Orange County Greenhouse Gas Emissions Inventory

2017 Calendar Year

March 2, 2020

ORANGE COUNTY
NORTH CAROLINA

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Acknowledgements

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Executive Summary

Introduction and background

The goal of this report is to understand the 2017 greenhouse gas (GHG) emissions attributable to human activities in Orange County and to establish a baseline for a climate action plan that will propose strategies to meet the County's GHG reduction goals. This emissions inventory also illustrates Orange County's ongoing commitment to climate action as a signatory to the Global Covenant of Mayors. Since joining in June of 2018, this covenant requires a comprehensive inventory of countywide GHG sources every two years including electric and gas utilities, combustion-engine powered transportation, solid and liquid waste, and other emission sources.

Methods

The Global Covenant of Mayors requires a GHG emission inventory that meets Basic level reporting requirements set out in the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC). The GPC specifies data collection, quantification and aggregation. The primary contribution to greenhouse gas emissions is the release of greenhouse gases from the combustion of fossil fuels for energy. This release is quantified with emission's factors (E-Factors) that relate the amount of a given greenhouse gas released for a given amount of energy generated. Carbon dioxide, methane, and nitrous oxide are the greenhouse gases inventoried. Since the ability of these gases to trap heat varies, the Intergovernmental panel on Climate Change (IPCC) created the concept of Global Warming Potential (GWP). Carbon dioxide is used as the base gas with a GWP of 1. Methane and nitrous oxide are converted to carbon dioxide equivalents (CO_2e) using their global warming potential (28 and 265 respectively) as specified in the IPCC 5^{th} assessment report 100 year values. For a given process the total CO_2e for that process is calculated by combining the CO_2e for the constituent greenhouse gases. The CO_2e for a constituent gas is the product of the energy generated, the E-factor, and the GWP. All emissions are reported in metric tons (1000 kg or 2204 pounds) of carbon dioxide equivalents (CO2e).

Findings

Orange County emissions are summarized in Table 1 and Figure 1 using the categories from the 2017 North Carolina Greenhouse Gas Inventory, January, 2019. As shown in the table, the estimated county-wide emissions for Orange County totaled 1,777,667 metric tons (mt) CO2e of which 95% come from energy-related sources.

After obtaining and compiling the emissions from Orange County's energy-related sources, the carbon dioxide emissions total for 2017 was 11.9 metric tons per capita (assuming 142,830 population from the North Carolina Office of State Budget and Management).

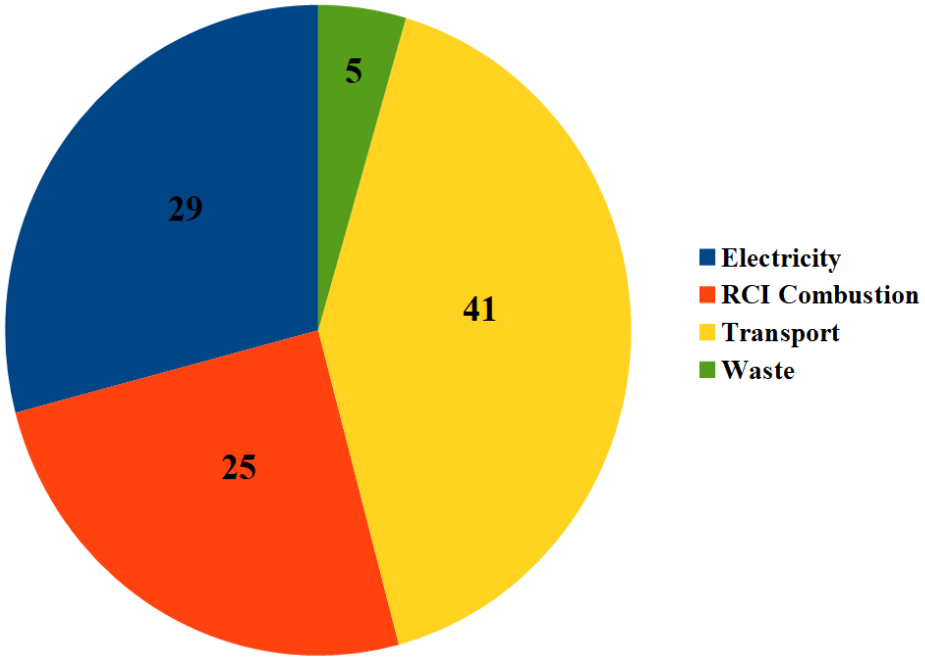
The most recent United States Energy Information Administration (EIA) totals for 2016 for North Carolina align with these local figures at 11.9 metric tons of carbon dioxide emitted per capita. For context, 11.9 metric tons per capita is 26% less than the national average reported by the EIA of 16 metric tons per capita.

The EIA estimates total greenhouse gas emissions from energy-related sources in each state. These emissions, primarily carbon dioxide, include those from direct fuel use across all sectors, including residential, commercial, industrial, and transportation, as well as primary fuels consumed for electricity generation. The most recent inventory, "The Energy-Related Carbon Dioxide Emissions by State, 2005-2016", was published in February, 2019.

