Community Greenhouse Gas Inventory

June 2018

Contents

Introduction

In July 2017, Cuyahoga County joined the [Global Covenant of Mayors for Climate & Energy](), an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low-emission, resilient society. By joining, the county committed to complete and publicly report on the following within three years:

1. County-wide greenhouse gas (GHG) emissions inventory consistent with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), within one year or less
2. Climate hazards faced by our county
3. Targets to reduce GHG emissions, within two years or less
4. Climate vulnerabilities faced by our county within two years or less
5. Plans to address climate change mitigation and adaptation within three years or less

The County's Department of Sustainability has worked with the [Brendle Group](), a sustainable engineering and planning firm with extensive experience completing greenhouse gas inventories for cities across the country including the City of Cleveland, to complete a Cuyahoga County community-wide inventory of greenhouse gas emissions. Due to the county's commitment to the Covenant, the [Global Protocol for Community-Scale GHG Inventories (GPC)]() was chosen as the basis for the inventory calculations, reporting at the Basic level. The following table depicts the various emission sources included in the inventory and distinguishes them further by the following:

Red = Emissions sources required by GPC Basic and included
Yellow = Emissions not required but included in the inventory due to significance to Cuyahoga County
Gray = Emissions sources required but data not readily available and emissions determined to be de minimis or not applicable for Cuyahoga and excluded

Emissions Source	Scope 1	Scope 2	Scope 3
Stationary Emissions			
Residential	🟥	🟥	
Commercial	🟥	🟥	
Industrial	🟥	🟥	
Energy Generation Supplied to Grid	🟧		
Agriculture, forestry, and fishing activities	⬜ (gray)		
Fugitive emissions from mining, processing, and transportation of coal	⬜ (gray)	⬜ (gray)	
Fugitive emissions from oil and natural gas systems	🟥		
Transportation			
On-Road	🟥	⬜ (gray)	
Railways	⬜ (gray)	⬜ (gray)	
Waterborne Navigation	🟥	⬜ (gray)	
Aviation	🟥	⬜ (gray)	
Waste			
Solid Waste Disposal	🟥		🟥
Wastewater	🟥		🟥
Industrial Products and Processes			
Industrial Processes	🟧		

Table 1. GPC Basic Protocol GHG Emissions Sources

Key Terms

Greenhouse Gas: Any gas that absorbs infrared radiation (heat) in the atmosphere. Greenhouse gases include carbon dioxide, methane, and nitrous oxide.

Carbon Dioxide Equivalents (CO₂e): A standard unit for measuring carbon footprints that expresses the impact of all gases in the amount of CO_2 it would take to create the same warming effect.

Metric Tons CO₂e (MT CO₂e): Standard units for reporting GHG emissions under international protocol.

Scope 1 (direct): Any emissions directly created within inventory boundaries (e.g., burning natural gas).

Scope 2 (indirect): Emissions from energy provided to in-boundary buildings through distribution systems (e.g., electricity).

Scope 3 (indirect): Emissions that occur outside the city boundary from activities taking place within the city boundary (e.g., solid waste generation within boundary and disposal outside boundary)

GLOBAL WARMING POTENTIAL (GWP) FACTORS

The Intergovernmental Panel on Climate Change (IPCC) assesses GWP factors for greenhouse gases (GHGs). GWP Factors help to convey the effect different GHGs will have on the environment over the next 100 years, with carbon dioxide (CO_2) being the reference point. For example, methane (CH_4) has a GWP of 28 which means that it has 28 times the heat trapping capacity as CO_2. The three GHGs examined in this inventory are listed below, along with each respective GWP factor.

Table 2. Global Warming Potential for Common Greenhouse Gases

Greenhouse Gas	GWP in Revised Inventory (IPCC 5th Report)
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265

Overview

This report details the GHG emissions from each source listed above for the County as well as outlines the calculation methodology.

GHG emissions for the Cuyahoga County community over the last seven years are shown in Figure 1. Since 2010, the County has seen an 10% reduction in overall GHG emissions from 26.1 to 23.5 million metric tons of carbon dioxide equivalent (MT CO₂e). To better understand the main drivers behind the overall GHG emissions trends for the county, the emissions by source are broken out along with the County's population to calculate per capita emissions. From 2010 to 2017, the County's population declined by 2%. While some of the reductions in GHG emissions may have been due to this slight decrease in the county's population, the overall emissions reductions, especially stationary energy, are higher than what would be expected from population change alone.

Emissions from waste and industrial process and product use (IPPU) have remained constant, while energy related emissions have decreased from 59% to 52% and transportation emissions have increased from 20% to 24% of the county's total GHG emissions.
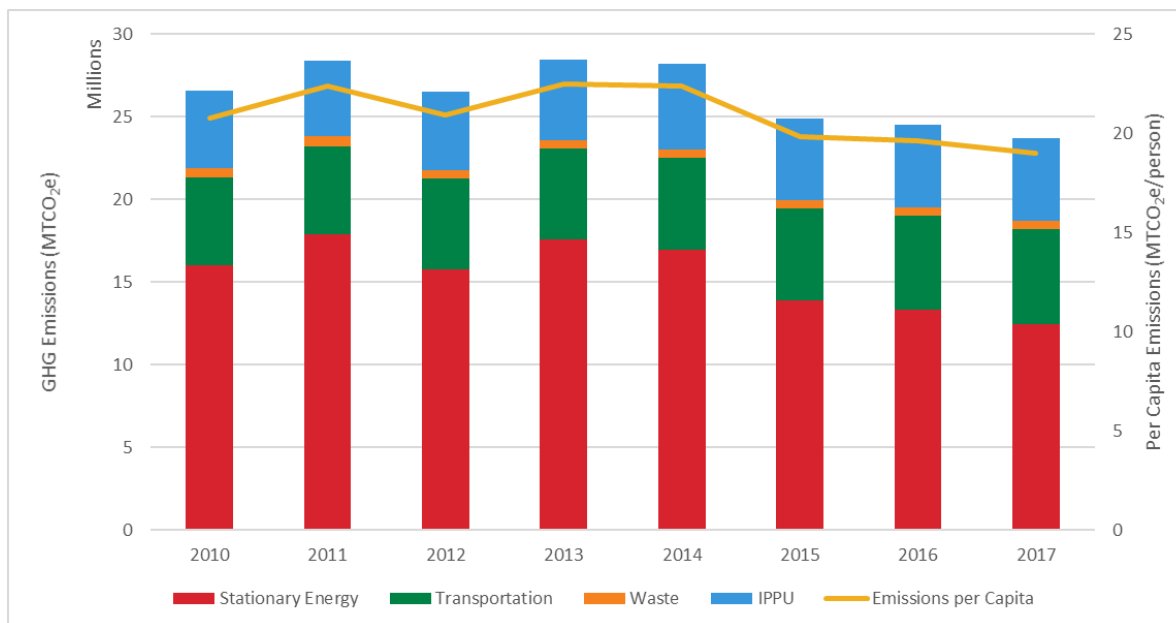

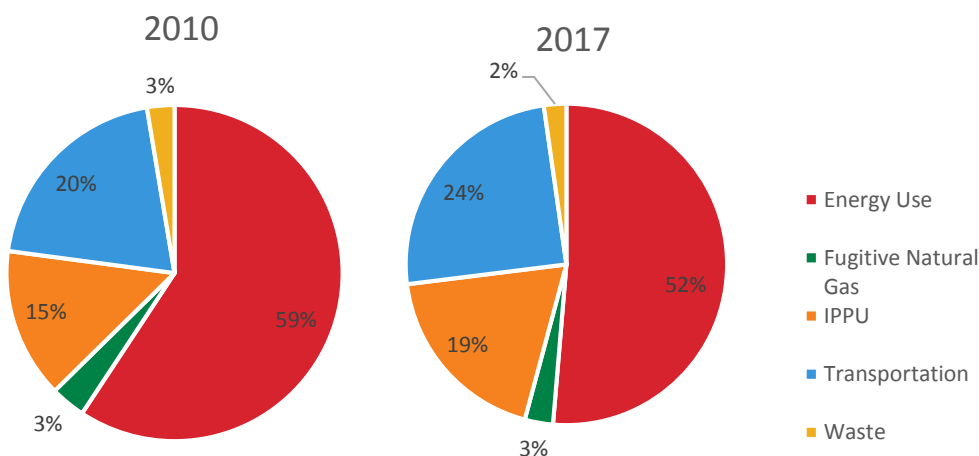*Figure 1. Cuyahoga County GHG Emissions 2010-2017*

Figure 2. Emissions by Source Comparison 2010-2017

In addition to data on overall county emissions, disaggregated data by each community in the county is also available for each sector for years 2010-17. These community breakouts can be viewed on our interactive tableau dashboard which filters data to show graphs for each community, comparison graphs for communities, and graphs and maps for overall county data. The following trends analysis includes

