Centre Region Council of Governments

2016 Community Wide GHG Inventory and Methodology Report

Produced by Centre Regional Planning Agency

With Assistance from PA Department of Environmental Protection and ICLEI - Local Governments for Sustainability USA

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Centre Regional Planning Agency

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Climate Action and Adaptation Planning Process

Based on a changing climate and its impacts on the Region, the Centre Region Council of Governments intends to develop a climate action and adaptation plan which identifies pragmatic, fiscally responsible actions to consider in order to:

1. mitigate the Region's contribution to greenhouse gas (GHG) emissions and
2. adapt to changing climate conditions.

The first step of managing emissions is to complete a GHG inventory which determines baseline emissions levels and the sources and activities generating emissions in the community. Centre Region COG will rely on the GHG inventory to set emissions reduction targets, identify tangible actions aimed at reducing greenhouse gas emissions, and measure progress toward achieving those targets, as identified in Figure 1.

COG analyzed its GHG emissions from both government operations and from the wider community as a whole to identify opportunities to reduce its GHG emissions.

While this report focuses on the inventory that will be used for mitigating emissions, the Centre Region recognizes the need to prepare for a changing climate. COG is planning to complete a vulnerability study in 2020 to address environmental vulnerabilities caused by climate change and to proactively prepare for these hazards and reduce the potential harm to the community. The results from both the inventory and the vulnerability assessment will be used by the Climate Action and Adaptation Technical Advisory Group (TAG) to develop a climate action and adaptation plan.

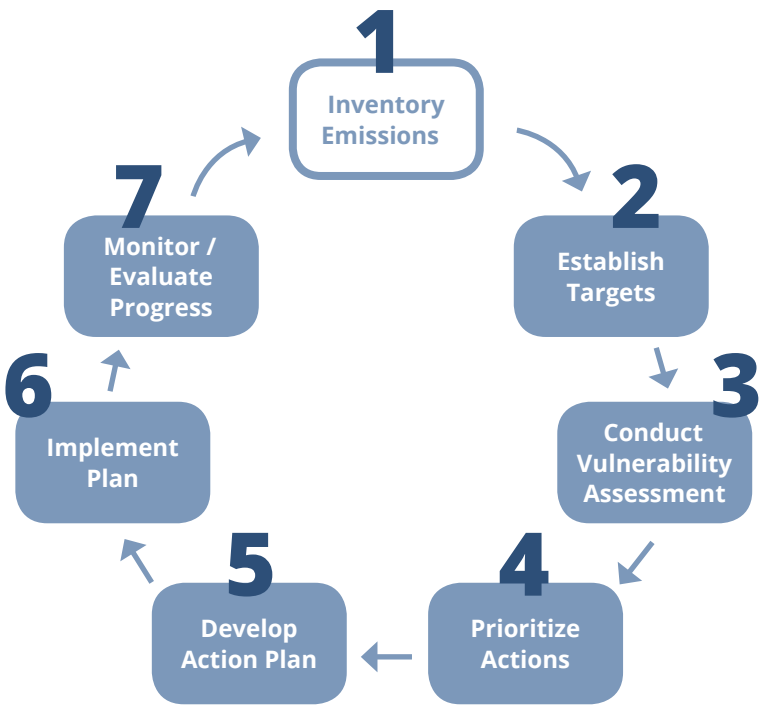


Figure 1: Seven Milestones of Emissions Management

Regional Profile

The Centre Region, which includes State College Borough and the Townships of College, Ferguson, Halfmoon, Harris, and Patton, has an estimated population of 96,700. It is roughly 150 square miles in Centre County located in the center of Pennsylvania. The main campus of Pennsylvania State University dominates the Centre Region demographically and economically. Penn State has its own GHG emissions inventory (http://sustainability.psu.edu/climate-action) and their data is not included in this community GHG inventory report. While each will have separate inventories and climate action plans, the two entities plan to work together to coordinate and support each other's climate action and adaptation efforts.

Climate Science

The Intergovernmental Panel on Climate Change (IPCC), the United Nations body that regularly convenes climate scientists, has identified human activity as the primary cause of the climate change. The release of the 2018 Intergovernmental Panel on Climate Change (IPCC) *Global Warming of 1.5 °C*[1] sends a strong message that limiting global warming to 1.5°C would significantly lower climate-related risks for human society and natural systems relative to 2°C. Appendix B includes the Headline Statements from the Summary for Policy Makers from the IPCC's Special Report.

Since the beginning of the 20th century, temperatures in Pennsylvania have risen around 2°F (1.11°C)[1] and temperatures in the 2000s have been higher than any other historical period[2] (Figure 2). Temperatures are expected to continue to warm in the next century. This warming has been concentrated in the winter and spring, while summer and fall have not warmed as much.

State College has experienced a 70% increase in the number of heavy rain events (precipitation greater than 2 inches) since the 1900s[3]. These rains can cause devastating flooding and damage to roads and infrastructure.

In response to the problem of climate change, the Centre Region is taking responsibility for addressing emissions at the local level. Since many of the major sources of GHG are directly or indirectly controlled through local policies, local governments have a strong role to play in reducing GHG within their boundaries. Through proactive measures around land use patterns, transportation demand management, energy efficiency, green building, waste diversion, and more, local governments can dramatically reduce emissions in their communities. In addition, local governments are primarily responsible for the provision of emergency services and the mitigation of natural disaster impacts.

Reducing fossil fuel use in the community can have many benefits in addition to reducing GHG. More efficient use of energy decreases utility and transportation costs for residents, businesses, and government. Retrofitting homes and businesses to be more efficient creates local jobs. In addition, money not spent on energy is more likely to be spent on a local business and add to the local economy. Reducing fossil fuel use improves air quality, and increasing opportunities for walking and bicycling improves residents' health.

