount of purchased electricity in the residential sector (from 24,231,849 kWh in 2019 to 25,755,966 kWh in 2022, according to Eversource), resulting in higher direct and upstream electricity emissions.

Figure 15. Residential Electricity Emissions (Purchased Electricity and T&D Losses) by Year



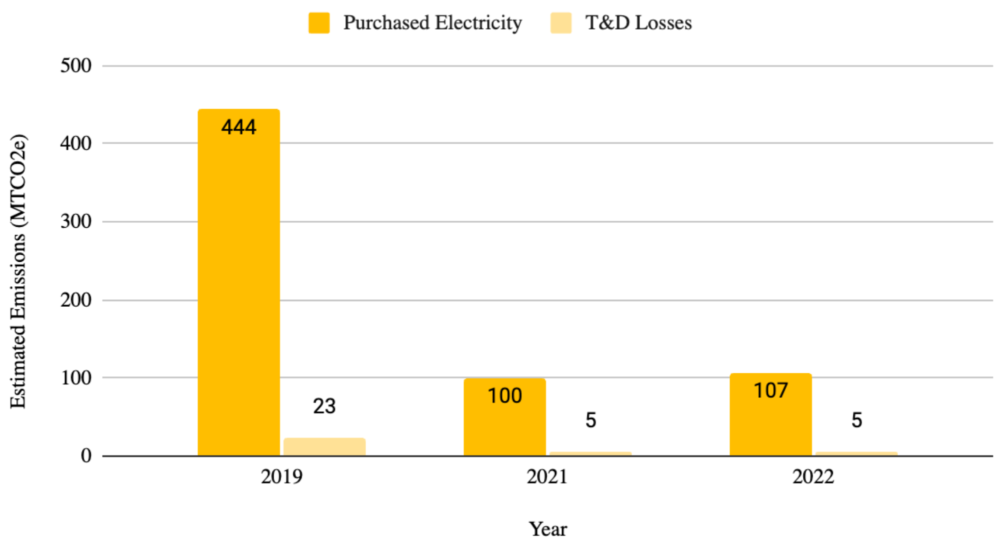
Municipal Sector

According to Eversource, Durham's municipal sector used 437,982 kWh of purchased electricity in 2022, resulting in approximately 107 MTCO2e in annual emissions (excluding T&D losses). Municipal purchased electricity usage accounted for 0.7% of the 2022 electricity footprint and 0.1% of the total community-wide emissions. T&D losses generated 5 MTCO2e in emissions and represented 0.03% of the 2022 electricity footprint and 0.01% of Durham's community-wide emissions.

Comparisons to Previous GHG Inventories

The municipal sector's total electricity emissions decreased from 467 MTCO2e in 2019 to 112 MTCO2e in 2022 (Figure 16). This reduction is due to the 77.8% decrease in municipal purchased electricity (from 1,980,894 kWh in 2019 to 437,982 kWh in 2022, according to Eversource), resulting in fewer GHG emissions and lower T&D losses.

Figure 16. Municipal Electricity Emissions (Purchased Electricity and T&D Losses) by Year



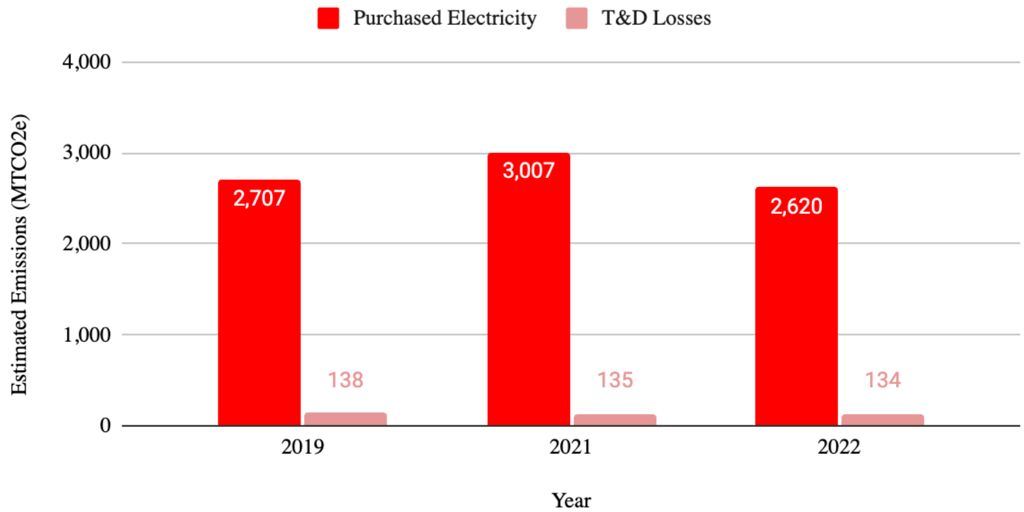
Commercial Sector

According to Eversource, Durham businesses used 10,691,121 kWh of purchased electricity in 2022, resulting in approximately 2,620 MTCO2e in annual emissions (excluding T&D losses). Commercial purchased electricity usage accounted for 17.4% of the annual electricity footprint and 2.7% of Durham's community-wide emissions. T&D losses generated 134 MTCO2e in emissions and represented 0.9% of the annual electricity footprint and 0.1% of the Town's community-wide emissions.