Detailed Trends Analysis

Table 3 breaks out emissions by source and shows the overall trends from 2010 to 2017. Where possible, additional context for the emissions trends shown here are detailed in the following sections. Electricity emissions had the highest percent change from 2010 to 2017 and energy related emissions had the greatest absolute reduction in emissions. The energy-related emission reductions were mostly driven by reductions in electricity emissions due to a decrease in fuel carbon intensity. However, a significant increase in

Source	2010	2017	GHG Change (million MTCO2e	Emissions % change
Stationary Energy	**15.4**	**12.2**	**-3.26**	**-21%**
Natural Gas	**6.5**	**6.0**	-0.54	-8%
Residential	**2.9**	**2.5**	-0.35	-12%
Commercial	**1.7**	**1.5**	-0.24	-14%
Industrial	**2.0**	**2.0**	0.05	3%
Electricity	**9.0**	**6.3**	-2.72	-30%
Residential	**2.5**	**1.7**	-0.83	-33%
Commercial	**3.3**	**2.2**	-1.05	-32%
Industrial	**3.2**	**2.3**	-0.82	-26%
Fugitive NG Emissions	**0.9**	**0.7**	-0.22	-25%
Transportation	**5.3**	**5.7**	**0.45**	**9%**
On-Road	**4.9**	**5.3**	0.45	9%
Commercial Air	**0.2**	**0.1**	-0.03	-17%
Municipal Air	**0.0**	**0.1**	0.01	11%
Marine Vessels	**0.2**	**0.2**	0.02	13%
Waste	**0.7**	**0.5**	**-0.16**	**-24%**
Solid Waste	**0.4**	**0.3**	-0.16	-36%
Wastewater	**0.2**	**0.2**	0.00	-1%
Industrial Process	**3.8**	**4.4**	**0.60**	**16%**
Total	**26.1**	**23.5**	**-2.59**	**-10%**

transportation led to an overall increase in transportation-related emissions. Aviation, waterborne, solid waste, and IPPU emissions were not available for 2017 at the time of writing this report, so 2016 data was used as a placeholder until 2017 data are available.

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*2017 Data are not available yet, so 2016 emissions are used as an estimate

STATIONARY ENERGY

Emissions in this category include natural gas (scope 1) and electricity (scope 2) use in all buildings.

Natural Gas

Natural gas emissions include metered natural gas use for residential, commercial, and industrial buildings. Overall metered natural gas consumption has decreased by about 8% over the last seven years while overall emissions follow this same trend since there is no change in the emissions factor. The trends in natural gas consumption by sector are illustrated in Figure 3. Residential use decreased by 12% and commercial use was down 14% from 2010 to 2017, while industrial use increased by 3%.
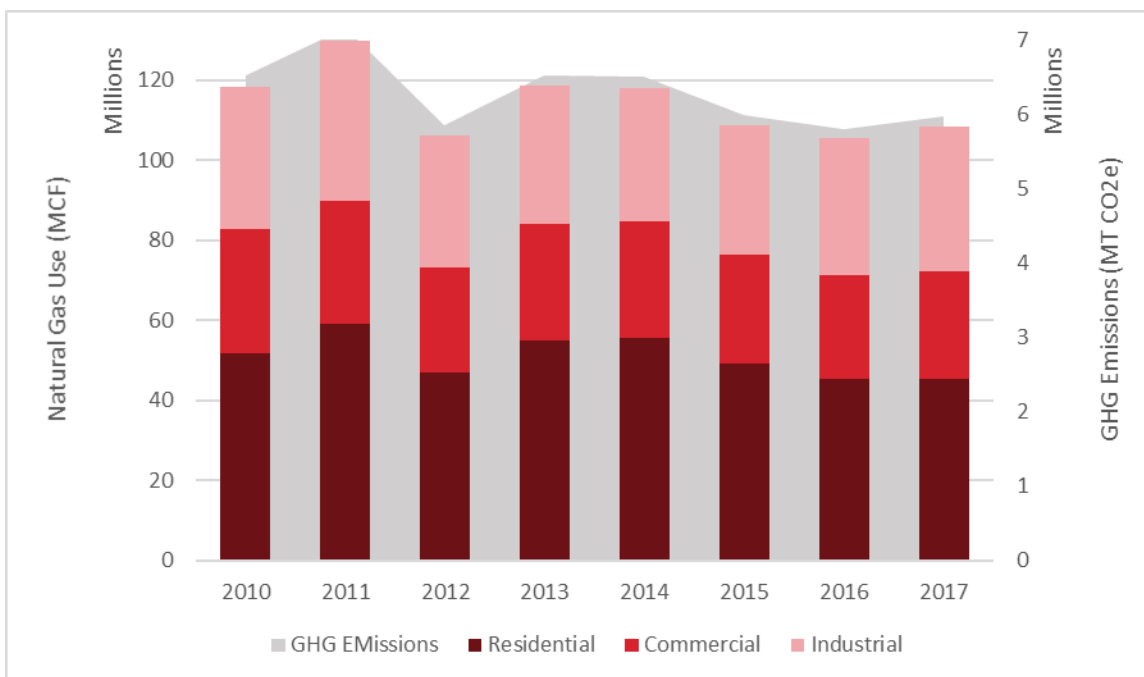

Figure 3. Trends in Natural Gas Consumption

Heating degree days (HDD) is a data point that helps to compare the heating demand year to year due to weather variations. Between 2010 and 2017, the number of HDD decreased by 10% as measured by the weather station at the Cleveland Burke Lakefront Airport and the population of Cuyahoga County has remained relatively constant, only decreased by 2%. **Since the reduction in residential natural gas use follows the same trends as HDD, weather is most likely the major factor driving this reduction.**

Key Terms

Heating Degree Day (HDD): A measurement that helps quantify the amount of heating required in a given year. The more heating degree days the more heating required.
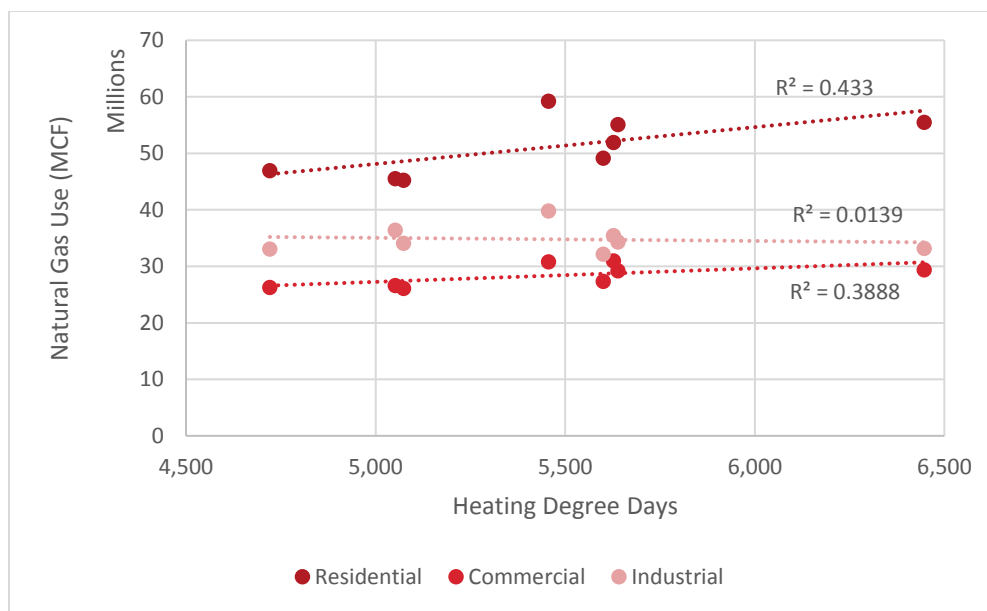
Figure 4: Correlation between HDD and Natural Gas use

Figure 4 shows the relationship between natural gas use on the vertical axis and HDD on the horizontal axis. The residential natural gas use shows a general trend of increasing use with increasing number of HDD (although the R^2-value is not as high as that of the commercial sector). This trendline provides additional supporting evidence that weather is a major driver in natural gas use.

For commercial natural gas use, the trend of use compared to HDD has a high R^2-value, so there is a strong correlation between these two data points. However, the trendline is relatively flat. This suggests that while weather is a factor in determining natural gas use in commercial buildings, there are likely other factors. One example might be a restaurant that uses natural gas for heating, so use goes up with colder weather, but they also use natural gas for cooking, so a portion of their use is constant regardless of the weather.

Industrial natural gas use had a very poor correlation with weather, which is expected. This sector's use is often dominated by process gas use that is more dependent on production and process efficiency rather than weather. For example, a manufacturing plant might use natural gas for its furnace and to heat the building. The natural gas use for the furnace is often a larger amount and relatively constant year-round. This means that there are smaller seasonal variations in the plant's gas use.