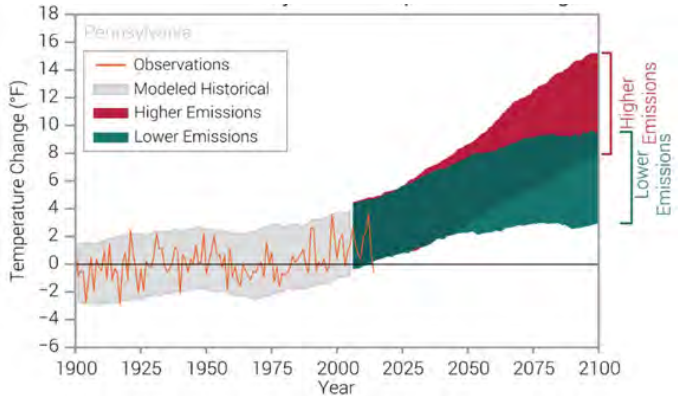


Figure 2: Observed & Projected Temperatures in Pennsylvania
Source CICS-NC and NOAA NCEI[2]

Purdue Mountain Road Collapse in 2016

Inventory Overview

The first milestone, a greenhouse gas (GHG) emissions inventory, was compiled in 2019 and identified the GHG emissions for the Centre Region community in 2016 were 824,209 metric tons of carbon dioxide equivalent (MTCO2e). The inventory estimates the GHG emissions resulting from activities and sources in 2016 for the Centre Region COG community, which includes College, Ferguson, Halfmoon, Harris, and Patton Townships, and State College Borough.

The 824,209 MTCO2e equates to an annual average carbon footprint of 10.21 MTCO2e per person. Figure 3 shows the scale of the 6 categories of GHG emissions for the Centre Region community. This amount is equivalent to a person driving over two billion miles annually or it equates to the need for a quarter of a coal fire power plant for one year. Our Region's emissions total represents 0.3% of Pennsylvania's total GHG emissions, which is approximately 264 million MTCO2e.

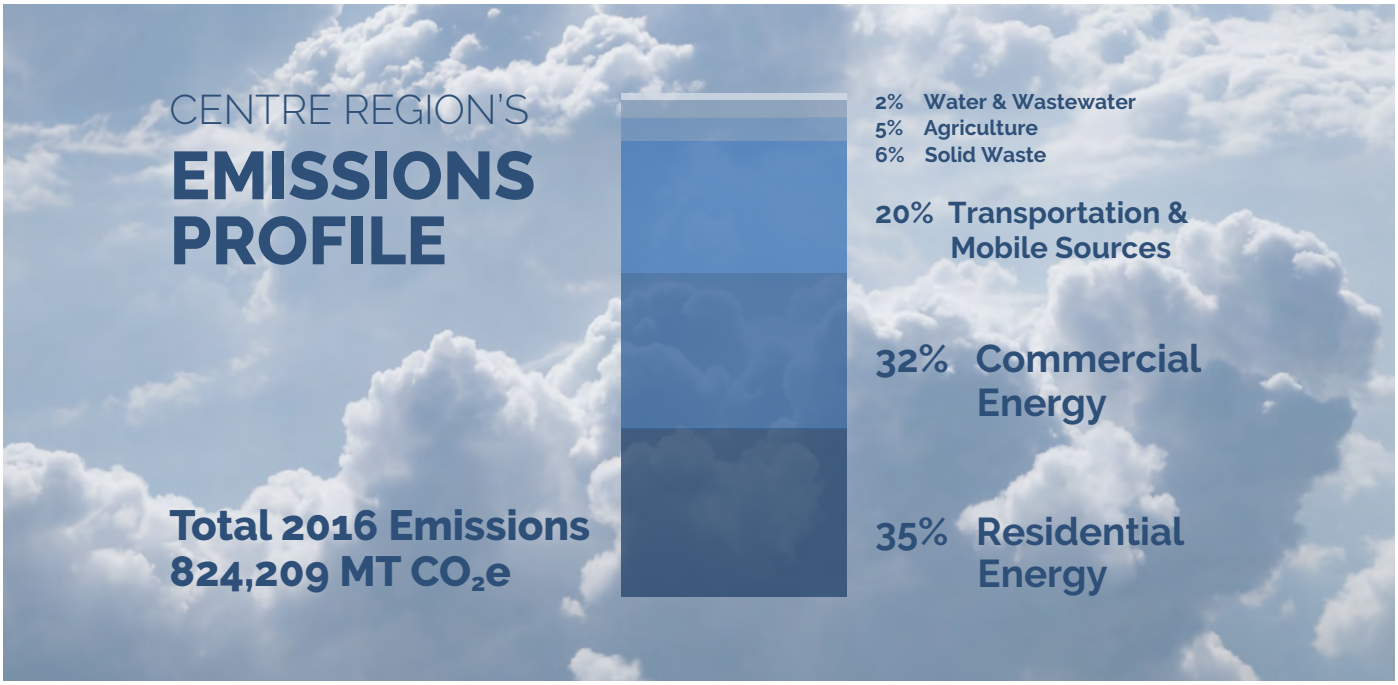


Figure 3: Centre Region Community GHG Emissions in 2016

Significantly Influenced Emissions Frame

The Centre Region COG has chosen first to focus on emissions over which the local governments have significant influence. This frame emphasizes policy relevance, highlighting a set of emission sources and activities that Centre Region COG and its member municipalities has the greatest opportunity to address. This frame includes all of the five Basic Emissions Generating Activities required by the U.S. Community Protocol[4], plus agriculture since it is of community significance. Centre Region COG will focus on these emissions sources and activities in developing a climate action and adaptation plan. The inventory results will assist in setting an emissions reduction target and measuring future emissions reductions against.