Table 1 - Orange County Greenhouse Gas Emissions in 2017

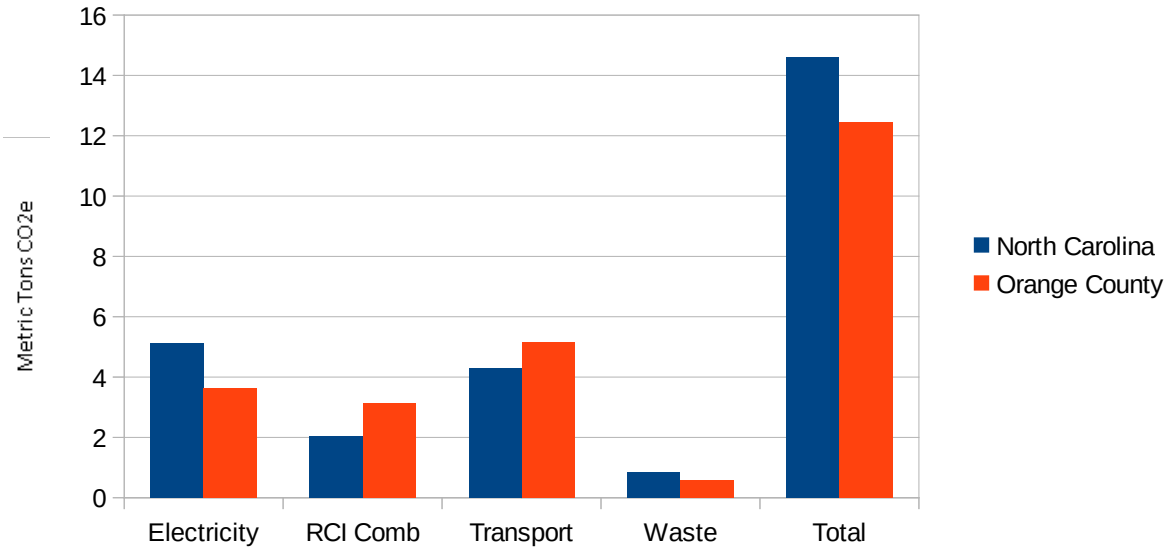
Emissions Sources	Orange County 2017 Emissions (mt CO_2e)
Electricity Generation and Use	516,755
Residential/Commercial/Industrial Combustion	445,366
Transportation – Highway	734,287
Waste Management	81,259
Total OC Emissions	**1,777,667**

Figure 1 - 2017 Orange County Greenhouse Gas Emissions by Percentage



The following graph compares the per capita emissions in 2017 from the North Carolina Greenhouse Gas Inventory, (Released Jan 2019, Assumes North Carolina population of 10.273 million as reported by the North Carolina Office of State Budget and Management) and from the Orange County 2017 Inventory.

Figure 2 - 2017 Per capita greenhouse gas emissions in Orange County vs North Carolina



Built Environment Emissions

Emissions from Natural Gas

Natural gas consumption data is provided by sector in 2017 from the sole community distributor of natural gas in Orange County, PSNC Energy (subdivision of Dominion Energy). The following table shows the energy generated from the combustion of natural gas by economic sector (residential, commercial and industrial), the relevant emissions factors, and the computed CO_2e emissions. The CO_2e emissions for each greenhouse gas were computed as described in the methods section. The emissions factors were obtained from U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Appendix C: Built Environment Emission Activities and Sources Version 1.1 July 2013 Table B.2.

Table 2 - Natural Gas Emissions by Sector

Sector	mmBTU	CO_2 E-Factor (mt/ mmBTU)	CO_2 emitted (mt CO2e)	CH_4 E-Factor (mt/ mmBTU)	CH_4 emitted (mt CO2e)	N_2O E-Factor (mt/ mmBTU)	N_2O emitted (mt CO2e)	Total CO_2e (mt)
Commercial	1,324,598	0.05302	70,230	0.000005	185	0.0000001	35	70,451
Industrial	89,535	0.05302	4,747	0.000001	3	0.0000001	2	4,752
Residential	1,196,433	0.05302	63,435	0.000005	168	0.0000001	32	63,634
Total	**2,610,565**		**138,412**		**355**		**69**	**138,837**

Emissions from University of North Carolina

The only user of coal within Orange County is the University of North Carolina – Chapel Hill (UNC). UNC uses coal, natural gas and fuel oil in a cogeneration plant to provide steam and electricity to university facilities. The fuel usage and emissions data for the cogeneration plant was obtained from the 2017 Annual Air Emissions Inventory Cogeneration Facility prepared by RST Engineering for UNC and released in June, 2018. The cogeneration plant emission sources were three boilers and two blackstart generators. The two primary boilers

are equipped with continuous emission monitoring devices to measure SO_2, NOx, and CO_2 emissions from each of the boilers. The following table shows the 2017 consumption of fuels at the cogeneration plant, the energy produced, and the greenhouse gases emitted for each fuel type.

Table 3 - Emissions by the University of North Carolina by Fuel Type

Fuel	Fuel Units	Amount	mmBTU	CO_2 emitted (mt CO2e)	CH_4 emitted (mt CO2e)	N_2O emitted (mt CO2e)	Total CO_2e (mt)
Coal	tons	74,426	1,899,500	216,189	584	721	217,495
Natural Gas	1000 ft^3	589,461	607,145	39,430	25	-	39,455
Fuel Oil	gallons	11,526	1,581	122	-	-	122
Total			2,508,226				257,073

The total carbon dioxide equivalent emissions from the cogeneration plant were 257,073 metric tons.
The University also purchases electricity from Duke Energy Carolinas and the emissions from that purchased power are included in the commercial sector of the Electric Utility emissions.

