Town of Kent: Community Greenhouse Gas Assessment, 2019

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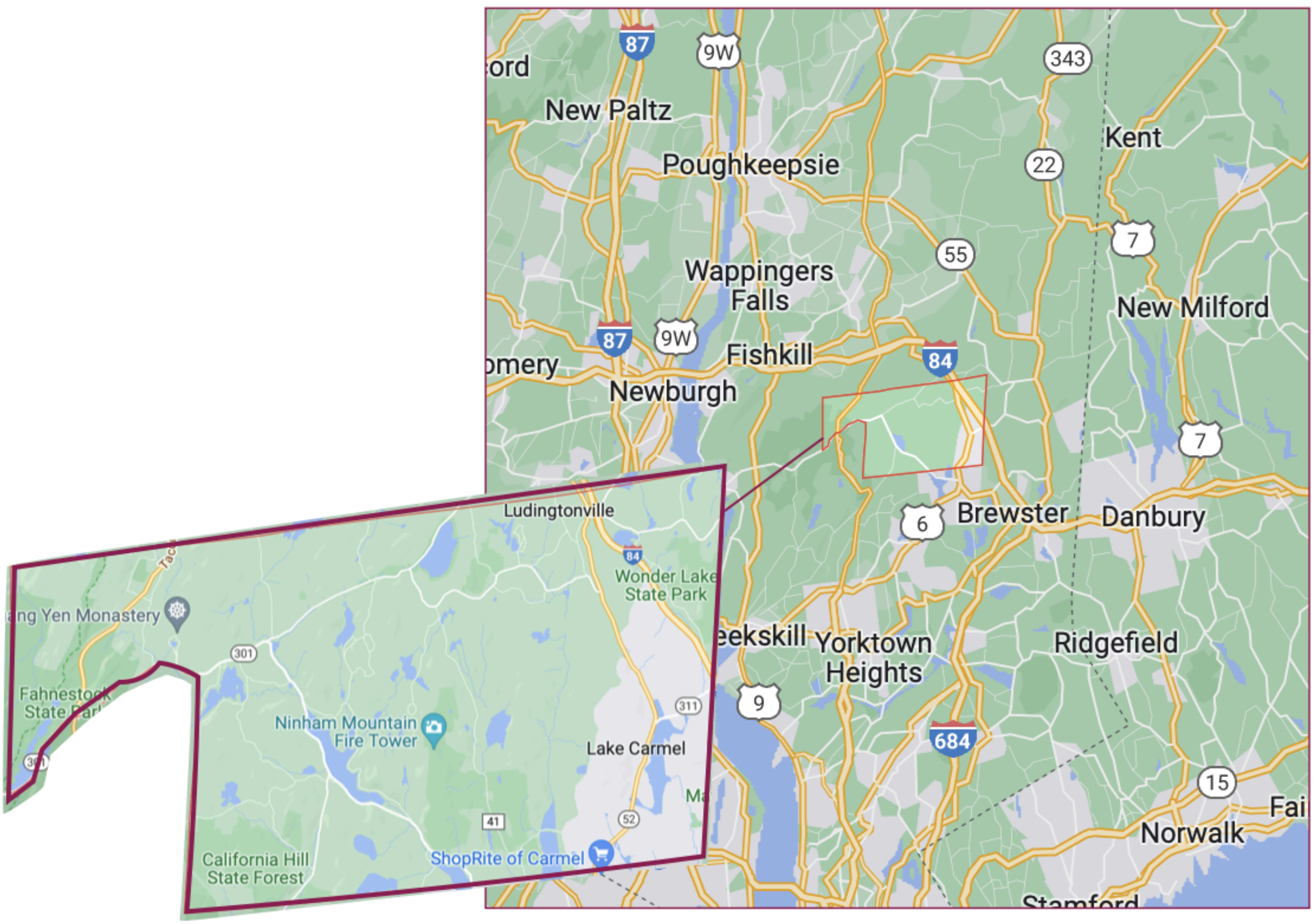

Figure 1. Map of the Town of Kent.

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Executive Summary

Greenhouse Gas (GHG) emissions and their global warming effects are having dramatic and far-reaching consequences for both humans and the environment. Emissions resulting from human activity are widely recognised as the main catalyst to global warming.

Creating a Greenhouse Gas inventory is an important step in understanding effective action towards reducing climate impacts from human activity. Accounting for energy use and greenhouse gas emissions through a GHG inventory can help a community understand their local impact on the environment. An inventory can also help a community identify cost-effective efficiency opportunities, both large and small.

This report represents the Town of Kent's community greenhouse gas emissions for 2019, and it fulfills a preliminary step in becoming a certified climate smart community (CSC) for the state of New York. The CSC program operates in alignment with New York State's Climate Act[1], which aims to reduce economy-wide greenhouse gas emissions 40 percent by 2030 and to cut emissions by 85 percent compared to 1990 levels by 2050. The CSC program provides planning support and project funding for enrolled CSC[2] communities. This certification, therefore, is a gateway to potential funding to help Kent become a more efficient and sustainable town.

This greenhouse gas inventory represents emissions from community uses within the boundary of Kent. An accompanying document reports emissions from local government operations. In both cases, reporting follows standard practices in focusing on emissions from within the boundaries of the town. Many of these emissions are within the purview of the community to address–for example, through electricity sourcing or building efficiency standards. Others are more difficult to address locally, for example, transportation on highway corridors and the local share of national industrial process and product use emissions. These are reported for consistency with other community and local government reporting practices.

Kent's emissions were dominated by transportation (72%), followed by waste management (13%), residential & commercial buildings (9%), and finally process and product use (7%). Transportation contributing to the largest share of emissions is consistent with other, similar, New York communities.

In addressing these emissions, the town has clear advantages that could be built on. As a starting point, Kent has shown a strong community capacity for innovation, planning, and funding acquisition, and these are an essential foundation for progress. In terms of transportation, electric

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2 Climate Smart Communities (CSC) is a New York State program that helps local governments take action to reduce greenhouse gas emissions and adapt to a changing climate. The program offers free technical assistance, grants, and rebates for electric vehicles. https://climatesmart.ny.gov/

cars are increasingly accessible and save both money and emissions over their lifetime, and the town has nearby train lines for energy-efficient commuting. Waste management is challenging, but Kent has long experience in its recycling and re-use program, which could be expanded to incorporate, for example, food scraps. Residential and commercial building heating rely on a combination of electric heating (easy to convert to all-renewable) and inefficient fuel sources such as fuel oil, propane, and wood, for which heat pump replacements have dramatic cost advantages.

Energy sources and prices are a topic of growing concern, and a first step in reducing both economic and environmental impacts is to inventory the largest consumption sectors and attached emissions. This inventory can help the process of identifying cost-effective efficiency upgrades. In considering efficiency measures, it's worth noting that both large and small steps are useful. While large steps can have large impacts, smaller steps provide important learning opportunities, as a community develops methods of accounting for savings, finding contractors, and other processes. Interventions at all scales, from large to small, from policy to technology, can be worth exploring.

This work was carried out in accordance with CSC and ICLEI[3] guidance. Funding was provided by a NYSERDA grant and leadership from members of the Town of Kent town board. Funding was also provided by the Vassar College Undergraduate Research Science Institute.[4]

[3] ICLEI-Local Governments for Sustainability is a global network of local and regional governments committed to sustainable urban development. ICLEI provides protocols, frameworks, and guidance for producing greenhouse gas inventories at a community level as well as at a local government level. https://iclei.org
[4]Vassar College Undergraduate Research Science Institute (URSI). https://www.vassar.edu/ursi/projects

Introduction

This report begins by laying out the groundwork for why such an inventory is needed and explaining crucial terminology in the report. Explanation of both scopes, boundaries and assumptions are discussed briefly. For those interested in, however, a much more detailed dive into the estimation process, including uncertainties in the data, decisions in methods, and the limitations of this report, see the Appendix at the end of the report.

The community inventory has four sections, representing standard designations of energy use sectors: built environment (residential,commercial, and process and product use), transportation, and waste. Calculating emissions values for these sections relied on publicly available data from sources such as NYSEG, the US Census, and Putnam County. The formulas used for calculating emissions from each sector followed the NYSERDA CSC document *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance*[5] published in 2015.

Kent's total community emissions, from all sectors analyzed, was **97,256 $MTCO_2e$**. This is approximately 20.5 $MTCO_2e$ per household. Of these emissions, 72% of emissions accounted for can be attributed to transportation (Table 1). Waste management is the second largest sector, followed by process and product use emissions (a community's share of national emissions from a variety of industrial processes, which involve emissions from a stack or leaked fugitive gas releases).

These emissions can also be evaluated in terms of direct combustion within Kent (scope 1), indirect emissions generated outside of Kent, but consumed within Kent (scope 2, using electricity from a power plant in a different town), and other indirect, upstream, or lifecycle emissions which occur outside the boundaries of Kent, but can be attributed to the community (scope 3). Among these, scope 1 is largest, primarily reflecting fuel consumption in transportation.

In addition to supporting CSC certification, this inventory can be used to guide planning in Kent, particularly in regards to climate action. Local climate action plans are an essential component of New York State's plans to reduce overall emissions. The New York Climate Leadership and Community Protection Act (CLCPA) of 2019 has outlined state-wide goals for renewable energy and conservation, much of it relying on local leadership and local decision-making. The economic and environmental benefits of planning for energy efficiency and climate protection

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[5] *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance,* 2015. https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf

coincide. Thus, the hope is that these findings can be used as a basis for Kent to generate a climate action plan (CAP) which is the next critical step to become a CSC community.

Table 1: *Summary of community emissions by sector and scope, 2019.*

Sector	Scope 1 ($MTCO_2e$)	Scope 2 ($MTCO_2e$)	Scope 3 ($MTCO_2e$)	Total ($MTCO_2e$)
Residential	633	6,528	-	7,161
Commercial	588	1,249	-	1,837
Process and product use	7,017	-	-	7,017
Transportation	68,459	-	-	68,459
Waste	2,897	-	9,886	12,783
Total	72,577	7,777	16,903	97,257
Per Household	15.3	1.6	3.6	20.5

Climate Smart Communities

The Climate Smart Communities Program incentivises local governments to increase energy efficiency while reducing GHG emissions, in order to adapt to the current climate landscape. The CSC program, launched by New York State in 2009, encourages municipalities to adopt a pledge that they will commit to climate actions, as a framework for guiding and implementing climate initiatives. The required ten elements of the Climate Smart Communities Pledge are:

1. Build a climate-smart community.
2. Inventory emissions, set goals, and plan for climate action.
3. Decrease energy use.
4. Shift to clean, renewable energy.
5. Use climate-smart materials management.
6. Implement climate-smart land use.
7. Enhance community resilience to climate change.
8. Support a green innovation economy.
9. Inform and inspire the public.
10. Engage in an evolving process of climate action.