Residential energy, commercial energy, and transportation are the largest contributors to emissions over which Centre Region COG has significant influence. These will be important activities to focus efforts on in developing a climate action and adaption plan. Figure 4 shows a more detailed breakdown of these emissions.

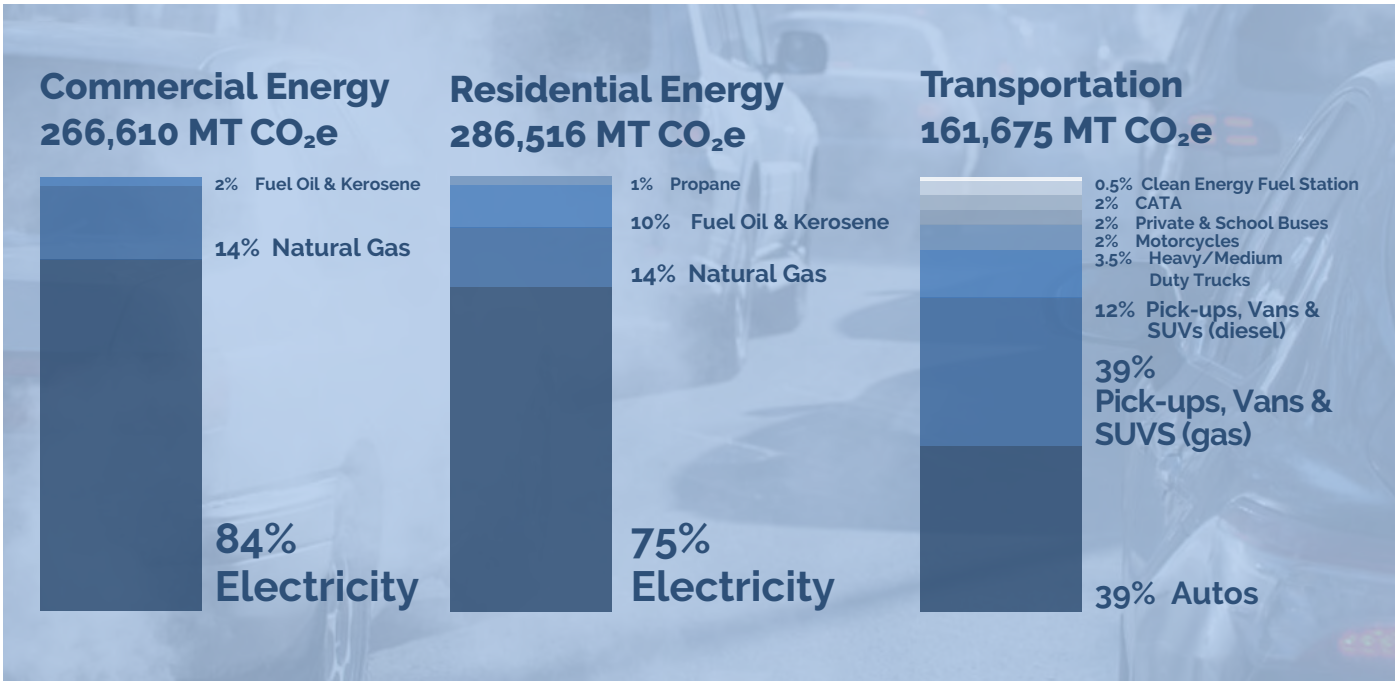


Figure 4: Centre Region Community Activities with largest GHG Emissions in 2016

GHG ACCOUNTING FRAMEWORK AND OVERVIEW

Community Emissions Protocol

This inventory uses the approach and methods provided by the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, version 1.2[4] . The Community Protocol was updated by ICLEI: Local Governments for Sustainability in July 2019 and represents a national standard in guidance to help U.S. local governments develop effective community GHG emissions inventories. It establishes reporting requirements for all community GHG emissions inventories, provides detailed accounting guidance for quantifying GHG emissions associated with a range of emission sources and community activities, and provides a number of optional reporting frameworks to help local governments customize their community GHG emissions inventory reports based on their local goals and capacities. The Pennsylvania Department of Environmental Protection (PA DEP) partnered with ICLEI to offer local governments assistance with completing a GHG inventory under ICLEI's guidance and with the use of ICLEI's GHG gas modeling tool, ClearPath. The Centre Region COG is a participating entity in this PA DEP-ICLEI Local Government Climate Assistance Program.

All emissions presented in this report are represented in metric tons of carbon dioxide equivalent (MTCO2e). Quantities of individual GHGs are accounted for in the ICLEI's ClearPath carbon calculator and include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). CO2-equivalencies are calculated with the Intergovernmental Panel on Climate Change (IPCC) 5th assessment 100 year Global Warming Potential (GWP) values. Due to lack of available data, this inventory does not capture the other three GHG gases: CFCs, PFCs and sulfur hexafluoride (SF5) identified per the Kyoto Protocol.

Scoping Process: Defining Inventory Boundary and Emission Sources

Centre Region COG identified five GHG emissions sources to appropriately reflect the GHG emission associated with the community and are shown in Figure 5. The first four sources are required in a Protocol-compliant GHG inventory and agriculture is included as an activity of community significance. These sources are selected because:

- local government typically has significant influence over the emission generating activity
- the data needed is reasonably available
- emissions associate with the activity tend to be significant in magnitude
- the activity is common across US communities

Stationary Energy

Transportation

Solid Waste

Water & Wastewater

Agriculture

Figure 5: Sources included in the GHG inventory

Table A-2 in Appendix A provides a summary of the emissions sources and activities that are included in the community inventory, as well as those potential sources that are excluded.