Key Terms

R^2-value: A statistical value between 0 and 1 used to show how well a trendline matches the data where 1 means the line describes the data perfectly.

Process Natural Gas Use: Natural gas uses other than building heating, such as cooking or blast furnace use.

Fugitive Natural Gas Emissions

A small portion of emissions from the energy sector are fugitive emissions, which typically occur during extraction, transformation, and transportation of primary fossil fuels. For Cuyahoga County, these emissions occur during the distribution through small leaks in the distribution network. These emissions are reported to the EPA by the East Ohio Gas company.

Calculation Methodology

To calculate emissions from natural gas, the total natural gas use by sector (residential, commercial, industrial) was multiplied by current stationary combustion emission factors (CO_2, CH_4 and N_2O) generated by the Environmental Protection Agency (EPA). After emissions per sector were determined, the sectors were summed to provide a total across sectors.

Community Breakout Estimation

Natural gas is provided to communities in Cuyahoga County by two utility providers - Dominion and Columbia. For both utilities, some estimation was required to apportion the County's natural gas use by residential, commercial, and industrial use by community for all years 2010 to 2017. Details of the estimation techniques used are outlined below by utility.

Dominion Natural Gas

Dominion only keeps three years of use data, so at the time of our data request in February of 2018 only data from February 2015 to present were available for all communities. The City of Cleveland has been tracking their use by sector since 2010 as part of their climate action plan, so historical data for all years were available. To complete data for all other communities, two separate estimation techniques were used.

1. Data from January 2016 were used as an estimate for January 2015.
2. For data from 2010 to 2014, natural gas use was estimated using the City of Cleveland's historical use trends. The average use for each community was compared to the City of Cleveland's use in 2015-2017 and expressed as a percentage. This percentage was then used to estimate the community's use for the missing years. An example calculation for Beachwood City residential natural gas use in 2014 is shown below.

   a) Gather the provided utility data: Residential data in thousand cubic feet (Mcf) is shown in Table 4.

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Key Terms

Thousand Cubic Feet (Mcf): Unit of measure for natural gas use

</div>

Table 4: Provided Data - Dominion Natural Gas

Community	2014	2015	2016	2017
Beachwood City	Not available	467,920	443,964	451,319
Cleveland City	17,132,531	15,445,852	13,988,615	14,029,377

   b) Compare average natural gas use for Beachwood City to Cleveland City.

$$\frac{Average\ Beachwood\ City}{Average\ Cleveland\ City} = \frac{477,721\ Mcf}{14,487,948\ Mcf} = 3.3\%$$

   c) Use the calculated percentage to estimate Beachwood City's residential natural gas use in 2014.

$$17,132,531\ Mcf \times 3.3\% = 564,923\ Mcf$$

This estimation process was used because any natural gas use trends due to weather were likely the same in Cleveland as the other Cuyahoga County communities and will be reflected in the estimated data. This model does not account for any community growth that does not follow the patterns of growth seen in Cleveland.

Note: This method only provides an estimation of the natural gas use from 2010 to 2015, which makes up a large portion of GHG emissions within the County. For this reason, we recommend using this data only to show trends. The County and all communities other than Cleveland should choose 2016 or 2017 as their reporting year for the Covenant of Mayors or other reporting platforms.

Columbia Natural Gas

The data provided by Columbia Natural Gas was broken out by zip code rather than community. A list of the zip codes included in the Columbia Natural Gas service territory and the corresponding communities are shown in Table 5.

Table 5: Zip Codes and Corresponding Communities in Columbia Natural Gas Service Area

ZIP CODE	COMMUNITIES
44140	Bay Village
44146	Bedford Heights, Walton Hills, Bedford, Oakwood Village
44017	Strongsville, Middleburg Heights, Berea
44147	Broadview Heights
44142	Cleveland, Brookpark
44109	Cleveland
44130	Middleburg Heights, Parma, Parma Heights
44070	North Olmsted
44133	North Royalton
44138	Olmsted Falls, North Olmsted
44129	Cleveland, Parma, Brooklyn
44134	Cleveland, Parma
44131	Seven Hills, Independence, Brooklyn Heights
44136	Strongsville
44149	Strongsville
44145	Westlake

For all zip codes with multiple communities, the data were broken out into their corresponding communities using a two-step estimation method.

1. The boundary of each zip code was compared to the community boundaries. Any community where only a small area was included in the zip code boundaries was eliminated, as shown in Table 6.

Table 6: Refined Community List by Zip Code

ZIP CODE	COMMUNITIES
44146	Bedford Heights, Walton Hills, Bedford, Oakwood Village
44017	Berea
44142	Brook Park City
44109	Cleveland
44130	Middleburg Heights, Parma Heights
44138	Olmsted Falls
44129	Parma City
44134	Parma City

44131	Seven Hills, Independence

2. For the remaining zip codes where there were still multiple communities with natural gas use (44146, 44130, and 44131), the reported use was broken out by population. The distribution of data for 2017 is shown in Table 2.

Table 7. Zip Code Data by Community (2017)

ZIP CODE	COMMUNITIES
44140	Bay Village (100%)
44146	Bedford Heights (36%), Walton Hills (8%), Bedford (43%), Oakwood Village (13%)
44017	Strongsville (0%), Middleburg Heights (0%), Berea (100%)
44147	Broadview Heights (100%)
44142	Cleveland (0%), Brookpark (100%)
44109	Cleveland (100%)
44130	Middleburg Heights (44%), Parma (56%), Parma Heights (0%)
44070	North Olmsted (100%)
44133	North Royalton (100%)
44138	Olmsted Falls (100%), North Olmsted (0%)
44129	Cleveland (0%), Parma (100%), Brooklyn (0%)
44134	Cleveland (0%), Parma (100%)
44131	Seven Hills (62%), Independence (38%), Brooklyn Heights (0%)
44136	Strongsville (100%)
44149	Strongsville (100%)
44145	Westlake (100%)

Note: The County's natural gas use by sector data as well as the data for the following communities is complete metered data that can be used for official GHG reporting: Bay Village, Broadview Heights, North Olmsted, North Royalton, Strongsville, and Westlake. Data for other communities should be considered an estimate to track emissions trends rather than for reporting purposes.

Electricity

Electricity emissions include all emissions that result from the generation of the electricity used within County boundaries. Cuyahoga County has two electricity providers - Cleveland Public Power (CPP) and First Energy (CEI). Total electricity use, CEI and CPP combined, is shown in Figure 6 along with the associated emissions from electricity generation. Based on this analysis, residential and commercial electricity use decreased from 2010 to 2017 by 7% and 6% respectively, while an increase of 3% was observed in the industrial sector.