Climate Change and Greenhouse Gasses

Greenhouse Gasses are gas molecules that have absorbed infrared radiation emitted from the Earth's surface and then reflected heat back, contributing to global warming. Carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons (CFCs) are all important GHG gasses that contribute to global warming and climate change.

Greenhouse Gas Inventory Framework

To generate a greenhouse gas inventory, we used existing frameworks on what to include and how to break down sources of emissions. As noted in the executive summary, this report was calculated utilizing the framework and guidelines of the NYSERDA CSC document *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance*[6] published in 2015 and the ICLEI *US Community Protocol*[7] published in 2010.

Definitions

Scope 1 Emissions: direct emissions from combustion within the geospatial boundaries of the town, including stationary fuel combustion, vehicle fleet emissions and processes and fugitive emissions.

Biogenic Emissions: CO2 emissions produced from combusting a variety of biofuels and biomass, such as biodiesel, ethanol, wood, wood waste and landfill gas.

Scope 2 Emissions: indirect emissions at electricity power plants based on the amount of electricity consumed within the boundary, regardless of where the power plants are located.[8]

Scope 3 Emissions: other indirect emissions not included in scope 2 such as emissions from solid waste processes or commuting outside the boundaries of the community.

Sector: organizational subdivision of the community: residential energy, commercial energy, industrial energy, process and fugitive, transportation, and waste.

Built Environment Emissions: combined residential, commercial, industrial emission sectors.

Source: fuel or energy source of emissions, for example electricity or fuel oil.

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[6] *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance,* 2015. https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf

[7] ICLEI *US Community Protocol for Accounting and Reporting of Greenhouse Gas Emission*s, 2010. https://icleiusa.org/us-community-protocol/

[8] *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance,* 2015, pg. 5

Greenhouse gasses (GHGs): primarily CO_2 but also CH_4, N_2O, and a variety of other trace gasses that contribute to global warming.

Metric tons CO_2 equivalent (MTCO_2e): because different GHGs have a different strength of impact on climate warming (also called global warming potential), a comparison is easiest when relative impacts are converted to equivalent impacts of CO_2. Most GHG inventories report emissions in terms of CO_2 equivalent.

Greenhouse Gas Inventory

Built Environment

Built environment emissions are composed of residential, commercial, industrial, and process and product use emissions. For Kent, there are no large industries. As a result, the sum of industrial emissions is zero, therefore that section is excluded from this report. Below is a summary table detailing emission totals from each sector and fuel type within the category of built environment.

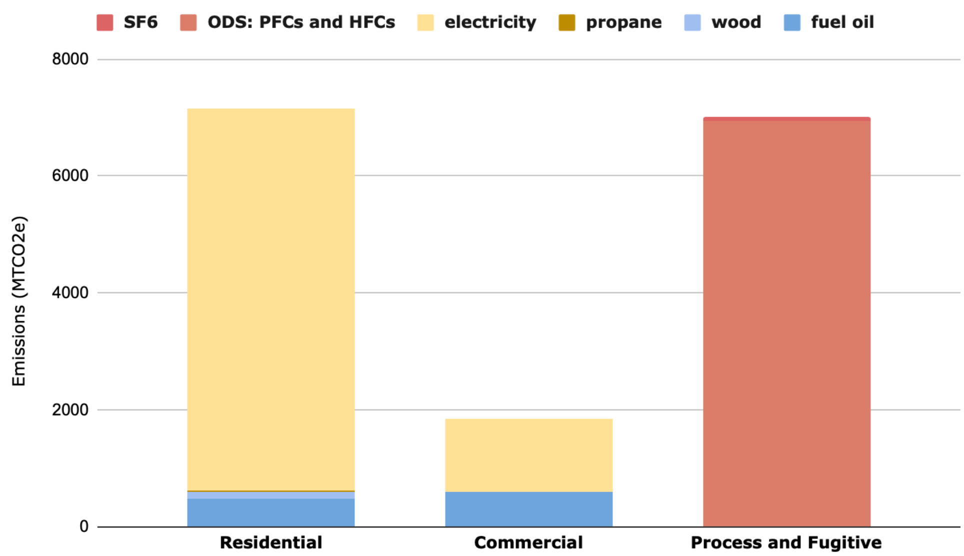

Figure 2 *Summary of Built Environment Emissions by Fuel Type/Source and Sector, 2019.*

1. Residential Energy

Residential energy refers to the direct (scope 1) emissions from fuels used in home-heating and the indirect (scope 2) emissions from electricity used both in home heating and everyday household usage. The heating fuels most commonly used in the town of Kent, according to the American Community Survey's (ACS, a US Census survey) data, include fuel oils (distillate fuel oil, hydrocarbon gas liquids (HGL), and kerosene), natural gas, wood, and propane.

From the ACS data,[9] it can be inferred that in 2019 most of the 4,850 occupied residences within the town of Kent used fuel oil (~64%) for heating, while approximately 24.9% used electricity, 4.1% used propane, 3.8% used wood, and 1.3% of homes used other unnamed heating fuels.

[9] United States Census Bureau Table DP04: Selected Housing Characteristics. https://data.census.gov/cedsci/table?q=dp04&g=0400000US36_0600000US3607939331&tid=ACSDP5Y2019.DP04

Methods

We calculated residential sector emissions using four different sources: the indirect source of electricity and the direct sources of fuel oils (particularly kerosene), propane, and wood.

For residential electricity consumption for the town of Kent, we used direct data found in NYSERDA's Utility Energy Registry (UER), which aggregates utility data for residential and commercial sectors. Specifically, we used the UER data for Kent's electricity supplier, New York State Electric and Gas Corporation (NYSEG)[10]. Adding up the "Residential Consumption" totals for the twelve months of the year, we found the summed 2019 residential consumption of electricity. We then used the US EPA's NPCC Upstate NY (NYUP) eGRID factors (MWh/metric tons) for 2019[11] to convert electricity consumption (in MWh) to emissions (in metric tons) of carbon dioxide, methane, and nitrous oxide. Finally, using the global warming potentials[12] (GWP) of methane and nitrous oxide we converted these emissions to the standard measurement of metric tons of carbon dioxide equivalents (MTCO2e).

Due to the way fuel sources are distributed, which can involve many private suppliers, we were unable to find direct data for the residential consumption of fuel oils (kerosene), wood, and propane. Instead, we approximated the consumption (in metric million British thermal units- MMBtu) of these fuels using a NYSERDA method[13] of downscaling statewide rates of consumption,[14] using Kent's mix of housing types[15] and fuel uses.[16] For more detailed instructions on this calculation method, see Appendix I.1.

After we estimated the residential fuel consumption, we converted consumption (MMBtu) to emissions (metric tons) of carbon dioxide, methane, and nitrous oxide by using ICLEI's

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[10] Residential consumption of electricity Kent's central energy supplier, NYSEG, was found using NYSERDA's Utility Energy Registry https://utilityregistry.org/app/#/datagrid. The UER site reports electricity and natural gas by utility, but for Kent, natural gas is not reported, presumably because it is not available in Kent.

[11] US EPA's NPCC Upstate NY (NYUP) eGRID factors for 2019 were found on the EPA's website: https://www.epa.gov/egrid/download-data .

[12] For GWP Potentials for methane and nitrous oxide, see the UN IPCC 2nd Assessment report's 20 year GWPs: https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials

[13] For step-by-step instructions on this modeling method for calculating residential fuel consumption, see pg 15-19 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

[14] Residential Energy Consumption numbers were found on US EIA Table C5: Residential Sector Energy Consumption Estimates for the year of 2019: https://www.epa.gov/egrid/download-data .

[15] We found the local and state number of different housing types by looking at the 2019 residential distribution of tax parcels on New York State's Office of Real Property Tax Services http://orps1.orpts.ny.gov/cfapps/MuniPro/ for 1) the town of Kent and 2) the state of New York. We then separated these residential tax parcels into three categories of "effective" housing units including single-family detached housing units (SFD), single-family attached housing units (SFA), and multi-family units (MF). We categorized property codes 210 (one family year-round residence), 240 (rural residence with acreage), 250 (estate), and 260 (seasonal residences) as SFDs, property codes 215 (one family year-round residences with accessory apartment), 280 (residential multi-purpose/multi-structure), and 281 (multiple residences) as SFAs and property codes 220 (two family year-round residence) and 230 (three family year-round residence) as MFs.

[16] Residential Fuel Preferences at a local and state level were found in the US Census Bureau's Table DP04: Selected Housing Characteristics Table: https://data.census.gov/cedsci/

conversion factors for each fuel (MMBtu/metric tons). For fuel oils, we used the kerosene conversion factor because kerosene is the most common type of fuel oil used in New York State. We then used the global warming potentials[17] (GWP) of methane and nitrous oxide to convert these emissions to the standard measurement of metric tons of carbon dioxide equivalents (MTCO2e).

Results

Table 2: *Summary of Residential emissions by fuel type and scope, 2019 (MMBtu=million British thermal units; MWh=megawatt-hours/million watt-hours)*

SECTOR	FUEL OR SOURCE	SCOPE	USAGE	EMISSIONS ($MTCO_2e$)
Residential	Electricity	2	61,551 MWh	6,528
	Fuel Oil	1	6,252 MMBtu	475
	Propane	1	433 MMBtu	27
	Wood	Biogenic	1,159 MMBtu	131
	Total			7,161

2. Commercial Energy

Commercial energy refers to the direct (scope 1) emissions of fuels used in the heating of commercial buildings and the indirect (scope 2) emissions of electricity used both in heating and common commercial usage. We report on the heating fuels that have available data and are commonly used in the state of New York. These include fuel oils (distillate fuel oil, HGL, kerosene, and motor gasoline) and natural gas.

From Kent tax parcel data, it can be estimated that there are 88 commercial buildings within the town of Kent. Factoring in the total commercial square footage of these spaces, we found the energy emissions of these commercial spaces.

[17] For GWP Potentials for methane and nitrous oxide, see the UN IPCC 2nd Assessment report's 20 year GWPs: https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials

Methods

We calculated commercial sector emissions using two different sources: the indirect source of electricity and the direct source of fuel oils (including distillate fuel oil, HGL, kerosene, motor gasoline and residual fuel oil).

Like for residential electricity consumption, for commercial electricity consumption, we used direct data found in NYSERDA's Utility Energy Registry (UER)[18]. Specifically, we added up the "Business Consumption" totals for the twelve months of the year to find the summed commercial consumption of electricity. We then used the methods detailed above for converting residential consumption into emissions to convert commercial electricity consumption (in MWh) into emissions (of $MTCO_2e$)

Because it is difficult to link commercial fuel consumption to sales data, we were unable to find direct data for the commercial consumption of fuels. Instead, we approximated fuel consumption using a NYSERDA method[19] of downscaling statewide rates of consumption[20] using Kent's total commercial square footage[21] and residential fuel preferences (found when calculating the residential fuel consumption in section 1. Residential Energy Emissions). For more detailed instructions on this calculation method, see Appendix I.2.