Activities taking place within our community can generate GHG emissions that occur inside the regional boundary as well as outside the regional boundary. To distinguish among them, the Protocol groups emissions into three categories based on where they occur: scope 1, scope 2, or scope 3 emissions, as defined in Figure 6.

Scope	Definition
1	GHG emissions from sources located within the regional boundary
2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam, and/or cooling within the regional boundary
3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the regional boundary

Figure 6: Definition of Sources

Figure 7 on the following page provides a summary of the emissions sources and activities included in the inventory and their scope category. Those emission sources or activities that cross outside of our boundary are those that are applicable to multiple scope categories. For example, emissions from solid waste are considered scope 1 for the waste generated within the community boundary, while emissions that happen to transport the waste to the landfill and occur at the landfill are considered Scope 3.

Emission Type	Scope	Data source
Stationary Energy		
Residential Buildings	2	Grid electricity consumption
	1	Natural gas consumption
	1	Fuel oil, propane, and-wood consumption
Non-Residental Buildings Lighting: Stop and Street	2	Grid electricity consumption
	1	Natural gas consumption
	1	Fuel oil & propane consumption
Natural gas fugitive emissions	1	ICLEI guidelines (see page 24)
Transportation		
Public Transportation	1	Natural gas consumption and vehicle miles traveled (VMT)
On Road Transportation	1	Passenger Autos VMT with gasoline
	1	Sports Utility Vehicles (SUVs) VMT with gasoline
	1	Pick-up Trucks VMT with gasoline
	1	Pick-up Trucks with diesel
	1	Heavy & Medium duty trucks VMT with diesel
	1	Private Buses VMT with diesel
Clean Energy Fuel Station	1	Heavy & Medium duty trucks with natural gas
Natural gas fugitive emissions	1	ICLEI guidelines (see page 24)
Solid Waste		
Residential waste	1	Centre Region waste generation
Commercial & Industrial waste	1	Centre Region waste generation
State College Borough Composting	1	Centre Region yard and food (State College Borough) generation
Collection and Transportation to the landfill	1 & 3	Routes miles
Processing emissions at landfill	3	Heavy equipment used to process waste
Water and Wastewater		
College Township Water Authority	2	Grid electricity consumption
State College Borough Water Authority	1& 2	Propane and grid electricity consumption
University Area Joint Authority	1 & 2	• Wastewater processed • Natural gas and grid electricity consumption
On-lot Septic Systems	1	Number of septic tanks
Agriculture and Parkland Management		
Cattle (Dairy and Beef) – Enteric Fermentation and Manure Management	1	Centre County Agriculture census data
Swine Manure Management	1	Centre County Agriculture census data
Fertilizer Application	1	Fertilizer consumption
Parkland Management	1	Gasoline & diesel consumption

Figure 7: Table of Emission and Scope categories

Exclusions from the Community Inventory

- The Pennsylvania State University GHG emissions from energy, transportation (fleet and commuting), waste, wastewater, and agriculture have not been included in this COG community inventory as the emissions resulting from the sources of these University activities are accounted for in the University's Climate Action Plan: http://sustainability.psu.edu/climate-action.
- Consumption-based emissions from households and local businesses are not accounted for in this inventory due to a lack of available data from which to estimate emissions.

Suggestions for Future Inventories

- Consumption Data and Methodology: Consumption-based emissions should be considered in the next inventory. The household consumption frame helps to illustrate the full, life cycle impacts of residents' activities. Household consumption would include the use of materials and services, such as food and purchased goods, in addition to the sources identified in this inventory. A range of actions can help to reduce these emissions, including materials management, reduction of wasted food, and sustainable purchasing practices by governments, businesses, and households.
- Refrigerant Data: Establish a process to collect accurate, local refrigerant data. Invite cooling equipment vendors and services to join the climate action and adaptation planning process with a primary goal of establishing voluntary, anonymous data collection methods.

INVENTORY METHODOLOGY

This section describes the methodology used for conducting an inventory of the GHG emissions for State College Borough and the Townships of College, Ferguson, Halfmoon, Harris and Patton. In Appendix A, Table A-2 provides a summary of the emissions sources and activities that are included in the community inventory, as well as those potential sources that are excluded. Table A-3 provides details on calculation methods and data sources for each included activity and source.

Demographic Characteristics

To put emissions inventory data in context, it is helpful to have some basic information about the community. The Centre Region, which includes State College Borough and the Townships of College, Ferguson, Halfmoon, Harris, and Patton, has an estimated total population of 96,700 in 2019. Figure 8 shows the demographics of the area in 2016 and 2006. The year 2006 was selected to show demographic differences over a decade and because Penn State University completed a GHG inventory for 2006 for the Centre Region. The 2006 inventory data will be discussed in the forthcoming action plan

2016 population and housing units are based on United States Census Bureau's 2012-2016 American Community Survey (ACS) 5-year estimates[5]. The net Centre Region total population number is equal to the total municipal populations minus the Penn State on-campus population. Penn State's on-campus population is included in their GHG emissions inventory and should not be double counted in the Centre Region's inventory.

The 2006 population are based on U.S. Census Bureau's 2008 Population Estimates Program[6].

2006 housing units were calculated by adding the sum of the residential unit building permits within each municipality from 2000 to 2006 to the total number of housing units in each municipality recorded in the 2000 Census.