Comparisons to Previous GHG Inventories

The commercial sector's total electricity emissions decreased from 2,707 MTCO2e in 2019 to 2,620 MTCO2e in 2022 (Figure 17). This 3.2% reduction is likely attributed to the 11.6% decrease in purchased electricity (12,088,908 kWh in 2019 to 10,691,121 kWh in 2022, according to Eversource), resulting in fewer GHG emissions and lower T&D losses.

Figure 17. Commercial Electricity Emissions (Purchased Electricity and T&D Losses) by Year



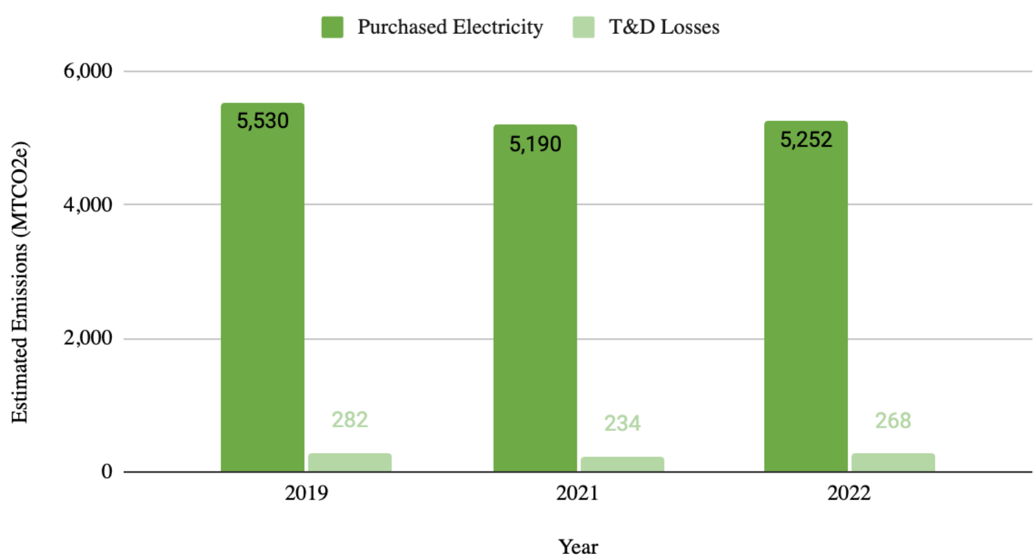
<u>UNH Sector</u>

According to SIMAP, UNH used an estimated 21,431,151 kWh of purchased electricity in 2022, resulting in approximately 5,252 MTCO2e in annual emissions (excluding T&D losses). UNH's purchased electricity usage accounted for 35% of the annual electricity footprint and 5.4% of Durham's total emissions. T&D losses generated 268 MTCO2e in emissions and represented 1.8% of the Town's electricity footprint and 0.3% of its community-wide emissions.

Comparisons to Previous GHG Inventories

UNH's total electricity emissions slightly decreased from 5,530 MTCO2e in 2019 to 5,252 MTCO2e in 2022 (Figure 18). This reduction is likely attributed to the decrease in purchased electricity (24,694,937 kWh in 2019 to 21,431,151 kWh in 2022), resulting in fewer GHG emissions and lower T&D losses.

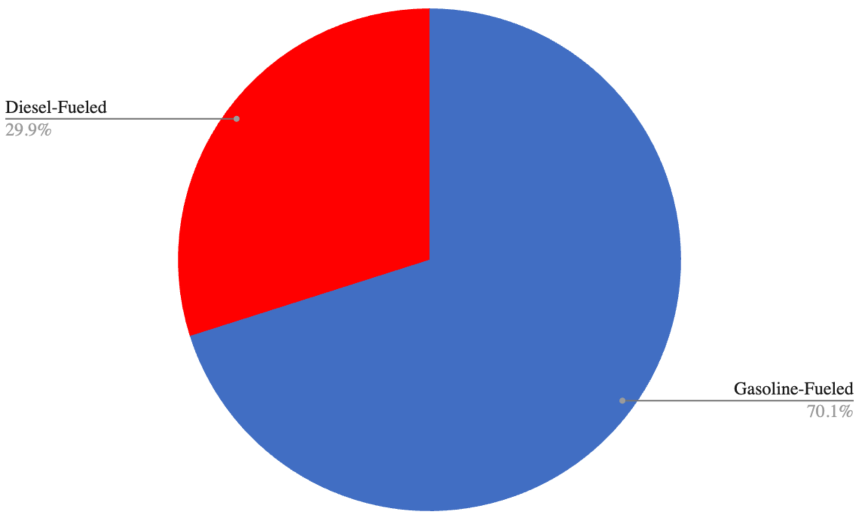
Figure 18. UNH Electricity Emissions (Purchased Electricity and T&D Losses) by Year



Transportation

In 2022, the "Transportation" category was Durham's second largest source of emissions, emitting 39,838 MTCO2e, or 41.1% of community-wide emissions. The Strafford Regional Planning Commission (SRPC) estimated that the average daily vehicle miles traveled (VMT) in Durham was 212,397 VMT, so the average annual vehicle miles traveled was approximately 77,524,971 VMT. Gasoline-fueled vehicles were associated with 69,253,056 VMT and emitted 27,924 MTCO2e (70.1% of the Town's total transportation emissions), while Diesel-fueled vehicles were associated with 8,271,914 VMT and emitted 11,914 MTCO2e (29.9% of the Town's total transportation emissions) (Figure 19).[4]

Figure 19. Contributions to Total Transportation Emissions by Fuel Type (2022)



Transportation emissions are associated with on-road passenger and freight motor vehicle travel through and within Durham. Since it is not yet possible to exclude pass-through traffic in the transportation category's emissions calculations, the resulting value is likely an overestimation. Finally, as in the 2019 and 2021 inventories, emissions from rail were determined to be insignificant (less than 1 MTCO2e annually) due to the infrequency of rail and track distance within Durham's boundary.