Emissions from Other Fuel Use in the Residential Sector (Propane, Kerosene)

Since the suppliers of propane and kerosene to Orange County households cannot readily be identified, this GHG inventory relies on government databases to estimate the use of propane and kerosene in OC households. Initially the average usage of these gases in North Carolina households was obtained from federal databases. The U.S. Energy Information Administration, 2015 Residential Energy Consumption Survey (RECS) estimated the total number of households in North Carolina using stationary fuel by fuel type: Propane – 500,000 and Kerosene – 200,000. The U.S. Energy Information Administration, 2016 State Energy Data System (SEDS) estimated total North Carolina residential energy usage: Propane – 14.8 trillion BTU and Kerosene – 1.2 trillion BTU. From these numbers, the energy use per North Carolina household was computed with 29.6 mmBTU/household coming from propane usage and 7.5 mmBTU/household coming from kerosene. The 2016 US Census estimated the number of Orange County households using each of these gases: propane 4,189 households and kerosene 387 households. From these numbers the multiplication of the estimated North Carolina household usage by the number of households in Orange County using each gas yielded the estimated residential energy consumption from these gases: propane 124,000 mmBTU and kerosene 2,900 mmBTU. The total Orange County residential emissions from propane and kerosene by applying the emissions factors for CO_2, CH_4, and N_2O, and the associated GWP factors were summed for total residential kerosene and propane CO_2e emissions in 2017.

Table 4 - Other Stationary Fuel Emissions by Fuel Type

Fuel	mmBTU	CO_2 E-Factor (mt CO_2 / mmBTU)	CO_2 Emitted (mt CO_2e)	CH_4 E-Factor (CH_4 mt / mmBTU)	CH_4 Emitted (CO_2e mt)	N_2O E-Factor (N_2O mt / mmBTU)	N_2O Emitted (CO_2e mt)	Total Emitted CO_2e (mt)
Propane	124,000	0.0615	7,626	0.000003	10	0.0000006	20	7,656
Kerosene	2,900	0.0752	218	0.000003	0	0.0000006	0	219

Emissions from Electricity Use and Electric Power Transmission and Distribution Losses

The community's 2017 electricity use was obtained from Orange County's two electric utilities: Duke Energy Carolinas (DEC) and Piedmont Electric Membership Corporation (PEMC). Both organizations

provided total kWh partitioned by sector: residential, commercial, and industrial, as well as the number of customers in each sector. We considered two sources for the electric utility emission factor: eGRID and Duke Energy Carolinas. The Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive inventory of environmental attributes of electric power systems. The preeminent source of air emission data for the electric power sector, eGRID is based on available plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. eGRID uses data from the Energy Information Administration (EIA) Forms EIA-860 and EIA-923 as well as the EPA's Clean Air Markets Program Data. The latest update to eGRID for 2016 was released February 2, 2018. For North Carolina, the total output emission rate (lbs/kWh) was as follows: carbon dioxide 0.867, methane 0.00080, and nitrous oxide 0.000011, summing to carbon dioxide equivalents of 0.872. However DEC provided an emissions factor reflecting their generation sources (approximately 54% nuclear and 45% fossil fuels) so it is considered more accurate than eGRID averages. DEC stated their 2017 emission factor was 0.69 lbs CO_2e/kWh which includes carbon dioxide, methane and nitrous oxide. PEMC did not provide any emissions factor. Since PEMC obtains its electricity from DEC, the DEC emissions factor was also used for PEMC.

GHG emissions were calculated by multiplying the electricity consumption (kWh) by the CO2e emission factor obtained in step 2 (0.69lbs CO_2e/kWh) and dividing by the conversion factor for pounds to metric tons, 2,204.6. These electricity consumption values are based on utility records from meter readings at the point of use. The electric power transmission and distribution losses are based on estimates for grid losses associated with the end-user consumption of electric energy. The losses are computed as a percentage of the consumed electricity. DEC does not provide any grid loss factors. The most recent eGRID grid loss factors are from 2016. Orange County is in the SRVC (SERC Virginia/Carolina) eGRID subregion. The 2016 Grid Gross Loss factor for SRVC from the eGRID summary tables 2016, Table 1 - Subregion – Output Emission Rates is 4.49%. The total CO_2e emissions from electricity generation for Orange County is 487,162 metric tons.

Table 5 - Electric Utility Emissions by Sector

Sector and Utility	Electricity Consumed (kWh)	eGRID 2016 Grid Gross Loss Factor for SRVC	E-Factor (lbs CO_2e/kWh)	CO_2e Emissions (mt)
Residential	**620,360,457**			**203,287**
Duke Energy Carolinas	497,602,240	1.047	0.69	163,060
PEMC	122,758,217	1.047	0.69	40,227
Commercial	**809,040,264**			**265,116**
Duke Energy Carolinas	776,643,905	1.047	0.69	254,500
PEMC	32,396,359	1.047	0.69	10,616
Industrial	**57,245,643**			**18,759**
Duke Energy Carolinas	57,245,643	1.047	0.69	18,759
PEMC	0	1.047	0.69	0
Total	1,486,646,364			487,162

Upstream Emissions from Stationary Fuel Combustion

Upstream emissions include primarily carbon dioxide and methane emissions that occur during resource extraction, production processing and conversion, and delivery to the site. To calculate the upstream emissions

from Orange County's fossil fuel sources, the mass of each fuel must be established since the upstream emissions depend on the type of fossil fuel. Since DEC and PEMC generate electricity with sources other than fossil fuels, the proportion of DEC's electricity generated from fossil fuels can be obtained from the December, 2017 Fuel Report. The following table specifies DEC's generation of electricity by fuel type.