The number of businesses were calculated based on the number of fire permits issued through the Code Agency. Every business in State College Borough and the Townships of College, Ferguson, Harris, and Patton Township must have a fire permit when in operation.

Location	Population		Housing Units		# of Businesses	
	2016	2006	2016	2006	2016	2010*
College Township	10,030	9,003	4,013	3,730	557	455
Ferguson Township	18,585	16,207	7,935	6,760	396	320
Halfmoon Township	2,724	2,939	1,017	925		
Harris Township	5,324	4,686	2,301	1,959	70	68
Patton Township	15,747	12,799	6,949	5,925	201	160
State College Borough	42,074	39,992	13,758	12,554	775	687
Total Centre Region Municipalities	**94,484**	**85,626**	**35,973**	**31,853**	**1,999**	**1,690**
Penn State On-campus *Population*	13,794	13,000				
Net Centre Region	**80,690**	**72,626**	**35,973**	**31,853**	**1,999**	**1,690**

* *Note: The oldest available Fire Permit count is from 2010.*

Figure 8: Demographics of Centre Region in 2016 and 2006

Emissions Calculation Method

Greenhouse gas emissions sources in this inventory are quantified using calculation-based methodologies. Activity data is used in conjunction with an emission factor to determine emissions using the following generalized equation:

Activity Data x Emission Factor = Emissions

Activity data refer to the relevant measurement of energy use or other greenhouse gas-generating processes such as fuel consumption by fuel type, metered annual electricity consumption, and annual vehicle miles traveled. Known emission factors are used to convert energy usage or other activity data into associated quantities of emissions. Emissions factors are usually expressed in terms of emissions per unit of activity data (e.g. lbs CO2/kWh of electricity).

In Appendix A, Table A-3 provides details on data sources and emission factors for each included activity and source.

Stationary Energy

Emissions in this category include any building energy use, mainly electricity (scope 2) and natural gas (scope 1). Other stationary combustion fuels (fuel oil and propane) are included in the inventory but represent a smaller source of community emissions. The remaining significant emissions sources related to buildings are fugitive emissions from the 1) processing, storage, and transport of natural gas, which is included in the inventory, and 2) escaping refrigerant gases from air conditioning and refrigeration units, which is not included due to the lack of data. Refrigerants have global warming potentials that are hundreds to thousands of times that of carbon dioxide. In other words, losing a little can add up quickly which is why a recommended action is to determine the best method for tracking refrigerants for future inventories (see page 9).

A. Electricity

Electricity emissions include all emissions that result from the generation of the electricity used within the Centre Region boundary. West Penn Power, a First Energy Company, provided consumption and customer count data broken into (1) residential, (2) commercial and industrial, and (3) lighting categories for the Centre Region. Lighting includes municipal stop lights and streetlights. For this report stationary energy emissions are broken into two categories: residential and commercial. The commercial energy sector includes electricity data from commercial, industrial, governmental, institutional, and lighting categories.

Emission factors are from the 2016 EPA e-Grid[7] for the Reliability First Corporation West (RFCW) sub-region. The e-GRID subregions are defined by EPA in order to establish an aggregated area where the emission rates most accurately match the generation and emissions from the plants within that subregion. Figure 9 shows the sources for the Region's electricity generation.