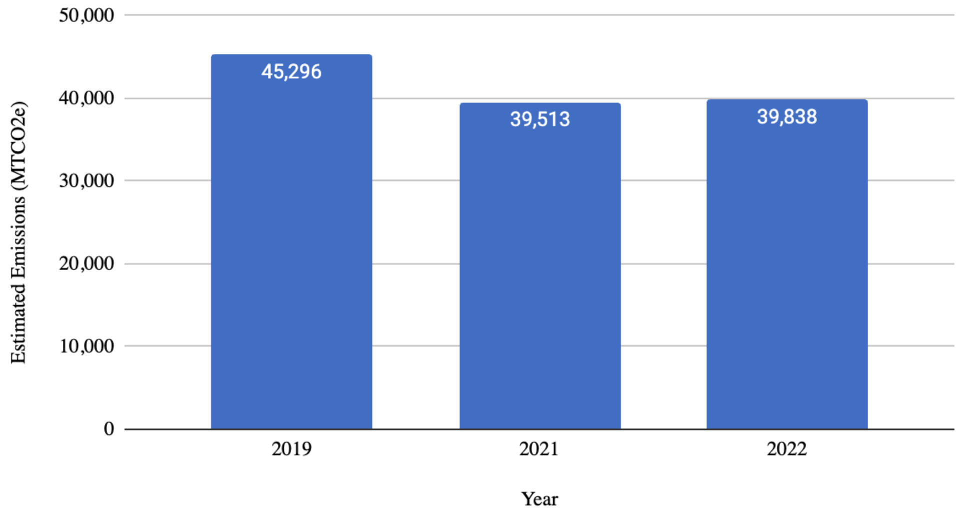
Comparisons to Previous GHG Inventories

In 2022, an estimated 77,524,971 VMT were estimated by the SRPC, emitting approximately 39,838 MTCO2e compared to 39,513 MTCO2e in 2021 and 45,296 MTCO2e in 2019. This difference in estimated emissions can be attributed to the effect of the COVID-19 lockdown on the number of vehicle miles traveled within Durham. For instance, since UNH's Main Campus was closed in the spring and summer of 2021, students and faculty were not commuting to and from campus during the first seven months of the year. Additionally, according to the SRPC, local buses were running less frequently, and more Durham residents were working remotely due to

[4] For more information on the method used to estimate Durham's on-road transportation emissions, refer to the "Transportation & Mobile Sources" section of the Handbook in the "GHGI Instructions" folder.

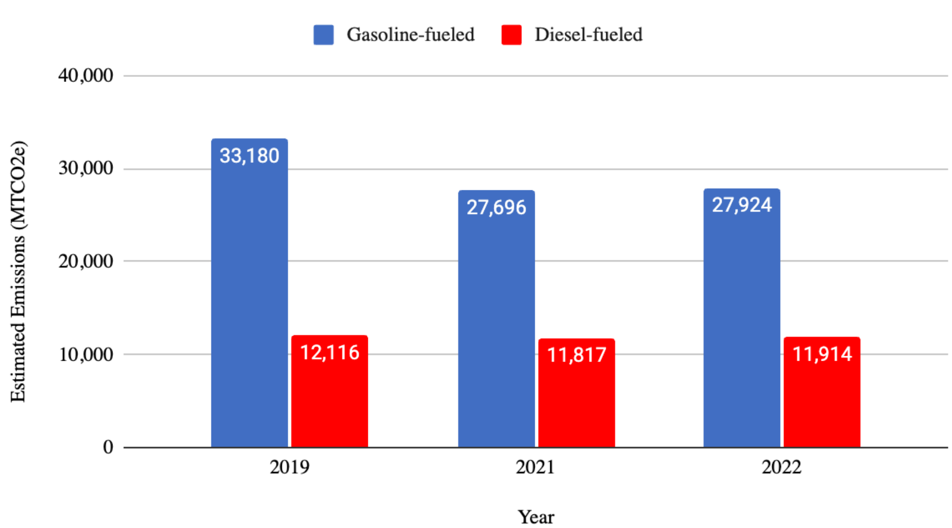
their employers' pandemic response. As a result, 10,777,054 fewer vehicle miles were traveled in 2021 than in 2019 (a 12.3% decrease), resulting in lower annual transportation emissions. However, it is worth noting that estimated VMT only increased by 0.8% between 2021 and 2022 (from 76,890,528 VMT to 77,524,971 VMT), suggesting that many workers may have continued working from home after the pandemic, resulting in fewer VMT and lower annual emissions than in pre-pandemic years (Figure 20).