Table 6 - Proportion of Duke Energy Carolinas Electricity Generation by Fuel Type

Fuel	Megawatt hours generated by Fuel	Percentage of Electricity Generated by Fuel
Coal	25,573,401	31.3
Fuel Oil	94,323	0.1
Natural Gas	10,862,304	13.3
Nuclear	44,387,125	54.3
Hydro	649,863	0.8
Solar	125,812	0.2
Total MWh	81,692,828	100.0

The following table summarizes all the fossil fuels burned for energy which was consumed in Orange County except for propane for which no upstream emissions data could be found.

Table 7 - Total energy generated for the built environment using fossil fuels

Fuel	Energy (mmBTUs)
Coal	**3,487,239**
UNC Cogen	1,899,500
Duke Energy	1,422,034
PEMC	165,705
Natural Gas	**3,892,372**
PSNC	2,610,565
UNC Cogen	607,145
Duke Energy	604,251
PEMC	70,411
Fuel Oil	**6,653**
UNC Cogen	1,581
Duke Energy	4,543
PEMC	529
Kerosene	**2,900**
Total	**7,389,164**

Upstream emissions in units of kg CO_2e per unit of fuel were obtained from Table B.13 of Appendix C of the 2013 U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (ver 1.1). The upstream emissions for the four fuels totaled 71,174 metric tons or roughly an additional 8% beyond the emissions for combustion alone.

Table 8 - Upstream emissions from fossil fuels consumed for Orange County

Fuel	Energy (mmBTU)	Fuel Units	Conversion factor from mmBTU to number of fuel units	Number of Fuel Units	Upstream Emissions in kg CO_2e per unit of fuel	Total Upstream CO_2e (mt)
Bituminous Coal	3,487,239	1000kg	28.1329	123,956	189	**23,428**
Natural Gas	3,892,372	1000 m^3	36.3742	107,009	445	**47,619**
Distillate Fuel Oil	6,653	1000 liters	36.2455	184	492	**90**
Kerosene	2,900	1000 liters	36.3170	80	459	**37**
Total						**71,174**

Built Environment Emissions Summary

The following table summarizes the energy generated by the combustion of fossil fuels by various suppliers and the associated carbon dioxide equivalents emitted from combustion and upstream emissions. The total emitted carbon dioxide equivalents from combustion and upstream emissions of stationary carbon fuels in Orange County for 2017 was 962,121 metric tons.

Table 9 Combustion and Upstream Emissions from Fossil fuels by fuel type and source

Fuel and Utility	Energy (mmBTUs)	Combustion Emissions CO_2e (mt)	Upstream Emissions CO_2e (mt)	Upstream Emissions for Fuel as Percent of Total for that Fuel	Total Emissions CO_2e (mt)	Fuel's Percentage of Total Emissions
Coal	**3,487,239**	**627,818**	**23,428**	**3.7**	**651,246**	**67.7**
UNC Cogen	1,899,500	217,495	8,116		225,611	
Duke Energy	1,422,034	367,499	13,714		381,213	
PEMC	165,705	42,824	1,598		44,422	
Natural Gas	**3,892,372**	**254,042**	**47,619**	**18.7**	**301,661**	**31.4**
PSNC	2,610,565	138,837	26,024		164,861	
UNC Cogen	607,145	39,455	7,396		46,851	
Duke Energy	604,251	67,844	12,717		80,561	
PEMC	70,411	7,906	1,482		9,388	
Fuel Oil	**6,653**	**1,212**	**90**	**7.4**	**1,302**	**0.1**
UNC Cogen	1,581	122	9		131	
Duke Energy	4,543	976	72		1,048	
PEMC	529	114	8		122	
Kerosene	**2,900**	**219**	**37**	**16.9**	**256**	**0.0**
Propane	**124,000**	**7,656**	**NA**		**7,656**	**0.8**
Total	**7,513,164**	**890,947**	**71,174**		**962,121**	**100**

The same data from Table 9 is reorganized in Table 10 to show combustion and upstream emissions by sector.

Table 10 - Emissions from fossil fuel combustion and upstream emissions by sector

Sector and Source	Energy Generated from Fossil Fuel (mmBTUs)	CO_2e (mt)	Percent Total CO_2e Emissions
Residential	**2,269,524**	**299,110**	**31**
Electricity	946,191	215,636	
Natural Gas	1,196,433	75,562	
Kerosene	2,900	256	
Propane	124,000	7,656	
Commercial	**2,558,569**	**364,877**	**38**
Electricity	1,233,971	281,221	
Natural Gas	1,324,598	83,656	
Industrial	**176,847**	**25,541**	**3**
Electricity	87,312	19,898	
Natural Gas	89,535	5,643	
UNC	**2,508,226**	**272,593**	**28**
Total	**7,513,166**	**962,121**	**100**

Transportation Emissions

Transportation emissions were developed from vehicle miles traveled (VMT) in the community as estimated by the DCHC MPO. The DCHC MPO estimated Orange County's VMT using the Triangle Regional Model which estimates past, present, and future transportation metrics. It is a travel demand model that utilizes a traditional four-step trip-based model process consisting of trip generation, trip distribution, mode choice, and trip assignment for the Research Triangle region. The estimated VMT for Orange County in 2017 was 1,718,977,020 miles. This estimated VMT was analyzed by the North Carolina Division of Air Quality using the *EPA's* Motor Vehicle Emission Simulator (*MOVES*) and received from Todd C. Pasley, an environmental engineer for the North Carolina Division of Air Quality. According to Mr. Pasley,

> "The MOVES model calculates vehicle power requirements and the fuel consumption needed to supply that power based on the physics of vehicle operation and does not use fuel efficiency or EPA predicted miles per gallon. Vehicle Specific Power (for light duty vehicles) and Scaled Tractive Power (for heavier duty vehicles) are calculated based on several vehicle operating parameters (such as speed, acceleration, vehicle weight, aerodynamic drag, road gradient, etc.) that define vehicle operating modes. Fuel consumption and subsequently GHG emissions are calculated based on vehicle operation over the entire series of operating modes."