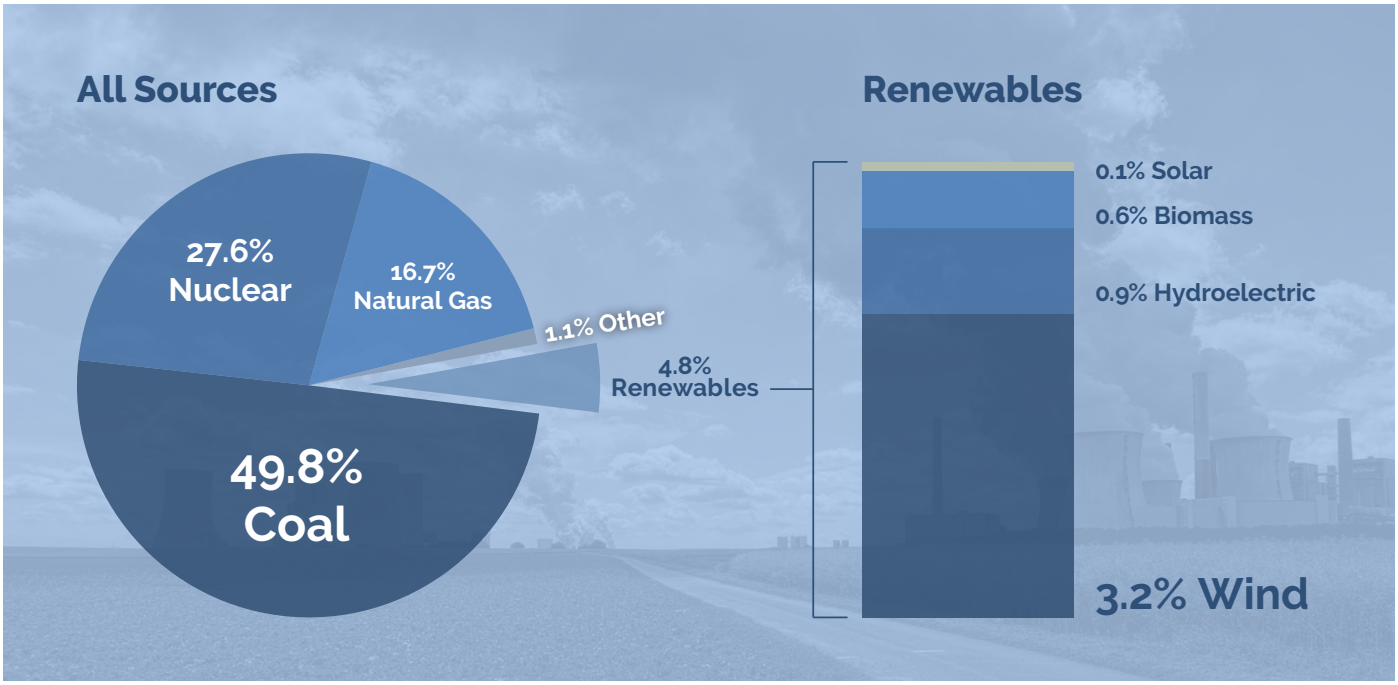


Figure 9: Centre Region Electricity Generation by Source

B. Natural Gas

Natural gas emissions include metered natural gas use for residential, commercial, industrial, governmental, and institutional buildings, as well as estimated natural gas losses through the distribution of natural gas within the Region. Columbia Gas provided consumption and customer count data broken into residential, commercial, and industrial categories for the County. The data was scaled down to the regional level by using the 2012-2016 American Community Survey (ACS)[5] data and 2012 Economic Census[8] of the U.S, both of which are supported by the US Census Bureau.

C. On-Site Fuels

The on-site fuels sector comprises of fossil fuels burned on-location, primarily for residential and commercial heating. Obtaining complete data on fuel oil, kerosene, wood, and other fuel use is currently not possible due to the nature of the distribution process, which involves many individual private suppliers. As a result, the fuel use was estimated based on the following methods described below.

Residential: The method for estimating fuel use is based on census data from the U.S. Census Bureau's 2012-2016 ACS[5] to first define the proportion of households in the Centre Region that utilize these fuels. Next, state-level data from the U.S. Energy Information Administration (EIA) is used to estimate the annual per-household energy intensity for each fuel type. This is performed by dividing total statewide fuel use by the total number of households in PA utilizing the fuel. The energy intensity is then multiplied by the number of households in the Region using that fuel type to determine the fuel consumed in the Region.

Commercial: The data available for the commercial sector is more limited than the residential sector and fuel oil is the only fuel that can be estimated. Using local data from the Code Agency, the square footage for commercial space is estimated for the Centre Region. Next, regional data from the U.S. EIA is used to determine the proportion of commercial buildings using fuel oil and determine the energy intensity, which is the amount of fuel oil gallons consumed per square foot. The fuel consumed is calculated by multiplying the energy intensity by the Centre Region's estimated square footage.

Transportation

The transportation sector encompasses direct fossil fuel combustion emissions in on-road vehicles driven within the boundaries of the Centre Region. The methods contained in this section were used to estimate the total CO2, N2O, and CH4 emissions from transportation fuels and attribute these emissions to the Centre Region. The inventory focused on road-bound vehicular traffic as data from mobile off-road sources since fuel purchased for use inside the Region was not readily available. The Centre Region does not have any water or rail transportation emissions sources, and aviation emissions from the University Park Airport were disregarded due to the inventory boundary (potential double-count) and lack of resident-specific travel data. Private aviation emissions may occur within the inventory boundary, such as agriculture applications or locally-stationed small aircraft, but data to recognize these sources was unavailable.

A. Passenger Vehicles and Freight & Service Trucks

Pennsylvania Department of Transportation (PennDOT) provided an estimate of annual vehicle miles traveled in 2016 within the Centre Region. They determine the Daily Vehicle Miles Traveled (DVMT) by collecting the current Annual Average Daily Traffic (AADT) associated with the primary direction segments (unless the route is bifurcated) in the Region. This covers both state-owned and municipal roadways. Next, PennDOT multiplies it by the length in feet of that segment. This process is continued for all the segments until completed. Those individual segment DVMT values are then summed to provide the DVMT for each municipality.

To avoid double counting, the miles from public transit provided by the Centre Area Transit Authority CATA and the miles traveled to and from work for Penn State faculty, staff, and students were subtracted out of the total DVMT for the Region. CATA miles traveled are accounted for separately in this inventory and the methods used are explained in the next section. The Penn State commuting miles are accounted for in the Penn State GHG inventory and excluded from this inventory.

The estimated annual vehicles miles traveled is divided into six categories using statewide registration and fuel sales statistics from the Federal Highway Administration: autos, motorcycles, buses (i.e, private and school), light duty trucks fueled with gasoline, light duty trucks fueled with diesel, and heavy-duty trucks.

Average fuel economy assumptions for gasoline and diesel vehicles were based on Department of Energy Alternative Fuels Data Center[9].

B. Public Transit Miles

The Centre Area Transportation Authority (CATA) operates a fleet of compressed natural gas (CNG) transit busses in the Centre Region (CATABUS), in addition to traditional gasoline and diesel fueled vans and small busses for rideshares (CATARIDE) and commuters (CATACOMMUTE).

According to their annual report, CATA is the third largest transit agency by ridership in Pennsylvania, behind only the Southeastern Pennsylvania Transportation Authority (SEPTA) in Philadelphia, and the Port Authority of Allegheny County (PAT) in Pittsburgh. Also, State College holds the distinction of being the fourth most transit-intensive small communities in the country, meaning that the people in State College and surrounding areas take more transit trips per capita than almost any other small urban area in the nation[10].

CATA provided their revenue mileage for CATABUS, CATARIDE and CATACOMMUTE and their annual fuel use of CNG, diesel, and gasoline.