Figure 20. Total On-Road Transportation Emissions by Year (2019-2022)



Yearly transportation emissions can also be further divided by fuel type (Figure 21). Between 2019 and 2022, estimated emissions from gasoline-fueled vehicles decreased by 15.8% (from 33,180 MTCO2e in 2019 to 27,924 MTCO2e in 2022). Emissions from diesel-fueled vehicles also decreased over the same period, but by a much smaller margin (12,116 MTCO2e in 2019 to 11,914 MTCO2e in 2022, which represents a 1.7% decrease).

Figure 21. Yearly Transportation Emissions by Fuel Type (2019-2022)



Solid Waste

The "Solid Waste" category includes emissions from solid waste produced by UNH as well as the broader Durham community. There are three sources of emissions in this category: municipal solid waste (MSW) from the Durham community (excluding UNH and ORCSD), construction and demolition waste, and solid waste from UNH. All of the waste is produced in Durham but is disposed of outside of the Town's jurisdiction.

The "Solid Waste" category was responsible for 1,225 MTCO2e in 2022, or 1.3% of Durham's community-wide emissions. Less than 1 MTCO2e was derived from the town's construction and demolition waste disposal, while 1,054 MTCO2e was from the disposal of community mixed solid waste (MSW). Finally 170 MTCO2e of waste was generated by UNH. As shown in Table 9, approximately 86% of the Town's 2022 solid waste emissions were attributed to the broader Durham community (excluding UNH and ORCSD), and 13.9% were attributed to UNH.[5]

Table 9. Solid Waste Emissions by Sector (2022)

Sector	Emissions (MTCO2e)	% of Solid Waste Emissions
Solid Waste Disposal - Durham Community (excluding UNH and ORCSD)	1054	86%
Construction & Demolition Waste Disposal - Durham Community (excluding UNH and ORCSD)	1	0.08%
Solid Waste Disposal - UNH only	170	13.9%
Total	**1,225**	-

Wastewater

The "Wastewater" category includes the process and fugitive emissions from the treatment of wastewater produced in the Town. There are three sources of emissions in this category: the process and fugitive emissions from Durham's Wastewater Treatment Plant (WWTP), which collects wastewater from town sewers, and emissions from residential septic tanks.

In 2022, the Wastewater category was Durham's smallest source of community emissions, emitting 367 MTCO2e, or 0.4% of its total annual emissions. As shown in Table 10, 86.4% of wastewater emissions came from septic tanks and 13.6% came from the WWTP, which serves both UNH and the greater Durham community.

[5] For more information on the methodologies used to estimate Durham's solid waste emissions, refer to the "Solid Waste" section of the Handbook in the "GHGI Instructions" folder.

Table 10. Wastewater Emissions by Sector (2022)

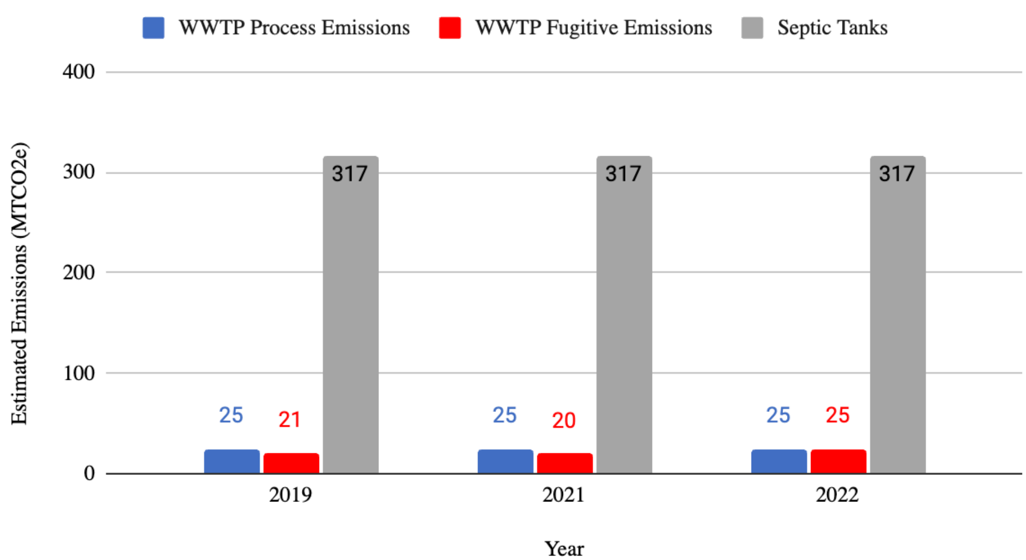
Sector	Emissions (MTCO2e)	% of Wastewater Emissions
Septic Tanks	317	86.4%
WWTP (process emissions)	25	6.8%
WWTP (fugitive emissions)	25	6.8%
Total	**367**	-

Durham's Wastewater Treatment Plant (WWTP) performs nitrogen removal during the wastewater process, which keeps annual emissions from Durham's sewers at relatively low levels (only 0.05% of the community's total emissions). As a result, most of the emissions from this category came from fugitive methane released from the use of septic tanks (0.3% of the community's total emissions).

Comparisons to Previous GHG Inventories

Wastewater emissions were relatively constant between 2019 and 2022, emitting 367 MTCO2e in 2022, 362 MTCO2e in 2021, and 363 MTCO2e in 2019 (Figure 22).