After finding the commercial consumption of fuel oil, we used the same methods of converting residential consumption of fuel (in MMBtu) to emissions (of $MTCO_2e$) outlined in the previous section to convert commercial consumption of fuel to emissions.

Results

Table 3: *Summary of Commercial emissions by fuel type and scope, 2019 (MMBtu=million British thermal units; MWh=megawatt-hours/million watt-hours)*

SECTOR	FUEL OR SOURCE	SCOPE	USAGE	EMISSIONS ($MTCO_2e$)
Commercial	Electricity	2	11,780 MWh	1,249
	Fuel Oils	1	7,732 MMBtu	588

[18] Commercial consumption of electricity Kent's central energy supplier, NYSEG, was found using NYSERDA's Utility Energy Registry https://utilityregistry.org/app/#/datagrid. The UER site reports electricity and natural gas by utility, but for Kent, natural gas is not reported, presumably because it is not available in Kent.
[19]For step-by-step instructions on this modeling method for calculating commercial fuel consumption, see pg 19-22 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.
[20] Commercial Energy Consumption numbers were found on US EIA Table C6: Commercial Sector Energy Consumption Estimates 2019: https://www.epa.gov/egrid/download-data .
[21] We found the commercial square footage for Kent by mapping out the commercial tax parcel data and adding up the square footage of these tax parcels.

	total			1,837

3. Industrial Energy

According to both the EPA's Greenhouse Gas Reporting Program[22] and the NYSDEC's Title V Air Permit Data Set,[23] there are no sites classified as industrial within Kent. As a result, we did not measure industrial emissions separately. Instead, we accounted for industrial energy (from the six buildings classified as light industries in Kent according to their tax parcel data) within our commercial energy emissions calculations above.

4. Process and Product Use

Industrial process and product use emissions refer to a community's share of national emissions from a variety of industrial processes (e.g production of iron, steel and cement, as well as different appliances like refrigerators, electronics and air conditioners) and from emissions resulting from the use of different products.[24] Despite Kent not having any significant industrial production, the community still produces emissions in this sector as consumers use household appliances that are producing emissions in their use and have produced emissions during their manufacture. Process emissions from the manufacturing of iron, steel, cement, and aluminum are not as relevant to Kent as product use emissions are.

Ozone Depleting Substances (ODS), such as hydrofluorocarbons (HFCs) and perfluorocarbons are commonly used as refrigerants in household fridges, air conditioners, and fire extinguishers. They are also used in commercial facilities such as ice rinks and supermarkets.

Sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons are also used by the utility industry for electric power transmission and distribution.

The EPA has historically regulated SF_6 and HFCs as ozone-depleting substances (ODS), however, they are also important greenhouse gasses because of their high global warming

[22]EPA Greenhouse Gas Reporting Program. https://www.epa.gov/ghgreporting
[23]NYSDEC's Title V Air Permit Data Set https://www.dec.ny.gov/dardata/boss/afs/issued_atv.html
[24] US GHG Emissions and Sinks: 1990-2020, chapter 4 https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf

potential (GWP), or ability to capture heat in the atmosphere. Many HFCs, for example, have GWPs thousands of times greater, per molecule, than CO_2.

Methods

Due to a lack of direct data on community level consumption of Ozone Depleting Substances (ODS), we estimated process and product use emissions by applying US average rates to Kent. We estimated the US ODS emissions rate for PFCs and HFCs (common refrigerants and fire retardants) by dividing the total ODS emissions in the U.S. National GHG inventory[25] by total US population and found the 2019 US emissions rate. We then multiplied Kent's total population with this average emissions rate to find the town's total ODS emissions in $MTCO_2e$.

We also estimated SF_6 emissions using a US average SF_6 rate (which assumed SF_6 emissions were proportional to the total electricity consumption rate) since communities do not manage these emissions. We calculated the US average by dividing total utility-related SF_6 emissions[26] in the U.S. National GHG Inventory by total retail electricity sales[27] to find the 2019 SF_6 emissions rate. We then multiplied this SF_6 rate by Kent's total electricity consumption[28] to find Kent's 2019 direct fugitive SF_6 emissions in $MTCO_2e$.

Results

Table 4: *Summary of Process and Fugitive Emissions divided by source and scope, 2019. (MT=metric tons)*

SECTOR	FUEL OR SOURCE	SCOPE	USAGE	EMISSIONS ($MTCO_2e$)
Process and Fugitive Emissions	ODS: PFCs and HFCs	1	-	6,936
	SF_6	1	-	81
	total			7,017

[25] Total ODS emissions for 2019 were found in Table 2-6: Emissions from Industrial Processes and Product Use of the EPA'S US National GHG Inventory Report: https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf.
[26] US total utility-related SF6 emissions for 2019 were found in Table 2-11: Electric Power-Related Greenhouse Gas Emissions of the EPA'S US National GHG Inventory Report: https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf
[27] Total retail electricity sales for 2019 were found in the EIA's Electric Power Monthly: Table 5.1 Sales of Electricity to Ultimate Customers: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_01
[28] Kent's 2019 electricity consumption was found in https://utilityregistry.org/app/#/datagrid
Refine search: Putnam county, Kent, 2019, Total consumption (T)

Transportation

According to NYSERDA's *2015 New York Community and Regional GHG Inventory Guidance*, transportation can be broken down into four categories: on-road, off-road, marine, and air. The town of Kent does not use marine travel and Lake Carmel does not allow motorized vehicles. Off-road emissions are negligible, taking a county wide average and scaling by population leads to a value of approximately only 50 $MTCO_2e$. Furthermore, air travel emissions are difficult to appropriately assess. Therefore, *only* on-road transportation emissions are included in the community greenhouse gas inventory. We also provided estimations of air travel emissions in the appendix, but this number is not calculated in the reported total of community transportation emissions.

On-road emissions refer to the direct emissions (scope 1) from gasoline, diesel, and ethanol burned within the geographic boundaries of Kent. Although ethanol falls within the scope 1 category, the guidelines of the NYSERDA Community GHG Inventory Guidance recommend reporting certain fuel types/emissions including ethanol as "biogenic" and *not* including these emissions in the summation of emissions from different scopes.

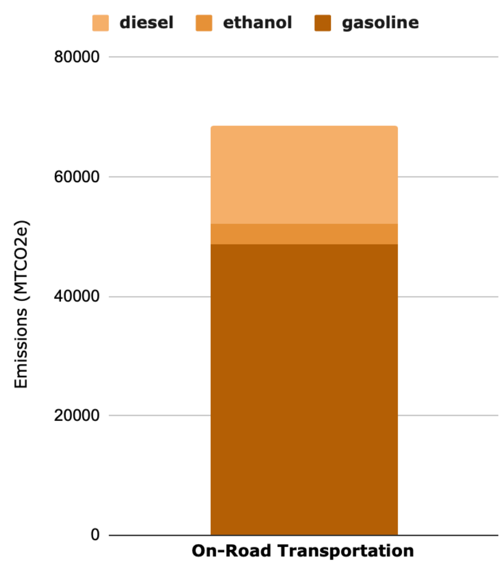

Figure 3 *Summary of Transportation Emissions by Fuel Source and Sector, 2019.*

Methods

To assess total on-road emissions, we estimated the Annual Average Daily Traffic (AADT) for all roads within Kent. For many (larger) roads within Kent, including I-Highway 84, AADT values are available.[29] Utilizing ArcGISPro we clipped road segments within the town of Kent.

[29] NYS Department of Transportation

This data also included average percentages of types of vehicles on each road segment. Not all roads, however, had measured AADT values. Thus, in order to estimate the AADT for the unmeasured roads, we implemented guidelines put forth in the *Minimum Maintenance Standards Regulation 239/02* produced by the Association of Municipalities of Ontario,[30] in which AADT can be estimated by multiplying the total number of households by a factor of 6. This method of AADT estimation from unmetered reports was supported by multiple other GHG Community Reports including those of Pulaski, Richland, and the Village of Hamilton.

From AADT values, we found vehicle miles traveled (VMT), by multiplying the length of the road segment in miles by the AADT value for each segment. Then, we used NYSERDA's Mid-Hudson Valley breakdown for vehicle and fuel type[31] (it is important to note that all gasoline used at the gas stations in New York use E-10, meaning 10% of gasoline burned in cars that drive in New York is ethanol) in conjunction with the Department of Transportation (DoT) AADT data on what percent prevalence of each vehicle on a given road segment in Kent. Finally we used the (DoT) estimates for miles per gallon based on vehicle type[32] to estimate total on-road scope 1 emissions. For a more detailed description of calculations, view Appendix I.3.

Results

Table 5: *Summary of Transportation emissions by fuel type and scope, 2019.*

SECTOR	FUEL OR SOURCE	SCOPE	Annual Vehicle Miles Traveled	USAGE (gallons)	EMISSIONS ($MTCO_2e$)
On-Road Transportation	Gasoline	1	127,538,562	5,516,452	48,675
	Ethanol*	Biogenic	n/a	571,223	3,524
	Diesel	1	5,605,359	1,590,594	16,260
	Total		133,143,921		68,459

Waste and Wastewater

[30] Association of Municipalities of Ontario's Minimum Maintenance Standards Regulation 239/02
[31] NYSERDA's regional breakdown for vehicle and fuel type, Community GHG guidelines, Table 17

[32] Department of Transportation, estimates for miles per gallon based on vehicle type, https://www.fhwa.dot.gov/policyinformation/statistics/2019/vm1.cfm

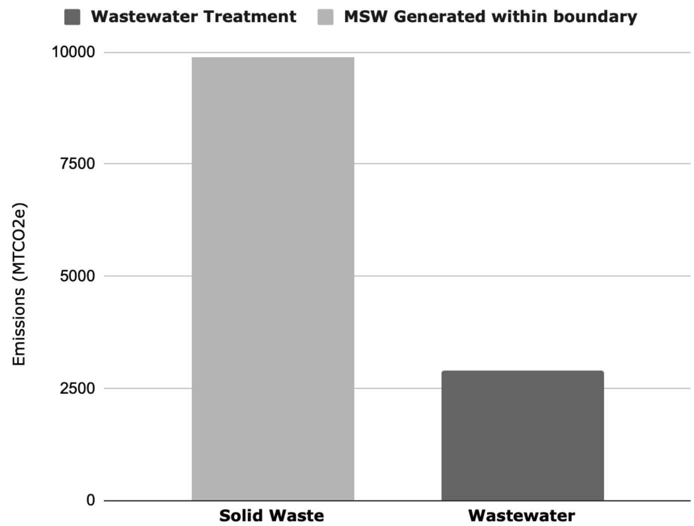

Figure 3 *Summary of Waste and Wastewater Emissions by Source and Sector*

1. Solid Waste

Solid waste buried in landfills decomposes and generates methane (CH_4), which is released over long periods of time. Some modern landfills capture this gas and flare it, or use it to generate power which converts it into carbon dioxide (CO_2) (which has a lower global warming potential). The landfill methane that escapes capture is referred to as fugitive emissions. Significant fugitive methane emissions come from landfills with partial or no methane capture methods. In our greenhouse gas inventory, we will not be calculating the direct (scope 1) emissions associated with Kent's waste management because no active landfills/WTE plants exist within the community boundary. There is one closed landfill but no data on the municipal solid waste (MSW) disposed of in the site or waste breakdowns exists. However, all communities, including Kent, generate solid waste and have to manage its disposal. Kent's MSW emissions reflect the indirect (scope 3) emissions resulting from solid waste generated and deposited in the 2019 inventory year.