For CATABUS, Penn State ridership/routes and routes outside of the Centre Region (Route XB – Bellefonte and XG – Please Gap) were subtracted from the total CATA revenue mileage to only account for emissions attributed to the Centre Region COG, which is 44.2%. Penn State accounted for all the campus routes and a portion of the routes using their 2011 Campus Travel Survey - this ratio indicated what portion of faculty, staff, and students take the CATA bus system to campus.

For CATARIDE, CATA determined that 80.6% of the trips provided by CATARIDE during their fiscal year 2016-17 were provided for people that reside in College, Ferguson, Harris, and Patton Townships and, State College Borough. Since all CATACOMMUTE trips originate outside of the Centre Region the emissions were not included in this inventory since our local government does not have operational control outside of the Region.

C. Clean Energy Fueling Station

Clean Energy began operating a private-public compressed natural gas (CNG) fueling station with the Centre Region Recycling and Refuse Authority (CCRRA) in 2016. Clean Energy provided the fuel consumed for the year and that amount was subtracted out of the Columbia Gas data used for the Stationary Energy and is included under the Transportation sector.

Based on known customers, it was estimated that 75% of the consumption is made by heavy-duty trucks and 25% by light duty trucks. Average fuel economy assumptions for heavy duty trucks were based on the Centre County Recycling and Refuse Authority's experience with recycling and refuse trucks. The light duty truck fuel economy is based upon the average of paratransit, autos, delivery trucks, and vans from the Department of Energy Alternative Fuels Data Center[9].

Solid Waste

Greenhouse gas (GHG) emissions result from management of solid waste of all types and from the natural decay of solid waste with biologic constituents. GHG emissions from the management of solid wastes include those from combustion of fossil fuel in equipment used to transport and process the waste and from the natural decay of biologic wastes associated with landfills. This section addresses emissions arising from solid waste generated by a community (scope1) as well as emissions arising from the landfill where the Region's solid waste is disposed (scope 3).

A. Solid Waste

The Centre County Refuse and Recycling Authority (CCRRA) provided solid waste data which includes residential, commercial, and construction and demolition waste from the Centre Region. Because the waste disposed is not all uniform, it was characterized based on the 2003 PA Statewide Waste Composition Study, using the Northcentral Region's data.

Landfill emissions are unique among sources of emissions in that the emissions are generated over long periods of time from the activity that caused them. Following the Protocol[4], the inventory method attributes future landfill gas generation to the inventory year in which the community's waste was generated and deposited. Emission calculations include information on the landfill methane collection scenario and annual moisture content.

The solid waste generated in the Centre Region in 2016 was disposed of at the Advanced Disposal Greentree Landfill located in Kersey, PA. It has a high BTU gas cleaning plant onsite, treating about 6,500 cubic feet per minutes of landfill gas. After the cleaning process, about half of the landfill gas is sent down a 6.5-mile pipeline to a compressor station where it is tied in to the National Fuel Interstate pipeline where it is sold as Green Power to power plants. This landfill's methane collection scenario was defined by Advanced Disposal as 'Aggressive Collection', which is typical for a bioreactor. The annual moisture content was defined as 'Moderate' for 20 to 40 inches/year based on historical weather data.

B. Composting

The Centre Region includes the State College Borough Compost Facility which provided the amount of food waste (majority from State College Borough) and leaf and brush waste composted in 2016. Advantages of composting include reduced volume in the waste material, stabilization of the waste, and destruction of pathogens in the waste material. The end products of composting are sold to be used as soil enhancers.

C. Collecting, Transporting and Processing Solid Waste

In order to get a complete picture of the emissions associated with waste management, it is important to calculate emissions from collection, transportation, and process emissions. Collection emissions consist predominately of CO2 emissions associated with powering the equipment necessary to collect the solid waste from within the community. Transportation emissions are similar, but instead cover the transportation of waste from the community to facilities located outside of the community. Process emissions come from CO2 emissions associated with powering the equipment necessary to manage the landfill.

The Advanced Disposal Greentree Landfill is located 160 miles round trip from the Centre County Recycling and Refuse Authority (CCRRA). In 2016, the vehicles collecting and transporting the solid waste were fueled by CNG heavy duty trucks. The processing equipment at the landfill used diesel fuel.

Water & Wastewater

Emissions in this category include building energy use for the distribution of water and the treatment of wastewater in the Centre Region. It also includes the biogenic emissions that result from the processing of wastewater and from septic tanks where public sewer is not available. The Centre Region has three separate municipal authorities that provide water and wastewater services: College Township Water Authority (CTWA), State College Borough Water Authority (SCBWA), and University Area Joint Authority (UAJA).

A. Water Supply

College Township Water Authority (CTWA) and State College Borough Water Authority (SCBWA) provided data on their annual electricity usage and SCBWA also used some propane in their operations. This data was subtracted out of the commercial energy sector (Stationary Energy) to avoid double counting.

B. Wastewater

Wastewater from properties located within the Regional Growth Boundary is sent to the University Area Joint Authority's (UAJA) Spring Creek Pollution Control Facility to remove soluble organic matter, and suspended solids, pathogenic organisms, and chemical contaminants before the water can be discharged to Spring Creek. Wastewater treatment processes include emissions from energy use and the biogenic emissions from the biological treatment of wastewater.

The UAJA completed a GHG emissions inventory in 2019 for the year 2015. This inventory uses the data from their inventory.

C. Septic Tanks

Septic Tanks are managed by the Centre Region Code Agency, and they provided the number of septic tanks that exist in the Centre Region. Under anaerobic conditions found in septic tanks, microorganisms biodegrade the soluble organic material found in the wastewater and some methane (CH4) produced during this degradation escapes from the septic systems into the atmosphere.