Figure 22. Yearly Wastewater Emissions by Source



Process and fugitive emissions from the WWTP were estimated using ICLEI Protocol methodologies and measured usage data from Durham's Wastewater Superintendent. However, estimated emissions from Durham's septic tank emissions were constant in the updated 2019, 2021, and 2022 inventories due to a lack of available data. To estimate emissions from septic tanks, the population of individuals using septic systems is needed. Unfortunately, after reaching out to the Town Planner, Town Assessor, Wastewater Superintendent, and Director of Public Works, a definitive population value of Durham residents using septic tanks could not be identified. Instead, the Town's Business Manager, Gail Jablonski, used the number of households receiving sewer bills to estimate the number of Durham residents using septic tanks.[6] Since the number of individuals using septic was unlikely to change significantly between 2019 and 2022, ICLEI staff suggested using the same estimated population value for all three inventories, resulting in equivalent emissions estimates. If future fellows are able to verify the number of Durham residents using septic tanks, emissions estimates in the 2022, 2021, and 2019 Wastewater category should be updated to reflect the correct population value.

Agriculture/Livestock

Emissions from the "Agriculture/Livestock" (AFOLU) category are from fertilizer and livestock in Durham. However, emissions for this category outside of the UNH campus were considered negligible and not included in the 2022 inventory, which is consistent with the 2019 and 2021 inventories. Thus, all AFOLU values are attributed to livestock and fertilizer emissions at UNH and recorded annually in SIMAP, UNH's carbon and nitrogen-accounting platform.

In 2022, the AFOLU category was responsible for 1,777 MTCO2e, which accounted for 1.8% of community-wide emissions. The majority of AFOLU emissions (approximately 96%) were attributed to UNH livestock, with the remaining 4% attributed to fertilizer use on campus.

Emissions can be further divided into categories by source. Livestock emissions sources include horses, organic dairy cows, and dairy cows, and agricultural emissions sources include synthetic and organic fertilizer use. Table 11 shows the breakdown of AFOLU emissions by source in 2022.

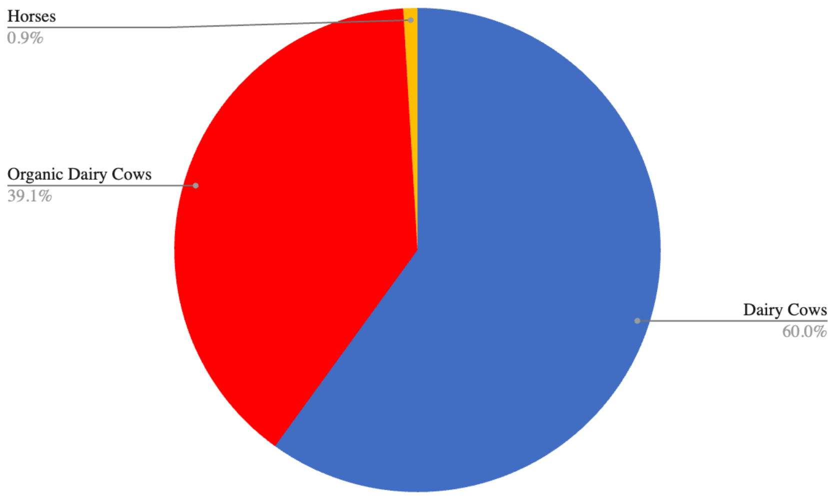
Table 11. Agriculture/Livestock Emissions by Source (2022)

Source	**Emissions (MTCO2e)**	**% of AFOLU Emissions**
UNH Dairy Cows	1,023	57.6%
UNH Organic Dairy Cows	667	37.5%
UNH Organic Fertilizer	70	3.9%
UNH Horses	16	0.9%
UNH Synthetic Fertilizer	1	0.1%
Total	**1,777**	-

In particular, UNH's dairy cows category (i.e., dairy cows and organic dairy cows) accounted for the majority (95%) of AFOLU emissions in 2022 (Figure 23).

[6] For more information on the method used to estimate Durham's septic tank emissions, refer to the "Water & Wastewater" section of the Handbook in the "GHGI Instructions" folder.

Figure 23. Livestock Emissions by Source (2022)



Comparisons to Previous GHG Inventories

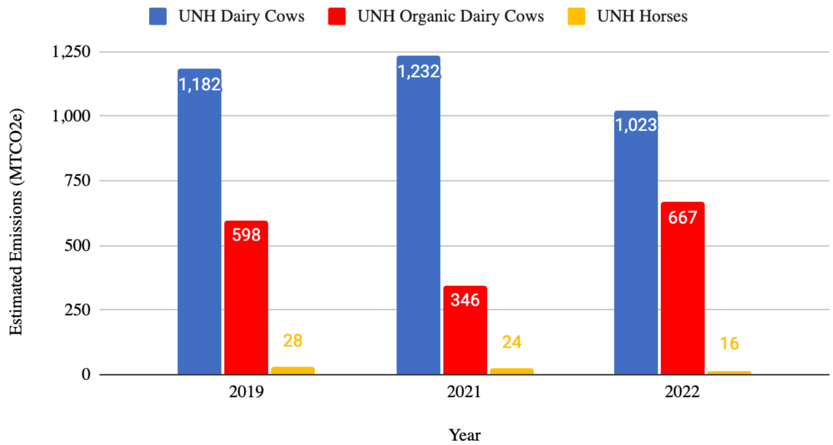
In 2022, the AFOLU category was responsible for 1,777 MTCO2e compared to 1,876 MTCO2e in 2019, representing a 5.3% decrease. UNH synthetic fertilizer use and horses exhibited the largest emissions reductions between 2019 and 2022, while UNH organic fertilizer use and dairy cows exhibited increased emissions estimates (Table 12).