As might be expected, the decrease in electricity use also led to a decrease in overall emissions stemming from electricity use. This decreased electricity use, coupled with decreasing carbon intensity on the grid, shown in Figure 6, led to a 30% decrease in electricity emissions from 2010 to 2017. Both electric utility providers in the county, Cleveland Public Power and First Energy, have decreased the carbon intensity of their fuel generation mix. As seen in Figure 5 and Figure 7, electricity generation has been moving away from coal-fired plants to low or non-carbon sources such as large hydro, natural gas, and nuclear generation.
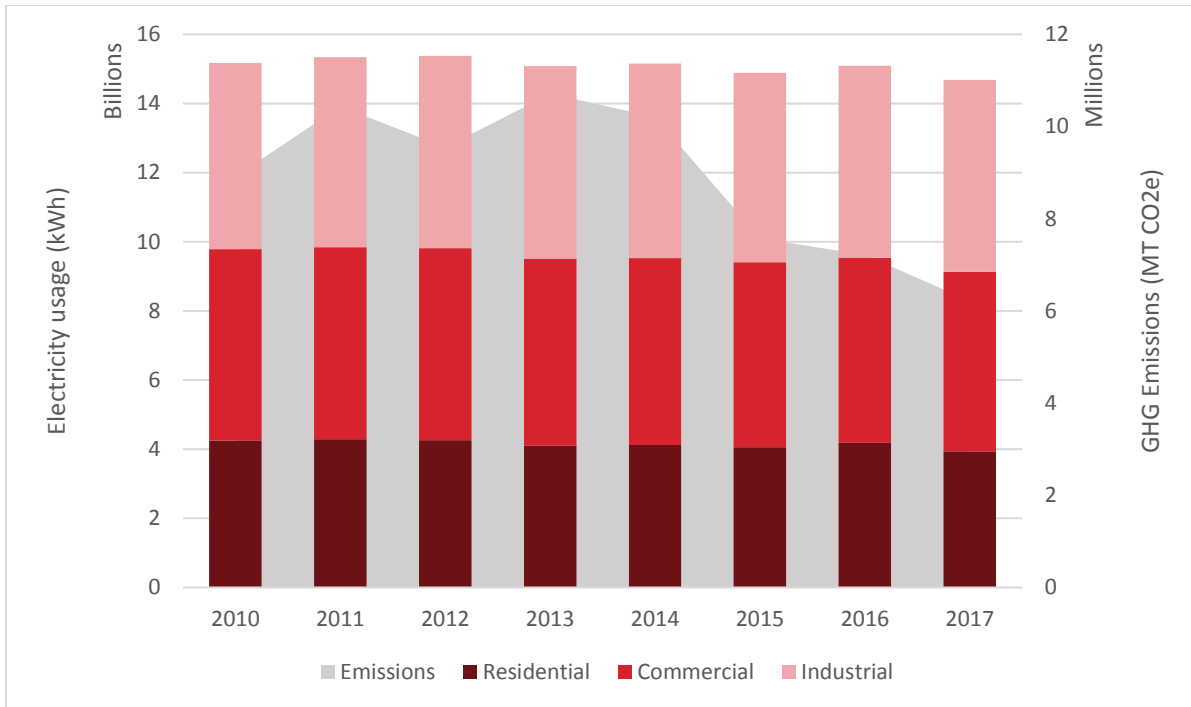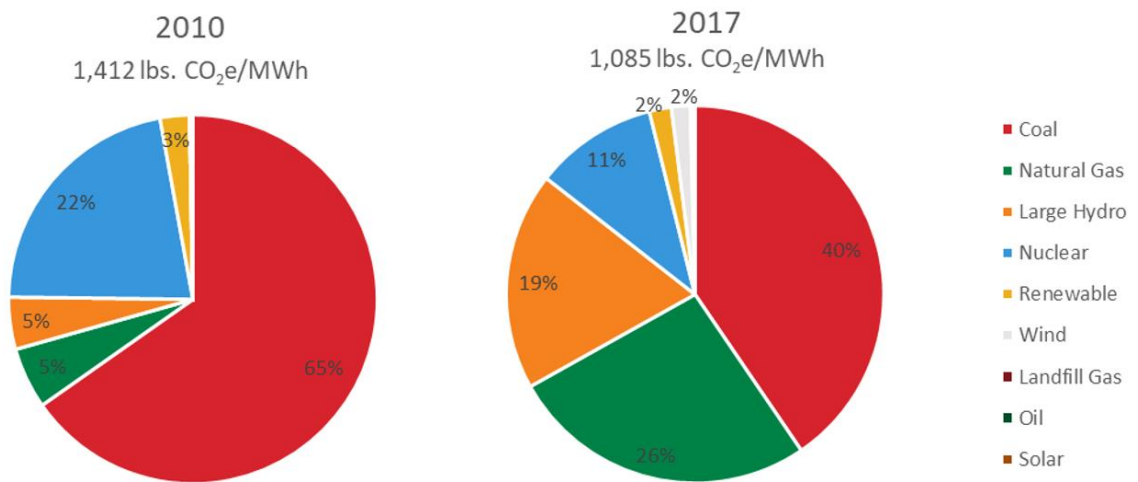
Figure 6. Trends in Electricity Use

Figure 5. Cleveland Public Power Generation Mix

2010
1,281 lbs. CO_2e/MWh

2017
915 lbs. CO_2e/MWh

Legend:
- Coal
- Natural Gas
- Large Hydro
- Nuclear
- Renewable
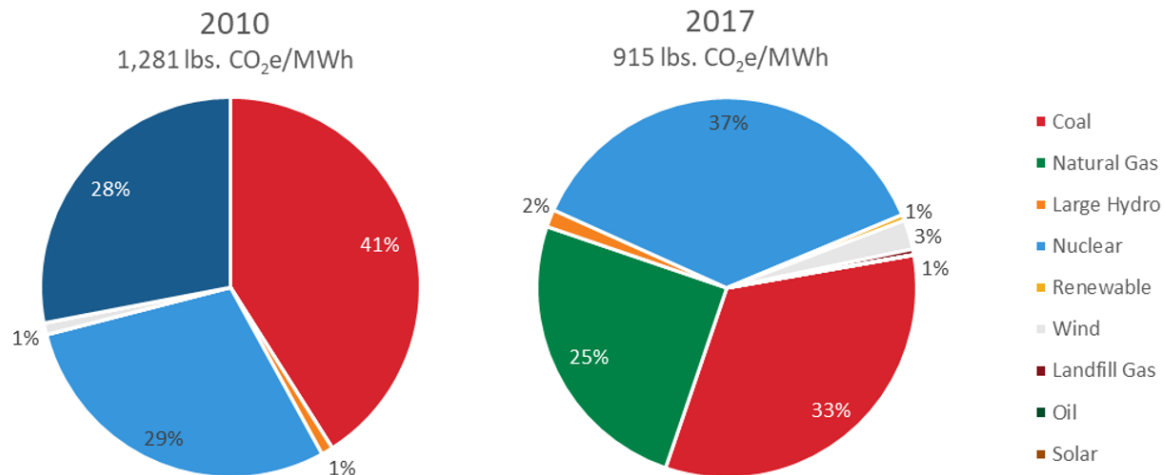- Wind
- Landfill Gas
- Oil
- Solar

Figure 7. First Energy Power Generation Mix

Note: In 2010, there was a portion of the electricity purchased from the electricity market by First Energy where the generation source was unknown. For this portion, a local average electricity emissions factor from eGrid was assumed. For more information, see the Calculation Methodology

To calculate emissions from electricity, electricity consumption by sector (residential, commercial, industrial) was broken out by the two utilities serving Cuyahoga County - CPP and First Energy. After consumption by sector and utility was determined, the sectoral totals by utility were multiplied by emission factors calculated for each utility. These emission totals by utility and sector were then summed to provide an emissions total for each sector.

The CO2 emissions factor for each utility was calculated based on the utility's published generation mix by multiplying a generation source-specific emissions factor by the percentage of the utility's total electricity that was provided by that source. The source-specific emissions factors were calculated from data provided by the Energy Information Administration (EIA) and shown in Table 8. Since the methane and nitrous oxide contribution to the electricity emissions factor is significantly less than CO2, the regional Emissions and Generation Resource Integrated Database (eGrid) factor (RFCW) was used for these gases. This methodology was employed instead of using the utility published factor because it provides transparency into the fuel shifts driving changes in the emissions factor.

Table 8: Emissions Factor by Fuel Type

Fuel	Emissions Factor (lb. CO2/MWh)
Coal	2,069
Petroleum (oil)	2,295
Natural Gas	896
Non-Carbon Sources	0

There are two electricity providers in the County - First Energy and Cleveland Public Power (CPP). CPP was able to provide electricity use by sector and by community for all years. For First Energy electricity use, there were privacy concerns in some smaller communities with large industrial users. It was felt that breaking out the energy use by community and sector would violate these customer's privacy. As a result, residential use was provided by community and by sector, but commercial and industrial use was bundled for all communities except Bay Village, Bentleyville, Broadview Heights, Brooklyn Heights, Chagrin Falls Township, Gates Mills, Linndale, Moreland Hills, Oakwood, Olmsted Falls, Olmsted Township, Orange, and Valley View, which had no industrial electrical use. For the communities that were bundled, the electricity use was split to match the proportion of commercial electricity use to industrial use in the County after the electricity use was removed for Cleveland and the other community's listed above.

section.

Cooling Degree Days (CDD) is a similar metric to HDD but measures the amount of cooling required during warmer months. The residential, commercial, and industrial electricity use as compared to CDD is shown in Figure 8.

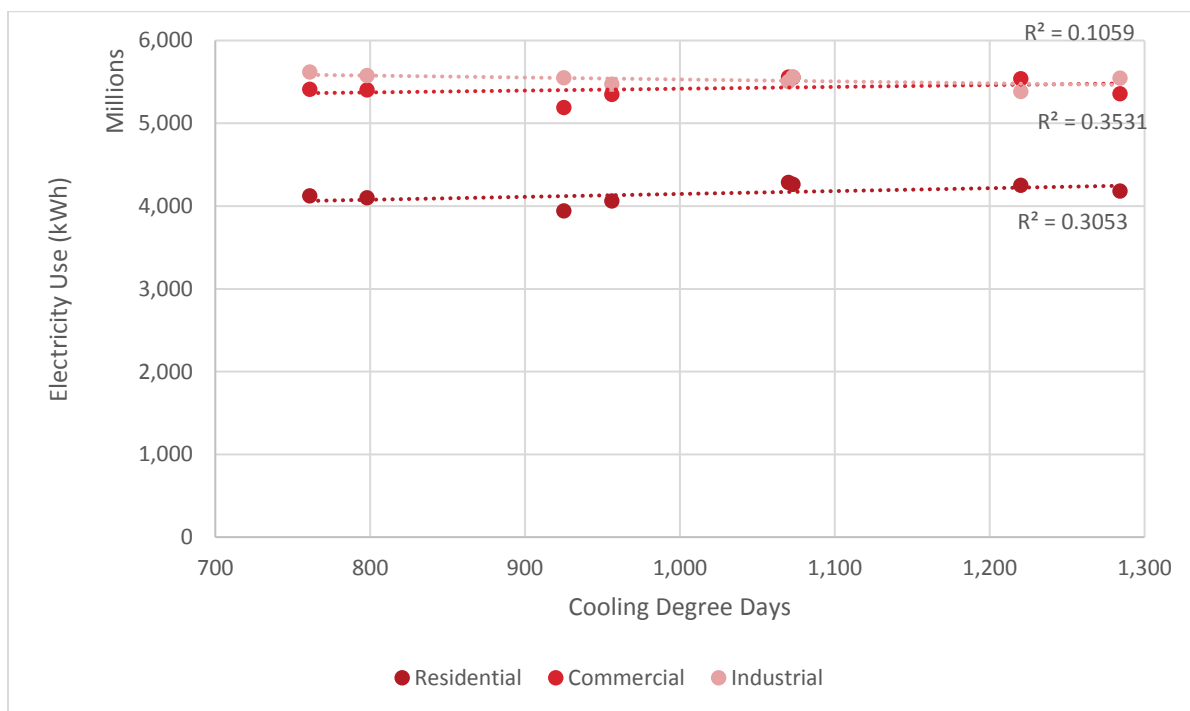| Key Terms |
|---|
| **Cooling Degree Day (CDD):** A measurement that helps quantify the amount of cooling required in a given year. The more cooling degree days the more cooling required. |