Table 11 contains MOVES estimates for VMT and greenhouse gas emissions by vehicle type.

Table 11 - Vehicle GHG Emissions and Energy Use by Vehicle Type 2017

Annual On-road Mobile Source GHG Emissions and Energy Use by Vehicle Regulatory Class - Orange County, NC - 2017				
Vehicle Regulatory Class	**Fuel Type**	**Annual Vehicle Miles Traveled (VMT)**	**Total Energy Consumption (MMBtu)**	**Total GHG Emissions CO_2e (mt)**
Motorcycles	Gasoline	9,020,229	42,956	3,275
Light Duty Vehicles	Gasoline	1,332,075,056	5,715,953	436,319
Light Duty Trucks	Gasoline	240,381,470	1,411,244	108,702
Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)	Gasoline	8,336,205	54,751	4,261
Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)	Gasoline	2,931,741	39,364	3,009
Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)	Gasoline	3,122,450	42,102	3,217
Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)	Gasoline	1,036,752	14,014	1,073
Class 8a and 8b Trucks (GVWR > 33,000 lbs)	Gasoline	37,254	577	44
Light Duty Vehicles	Diesel Fuel	10,653,963	44,789	3,495
Light Duty Trucks	Diesel Fuel	2,738,515	18,665	1,454
Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)	Diesel Fuel	4,174,375	36,928	2,878
Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)	Diesel Fuel	5,813,504	84,899	6,612
Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)	Diesel Fuel	4,931,605	63,624	4,957
Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)	Diesel Fuel	14,659,530	265,871	20,711
Class 8a and 8b Trucks (GVWR > 33,000 lbs)	Diesel Fuel	72,175,654	1,662,459	129,822
Urban Bus (see CFR Sec 86.091_2)	Diesel Fuel	1,830,248	30,748	2,394
Urban Bus (see CFR Sec 86.091_2)	CNG	290,259	5,758	415
Light Duty Vehicles	Ethanol (E-85)	3,301,381	13,947	1,052
Light Duty Trucks	Ethanol (E-85)	1,466,830	7,894	596
Total - All Vehicle Types		**1,718,977,020**	**9,556,542**	**734,287**

Liquid and Solid Waste

Chapter 8 of the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC) contains the methods for analyzing Orange County waste that was generated and treated in the county and waste that was generated in the county and exported for treatment. The Orange County solid waste came in three streams: solid waste collected from homes and businesses and hauled to Sampson County, biogas collected from a capped landfill and delivered to UNC for combustion, and yard and food waste that was composted. For the solid waste hauled to Sampson County, the composition of the waste was obtained from the Orange County Waste Composition Study, June, 2017. The quantification of GHG emissions from this waste was determined by two main factors: the amount of degradable organic carbon (DOC) within the waste and the methane generation potential. The calculation of these factors is shown in Appendix C. For the methane derived from landfill biogas, it was assumed that all the gas was fully combusted into carbon dioxide. For the yard and food waste it was assumed that half the waste was dry and half was wet. Based on data from fiscal year 2016-17 the results from these assumptions and calculations are displayed in Table 12.

Table 12 - Greenhouse Gas emissions from Orange County Municipal Solid Waste

Orange County Municipal Solid Waste	Volume (mt)	Methane Released (mt)	Carbon Dioxide Released (mt)	CO_2e released (mt)
MSW shipped to Sampson	52,000	2,543	-	71,204
Methane delivered to UNC for combustion	1,500	-	4,125	4,125
Composted Solid Waste	17,187	120		3,360
Truck Hauling to Sampson(2605 trips) by class 8 truck burning diesel – 90 miles one-way				420
Total CO_2e emissions from MSW				**79,109**

For treatment of liquid waste Orange Water and Sewer Authority (OWASA) obtained about 65 billion BTUs of energy from utilities during 2017. This energy usage is included in previous analysis. However, OWASA's Mason Farm Waste Water Treatment Plant produces about 110,000 cubic feet of biogas each day which contains approximately 65% methane and 34% carbon dioxide with other trace constituents based on a sample analysis done by Unison Solutions. The yearly volume of methane and carbon dioxide are about 26.1 and 13.65 million cubic feet respectively. The combustion of this methane yields about 1385 metric tons of carbon dioxide/year and 13.65 million cubic feet of carbon dioxide at standard temperature and pressure weighs about 765 metric tons (See Appendix C for an explanation of these calculations).