Table 12. Percent Change in Yearly AFOLU Emissions by Source (2019-2022)

Source	% Change in AFOLU Emissions (2019-2022)
UNH Dairy Cows	-13.5%
UNH Organic Dairy Cows	+11.5%
UNH Horses	-42.9%
UNH Organic Fertilizer	+40%
UNH Synthetic Fertilizer	-94.4%

UNH livestock emissions fluctuated over time, with emissions from UNH dairy cows slightly increasing (by 4.2%) between 2019 and 2021 before exhibiting a 17% emissions reduction between 2021 and 2022. Additionally, UNH organic dairy cow emissions varied greatly from year to year, first decreasing by 42.1% between 2019 and 2021 before increasing by approximately 92.8% between 2021 and 2022 (Figure 24).

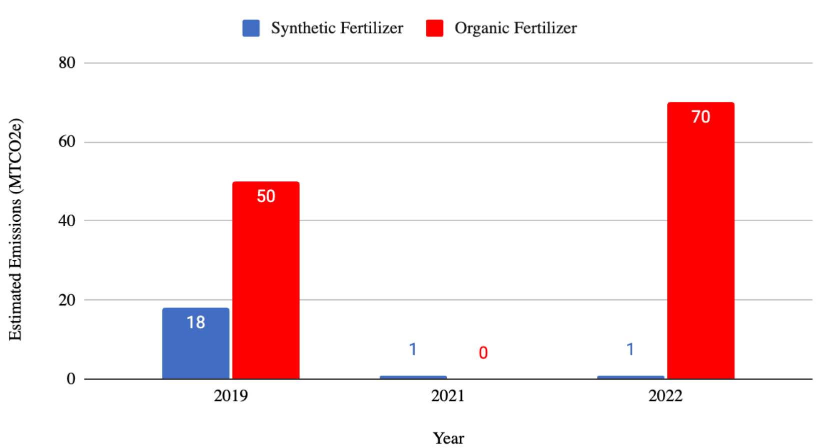
Figure 24. Yearly Livestock Emissions by Source (2019-2022)



Campus fertilizer use also fluctuated between 2019 and 2022. According to SIMAP, there was only 1 pound of organic fertilizer used in 2021, which would produce negligible emissions. This was an anomaly from 2019, when 17,921 pounds N of organic fertilizer was used, emitting approximately 50 MTCO2e. However, in 2022, this value rose to 25,083 pounds N, emitting approximately 70 MTCO2e and representing a 40% increase in organic fertilizer emissions between 2019 and 2022. Therefore, it can be assumed that the reduction in organic fertilizer use in 2021 may have been an anomaly, due perhaps to the pandemic closure of UNH's Main Campus from January 2021 through July 2021.

Synthetic fertilizer use and associated emissions also fluctuated between 2019 and 2022. According to SIMAP, 6,941 pounds N of synthetic fertilizer were used on campus in 2019, compared to 440 pound N in 2021 and 490 pound N in 2022. Consequently, emissions from synthetic fertilizer decreased from approximately 18 MTCO2e in 2019 to approximately 1 MTCO2e in 2021 and 2022 (Figure 25). This suggests a more permanent change in campus landscaping practices, as the amount of synthetic fertilizer did not return to pre-pandemic levels in 2022 as it did with organic fertilizer.

Figure 25. Yearly Agriculture Emissions by Source (2019-2022)



Sequestration Potential

The Potential Sequestration category includes emissions reductions from activities and land-use within the Town, including composting, land use sequestration, and purchasing of Renewable Energy Certificates (RECs). However, the Protocol does not allow these reductions to be directly subtracted from Durham's total emissions, and since land use and compost activities did not change significantly between 2019-2022, they were not included in the 2022 inventory update. However, according to former UNH fellow Cathy Fletcher (2021), Durham sequesters approximately 25,470 MTCO2e, which could be subtracted from the Town's 97,019 MTCO2e total in 2022 (or from the 2019 and 2021 totals, which were 104,472 MTCO2e and 83,622 MTCO2e, respectively). For more information on land use in Durham and its sequestration potential, see Cathy Fletcher's 2021 "Land Use Greenhouse Gas Inventory" report.[7] If land use and composting activities change significantly between 2022 and the next GHG inventory, Durham's sequestration potential will need to be recalculated using the same methodology as Cathy Fletcher's 2021 report to enable comparison.