Figure 8: Correlation between CDD and Electricity Use

From this graph, it is clear weather is not a major driver in electricity use in any sector, since all trend lines are relatively flat with low R^2-values. This suggests other uses that are not weather dependent, like lighting, appliances, or process uses, dominate electricity uses.

Calculation Methodology

To calculate emissions from electricity, electricity consumption by sector (residential, commercial, industrial) was broken out by the two utilities serving Cuyahoga County - CPP and First Energy. After consumption by sector and utility was determined, the sectoral totals by utility were multiplied by emission factors calculated for each utility. These emission totals by utility and sector were then summed to provide an emissions total for each sector.

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Key Terms
eGrid: Published by the EPA every two years estimating the electricity factor by region.

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Key Terms
Transboundary: Any trip that starts within the County's boundaries and ends outside or a trip that starts outside the County and ends inside the boundaries.
Vehicle Miles Traveled (VMT): A measurement used to quantify on-road travel that measures the distance traveled by all on-road vehicles
MOVES 2014a: A transportation model developed by the EPA to estimate air quality impacts from on-road transportation including air pollution and GHG emissions.

TRANSPORTATION

Transportation emissions include all in boundary transportation, as well as selected transboundary emissions centered around aviation and waterborne transportation. In boundary transportation emissions are estimated using on-road vehicle travel only. Using national statistics available from the Environmental Protection Agency (EPA), an order of magnitude estimate of GHG emissions from off-road vehicles and railways was calculated. In each case, the estimated emissions were significantly less than 1% of the overall inventory, so these data sources were deemed de minimis and excluded.

On-Road Transportation

Emissions from on-road transportation include all vehicle travel within Cuyahoga County limits, regardless of origin or destination. The vehicle miles travelled (VMT) and emission data were provided by Northeast Ohio Areawide Coordinating Agency (NOACA) using the EPA MOVES 2014a model. Over the last seven years, emissions from on-road transportation has increased by 9%, as shown in Figure 9, which corresponds with a continual increase in VMT. Personal driving habits have the largest impact on the overall on-road transportation emissions as passenger vehicles make up 93% of the total VMT and 78% of the on-road transportation emissions.
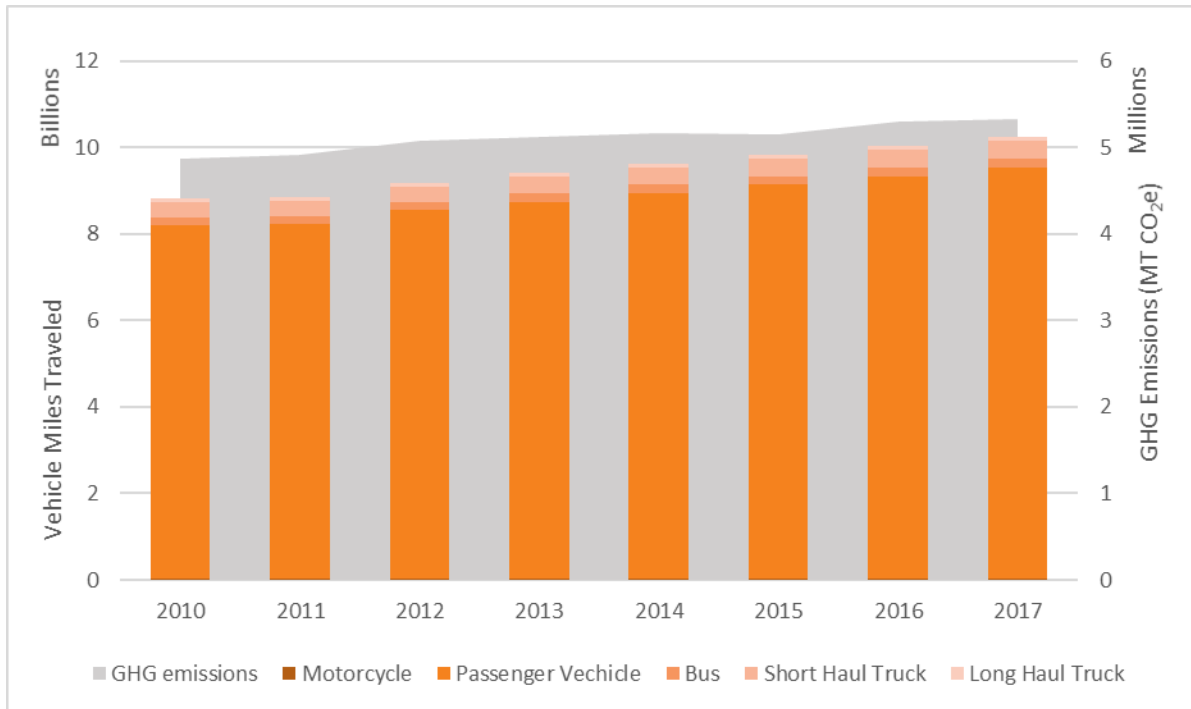
Figure 9. Trends in Vehicle Miles Traveled and Emissions

Although the population decreased from 2010 to 2016, there were more commuters due to an increase in the number of people employed. Other commuting statistics that can help explain the increase in VMT are shown in Table 9.

Key Terms
Single-Occupancy Vehicles: A passenger vehicle who's only occupant is the driver.

Table 9: Commuter Characteristics as Compared to Baseline

	2010	2016	Difference
Workers	559,301	579,624	20,323
Single Occupancy Vehicle Drivers	442,426	455,650	13,224
SOV %	79.10%	78.61%	-0.49%
Carpoolers	43,658	46,034	2,376
Carpool %	7.81%	7.94%	0.14%
Transit Riders	31,187	27,705	(3,482)
Transit %	5.58%	4.78%	-0.80%
% Commute > 30 minutes	31.1	31.8	0.70
Mean Commute	22.70	23.20	0.50
Zero Car Households	5%	4.5%	-0.5%

It should also be noted that a 2013 national transportation study found that commuting accounted for less than 30% of total household travel (American Association of State Highway and Transporation

Officials, 2013). This means that much of the passenger vehicle travel and emissions are for trips other than employee commuting.

Calculation Methodology

NOACA calculated on-road greenhouse gas emissions (GHG) using the most recent version of the US EPA's Motor Vehicle Emissions Simulator, version 2014a (MOVES2014a). Emissions factors for all vehicle class types (e.g. passenger vehicles, buses, heavy-duty trucks) were developed in carbon dioxide equivalent (CO_2e). These emissions factors estimate the grams of each pollutant released per mile (g/mi) for each vehicle class, under various parameters. Emissions factors were selected for vehicles traveling 27.5-32.5 miles per hour (mph), which is approximately the average travel speed for vehicles in the US, according to the US Department of Transportation (US DOT) Department of Transportation Statistics. Emission factors were also selected for buses traveling 12.5-17.5 mph, which covers the average travel speed for buses in the NOACA region.

The selected emission factors (in g/mi) were then multiplied by the total Vehicle Miles Traveled (VMT) for the City of Cleveland and Cuyahoga County for each analysis year. VMT is an indicator of the travel levels on the roadway system by motor vehicles and varies by year. These VMT values are calculated using the NOACA travel demand model and are broken down into vehicle classes. NOACA utilized their travel demand model to develop VMT totals for 2010, 2011, 2018, and 2020, and it then interpolated VMT for the intervening years (2012-2017) using these data. The resulting emissions estimates are expressed in $MtCO_2e$.