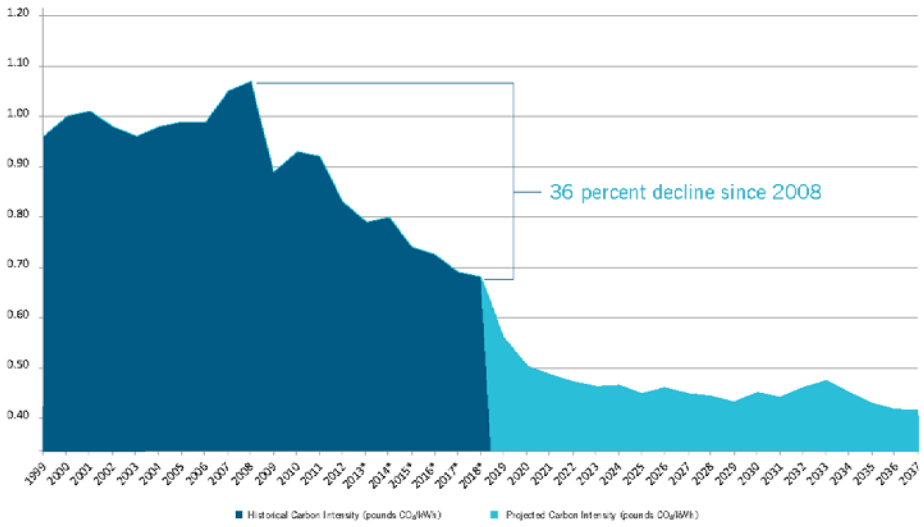
DUKE ENERGY CAROLINAS

Historical and Projected Carbon Intensity of Generated Electricity

Projections based on 2018 Integrated Resource Plan (IRP) with Joint Dispatch

HISTORICAL	
Year	Duke Energy Carolinas'* CO_2 Carbon Intensity
1999	0.96 pound/kWh
2000	1.00 pound/kWh
2001	1.01 pounds/kWh
2002	0.98 pound/kWh
2003	0.96 pound/kWh
2004	0.98 pound/kWh
2005	0.99 pound/kWh
2006	0.99 pound/kWh
2007	1.05 pounds/kWh
2008	1.07 pounds/kWh
2009	0.89 pound/kWh
2010	0.93 pound/kWh
2011	0.92 pound/kWh
2012	0.83 pound/kWh
2013*	0.79 pound/kWh
2014*	0.80 pound/kWh
2015*	0.74 pound/kWh
2016*	0.73 pound/kWh
2017*	0.69 pound/kWh
2018*	0.68 pound/kWh

* Note: Results since 2013 are for the combined DEC and DEP fleet.



**Notes:

1. Based on the results of the 2018 IRPs for Duke Energy jurisdictions in the Carolinas.
2. This forecast includes a carbon penalty beginning in 2025 at $5/ton CO_2 emitted and escalates by $3/year throughout the study.
3. Capacity expansion and retirements are as detailed in the 2018 IRP document.
4. Projections include only Duke Energy's ownership portion of Catawba Nuclear Station.
5. Projections include pump load required at pump storage facilities.
6. Projections include Second License Renewal at all of Duke Energy's nuclear units.
7. Projections include Ancillary Requirements. Throughout time, the increase in renewable penetration requires larger ancillary requirements.

PROJECTED**	
Year	Duke Energy Carolinas'* CO_2 Carbon Intensity
2019	0.56 pound/kWh
2020	0.50 pound/kWh
2021	0.48 pound/kWh
2022	0.47 pound/kWh
2023	0.46 pound/kWh
2024	0.46 pound/kWh
2025	0.45 pound/kWh
2026	0.46 pound/kWh
2027	0.45 pound/kWh
2028	0.44 pound/kWh
2029	0.43 pound/kWh
2030	0.45 pound/kWh
2031	0.44 pound/kWh
2032	0.46 pound/kWh
2033	0.47 pound/kWh
2034	0.45 pound/kWh
2035	0.43 pound/kWh
2036	0.42 pound/kWh
2037	0.41 pound/kWh

Piedmont Electric Membership Corporation (PEMC) Emissions Factor:

PEMC is a power distribution cooperative that receives its power from Duke Energy. For that reason, we use the same emission's factor as Duke Energy Carolinas.

UNC Cogeneration Plant Emissions Factors:

Emission Factors for UNC Cogen Plant from US EIA	lbs CO_2/ mmBTU
Coal	205.3
Natural Gas	117
Fuel Oil	161

Appendix B – Unit Conversion Factors

1 mmBTU = 293.071 kWh
1 metric ton = 2204.6 pounds = 1000 kilograms
1 ton = 0.907185 metric tons

Appendix C - Waste Calculations

	Proportion of Orange County MSW
Food Waste	**0.253**
Food Waste	
Paper	**0.261**
Newspaper	**0.008**
Glossy magazines	**0.009**
Corrugated cardboard	**0.026**
Paperboard	**0.026**
Other books	**0.003**
White Ledger	**0.012**
Mixed recyclable paper	**0.036**
Low-grade paper	**0.141**
Wood	**0.012**
Wood pallets	**0.004**
Wood lumber	**0.008**
Textiles	**0.053**
Textiles/leather	**0.053**

Methane Emission Factors	Dry Waste (g CH_4/kg waste)	Wet Waste (g CH_4/kg waste)
Composting	10	4

MSW Component	PerCent	Degradable Organic Carbon (DOC) Factor	Product
Food Waste	0.253	0.15	0.03795
Paper	0.261	0.4	0.1044
Wood	0.012	0.43	0.00516
Textiles	0.053	0.24	0.01272
DOC (tonnes carbon/tonnes of MSW)			**0.16023**
Methane correction factor (Default=1)	1		
DOC (tonnes carbon/tonnes of MSW)	0.16023		
Fraction of DOC degraded (Default=0.6)	0.6		
Fraction of methane in landfill gas (Default=0.5)	0.5		
Conversion factor from carbon to methane	1.33		
Methane Generation Potential (product of above 5 factors)	0.06393177		
Methane Generation Potential	0.06393177		
OC MSW in metric tonnes	52000		
Fraction of Methane not Recovered at Sampson	0.85		
Oxidation Factor Default =0.9 for well-managed landfills	0.9		
Methane Emissions in metric tons (product of above 4 factors)	2543.2058106		

Waste Water Calculations:

The conversion of OWASA's biogas production to release of carbon dioxide is based on the following assumptions:

1. OWASA reports that the Mason Farm WWTP produces about 110,000 cubic feet of biogas each day as a by-product of the anaerobic digestion process.
2. From a test sample of this biogas Unison Solutions determined that the sample was comprised of approximately 65% methane and 34% carbon dioxide with other trace constituents.
3. 110,000 cubic feet of biogas /day for 365 days yields 40,150,000 cubic feet of biogas/year or 26,100,000 cubic feet of methane/year (65%) and 13,650,000 cubic feet of carbon dioxide/year (34%).
4. Assuming this methane has the same emissions factor as natural gas and using the EIA emissions factor of 117lbs CO2 per 1000 cubic feet, the burning of this methane would release about 1,385 metric tons of CO2 in 2017.
5. Assuming a metric ton of carbon dioxide occupies 17,836 cubic feet at standard temperature and pressure and the volume of the biogas was measured at standard temperature and pressure, then the 13,650,000 cubic feet of carbon dioxide weighs approximately 765 mt.

Appendix D – Abbreviations

CNG	compressed natural gas
CO_2e	carbon dioxide equivalent
Cogen	cogeneration plant
E-85	gasoline with up to 85% ethanol
E-factor	emissions factor
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
gal	gallon
GHG	greenhouse gas
GPC	Global Protocol for Community-scale GHG emissions
GVWR	gross vehicle weight rating
GWP	global warming potential
kg	kilogram
kWh	kilowatt-hours
L	liter
lbs	pounds
m^3	cubic meters
mmBTU	million British Thermal Units
MOVES	Motor Vehicle Emission Simulator
mt	metric ton
MWh	megawatt-hours
NG	natural gas
OWASA	Orange Water and Sewer Authority
RECS	Residential Energy Consumption Survey
SEDS	State Energy Data System
UNC	University of North Carolina
US EIA	United States Energy Information Agency
VMT	vehicle miles traveled
yr	year

Appendix E – Data Sources

Duke Energy Carolinas
Piedmont Electric Membership Corporation
PSNC Energy
Blair Pollock, Orange County Solid Waste Planner
Orange County Waste Composition Study, June, 2017
OWASA Energy Management Plan Update, March, 2018
OWASA Natural Resources and Technical Services Committee Memorandum Dec 5 2017
OWASA Gas Testing Results by Unison Solutions dated November 27, 2017
2017 Annual Air Emissions Inventory Cogeneration Facility prepared by RST Engineering for UNC and released in June, 2018
2006 IPCC Guidelines for National Greenhouse Gas Inventories
CHAPTER 2, WASTE GENERATION, COMPOSITION AND MANAGEMENT DATA
https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
Community-scale Greenhouse Gas Emission Inventories (GPC) Chapter 8 Waste
North Carolina's Greenhouse Gas Inventory released in January, 2019
Todd C. Pasley, Environmental Engineer for North Carolina Division of Air Quality

Appendix F – Raw Data Received From Utilities

Duke Energy Carolinas:
Kilowatt-hours delivered

	Residential	Commercial	Industrial
Carrboro	71,316,824	36,933,731	150,343
Chapel Hill	206,779,285	617,992,340	883,413
Durham	239,038	1,016,198	0
Hillsborough	27,051,056	69,163,886	2,691,935
Mebane	11,240,963	4,080,746	36,743,822
Rural	180,975,074	47,457,004	16,776,130
Total	497,602,240	776,643,905	57,245,643

Number of Accounts

	Residential	Commercial	Industrial
Carrboro	7,581	907	2
Chapel Hill	20,914	3,263	1
Durham	16	6	0
Hillsborough	2,882	1,146	7
Mebane	1,096	127	11
Rural	12,537	4,401	25
Total	45025	9850	46

Piedmont Electric Membership Corporation:
"Orange County Greenhouse Gas Inventory Data Request Form" reproduced below:
"Please fill in the following information for the accounts you serve **within Orange County's Boundaries for the 2017 calendar year.**

For questions or concerns, please contact Orange County's Sustainability Coordinator, Brennan Bouma bbouma@orangecountync.gov.

Electricity Generation

For residential customers:

Electricity used (kWh) ___122,758,217

Number of households served ___12,414____

For commercial customers:

Electricity used (kWh) ____32,396,359

Number of customers (accounts) served ____1210____"

Dominion Energy (Formerly PSNC):

Town of Chapel Hill (676)			
2017			
Class	MMBTU		# Customers
Commercial	963,237.1		720
Industrial	27,235.4		4
Residential	631,684.7		11,950
	1,622,157.2		12,674

Town of Hillsborough (680)			
2017			
Class	MMBTU		# Customers
Commercial	119,693.9		390
Industrial	46,256.0		12
Residential	93,188.2		1,890
	259,138.1		2,292

Town of Carrboro (678)			
2017			
Class	MMBTU		# Customers
Commercial	67,991.1		225
Industrial	263.6		1
Residential	191,284.7		4,066
	259,539.4		4,292

Rural Orange County			
2017			
Class	MMBTU		# Customers
Commercial	173,675.8		368.0
Industrial	15,779.7		4.0
Residential	280,274.9		5,516.0
	469,730.4		5,888

Orange County			
2017			
Class	MMBTU		# Customers
Commercial	1,324,597.9		1,703
Industrial	89,534.7		21
Residential	1,196,432.5		23,422
	2,610,565.1		25,146

Orange County			
2017			
Class	MMBTU		# Customers
Commercial	1,324,597.9		1,703
Industrial	89,534.7		21
Residential	1,196,432.5		23,422
	2,610,565.1		25,146