Discussion

A Note on Updated Methodologies for Estimating Local Emissions

The impact of new methodologies and calculators on usage and emission estimates is worth highlighting. This was especially evident in the stationary energy and solid waste categories, as the latest methods and calculators used to estimate usage and emissions data resulted in vastly different values compared to the original 2019 inventory. These new methodologies were recommended by the ICLEI team, which is in the process of updating its 2019 Community Protocol. Although the updated protocol hasn't been published, I retrieved an advanced copy of the updated recommendations for stationary energy and transportation calculations and used them in the 2021 and 2022 inventories as well as the 2019 inventory update. I also calculated all emissions within ClearPath using its new calculators for carbon accounting. Though ClearPath's updated 2019 usage and emissions estimates were comparable to the original 2019 inventory estimates in many categories, the differences in solid waste estimates were stark. Therefore, future inventories should examine the pros and cons of updating methodologies and adopting new carbon accounting calculators to facilitate analysis across multiple inventory updates.[8]

A Note on the ORCSD-D

Finally, 2021 and 2022 emissions for the ORCSD-D sector could not be calculated since it has yet to track its emissions since its 2019 inventory. However, if the Town wanted to include ORCSD-D in its 2021 and 2022 inventories, it could add ~1,000 MTCO2e to its community totals, since this is the approximate value attributed to ORCSD-D emissions (from stationary fuels, purchased electricity, and solid waste) in the original 2019 inventory performed by Emily Mello, accounting for less than 1% of the total community-wide emissions. If the ORCSD-D does not have the internal capacity to update its GHG emissions, it could collaborate with the UNH Sustainability

[7] Cathy Fletcher. Exploring Land Use as an Aspect of Community Climate Action: Land Use Greenhouse Gas Inventory. UNH Sustainability Institute, Town of Durham, 2021.

[8] For a detailed overview of each category and sector and their 2022, 2021, and updated 2019 emissions, please refer to the "GHG Data" folder in the Durham Drive.

Institute through the Carbon Clinic. The Carbon Clinic is a UNH program that trains students to complete a carbon footprint analysis for a leading regional business, nonprofit, or community. As a participating organization, the ORCSD-D would be assigned a team of students to complete the inventory on its behalf. Once the Carbon Clinic team calculates ORCSD-D's 2022 emissions, the results can be added to this report, and all tables and figures can be updated accordingly.

Recommendations

Recommendation #1: Form an Internal Sustainability Task Force

I recommend that Durham establish an internal Climate Task Force composed of town staff responsible for executing actions outlined in the climate action plan (CAP). This task force will serve as a dedicated team, ensuring that Durham's CAP initiatives are systematically and effectively implemented. By meeting quarterly or biannually, the task force can provide regular updates on their progress, maintain accountability, and ensure that each action item receives the attention it requires.

The meetings will also create an opportunity for task force members to request assistance, share resources, and collectively troubleshoot issues. This collaborative approach will facilitate the exchange of ideas and best practices, helping to overcome any obstacles lead actors encounter during CAP implementation. By fostering a supportive environment, the task force can address challenges more effectively.

Furthermore, the Climate Task Force will play a crucial role in maintaining momentum as Durham works to implement its CAP. Regularly scheduled meetings and progress reviews will keep sustainability efforts at the forefront of Durham's agenda, preventing initiatives from stagnating. This ongoing commitment will demonstrate Durham's dedication to climate action, enhancing the likelihood of successful implementation and long-term sustainability. Thus, establishing the task force will be a strategic move to help Durham meet its climate action goals.

Recommendation #2: Create a Community Climate Ambassadors Program

I recommend that Durham create a Climate Ambassadors Program to harness the enthusiasm and dedication of residents passionate about the environment. This program will recruit community members to actively support the implementation of Durham's updated CAP. By involving residents directly, Durham can take on more ambitious climate initiatives, as it can delegate a portion of the workload to these committed volunteers. This approach not only expands the Town's capacity for climate action but also fosters a sense of shared ownership and participation in the fight against climate change.

Public education tasks, in particular, are well-suited for delegation to Climate Ambassadors. These individuals can share educational materials with their neighbors and other residents within their networks, increasing awareness and understanding of climate issues and Durham's initiatives. By leveraging the social reach and influence of these ambassadors, Durham can effectively disseminate information and encourage sustainable practices across town. This grassroots approach to public education is likely to be more impactful, as residents often respond positively to information shared by their peers.

Moreover, the Climate Ambassadors Program will serve as a vital feedback mechanism. Ambassadors can gather and relay community feedback, providing valuable insights into the public's perception and acceptance of various initiatives. This two-way communication channel ensures that Durham's climate strategies are responsive to residents' needs and concerns, fostering greater public support and engagement.

The Climate Ambassadors could meet monthly in meetings hosted by the UNH Sustainability Fellow. They could include full-time residents or focus on UNH students (through collaborations with existing UNH clubs or programs). The Fellow could then work with the Energy Committee and other Durham committees to identify public education or outreach tasks that could assist the committees in completing their assigned CAP initiatives. For instance, the ambassadors could collect responses for the Energy Committee's EV Survey or disseminate information about weatherization programs or energy efficiency rebates (either at busy public spaces or at community events).

Moreover, ambassadors could be divided into teams to create more targeted volunteer opportunities. For example, a few ambassadors could be trained to conduct basic energy audits and can help residents and businesses identify ways to reduce energy consumption. That is, the volunteer energy audit team would conduct the audits around town and provide simple, actionable recommendations (as suggested by the Energy Committee). Alternatively, there could be a team that holds community tree planting events or plants and maintains local rain gardens to reduce flooding. Finally, if Durham decided to pilot its own composting program, ambassadors could host composting workshops and assist with community education and collection. These are just some examples of ambassador volunteer opportunities that Durham could outsource, generating enthusiasm within the community while also expanding the Town's capacity to pursue and achieve more ambitious climate goals. It would also provide the UNH Sustainability Fellow with valuable experience in volunteer management and community engagement. In summary, the Climate Ambassadors Program would enhance Durham's ability to execute its CAP, promote environmental education, and create a collaborative, community-driven approach to climate action.