Community Breakout

The MOVES model was run for each community to calculate the miles traveled by vehicle type within community boundaries. Modeling provided by Northeast Ohio Areawide Coordinating Agency (NOACA).

Note: The model was run for 2010, 2011, 2018 and 2020 and the interim years were estimated due to the time commitment required to model each year. This means that some communities show unusual jumps in miles traveled or emissions from year to year, but the overall trends from 2010 to 2017 are accurate and consistent. For more information on the change in model parameters, see appendix A.

Aviation

Aviation emissions include commercial flights from Cleveland-Hopkins International (CLE) airport as well as municipal and private flights from both CLE and Burke Lakefront (BKL) airports. As shown in Figure 10, a decreasing number of passengers, coupled with a 9% decrease in fuel consumption per passenger, have resulted in a 17% decrease in commercial air emissions in 2017 from the 2010 baseline.
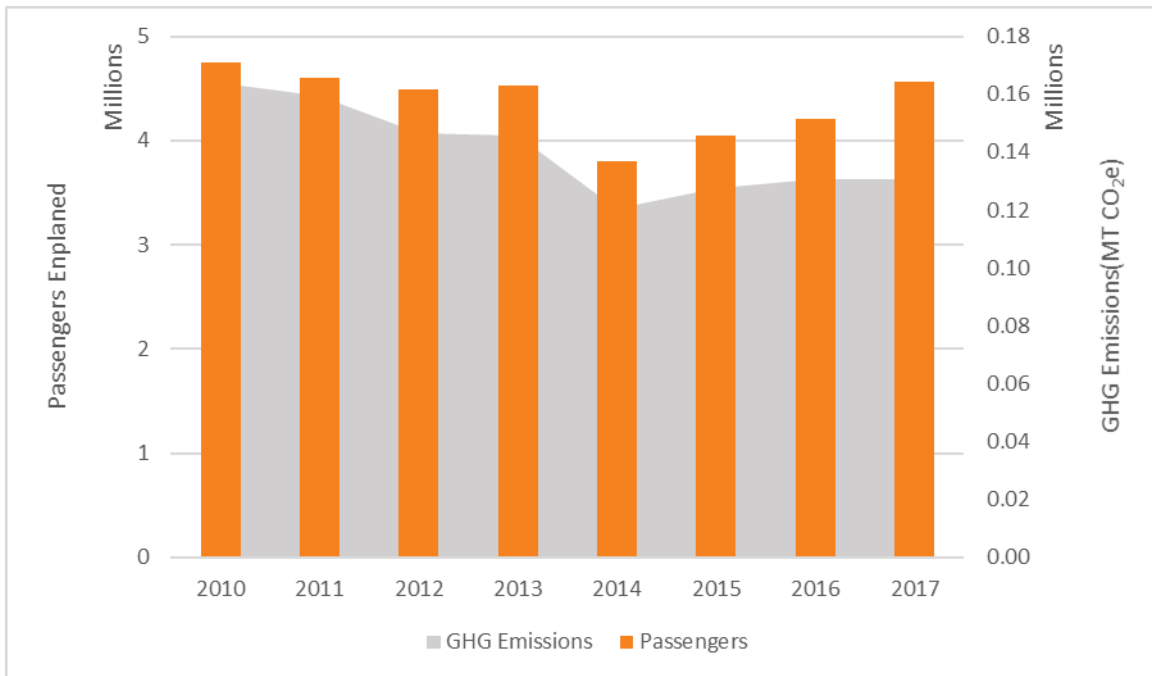
Figure 10. Trends in Passenger Travel at CLE Airport

The sharp decrease in passengers in 2014 correlates to the loss of the Delta Airlines hub at CLE airport.

Note: National flight statistics estimate GHG emissions from passengers was not updated for 2017, so 2016 statistics were used.

Trends for municipal and private flight fuel use at BKL, CLE and Cuyahoga County Airport are shown in Figure 11. Municipal and private flight fuel and emissions have increased by 11% since 2010, but these flights only make up about 28% of aviation emissions and remain a very small portion of the County's overall GHG emissions.
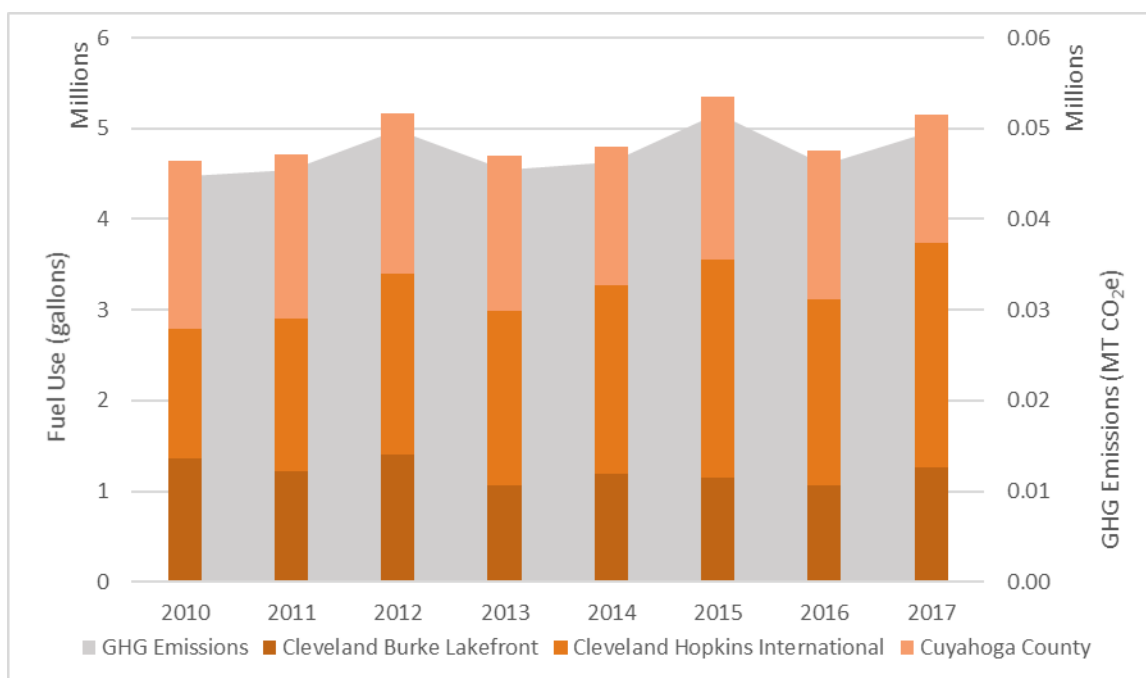
Figure 11. Trends in Passenger Travel at CLE Airport

Calculation Methodology

Commercial Air Travel

To calculate emissions from commercial air travel, total enplaned passengers originating within the city of Cleveland were multiplied by the GHG emissions generated per passenger enplaned and converted from kg CO_2e to MT CO_2e. Total emplaned passengers and GHG emissions generated per passenger were determined through a multistep process outlined below.

Municipal Air Travel

Municipal air travel emissions were determined by multiplying Jet Fuel A and Avgas usage amounts at each of the three airports by each fuel's subsequent emission factors (CO_2, CH_4 and N_2O) which were provided by The Climate Registry (The Climate Registry, 2016). Emissions by fuel type were summed together to provide an emissions total by fuel type and ultimately across fuel types.

Community Breakout

Emissions from all commercial air travel as well as municipal air travel from CLE and BKL airports were attributed to the City of Cleveland, and the emissions from municipal air travel originating at the County airport were attributed to Richmond Heights.

Waterborne Navigation

Waterborne emissions include estimated emissions from all harbor vessel traffic and not only vessels using the Port of Cleveland. This includes vessels that travel up the Cuyahoga River to docks further

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Key Terms

The Climate Registry: A non-profit organization established in 2007 that designs and operates GHG reporting programs in the US and Canada.