		Proportion of Orange Co	
	Town		
	Chapel Hill	62.1%	
	Hillsborough	9.9%	
	Carrboro	9.9%	

UNC Cogeneration Plant Fuel Usage and Emissions Data:

2017 UNC Cogen Plant Fuel Usage	Coal(tons)	Gas(1000 cubic feet)	Oil (gallons)
Boiler #6	36516	324064	15
Boiler #7	37910	243925	0
Boiler #8	0	21472	3811
Blackstart Generators G1 & G2	0	0	7700
Total	74426	589461	11526

Energy Conversion	
Coal (btu/lb)	12761
Natural Gas(btu/ft^3)	1030
Fuel Oil (btu/gallon)	137204

Emission Factors for UNC Cogen Plant from US EIA	lbs CO_2/ mmBTU
Coal	205.3
Natural Gas	117
Fuel Oil	161

	CO2 (tons/yr)	Methane (tons/yr)	Nitrous Oxide (tons/yr)
Boiler #6 Natural Gas	24644	0.37	0.037
Boiler #6 Fuel Oil	0.21	0.00000667	0.00000133
Boiler #6 Coal	120462	11.3	1.6
Boiler #6 Total	145106	11.62	1.67
Boiler #7 Natural Gas	17333	0.28	0.0277
Boiler #7 Fuel Oil	0	0	0
Boiler #7 Coal	117846	11.78	1.71
Boiler #7 Total	135179	12.06	1.74
Boiler #8 Natural Gas	1487	0.024	0.002
Boiler #8 Fuel Oil	49	0.00173	0.000346
Boiler #8 Total	1536	0.026	0.003
Blackstart Generators G1 & G2	86.13	0.003	0.0007
Grand Total	281908	23.7	3.4

Orange County Municipal Solid Waste:

All data is for Fiscal Year 2016-2017

- Methane gas capture at Sampson is estimated at 15% since it is an active landfill.
- MSW transported to Sampson was 57,300 tons.
- Hauling waste to Sampson was 22 tons/trip and 90 miles one-way.
- Methane captured at Eubanks facility and transferred to UNC was 1666 tons.
- Compostable organics collected at Eubanks facility totaled 18,946 tons.

Orange County Waste Composition Study – Results:

Table 3-1: Composition of Aggregate MSW by Season

	Material Categories	Fall (n=51)	Spring (n=50)	Annual (n=101)
1	Newspaper	1.0%	0.5%	0.8%
2	Glossy Magazines	1.0%	0.8%	0.9%
3	Corrugated Cardboard	2.9%	2.3%	2.6%
5	Phone Books	0.1%	0.0%	0.0%
6	Paperboard	3.1%	2.1%	2.6%
7	Other Books	0.4%	0.1%	0.3%
8	White Ledger	1.7%	0.8%	1.2%
9	Mixed Recyclable Paper	4.3%	2.9%	3.6%
40	Aseptic Containers	0.7%	0.5%	0.6%
11	All Plastic Bottles	3.5%	2.3%	2.9%
13A	Dairy Plastic Containers	1.2%	0.6%	0.9%
19	Tin/Steel Cans	0.9%	0.7%	0.8%
20	Aerosol Cans	0.4%	0.2%	0.3%
22	Aluminum Cans	0.7%	0.6%	0.6%
23	Aluminum Foil	0.4%	0.4%	0.4%
25	Glass Bottles and Jars	3.0%	2.4%	2.7%
	Total Program Recyclables	**25.2%**	**17.2%**	**21.2%**
12B	Retail Plastic Bags & Stretch Film	1.6%	1.3%	1.5%
16	Textiles/Leather	5.1%	5.7%	5.3%
21	Other Ferrous	0.6%	1.6%	1.1%
24	Other Non-Ferrous	0.4%	0.5%	0.4%
33	Lead Acid Batteries	0.0%	0.0%	0.0%
34	Dry Cell Batteries	0.1%	0.4%	0.2%
35	Oil Filters	0.0%	0.0%	0.0%
36	Other Hazardous Waste	0.0%	0.7%	0.4%
38	Reusable Waste	0.6%	0.3%	0.5%
39	Electronic Waste	0.6%	0.6%	0.6%
	Other Potential Recyclables/Reusables	**9.1%**	**11.0%**	**10.0%**
4	Waxy Cardboard	0.1%	0.3%	0.2%
15	Food Waste	22.6%	27.9%	25.3%
10	Low-Grade Paper	14.2%	13.9%	14.1%
18	Other Organics & Rubber	3.3%	4.7%	4.0%
27	Wood Pallets	0.5%	0.4%	0.4%
28	Wood Lumber	0.8%	0.8%	0.8%
30	Stumps/Branches	0.0%	0.0%	0.0%
32	Yard Waste	2.0%	1.1%	1.6%
	Total Compostables	**43.6%**	**49.1%**	**46.5%**
12A	Plastic Film	6.8%	7.0%	6.9%
13B	Mixed Plastic Containers	0.5%	1.0%	0.7%
14	All Other Plastics	6.7%	5.9%	6.3%
17	Diapers	5.1%	4.1%	4.6%
26	Other Glass	0.5%	1.0%	0.7%
29	Painted/Treated Wood	1.2%	1.7%	1.4%
31	Brick/Concrete/Dirt	0.4%	1.9%	1.2%
37	Infectious Waste	0.9%	0.1%	0.5%
	All Other Waste	**22.1%**	**22.6%**	**22.4%**
	TOTALS	**100.0%**	**100.0%**	**100.0%**

Note: Columns may not appear to calculate correctly due to rounding.