Methods

Emissions associated with the municipal solid waste (MSW) generated within the community were calculated using an equation developed by ICLEI.[33] We first found total 2019 MSW generated by the Kent community by looking at receipts from Win-City Carting and Recycling between Jan 1, 2019 to Dec 31, 2019 and adding up the MSW, construction and debris, and 3rd

[33] P25, Appendix E: Solid Waste Emission U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions www.icleiusa.org.

party recycling sent to landfills/WTE plants in wet short tons (TN). We then multiplied this total mass of MSW by the CH_4 Global Warming Potential, landfill gas collection efficiency, oxidation rate, and the emission factor for the material (MTCH4/wet short ton) to find the methane emissions associated with municipal solid waste (in $MTCO_2$ e). For our calculations, landfill gas efficiency was zero as we were operating on the assumption that the landfill does not capture gas.

Results

Table 6. *Summary of Waste emissions by source and scope, 2019.*
(TN=wet short ton)

SECTOR	FUEL OR SOURCE	SCOPE	USAGE	EMISSIONS ($MTCO_2e$)
Waste	MSW generated within boundary	3	3,269 TN	9,886
	total			9,886

2. Wastewater Treatment

Wastewater plants (WWTP) can produce methane (CH_4) and nitrous oxide (N_2O) at various stages of the treatment process. Methane is produced when microorganisms degrade the soluble organic material in wastewater under anaerobic conditions. During collection and treatment, uncaptured or uncombusted methane is potentially released into the environment. Nitrous oxide is an intermediary product of treatment to remove excess nitrogen from the wastewater. The Town of Kent's primary means of wastewater treatment is through individual household septic tanks. This is typically the case for rural and suburban communities with dispersed population centers. The main Wastewater WTP utilized by commercial businesses and some private individuals along Route 52 is the Kent Manor sewer corporation located on Nichols street.

Lake Carmel and Lake Palmer are locations where effluent discharge from Kent Manor has caused excessive nutrients (phosphorus) in the water supply and subsequently caused algal blooms. Excess nutrient concentrations are the result of discharge from wastewater treatment plants, septic systems, and fertilizer runoff. Both lakes have been designated as impaired water bodies by the NYSDEC federal Clean Water Act.[34]

[34] Lake Carmel Regional Wastewater Collection and Treatment feasibility report
https://www.townofkentny.gov/sites/g/files/vyhlif4576/f/file/file/lake20carmel20report20final20combined20rev1_0.pdf

Methods

Wastewater treatment emissions were also calculated using equations developed by ICLEI (found in Appendix F of ICLEI's *U.S. Community Guidelines*). Kent Manor Sewer corporation operates using a conventional treatment system that degrades the dissolved organics in wastewater under aerobic conditions. They also employ additional treatment through nitrification, which involves the oxidation of nitrogenous wastes to oxidized forms of nitrogen. To calculate N_2O process emissions, we multiplied the population served by the WWTP by the emissions factor for a plant using nitrification/denitrification and the Global Warming Potential for N_2O. The population served by the WWTP was only 40 (mainly commercial businesses along Route 52), as the majority of the homeowners in the area use septic tanks. Fugitive N_2O emissions from effluent discharge (wastewater released from facility) were calculated using the population served by the WWTP and the EPA's default nitrogen load factor. We calculated septic tank emissions by multiplying the population using septic systems by ICLEI's default emissions factors. We used the US census bureau's rural default percentage for septic tanks and multiplied it by Kent's population to estimate the population using septic tanks since exact data on the number of people using these systems was unavailable.

Results

Table 6. *Summary of Wastewater emissions by source and scope, 2019.*

SECTOR	FUEL OR SOURCE	SCOPE	USAGE	EMISSIONS ($MTCO_2e$)
Wastewater	Wastewater Treatment	1	-	2,897
	total			2,897

Conclusion

This report serves as Kent's inventory of community-wide greenhouse gas emissions, which is a requirement for participating in New York State's Climate Smart Community program. This inventory and report can help the town of Kent develop a **Climate Action Plan**: a set of steps that the Town of Kent and the households within Kent can take to reduce their emissions, maximize carbon sequestration, and set targets to reach carbon neutrality.

Kent is already fairly efficient in heating and cooling their buildings, as much of its housing stock already uses electricity for heating, rather than oil, propane, or gas. This puts Kent residents at an advantage at a time when fuel oil prices are volatile. Further investment in electric heating is recommended for the town especially because highly efficient heat pump technology is currently available. Heat pumps act like air conditioners or refrigerators that run both ways, by compressing and expanding a refrigerant gas. In winter, they concentrate outdoor heat energy (even at low temperatures) to send heat into a house, and in summer, they send indoor heat outside. This heating and cooling approach is far more efficient (3-4 times as much heat energy output as input energy) than burning oil or gas (up to 0.9 times as much heat energy output as input), and it can use electricity from any source, thus making it less vulnerable to price spikes in a single fuel source, such as heating oil.[35]

Grid electricity relies heavily on natural gas, which can also have volatile pricing, so one way for Kent residents to reduce energy costs and GHG emissions is to engage with NYSEG to encourage more renewables and less reliance on fossil fuels. Price spikes and rising electricity bills in 2022 underscore the system's vulnerability to global energy markets. New York's focus on developing offshore wind and solar is intended to reduce this vulnerability, while also reducing the state's exposure to climate-induced hurricane flooding and rising storm intensity and flooding.

Transportation is Kent's largest energy and GHG emitting sector. Energy consumption in transportation is a familiar and perennially challenging issue. Our transportation and housing infrastructure are built around private vehicles, so transforming the system requires countless individual decisions to buy new vehicles. This contrasts with New York City which can, for example, undertake centralized decisions to electrify bus fleets. Fortunately, the cost advantage of fossil-free cars and trucks, which again are less vulnerable to fuel price spikes, is rapidly improving thus increasing the incentive to switch to these vehicles.

Consumption of goods, services, and food represents another substantial component of a community's greenhouse gas responsibility, but this sector is omitted from most GHG

[35] Energy Bill Security for American Households Through Electrification, https://www.rewiringamerica.org/policy/energy-bill-security

inventories because it requires intensive effort in surveys. However, estimates by zip code are available from national sources such as CoolClimate.[36]

Waste management is a direct emissions source for any community. Kent already has an active recycling and reuse program in which a majority of the community participates. This system puts Kent at an advantage in reducing both costs and emissions, as it 1) diverts material from the waste stream, 2) increases recycling rates 3) saves residents the cost of household pickup, 4) reduces mileage driven by trash haulers, and 5) makes waste management less invisible and more thoughtful for residents. For other aspects of waste management, a variety of strategies exist to reduce organic components (the main source landfill methane) and other approaches to reducing economic and environmental costs.

Although a greenhouse gas inventory may indicate which sectors produce relatively greater and fewer emissions, this should not inform the community to disregard certain sectors while focusing on others. A good Climate Action Plan should address as many sectors, scopes and sources of emissions within the community as possible.

This 2019 community greenhouse gas inventory serves as the benchmark for measurable emission reductions progress within the town of Kent. It can (a) be used to generate Kent's Climate Action Plan and (b) be used as an existing framework for future inventories to identify successes and sources of improvement in Climate Action Plans.

[36] Cool Climate Website. https://coolclimate.org

Appendix

I. Calculations

1. Residential Fuel Energy

Because of the lack of direct data on consumption of sources of emissions for the direct environment—natural gas, fuel oil (kerosene), wood, and propane—we used the modeling method outlined in NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance[37] to estimate Kent's residential consumption of these fuels in metric million British thermal units (MMBtu).

This modeling method lies on the assumptions published by the EPA in the 2011 white paper, "Location Efficiency and Housing Type: Boiling it Down to BTUs"[38] linking household energy consumption and residential development patterns. We followed the following steps in order to calculate the residential consumption of fuel oil (kerosene), wood, and propane. We also performed all our calculations on this attached google sheet.[39]

Step 1. Find the number of state "effective" housing units and the number of local "effective" housing units.

To find the number of state "effective" housing units, we went to the New York State Office of Real Property Tax Services Municipal Profiles[40] webpage and viewed the "Distribution of Parcels by Property Class." We selected 2019 as the year of annual assessment and looked at the parcel counts under "Residential Properties." We then separated these residential tax parcels into three categories of "effective" housing units including single-family detached housing units (SFD), single-family attached housing units (SFA), and multi-family units (MF). We categorized property codes 210 (one family year-round residence), 240 (rural residence with acreage), 250 (estate), and 260 (seasonal residences) as SFDs, property codes 215 (one family year-round residences with accessory apartment), 280 (residential multi-purpose/multi-structure), and 281 (multiple

[37]Step-by-step instructions on this modeling method for calculating residential fuel consumption can be found on pg 15-19 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

[38] https://www.epa.gov/sites/default/files/2014-03/documents/location_efficiency_btu.pdf

[39] Residential Energy: Direct Emissions from natural gas, fuel, oils, wood, and propane consumed within the boundary Mo…

[40] New York State Office of Real Property Tax Services Municipal Profiles http://orps1.orpts.ny.gov/cfapps/MuniPro/

residences) as SFAs and property codes 220 (two family year-round residence) and 230 (three family year-round residence) as MFs.

New York State 2019 Distribution of Residential Parcels by Property Code Number

Property Code Number	210	215	220	230	240	250	260	280	281
Number of Parcels	303,083,073	16,212	466,139	26,507	88,856	1,524	43,638	18,852	7,195

=single family detached (SFD)

=single family attached (SFA)

=multi-family units (MF)

We added together the number of SFD residential parcels together, the number of SFA residential parcels together, and the number of MF residential parcels together.

As a result, we found:
SFD_{state}= 303,217,091 housing units
SFA_{state}= 42,259 housing units
MF_{state}= 492,646 housing units

Using these numbers, we found the state number of "effective" housing units (EHU_{state}) by using the "Energy Use by Housing Type" equation[41]:

$$\mathbf{EHU_{state}= \frac{108}{108}SFD_{state} + \frac{89}{108}SFA_{state} + \frac{54}{108}MF_{state}}$$

$EHU_{state}= \frac{108}{108}$(303,217,091 housing units) + $\frac{89}{108}$(42,259 housing units) + $\frac{54}{108}$(492,646 housing units)

EHU_{state}= 303,498,238 "effective" housing units

There were 303,498,238 "effective" housing units in the state of New York for 2019.