Jet Fuel A: Unleaded kerosene fuel used in aircraft

Avgas: A gasoline type specially formulated for use in internal-combustion aircraft

upriver. The emissions estimated are limited to the approach and docking of these vessels and do not include any portion of the vessel's travel between ports.
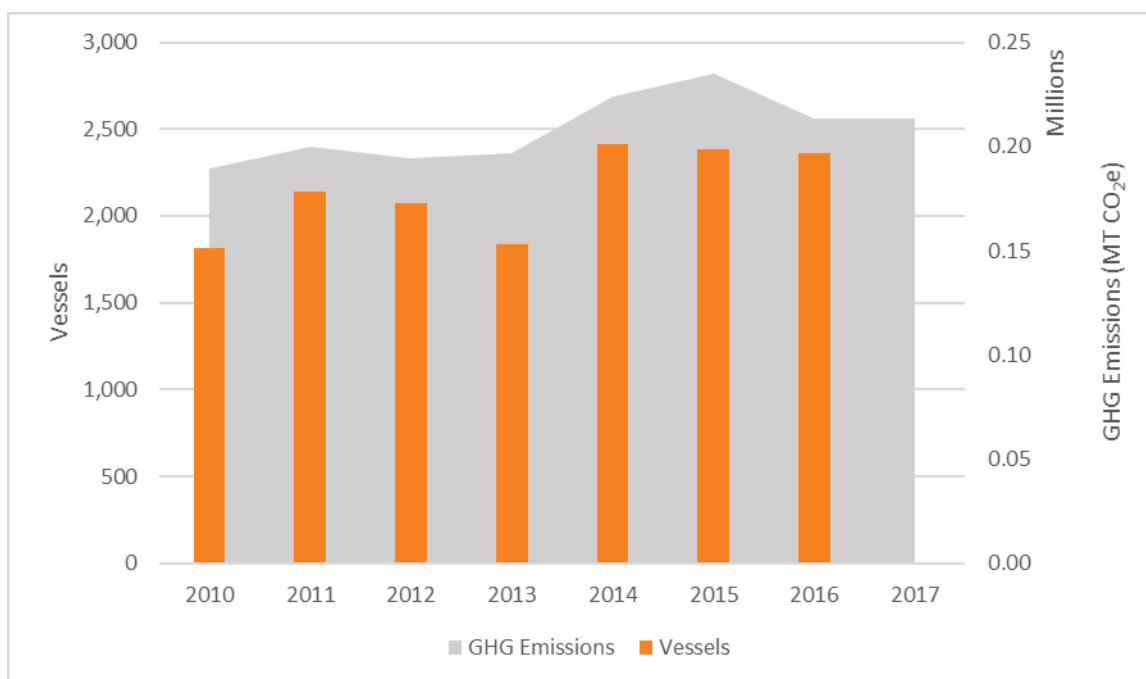

Figure 12. Trends in Waterborne Navigation

Note: At the time of writing this report, 2017 vessel number had not been published yet, so 2016 emissions were used as an estimate.

After seeing an emissions level off from waterborne transportation from 2010 to 2013, emissions rose in 2014 and 2015, which was likely driven by an increase in steel production and shipping from ArcelorMittal Inc.

Calculation Methodology
To estimate the emissions from marine vessels in Cleveland Harbor, the total vessel movement was taken from the Army Corps of Engineer vessel movement reports. The number of vessels is multiplied by emissions factors based on ship type, solid or liquid bulk, and load factors based on movement type, cruise mode, reduced speed mode, and maneuvering mode (Jun & Gillenwater).This data is then applied to time estimates for the amount of time each ship spends in the appropriate mode entering and leaving the docking area.

Community Breakout
All port emissions were attributed to the City of Cleveland.

WASTE
The waste emissions incorporate GHG emissions from solid waste and wastewater generated within the Cuyahoga County boundaries regardless of where the waste is treated.

Solid Waste

Cuyahoga County has seen a 36% decrease in solid waste related GHG emissions between 2010 and 2017. Overall, waste generated from the County has decreased by 2% with residential and commercial waste reduction of 10% and an industrial waste increase of 40%. Emissions have been able to decrease more significantly than the waste reduction due to the capture and use of the landfill gas to generate electricity at Lorain Landfill. The landfill's electricity generation capacity was increased in 2012 to allow the use of all collected landfill gas.
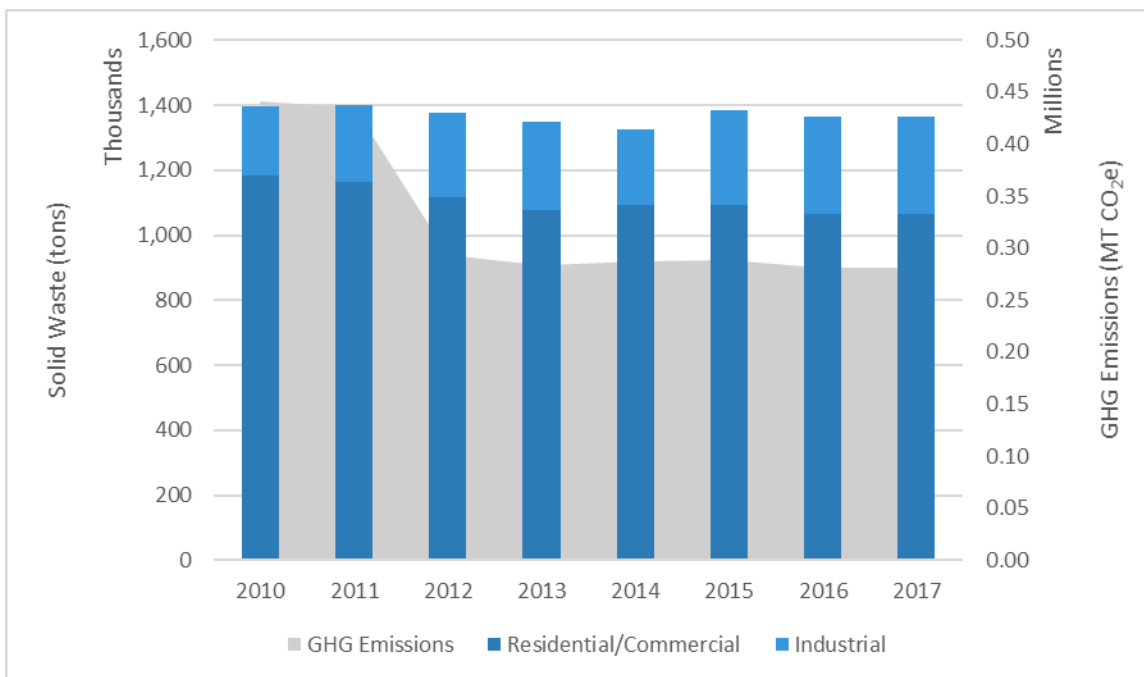

Figure 13. Solid Waste and Emissions by Sector

Calculation Methodology

Solid waste calculations were completed using the methane commitment methodology. In this methodology, the total weight of solid waste disposed of each year is multiplied by the estimated amount of methane that will be given off over that waste's lifetime as it decomposes. Total waste tonnage for the County broken out by residential/commercial waste and industrial waste was used for this analysis. This allowed a separate emissions factor to be applied to each waste type since industrial waste tends to have a lower carbon content than typical municipal solid waste and therefore lower GHG emissions.

Key Terms
Biogenic CO₂: Carbon originating from an organic source such as food waste. This carbon is part of the planet's natural carbon cycle and doesn't contribute to global warming like fossil fuel carbon.

Since the Lorain landfill has a methane capture and electric generation system, the captured methane estimate is then multiplied by a separate emissions factor to account for the conversion of methane to CO_2 during combustion. Any CO_2 released because of the combustion of biogases is considered to be biogenic and excluded.

The solid waste emissions were allocated to the community in which the waste was generated based on population for all communities.

Wastewater

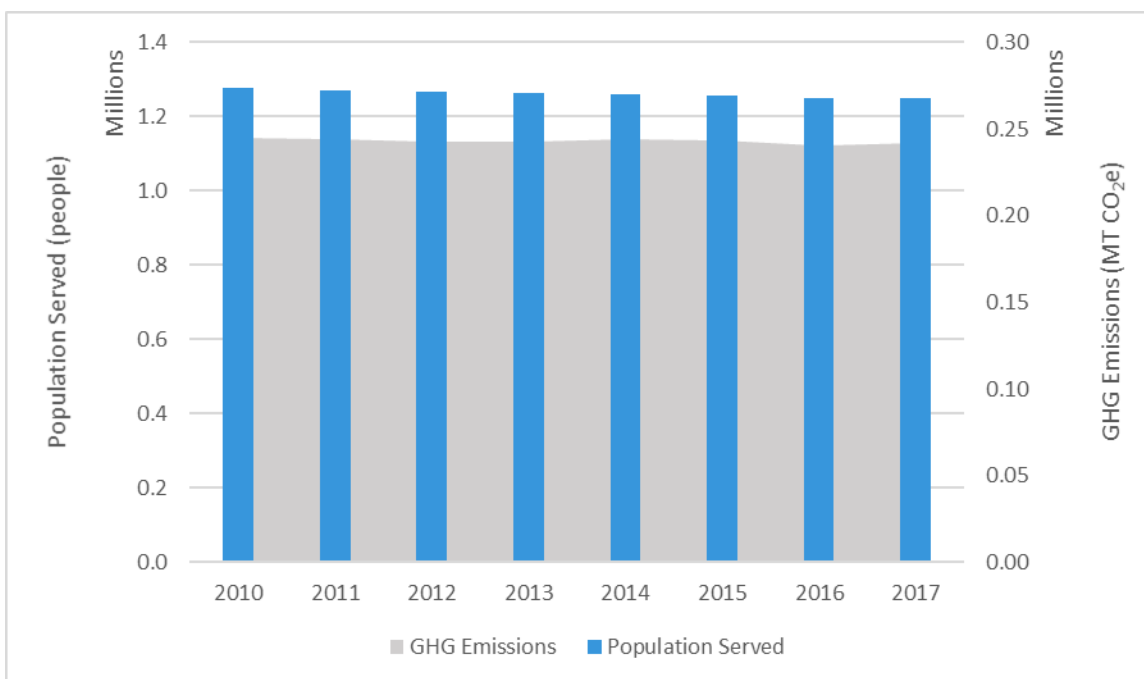The emissions from wastewater treatment processes has remained relatively constant since the 2010 baseline.