Recommendation #3: Leverage Free Technical Support

I recommend that Durham capitalize on the free technical support provided by member organizations to advance its solar, electric vehicle (EV), and electrification projects. For example, as an ICLEI member, Durham is eligible for 10 hours of free technical support. Furthermore, if it applies for one-time designation with SolSmart or Charging Smart, Durham would be entitled to up to 20 hours of complementary technical assistance for solar and electric vehicle projects. For instance, SolSmart can create solar feasibility studies, identify funding opportunities, and draft or review grant proposals. Utilizing SolSmart's services will streamline Durham's solar projects and enhance their potential for securing essential funding. Similarly, Charging Smart provides critical support for local leaders looking to expand EV ownership and charging infrastructure. Their assistance can help Durham develop and implement a comprehensive EV strategy. Finally, Rewiring America offers extensive resources and guidance for promoting electrification, energy efficiency, and clean energy. Leveraging these free services will enable Durham to effectively plan and execute more sustainability projects.

There are also state-specific technical support organizations that Durham can leverage. For example, Durham is a member of Clean Energy NH. As a member, Durham can receive clean energy and energy efficiency education along with technical assistance in "conceiving, designing, and carrying out new clean energy projects."[9] They also can help member communities secure grant and funding opportunities for clean energy proposals. Finally, their Energy Circuit Riders program helps "municipalities and small businesses plan, finance, and implement energy-saving upgrades to buildings and infrastructure, as well as clean energy technologies such as renewable energy or electric vehicle charging infrastructure."[10] Finally, the Strafford Regional Planning Commission offers technical support at no-to-low cost. Their services include custom mapping and analysis, traffic counts, bicycle and pedestrian counts, and grant writing support, to name a few.[11]

Outsourcing tasks to these specialized organizations will not only advance Durham's climate goals but also build internal capacity. Given the absence of a full-time sustainability expert, the guidance and support from these technical experts would provide critical expertise and resources that Durham might otherwise lack. This strategic delegation allows Durham to maximize its climate action efforts, making significant progress without the need for extensive in-house resources.

Recommendation #4: Establish a Climate Coalition of "Green" NH Towns

I recommend that Durham establish a coalition of environmentally conscious communities within New Hampshire. This coalition would convene biannually, providing a platform for member towns to share updates on their climate action initiatives. By engaging in regular knowledge exchange, each community can benefit from the experiences of others, learning from both successful strategies and common challenges. This collaborative environment will foster continuous improvement and innovation in Durham's climate efforts, ensuring that new climate initiatives are informed by a broader collective wisdom.

Furthermore, the coalition would facilitate collaboration on larger-scale projects, allowing communities to pool their resources and expertise. For instance, towns with similar climate goals, such as expanding residential solar projects or electric vehicle infrastructure, could join forces to achieve greater efficiency and impact. Collaborative projects not only distribute the costs and efforts but also enhance the competitiveness of grant applications. By presenting

[9] "Energy Circuit Riders." *Clean Energy NH*, www.cleanenergynh.org/energy-circuit-riders. Accessed 10 December 2023.

[10] Ibid.

[11] "Municipal Assistance." *Strafford Regional Planning Commission*, www.strafford.org/plan/municipal-assistance/. Accessed 10 December 2023.

united and comprehensive proposals, the climate coalition increases the likelihood of securing state and federal funding. Thus, strategic partnerships with other “green” towns will amplify Durham’s capacity for impactful climate action, driving substantial progress towards CAP implementation.

Recommendation #5: Develop a “Proposal Bank” of Climate Projects

Finally, I recommend that Durham develop a "wish list" or "proposal bank" of short project proposals focused on its CAP initiatives. By having a repository of well-thought-out proposals, Durham can quickly and efficiently submit grant applications, significantly reducing the time and effort required compared to starting from scratch. These draft proposals will also make it less likely that Durham will miss a grant application deadline, thus increasing the likelihood of securing funding for more expensive climate action projects. For example, developing a short proposal for the solar canopy project at the Amtrak station (using the preliminary evaluation supplied by ReVision Energy) could serve as the first proposal in the "proposal bank." Consequently, when EV charging and/or solar installation funding becomes available, Durham will already have a draft proposal prepared and will not need to devote much time to completing the application, drawing instead on its draft proposal. Durham can also draw on the technical support organizations mentioned in Recommendation #3 (e.g, ICLEI, SolSmart, Charging Smart, Rewiring America, or Clean Energy NH) to assist with writing grant applications or reviewing completed applications.

Moreover, maintaining a project "wish list" compels Durham to stay vigilant and continually search for new and relevant funding opportunities. For instance, the Energy Committee could task the UNH Sustainability Fellow with regularly reviewing open state, federal, and private grant applications for solar energy, energy efficiency, or electric vehicle funding, allowing the committee to take advantage of emerging funding opportunities. Thus, this systematic approach to fundraising positions Durham to swiftly capitalize on climate grants, likely resulting in increased capital to implement its CAP initiatives.