[41] CSC Greenhouse Gas Inventory guide, P16 https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

To find the number of local "effective" housing units, we went to the New York State Office of Real Property Tax Services Municipal Profiles[42] webpage and clicked on "37-Putnam," then clicked on "Town of Kent" and viewed the "Distribution of Parcels by Property Class." We selected 2019 as the year of annual assessment and looked at the parcel counts under "Residential Properties." We then separated these residential tax parcels into three categories of "effective" housing units including single-family detached housing units (SFD), single-family attached housing units (SFA), and multi-family units (MF). We categorized property codes 210 (one family year-round residence), 240 (rural residence with acreage), 250 (estate), and 260 (seasonal residences) as SFDs, property codes 215 (one family year-round residences with accessory apartment), 280 (residential multi-purpose/multi-structure), and 281 (multiple residences) as SFAs and property codes 220 (two family year-round residence) and 230 (three family year-round residence) as MFs.

Town of Kent 2019 Distribution of Residential Parcels by Property Code Number

Property Code Number	210	215	220	230	240	250	260	280	281
Number of Parcels	4,132	113	54	15	64	6	27	2	85

=single family detached (SFD)
=single family attached (SFA)
=multi-family units (MF)

We added together the number of SFD residential parcels together, the number of SFA residential parcels together, and the number of MF residential parcels together.

As a result, we found:
SFD_{local}= 4,229 housing units
SFA_{local}= 200 housing units
MF_{local}= 69 housing units

Using these numbers, we found the local number of "effective" housing units (EHU_{local})by using the "Energy Use by Housing Type" equation[43]:

[42] http://orps1.orpts.ny.gov/cfapps/MuniPro/
[43] CSC Greenhouse Gas Inventory Guide https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

$$\mathbf{EHU_{local}} = \frac{108}{108}\mathbf{SFD_{state}} + \frac{89}{108}\mathbf{SFA_{state}} + \frac{54}{108}\mathbf{MF_{state}}$$

$$EHU_{local} = \frac{108}{108}(4{,}229 \text{ housing units}) + \frac{89}{108}(200 \text{ housing units}) + \frac{54}{108}(69 \text{ housing units})$$

EHU_{local}= 4,428 "effective" housing units

There were 4,428 "effective" housing units in the town of Kent for 2019.

Step 2. Find the number of state "effective" housing units categorized by heating-fuel preference and the number of local "effective" housing units categorized by heating-fuel preference.

To find the number of state "effective" housing units categorized by heating-fuel preference, we went to the United States Census Bureau Census Data[44] webpage and searched for "DP04,"the "Selected Housing Characteristics Table." We clicked on this table then adjusted the filter, using the drop down menu, to 2019: ACS 5-Year Estimates Data Profiles (as our assessment was for the year of 2019). We then clicked on "filters," then clicked on "Geography, " and clicked on the category "State," then selected New York. After filtering for the appropriate geographic regions, we went back to the "Tables" section, clicked the appropriate (DP04) table and clicked Excel to download the data as an excel sheet.

New York State 2019 Distribution of Occupied Housing Units classified by Heating-Fuel Preference

Type of Fuel	Number of Occupied Housing Units that heat with fuel	Percent Margin of Error
fuel oils "fuel oil, kerosene, etc." ($HU_{state, fuel oils}$)	1,521,756	±0.1
wood ($HU_{state, wood}$)	126,612	±0.1
propane "bottled, tank, or LP gas" ($HU_{state, propane}$)	295,680	±0.1

We also found the total number of occupied housing units within New York State in this same census table:

[44] US Census, https://data.census.gov/cedsci/

HU_{state}= 7,343,234 housing units with a ±0.2 percent margin of error

Using these numbers, we found the state number of "effective" housing units classified by heating-fuel preference ($EHU_{state,\ fuel}$) by multiplying the number of state "effective" housing units (EHU_{state}) found in step 1 by the ratio of occupied housing units that heat with each fuel ($HU_{state,\ fuel}$) over the total number of occupied housing units (HU_{state}).

$$\mathbf{EHU_{state,\ fuel} = EHU_{state}\ x}\ \frac{HUstate, fuel}{HUstate}$$

$$\mathbf{EHU_{state,fuel\ oil}} = (303{,}498{,}238\text{ “effective” housing units})\ \mathbf{x}\ \frac{(1{,}521{,}756\ housing\ units)}{(7{,}343{,}234\ housing\ units)}$$

$EHU_{state,\ fuel\ oil}$ = 62,894,668 "effective" housing units

$$\mathbf{EHU_{state,\ wood}} = (303{,}498{,}238\text{ “effective” housing units})\ \mathbf{x}\ \frac{(126{,}612\ housing\ units)}{(7{,}343{,}234\ housing\ units)}$$

$EHU_{state,\ wood}$ = 5,232,915 "effective" housing units

$$\mathbf{EHU_{state,\ propane}} = (303{,}498{,}238\text{ “effective” housing units})\ \mathbf{x}\ \frac{(295{,}680\ housing\ units)}{(7{,}343{,}234\ housing\ units)}$$

$EHU_{state,\ propane}$= 12,220,550 "effective" housing units

To find the number of local "effective" housing units categorized by heating-fuel preference, we went to the United States Census Bureau Census Data[45] webpage and searched for "DP04,"the "Selected Housing Characteristics Table." We clicked on this table then adjusted the filter to 2019: ACS 5-Year Estimates Data Profiles (as our assessment was for the year of 2019). We then clicked on "filters," then clicked on "Geography, " and clicked on the category "County Subdivision," then selected New York, then Putnam County, then Kent town. After filtering for the appropriate geographic regions, we went back to the "Tables" section, clicked the appropriate (DP04) table and clicked Excel to download the data as an excel sheet.

Town of Kent 2019 Distribution of Occupied Housing Units classified by Heating-Fuel Preference

Type of Fuel	Number of Occupied Housing Units that heat with fuel	Percent Margin of Error
fuel oils "fuel oil, kerosene, etc." ($HU_{local,\ fuel\ oils}$)	3,075	±4.0
wood ($HU_{local,\ wood}$)	184	±1.8

[45] https://data.census.gov/cedsci/

propane “bottled, tank, or LP gas” ($HU_{local, propane}$)	201	±2.0

We also found the total number of occupied housing units within the town of Kent in this same census table:
HU_{local}= 4,850 housing units with a ±2.7 percent margin of error

Using these numbers, we found the local number of “effective” housing units classified by heating-fuel preference ($EHU_{local, fuel}$) by multiplying the number of local “effective” housing units (EHU_{local}) found in step 1 by the ratio of occupied housing units that heat with each fuel ($HU_{local, fuel}$) over the total number of occupied housing units (HU_{local}).

$$EHU_{local, fuel} = EHU_{local} \times \frac{HUlocal, fuel}{HUlocal}$$

$$EHU_{local,fuel\ oil} = (4{,}428 \text{ “effective” housing units}) \times \frac{(3{,}075\ housing\ units)}{(4{,}850\ housing\ units)}$$
$EHU_{local, fuel\ oil}$ = 2,808 “effective” housing units

$$EHU_{local, wood} = (4{,}428 \text{ “effective” housing units}) \times \frac{(184\ housing\ units)}{(4{,}850\ housing\ units)}$$
$EHU_{local, wood}$ = 168 “effective” housing units

$$EHU_{local, propane} = (4{,}428 \text{ “effective” housing units}) \times \frac{(201\ housing\ units)}{(4{,}850\ housing\ units)}$$
$EHU_{local, propane}$= 184 “effective” housing units

Step 3. Find the local consumption of each fuel by scaling down EIA-reported state consumption of each fuel and factoring in the above calculations.

To find the state consumption of each fuel, we went to the US Energy Information Administration (EIA) State Energy Data Systems[46] webpage and under data selected “Consumption and Expenditures” for the state of New York. We then looked at the data for end-use sector, and clicked on see more under “Residential” and looked for Table C5. Residential Sector Energy Consumption Estimates 2019[47] to find the state consumption of each fuel. We want to note that the EIA data lists distillate fuel oil, HGL (hydrocarbon

[46]State Energy Data System (SEDS): https://www.eia.gov/state/seds/

[47]Table C5. Residential Sector Energy Consumption Estimates, 2020, https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_btu_res.html

gas liquids), and kerosene as separate categories but we added the three together to get the residential sector "fuel oil" consumption .

New York State 2019 Residential Sector Consumption Estimates

Type of Fuel	Consumption (trillion Btu)
fuel oils "petroleum." **($\text{consumption}_{\text{state, fuel oils}}$)**	137.3
wood **($\text{consumption}_{\text{state, wood}}$)**	35.4
propane "bottled, tank, or LP gas" **($\text{consumption}_{\text{state, propane}}$)**	28.3

Using these numbers, we found the local consumption of each fuel by multiplying the U.S. EIA-reported state residential consumption by the ratio of the number of local "effective" housing units classified by heating-fuel preference ($\text{EHU}_{\text{local, fuel}}$) over the number of state "effective" housing units classified by heating-fuel preference ($\text{EHU}_{\text{state, fuel}}$)

$$\textbf{Consumption}_{\textbf{local, fuel}} = \textbf{Consumption}_{\textbf{state, fuel}} \times \frac{EHUlocal, fuel}{EHUstate, fuel}$$

$$\textbf{Consumption}_{\textbf{local, fuel oils}} = \textbf{(137.3 trillion Btu)} \times \frac{(2{,}808\ \text{“}effective\text{” } housing\ units)}{(62{,}894{,}668\ \text{“}effective\text{” } housing\ units)}$$

$$\textbf{Consumption}_{\textbf{local, fuel oils}} = \textbf{6,129.12 MMBtu}$$

$$\textbf{Consumption}_{\textbf{local, wood}} = \textbf{(35.4 trillion Btu)} \times \frac{(168\ \text{“}effective\text{” } housing\ units)}{(5{,}232{,}915\ \text{“}effective\text{” } housing\ units)}$$

$$\textbf{Consumption}_{\textbf{local, wood}} = \textbf{1,136.51 MMBtu}$$

$$\textbf{Consumption}_{\textbf{local, propane}} = \textbf{(28.3 trillion Btu)} \times \frac{(853\ \text{“}effective\text{” } housing\ units)}{(12{,}220{,}550\ \text{“}effective\text{” } housing\ units)}$$

$$\textbf{Consumption}_{\textbf{local, propane}} = \textbf{425.00 MMBtu}$$

Step 4. Correct local consumption for each fuel calculation for regional climate difference.