Figure 14. Trend in Biosolids from Wastewater Treatment Processing

Note: These calculations only include gasses released by the wastewater during the treatment process and do not include any electricity or natural gas used in the treatment process.

Calculation Methodology

There are three components of wastewater treatment that result in GHG emissions. Each is described below along with the major factor influencing the magnitude of emissions.

1. **Fugitive Effluent Discharge**: These emissions result from water after it is released from the treatment plant. The main factor in the magnitude of these emissions is the nitrogen content of the water leaving the plant, which depends on the water treatment processing in the plant and the nitrogen load of the water entering the plant. If the treatment plant uses nitrification/denitrification in the treatment process, then 70% of the nitrogen in the water is removed. If the water entering the plant has significant amounts of commercial or industrial wastewater, it is assumed to have about 25% more nitrogen than household wastewater.
2. **Treatment Process:** This calculates the emissions as the water is being treated and is calculated based on the population served by the plant and the process that the plant uses to treat the wastewater, whether nitrification/denitrification is used.

3. **Sludge Incineration**: Some treatment plants incinerate the solids removed during the wastewater treatment process. Any carbon released during this process is assumed to be biogenic and is excluded from the inventory, so the only emissions calculated are CH_4 and N_2O resulting from incomplete combustion.
4. **Biogas Incineration**: Methane gas released from the wastewater during the treatment can be captured and used as heating fuel. Again, any carbon released during this process is assumed to be biogenic and is excluded from the inventory, so the only emissions calculated are CH_4 and N_2O resulting from incomplete combustion.

Community Breakout

Wastewater treatment data were available for Cleveland, Euclid, Lakewater, North Olmsted, and Solon. For these communities, the emissions were calculated directly based on the data provided by the wastewater treatment plants. For all other communities, the calculated average GHG emissions per person of all the small wastewater treatment plants (Cleveland excluded) was used to estimate emissions based on population. Only the small plants were included in the per capita emissions estimate because the treatment process is assumed to be similar between all the smaller treatment plants.

INDUSTRIAL PROCESSES AND PRODUCTS

Emissions in this category are taken from the EPA large facility database, which includes any facility that emits 25,000 $MTCO_2e$ or more per year. These emissions come from two categories - stationary combustion in industrial processes and industrial product emissions. Stationary combustion in industrial processes includes any fuel burned on-site other than natural gas including coal and fuel oil usually used for the purposes of running industrial furnaces or boilers. Industrial product use includes any gasses given off by products such as paints or other chemicals used in an industrial process.
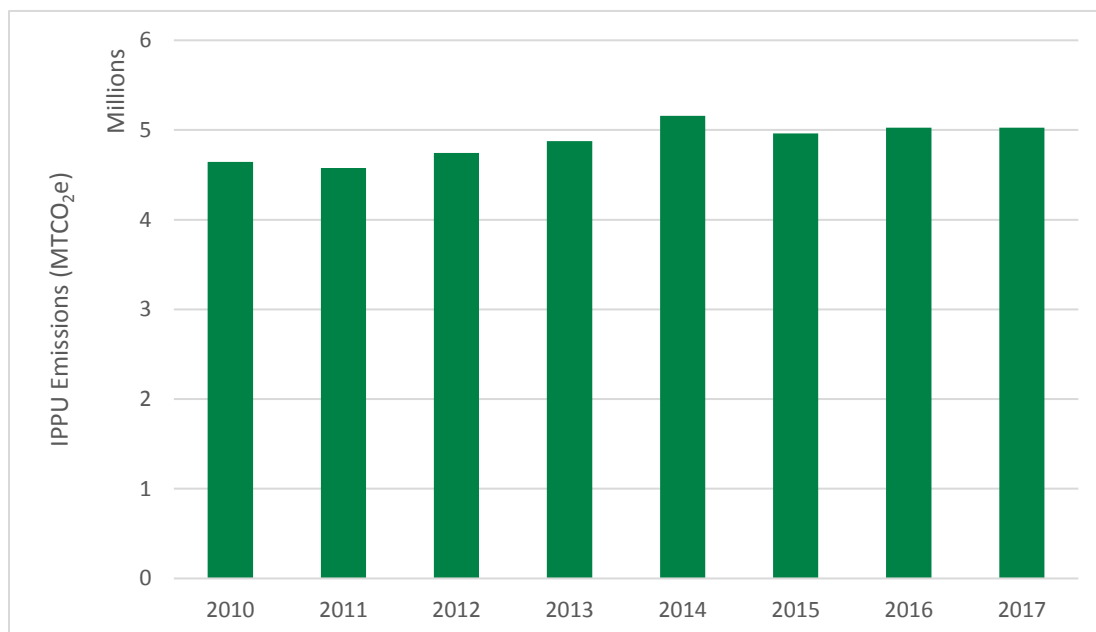

Figure 15. Industrial Process and Product Emissions

These emissions are taken directly from the EPA database and allocated to the community in which the facility is located. The large facilities located in Cuyahoga County are:

1. ArcelorMittal Cleveland, Inc.
2. Arconic Inc.
3. Charter Steel Cleveland
4. Cleveland Clinic
5. Cleveland Thermal, LLC
6. DAY-GLOW Color Corp
7. Digeronimo Aggregates LLC
8. Ford Motors
9. Lincoln Electric Co
10. Medical Center Company

Next Steps

Based on our work developing the GHG inventory for the County, Brendle Group recommends prioritizing the following three objectives in the County's climate action plan (CAP) process. These objectives were identified as those with the possibility for the largest impact on emissions or where we felt that collaboration between the City of Cleveland and the County would be most beneficial.

1. **Regional Public Transportation**: Through the GHG inventory process we found that on-road transportation emissions have increased in the county significantly between 2010 and 2017. Since significant progress in reducing on-road emissions often requires regional collaboration on public transit project, we recommend the county choose to make public transportation a focus of their CAP. Based on our experience in transportation related initiatives, we expect emissions reductions of approximately 5% of total on-road emissions.
2. **Support Clean Energy Policy**: As directed by the Ohio Public Utility Commission (PUC), utilities are required to incorporate at least 12.5% renewable energy into their generation mix by 2025. Incorporating renewable energy has led to some of the largest decreases in GHG emissions in the County over the last 7 years, so we recommend the County work to encourage utility investment in renewable energy beyond the PUC mandate. If the County worked with the City to push local utilities to at least 20% renewable energy by 2030, that could result in an estimated 15% reduction in electricity emissions.
3. **Energy Efficiency**: Many energy efficiency measures have a short payback period and can lead to overall cost savings to utility customer, so objectives targeted to promote energy efficiency in the County have co-benefits of reducing resident utility costs and reducing GHG emissions. Energy efficiency measures can typically save about 30% of building energy use. Based on typical energy efficiency program participation, energy efficiency objectives could save approximately 5% of all building energy emissions by 2030.

Due to data quality issues between 2010 and 2015, we recommend the County employs a 2016 baseline year for reporting to the Covenant of Mayors and for its CAP goals. There are two benefits from using this year 1) this is the first year in which all data were available 2) Cleveland's updated CAP uses the 2016 GHG

inventory for interim analysis for progress towards 2030 goals, so the County's CAP would align well with the City's.

The estimated emissions savings from these three initiatives represent about 10% emissions savings between 2016 and 2030. Depending on how aspirational the County is looking to be with their emissions reduction targets, we would recommend setting a goal between 10-20% emissions reduction from the 2016 baseline by 2030.

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Appendix A: MOVES 2014a Model Parameters

The following updates to the VMT model occurred between 2010/2010 and 2018/2020 modeling years:

Socioeconomic:
- 2010-2011 Run Years: 2000 Census
- 2018, 2020 Run Years: 2010 Census

Traffic Analysis Zones (TAZ)
- 2010-2011 Run Years: 1,236
- 2018, 2020 Run Years: 5,300

Modeling Periods:
- 2010-2011 Run Years: Fewer
- 2018, 2020 Run Years: More. "Early Moring", "AM Peak", "Mid-day Off-Peak", "PM Peak", and "Night Time."

Modeling highway and transit network:
- 2010-2011 Run Years: Fewer
- 2018, 2020 Run Years: More

2012 – 2017 Inventory Years:
- Interpolated based on 2010, 2011 and 2018 model run outputs.

Finally, in the near future, NOACA will utilize two travel forecasting model; Trip-based model and activity-based model.