We multiplied our local consumption totals calculated above by the coefficient for the Mid-Hudson REDC Region in Table 8 of NYSERDA's 2015 New York Community and

Regional GHG Inventory Guidance[48] in order to find the corrected local consumption of each fuel

Table 8: HDD Correction Coefficients by REDC Region

REDC	HDD	EHU	HDD Correction Coefficient
Western New York	6,609	572,929	1.13
Finger Lakes	6,570	472,542	1.13
Southern Tier	7,025	263,211	1.21
Central New York	6,618	306,081	1.14
Mohawk Valley	7,096	199,590	1.22
North Country	9,032	165,539	1.55
Capital Region	6,519	430,474	1.12
Mid-Hudson	5,936	810,003	1.02
New York City	4,776	3,047,249	0.82
Long Island	5,224	938,122	0.90

Source: 30 year average HDD data from National Weather Service. EHU and HDD Correction Coefficient for each REDC calculated by the Working Group.[4]

$$\textbf{Corrected Consumption}_{\text{local, fuel}} = \textbf{Consumption}_{\text{local, fuel}} \times \textbf{HDD Correction Coefficient}$$

$$\textbf{Corrected Consumption}_{\text{local, fuel oils}} = \textbf{6251.7 MMBtu}$$
$$\textbf{Corrected Consumption}_{\text{local, wood}} = \textbf{1,159.24 MMBtu}$$
$$\textbf{Corrected Consumption}_{\text{local, propane}} = \textbf{433.50 MMBtu}$$

After estimating Kent's residential consumption of these fuels in metric million British thermal units (MMBtu), we converted consumption to emissions using conversion factors available in the ICLEI *US Community Protocol*.

2. Commercial Fuel Energy

Because of the lack of direct data for natural gas and fuel consumption for commercial energy, we used the modeling method outlined in NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance[49] to estimate Kent's commercial consumption of these fuels in metric million British thermal units (MMBtu).

This modeling method uses the numbers of residential energy fuel preferences calculated above in Appendix 1.1 as well as commercial square footage for New York State and the Town of Kent to find the commercial energy consumption within Kent. We followed these steps to calculate the residential consumption of natural gas and fuel oil (consisting of distillate fuel oil, HGL,

[48]Pg. 19 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

[49]Step-by-step instructions on this modeling method for calculating commercial fuel consumption can be found on pg 19-22 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

kerosene, motor gasoline and residual fuel oil). We also performed all our calculations on a google sheet attached below.[50]

Step 1. Find the commercial square footage for the town of Kent.

Using tax parcel data to find the commercial buildings within NY State and mapping it using GIS software, we calculated the commercial square footage for the town of Kent.

The commercial square footage for the town of Kent for 2019 was 322,865.12 square feet

Step 2. Find the commercial square footage for the state of New York.

In order to find the commercial square footage for New York state (CSF_{state}), we first found the number of non-farm workers within the state. We went to the New York State Department of Labor's Current Employment Statistics and looked for employment totals for the year of 2019. We added up the employment totals for the twelve months of the year then divided this total by 12 to calculate the average number of workers for the year of 2019.

average number of workers for 2019= 9,789,225 workers

We then multiplied this number by the average square footage per worker (for total commercial), which we found on pg. 22 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance[51].

average square footage per worker (total commercial) = 977 ft^2/worker

$$CSF_{state} = (9{,}789{,}225 \text{ workers})(977 \text{ ft}^2/\text{worker})$$
$$CSF_{state} = 9{,}564{,}072{,}825 \text{ ft}^2$$

The commercial square footage for the state of New York for 2019 was 9,564,072,825 square feet.

Step 3. Find the state amount of commercial square footage that prefers each fuel and the local amount of commercial square footage that prefers each fuel.

[50] Commercial Energy Template
https://docs.google.com/spreadsheets/u/1/d/1XiP5Xg6-SleMtKXtHL4zXMsw7eUJ6M6_iLYaMW5mylc/template/preview

[51] NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance
https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

In order to find the state amount of commercial square footage that prefers each fuel, we multiplied the state commercial square footage by the state number of effective housing units that heat with each fuel ($EHU_{state,fuel}$) divided by the state number of "effective" housing units (EHU_{state}). Instructions on how we calculated these EHU numbers are above in Appendix 1.1 (for residential energy emissions).

$$\mathbf{CSF_{state,\ fuel} = CSF_{state}\ x}\ \frac{EHUstate,fuel}{EHUstate}$$

$$\mathbf{CSF_{state,\ fuel\ oils} = (9{,}564{,}072{,}825\ ft^2)\ x}\ \frac{(62{,}894{,}668\ effective\ housing\ units\ )}{(303{,}498{,}238\ effective\ housing\ units)}$$

$$\mathbf{CSF_{state,\ fuel\ oils} = 1{,}981{,}985{,}785\ ft^2}$$

In order to find the local amount of commercial square footage that prefers each fuel, we multiplied the local commercial square footage by the local number of effective housing units that heat with each fuel ($EHU_{state,fuel}$) divided by the total local number of "effective" housing units (EHU_{state}). Instructions on how we calculated these two EHU numbers are above in Appendix 1.1 (for residential energy emissions).

$$\mathbf{CSF_{local,\ fuel} = CSF_{local}\ x}\ \frac{EHUlocal,fuel}{EHUlocal}$$

$$\mathbf{CSF_{local,\ fuel\ oils} = (322{,}865\ ft^2)\ x}\ \frac{(2{,}807\ effective\ housing\ units\ )}{(4428\ effective\ housing\ units)}$$

$$\mathbf{CSF_{local,\ fuel\ oils} = 204{,}703\ ft^2}$$

Step 4. Find the local commercial consumption of each fuel by scaling down EIA-reported state consumption of each fuel and factoring in the above calculations.

In order to find the EIA-reported state consumption of each fuel, we went to the US EIA State Energy Data Systems[52] webpage and under data selected "Consumption and Expenditures" for the state of New York. We then looked at the data for end-use sector, and clicked on findsee more under "Commercial" and looked for Table C6. Commercial Sector Energy Consumption Estimates 2019[53] to find the state commercial consumption of each fuel. We want to note that the EIA data lists distillate fuel oil, HGL, kerosene, and motor gasoline as separate categories but we added the four together to get the total commercial sector "fuel oil" consumption.

New York State 2019 Commercial Sector Consumption Estimates

[52]EIA, US States: https://www.eia.gov/state/seds/

[53]Table C5. Residential Sector Energy Consumption Estimates, 2020
https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/sum_btu_com.html&sid=US

Type of Fuel	Consumption (trillion Btu)
fuel oils “petroleum” ($consumption_{state,\ fuel\ oils}$)	73.4

Using these numbers, we found the local consumption of each fuel by multiplying the U.S. EIA-reported state commercial consumption by the ratio of the number of local commercial square footage preferring each fuel ($CSF_{local,\ fuel}$) over the number of state commercial square footage preferring each fuel ($CSF_{state,\ fuel}$).

$$\textbf{Consumption}_{local,\ fuel} = \textbf{Consumption}_{state,\ fuel} \times \frac{CSFlocal, fuel}{CSFstate, fuel}$$

$$\textbf{Consumption}_{local,\ fuel\ oils} = \textbf{(73.4 trillion Btu)} \times \frac{204{,}703\ ft2}{1{,}981{,}985{,}785\ ft2}$$

$$\textbf{Consumption}_{local,\ fuel\ oils} = \textbf{7580.9 MMBtu}$$

Step 5. Correct the local consumption for each fuel calculation for regional climate difference.

We multiplied our local consumption totals calculated above by the coefficient for the Mid-Hudson REDC Region in Table 8 of NYSERDA’s 2015 New York Community and Regional GHG Inventory Guidance[54] in order to find the corrected local consumption of each fuel

Table 8: HDD Correction Coefficients by REDC Region

REDC	HDD	EHU	HDD Correction Coefficient
Western New York	6,609	572,929	1.13
Finger Lakes	6,570	472,542	1.13
Southern Tier	7,025	263,211	1.21
Central New York	6,618	306,081	1.14
Mohawk Valley	7,096	199,590	1.22
North Country	9,032	165,539	1.55
Capital Region	6,519	430,474	1.12
Mid-Hudson	5,936	810,003	1.02
New York City	4,776	3,047,249	0.82
Long Island	5,224	938,122	0.90

Source: 30 year average HDD data from National Weather Service. EHU and HDD Correction Coefficient for each REDC calculated by the Working Group.[4]

$$\textbf{Corrected Consumption}_{local,\ fuel} = \textbf{Consumption}_{local,\ fuel} \times \textbf{HDD Correction Coefficient}$$

$$\textbf{Corrected Consumption}_{local,\ natural\ gas} = \textbf{471.7 MMBtu}$$

$$\textbf{Corrected Consumption}_{local,\ fuel\ oils} = \textbf{7,732.5 MMBtu}$$

[54]Pg. 19 of NYSERDA’s 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.

After estimating Kent's commercial consumption of these fuels in metric million British thermal units (MMBtu), we converted consumption to emissions using conversion factors available in the ICLEI *US Community Protocol*.

3. Transportation

VMT On-Road Emissions

From the GIS data of New York State, we are able to isolate solely AADT segments within the town of Kent. These road segments also include length as well as vehicle percentages. Multiplying road segment length and respective AADT value generates Daily Vehicle Miles Traveled (DVMT) values for each road segment. Multiplying the DVMT value by 365 generates Annual VMT (AVMT) values. A summation of AVMT leads to Total VMT (TVMT) of the region over the course of a year. We can multiply this by vehicle percentage.

$$\mathbf{VMT_{metered} = AADT_{metered} * \ Length\ of\ Road_{miles}}$$
$$\mathbf{AVMT_{metered} = (VMT_{metered})*365}$$
$$\mathbf{TVMT_{metered} = \sum_{\#\ of\ road\ segments} VMT_{metered}}$$
$$\mathbf{Vehicle_x\ TVMT_{metered} = TVMT_{metered} * \ Vehicle\%_x}$$

For unmetered roads, imploring Ontario's technique led to our estimated value of $TVMT_{unmetered}$. We assumed all roads were rural, thus used a scalar value of 6 multiplied by the number of households in Kent. This generates a Total Daily VMT (DTVMT) value for all roads not included in the metered measurement. Multiplying this value by 365 generates the $TVMT_{unmetered}$ for the year. The vehicle breakdown is unknown for these roads, thus we took an aggregated average of vehicle percentages within the town of Kent and applied those averages to roads unmetered.

$$\mathbf{DTVMT_{unmetered}} = \#\text{ of households in the region} * 6$$
$$\text{Kent } DTVMT_{unmetered} = 4{,}752 \ * 6 = 28512$$

$$\mathbf{TVMT_{unmetered}} = (DTVMT_{metered})*365$$
$$\text{Kent } TVMT_{unmetered} = (4{,}752 \ * 6) * 365 = 10{,}406{,}880$$

The validity of this Ontario approach was supported by generating another $TVMT_{unmetered}$ value, however this time utilizing a method described within the Phillipstown Community GHG report.[55] In this report, the group estimated $TVMT_{unmetered}$ by taking an average of AADT values for roads which were metered within their geospatial boundary and were classified within the

[55] Philipstown Greenhouse Gas Inventory 2020: https://philipstown.com/cs/2020-CSCommunityGHGEmissionsInventory.pdf

functional groups 9 and 19. Functional groups 9 and 19 are coded for local roads. This average AADT value is said to apply for all roads which are unmetered due to the underlying assumption that all unmetered roads within Kent are local. From this average value, we can multiply again by the length of total road segments unmetered (which can be found by subtracting total length of metered road in the region from total length of road in the region). This procedure generates a similar value to the Ontario method. We choose to use the Ontario method out of ease, because it does not require generating the average AADT value or finding the total length of unmetered roads and thus is much easier to replicate for other towns.

Average AADT = $\sum AADT_{\text{functional groups 9 and 19}} / \#$ of road segments$_{\text{functional groups 9 and 19}}$

Average AADT for Kent = 281.545

TVMT$_{\text{unmetered}}$ = Average AADT * Length of Roads$_{\text{unmetered}}$ * 365

$TVMT_{\text{unmetered}}$ = 281.545*122.49$_{\text{miles}}$ * 365 = 12,587,553

Adding together the $TVMT_{\text{unmetered}}$ and $TVMT_{\text{metered}}$ leads to an estimate of $TVMT_{\text{total}}$ which is essential in estimating on road emissions.

Average breakdown of vehicle type on the roads can be found from the same segmented GIS data. The breakdown of each vehicle type dependent on fuel (gasoline or diesel) can be found via NYSERDA 2015 guide for NY. We can estimate the percentage of each vehicle type split into fuel category via the following formula:

Vehicle Prevalence Percentage (VPP)$_{\text{type+ fuel1}}$ = Average% Prevalence$_{\text{type}}$ * (Percentage$_{\text{fuel1}}$/percentage$_{\text{fuel1}}$ + percentage$_{\text{fuel2}}$)

These VPP numbers can be combined in accordance with average miles per gallon (mpg) and TVMT to estimate total gallons consumed of each vehicle, utilizing the formula written in the NYSERDA report. The formula should be used for all combinations of vehicle and fuel type (IE, account for both gasoline trucks and diesel trucks separately). Note the reason VPP is divided by 100, is to change the VPP from a 1 to 100 scale to a fraction of 0 to 1, thus computing the portion of TVMT attributed to the vehicle and respective fuel type combination.

Fuel Consumption = TVMT * ($VPP_{\text{type+fuel}}$/100) * (1/$MPG_{\text{type + fuel}}$)

Once Fuel Consumption figures are derived then all that is left is to (1) account for ethanol (biogenic) used in gasoline, (2) use multipliers to estimate total kgCO2 emitted, total gCH4, and total emitted based fuel consumption, and (3) standardize those estimates in forms of $MTCO_2e$.

For simplicity sake we assume that all gasoline consumed was E-10, thus 10% of the fuel consumed in cars is ethanol. This is also consistent with other reports and the 2015 community framework's guidelines. To account for this simply multiply the Fuel Consumption for gasoline of each vehicle type by .9 and .1 respectively to break down the fuel consumption into true gasoline and ethanol.

Next, emission factors can be found which convert gallons consumed of gasoline, ethanol, or diesel by $kgCO_2$, gCH_4, and gN_2O. These emissions factors can be found on the EPA website along with many other places.

$$\text{Quantity of Chemical Emitted}_{\text{fuel +type}} = \text{Fuel Consumption}_{\text{fuel+type}} * \text{emission factor}_{\text{chemical+type}}$$

Two concerns arise in this step. First, is that the emissions factor for gCH_4 and gN_2O diesel vary depending on the type of vehicle that is using diesel and the breakdown of emissions factors for diesel vary from the breakdown of vehicle types used by NYSERDA *or* used by the GIS source. Furthermore, depending on the source, emission factors for diesel emissions of gCH_4 and gN_2O vary. However, none of this is too concerning due to the fact that the total effect of gCH_4 and gN_2O on transportation emissions is small (less than 1%), regardless of emission factors used.

Finally, these quantities of chemical emitted values must all be converted into a singular unit, $MTCO_2e$. For $kgCO_2$ all that needs to be done is to divide the value found above by 1000. For gCH_4 and gN_2O divide by 10 million then multiply emissions equivalency values to CO_2 found on the EPA website. The values selected were on a 20-year scale, because this is most in line with current New York state Greenhouse gas accounting.

IVMT On-Road Emissions

Philipstown Community GHG report implemented a "demand side" approach to find the induced vehicle miles traveled (IVMT). Those conducting the report sent out a survey to residents to get estimates of where these residents drove to. Another approach could be to use Google's Environmental Insights tool to approximate a total number of transportation emissions: both scope 1 and scope 3 (IVMT) emissions from on-road transportation.

Utilizing Google's tool generates a total transportation emissions for Putnam County of 363,000 $MTCO_2e$ in 2019. Multiplying this by the proportion of Putnam County's population which can be attributed to Kent results in a value of **46,221 $MTCO_2e$**. Multiplying the 363,000 value by the proportion of the square kilometers of Putnam County which can be attributed to Kent results in a value for total transportation emissions of **24,675 $MTCO_2e$**. Which method (proportion of land or proportion of population) would give a better approximation of total on-road emissions for a given town within a county is uncertain. It is important however to include such values, due to the limitations of scope 1 on-road emissions.

IVMT Air Travel Emissions

As explained in the report there is not a clear method, besides surveying town residents, to astimed IVMT, and subsequent emissions, from air travel. Two potential methods for estimation are explained below.

One method would be to take a summation of all flights leaving NY state and multiply this by the proportion of people living in Kent relative to all of NY and then multiply that by the emission factor of $MTCO_2e$/miles which is 0.0238 in the NYSERDA 2015 report. This method is an expansion on the idea of assigning a portion of emissions of a regional airport to the towns within the region. Of course, this method has very low significance to the members of Kent's community and most likely very low accuracy.

Another method is to calculate the average number of flights per year a member of the Kent community takes per year. This can be done by using household income. A study in 2017 found the average number of flights per $25K intervals of household income (up to $200K). Combine these results with household income percentages found on the US census to generate a weighted average of the number of flights per year.

 # flights/person/year = percentage of households in $\text{region}_{0\text{-}50k}$*(.95) + percentage of households in $\text{region}_{50\text{-}100k}$*(3.4) + percentage of households in $\text{region}_{100\text{-}150k}$*(3.2) + percentage of households in region_{150K+}*(5.4)

# of flights/person/year for Kent = (.21)*(.95) + (.29)*(3.4) + (.22)*(3.2) + (.29)*(5.2) = 3.4

Then multiply this by the average length of a flight, the population of Kent, and a per person per mile emission factor. This could give a somewhat coarse estimate of the $MTCO_2e$ per year emissions from Kent traveling.

GHG from air IVMT in $MTCO_2e$ = Population of Town * Average Flight Miles * Average Number of Flights * 0.02kgCO_2/passenger mile * (1/1000)

GHG from air IVMT in $MTCO_2e$ = 13255 * 495 * 3.4 * 0.02kgCO_2 * (1/1000) = **4,558 $MTCO_2e$**

4. Solid Waste and Wastewater

Solid Waste calculations

I. MSW generated within boundary:
(equation found in ICLEI's Appendix E Section 4 on community-generated waste

emissions)[56]

$$CH4\ Emissions\ = GWP_{CH4} \times (1 - CE) \times (1 - OX)\ \times\ M\ \times\ \sum_i P_i \times EF_i$$

$$= (56)\ \times\ (1 - (0)) \times (1 - (0.10))\ \times\ (1)\ \times\ (0.060)\ =$$

= 9886.27248 $MTCO_2e$

GWP $CH4$ (Global Warming Potential for Methane) = 56
CE (Landfill gas collection efficiency) = 0, because the facility doesn't collect gas
OX (Oxidation rate) = 10% (0.10).
M = total mass of waste entering landfill (wet short ton)
EF (emissions factor for material) = We used the ICLEI given emissions factor for mixed MSW which was 0.060.[57]

Wastewater calculations

II. Kent Manor Sewer corporation conventional treatment with Nitrification**:**
(equation found in ICLEI's Appendix F Process Emissions section WW7)[58]

$$Annual\ N_2O\ emissions = ((P \times F_{ind\text{-}com}) \times EF \times 10^{-6}) \times GWP$$

$$((40\ \times\ 1)\ \times\ 7\ \times\ 0.10)\ \times 280$$
= 4.312 $MTCO_2e$

P (population) = 40
$F_{ind\text{-}com}$(Factor for high nitrogen loading of industrial or commercial discharge) = 1, if there is no significant discharge
EF (emissions factor for a WWTP with nitrification or denitrification) = 7
GWP N_2O = 280

III. Kent Manor Sewer corporation N_2O effluent discharge:
(equation found in ICLEI's Appendix F Fugitive Emissions section WW12)

$$Annual\ N_2O\ emissions = ((P \times F_{ind\text{-}com}) \times (Total\ N\ load - N\ uptake\ x\ BOD5\ load) \times EF\ effluent \times 44/28 \times (1 - Fplant\ nit/denite) \times 365.25 \times 10^{-3}) \times GWP$$

(40 x 1) x (0.026- 0.005 x 0.090) x 0.005 x 1.57 x (1 - 0.0) x 365.25 x 10-3) x 280

[56] Appendix E - Solid Waste Emission Activities and Sources - ICLEI U.S. Community Protocol, p23

[57] Table 18: U.S. EPA Landfill Emission Factors, p43
https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf

[58] WW.7 Process Nitrous Oxide Emissions from Wastewater Treatment Plants with Nitrification or Denitrification, P40 - U.S. Community Protocol Appendix F

= 0.82 MTCO2e

IV. Septic Tank Methane emissions:
(equation found in Appendix F Fugitive Emissions section WW11)

$$\textit{Annual } CH_4 \textit{ emissions} = (P \times BOD_5 \textit{ load} \times Bo \times MCFs \times 365.25 \times 10^{-3}) \times GWP$$

(11921 * 0.090 * 0.6 * 0.22 * 365.25 * 0.001) * 56

= 2897 MTCO2e

II. Uncertainties

The methods used to generate our numbers are in line with the most up to date community GHG accounting strategies in use. However, no numbers within this report have a 100% certainty. These are estimates made to understand at a large scale where emissions are coming from, the largest sectors, and which areas are most critical for improvement. This is an inherent shortcoming of GHG inventories, however this should not be a deterrent from using the numbers generated in this report as a basis for climate action. For each sector, discussions of the uncertainties, including sources of error and limitations, is included below.

Built Environment

1. Residential

For electricity, the utility-specific greenhouse gas emission factor for NYSEG electricity was unavailable and as a result this was substituted with the less accurate, regional emission factor: the US EPA's NPCC Upstate NY (NYUP) eGRID factors for 2019 (most recent). In future calculations, the NYSEG-specific electricity emission factor (if available) should be used both to achieve greater accuracy and to understand the specific emissions from Kent produced from NYSEG's electricity mix.

Because direct consumption data was unavailable for heating fuels, to approximate, we scaled down total state consumption relying on a set of assumptions from a 2011 white paper published by the EPA[59] that linked household energy consumption and residential development patterns. The calculations performed in our modeling method give relative approximations of the total amount of local fuel consumption, and furthermore the ACS census data used in these calculations has margins of error (as the ACS records a population sample, not the total

[59]Location Efficiency and Housing Type, https://www.epa.gov/sites/default/files/2014-03/documents/location_efficiency_btu.pdf

population). We also note that when calculating the number of "effective" household units, we considered "seasonal residences" as single-family detached housing units (SFDs), however the energy usage of these seasonal residences would likely be less significant than typical SFDs due to the temporary nature of these residences. In the future, if available, direct data for fuel consumption should be used for greater accuracy. Such direct data may be attained in the future through a local survey of town residents or a centralized fuel consumption database (separated by geospatial area).

2. Commercial

Similar to residential electricity, for commercial electricity, the utility-specific greenhouse gas emission factor for NYSEG electricity was unavailable and as a result this was substituted with the less accurate, regional emission factor: the US EPA's NPCC Upstate NY (NYUP) eGRID factors for 2019 (most recent). In future calculations, the NYSEG-specific electricity emission factor (if available) should be used both to achieve greater accuracy and to understand the specific emissions from Kent produced from NYSEG's electricity mix.

Like residential heating fuels, because for commercial fuels, direct consumption data was unavailable, to approximate, we scaled down total state fuel consumption data by relying on the same set of assumptions in the residential consumption above, in effect allowing for the same uncertainties detailed above to occur in our commercial energy calculations. We also factored in the commercial square footage of both New York State and Kent using approximating methods. We used GIS mapping software and tax parcel data to come up with a relatively accurate estimate for the commercial square footage of Kent, however for New York State, we estimated commercial square footage by multiplying the average total square foot per worker[60] (based off of a 2015 table) by the number of workers in New York State.[61] In the future, if available, direct data for fuel consumption should be used for greater accuracy. Such direct data may be attained through a centralized commercial buildings energy consumption fuel consumption database (separated by geospatial area).

3. Process and Product Use

For process and product use emissions, we estimated Kent's emissions using US averages. We were unable to obtain a specific ODS emissions rate for Kent because local ODS emissions data

[60] We used the value for average total square foot per worker found on pg. 22 of NYSERDA's 2015 New York Community and Regional GHG Inventory Guidance https://climatesmart.ny.gov/fileadmin/csc/documents/GHG_Inventories/ghgguide.pdf.
[61] We found the number of workers in New York State (on the Department of Labor's Employment Statistics page) by adding up the total nonfarm employment for the twelve months of the year in 2019, and dividing that number by 12 https://dol.ny.gov/current-employment-statistics-0

is not available. As a result, our recorded numbers are estimates based on the whole country, and Kent's true share of emissions may be higher or, more likely, lower since there is no significant industry in the town.

Similarly with SF6, emissions were calculated using a US average rate. We were unable to obtain a Kent-specific SF6 emissions use rate (as SF6 use / KWh sold) from NYSEG so we approximated using a US average.

Transportation

Due to classification inconsistencies amongst the various data sources we used in calculating the AADT, certain assumptions had to be made which decreased accuracy. First, the Department of Transportation does not further breakdown the average MPG by fuel type. Furthermore, the classification systems between the tables used in the NYSERDA guidelines do not match with the vehicle classifications used by GIS data or DoT. The main inconsistency is that GIS DoT data has a "light truck" classification unlike the NYSERDA table.[62] The NYSERDA report gives averages dependent on fuel type. We estimated fuel type proportion breakdown for those vehicles classified as light trucks by taking the average of the proportion breakdown (between diesel and gas) of both short base and long-wheel base vehicles. This potentially decreases the accuracy of the estimated proportion of diesel vehicles to gas vehicles which have light truck classification in our model. Furthermore NYSERDA also only has a regional breakdown of vehicles in the Mid-Hudson Valley and not Kent creating possible inaccuracies.

Emission factors for diesel vehicles are dependent on the classification of the vehicle as well as the year it was produced. However, the AADT data acquired does not include the year in which the cars driving through Kent were produced. Thus, for CO_2 status quo emission factors for diesel and gas were used—which disregard vehicle year. Emission factors for CH_4 and N_2O for diesel vehicles are also different depending on source used, and differ based on the type of vehicle, nevertheless the total impact of CH_4 and N_2O on vehicle emissions is very small thus these potential sources of error do not discredit the estimation. This is all consistent with other reports.

Since there were some roads without measured AADT values, we had to estimate these values. This comes as a potential source of error as we are operating under assumptions. Multiplying the number of households solely by a factor of 6 assumes every household is on a road which could be classified as rural. This assumption is safe, because Kent is a rural town without a main city hub. We also assume none of the households were on streets already counted in the metered AADT segment. This is also a safe assumption, *if* the first assumption is true, given metered

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[62] *Climate Smart Communities: New York Community and Regional GHG Inventory Guidance,* 2015, Table 17: Default Vehicle Mix by Economic Development Region, pg. 36

AADT values are rare for small rural roads. Approximately 120 miles of Kent's roads are unmetered, about 70%, thus this method of estimation has an impact on the total VMT and subsequent on-road emissions of the region. As mentioned in the calculation section of this appendix, an alternative method, similar to that conducted in the philipstown report was tested as well. Although the numbers are different, it is not so great that it is cause for concern in the overall findings of the report.

There is also a systematic issue that must be addressed (or at the very least mentioned). Currently, this emission total is an estimate of all on-road emissions within the geospatial boundaries of Kent, including Highway 84 and the Taconic State Parkway. These roads are used by many vehicles which are not connected to the town of Kent in any way. Approximately 44,000 $MTCO_2e$ or 67% of transportation emissions can be attributed specifically to these interstate segments which run through Kent. Regardless of fairness in assigning "blame" of emissions, the supply side (within geospatial boundary approach) is far easier to replicate and currently the method most GHG reports utilize.

Similarly, this method of calculation does not include induced vehicle emissions. On average, an employed member of the Kent community commutes 40+ minutes a day for work. Once this person leaves the boundaries of the Town of Kent, their emissions are not counted (within this model) towards Kent's community emissions. As discussed in calculations, there are a couple solutions which attempt to rectify this issue of scope.

Another Indirect, scope 3, transportation emission not included in the assessment, due to current modeling framework and lack of standardized methodology, is the Town of Kent's emissions from travel via airplane. Most community GHG assessments did not include IVMT for airplanes. The only assessment which included $MTCO_2e$ values for air emissions had an airport within their geospatial boundaries. This precedent is in part the reason why we refrained from including an estimate of am Induced Vehicle Miles Traveled (IVMT) for air travel in our transportation value. However, the main reason is the lack of a clear way to calculate IVMT for flight. NYSERDA outlines a strategy in which one analyzes the emissions of a regional airport and then hands a proportion of that emissions sum to each town which makes up the region relative to the total population of a given town. This method does not seem appropriate to the Town of Kent due to its location relative to major airports of JFK, Newark, and Laguardia. We derived a simple method to calculate IVMT for Kent of air travel which can be viewed in the calculations section that led to a value of 4,558 $MTCO_2e$. However, we refrain from including this number in our GHG assessment value due to the uncertainty of how best to calculate Kent's air travel emissions.

Waste and Wastewater

Solid waste emissions were calculated using standardized factors such as the oxidation rate and ICLEI's given emission factor for mixed MSW. The mixed MSW factor was used for the entire MSW waste stream because specific waste composition data for Kent was unavailable. Thus, emissions are not as precise as they could be if we knew Kent's specific waste breakdowns. We were also operating on the assumption that the landfill processing the town's waste does not capture gas since it is uncommon in New York State.

Wastewater emissions were also calculated mainly with ICLEI's standardized factors. To calculate septic tank emissions, we had to estimate the population of Kent using these systems because exact numbers were unavailable. Thus, there is a margin of error for estimating the exact population using private septic systems.

III. Additional Sectors

While we elected to follow the framework put forth by the NYSERDA in 2015, there are additional sectors that can be calculated which are important in considering the total picture of a communities Greenhouse gas portfolio.

Upstream Emissions Attributed to Food Consumption

Neither the New York specific or ICLEI's *US Community Protocol* requires the calculation of any upstream emissions: emissions generated in other locations in order to achieve the desired goods and services of the community. This is in part due to difficulty of calculations, but also in part due to a fundamentally different—demand side—methodology of accounting GHGs. Regardless, it is important to consider what is not being caught in the current supply side, predominantly scope 1, approach.

A method to calculate upstream emissions attributed to food consumption is laid out in Appendix H of ICLEI's *US Community Protocol*. For Kent, an estimated **40,100 $MTCO_2e$** is emitted each year to produce the food and ship the food that feeds its residents. **7,100 $MTCO_2e$** of the total is associated with eating out. While these emissions are difficult to reduce and the town have little control over, it is still important to understand that the total shown in *Table 1* of this document does ont represent *all emissions* connected to the community.

Carbon Sequestration and Natural Resources

Using i-Tree Canopy,[63] we measured the tree coverage within the town of Kent using random sampling statistics. Using 1000 points, we estimated that around 80.7% of Kent was covered by trees/shrub, 7.8% of land was covered by grass/ herbaceous, 6.7% was covered by water, 4.5% was covered by impervious (buildings, concrete, etc.), and 0.3% was covered by soil/bare ground.

Note, sequestration refers to the amount of carbon the trees within the boundaries of Kent are, in total, absorbing each year. Trees also supply various other health, environmental, and aesthetic benefits.

Table 7. Town of Kent Tree Benefits

SECTOR	FUEL OR SOURCE	Amount (kT = kilotons)	EMISSIONS ($MTCO_2e$)
Carbon	Sequestration	30.57 kT	112,090

Similarly to food consumption, sequestration is rarely included in Greenhouse gas inventories. I-Tree makes the process of calculating an estimate of sequestration simple, but the interpretation of annual CO_2 absorption can be misleading. Kent's net emissions would be negative given that total sector emissions is 93,739 $MTCO_2e$ while estimated sequestration is over 100,000 $MTCO_2e$. The conclusion inferred from this result would be that Kent does not need to reduce their emissions because of their carbon sequestration. This is not the town should be taking away from this inventory. Rather, It is important to understand the power of the natural ecosystem and its economic benefits when making decisions associated with land management and development.

[63] ITree Canopy. https://canopy.itreetools.org