Agriculture and Parkland Management

Agriculture occupies the second highest volume of land area in the Centre Region which makes it of significant to our community and is included as a category in the inventory. Based upon a 2014 land use inventory, approximately 25,000 acres (26%) of the Centre Region's land area was devoted to agricultural land uses. The other land use that is included in this category is management of the Centre Region parks, consisting of 855 acres. Parkland is included in this inventory because (a) it is under the control of local government and (b) by implementing best practices, local government can lead the community in ways to reduce emissions for this type of activity.

A. Agriculture

The emissions in this category include agricultural emissions of methane (CH4) and nitrous oxide (N20) from livestock (enteric fermentation and manure) and soil management (fertilizer usage). Off-road (tractor) fuel data was unavailable and is not included in this inventory.

For estimating the emissions resulting from animal and manure management, the number of livestock of cattle and swine were determined from county data in the 2012 and 2017 Census of Agriculture reported by the Department of Agriculture[12]. Soil management emissions were calculated based on the fertilizer usage in Centre County from the PA Department of Agriculture Bureau of Plant Industry Fertilizer report[13]. The County information in all cases was scaled down to the regional level based on 33% of agriculture security areas in Centre County are in the Centre Region[14].

B. Parkland Management

The emissions for maintaining the 855 acres of parks in the Centre Region include the transportation, mowing, and landscaping activities that consume gasoline and diesel fuels. The parks include those that are maintained by the Centre Region Parks and Recreation Agency as well as those that are maintained by municipal staff.

NEXT STEPS

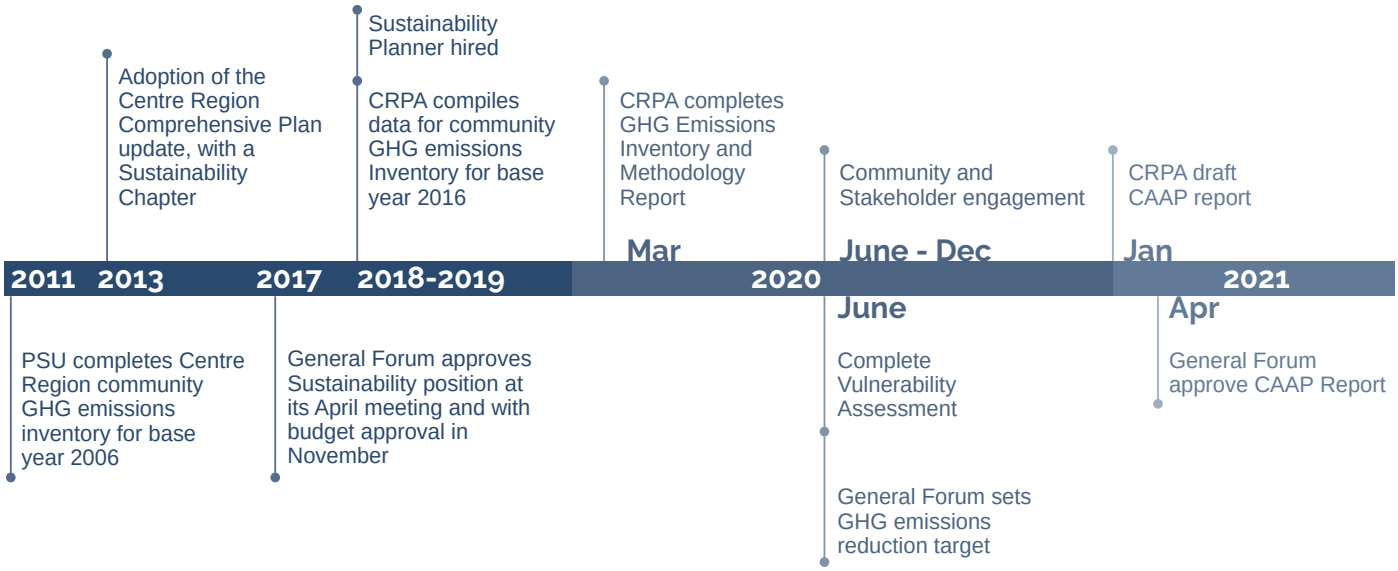
This inventory is only the beginning of an on-going process. The next steps are to set emissions reduction targets, and to develop a climate action and adaptation plan. Emissions reduction strategies to consider for the action plan include energy efficiency, renewable energy, vehicle fuel efficiency, alternative transportation, vehicle trip reduction, land use and transit planning, and waste reduction, among others. The plan should provide a proposed structure for ongoing plan implementation, monitoring, evaluation, and adaptive management, as well as a list of key actions to be taken in the initial phase of implementation. The Climate Action and Adaptation Technical Advisory Group (TAG) will utilize available data and research best practices to identify short-term and long-term implementation projects that provide significant, quantifiable reductions to carbon emissions and deliver quality of life benefits to our Region.

The project timeline is shown below.

Initiatives to reduce GHG emissions in the Centre Region have already been completed since 2016 and more are underway. The University Area Joint Authority has begun its second phase of installing solar arrays that will provide a combined capacity of just under five megawatts of electricity. When completed, renewable energy will provide between 65 and 70 percent of the UAJA plant's total energy consumption. The State College Area School District has installed solar arrays on four of their new LEED-silver school buildings. Local municipalities have been improving the electric vehicle infrastructure by adding charging stations to their parking lots and garages. As identified in their Sustainability 2022 Plan, State College Borough is taking actions to reduce its net greenhouse gas emissions by 10% of 2007 levels by 2022. Ferguson Township has a Climate Action Committee comprised of volunteer residents who completed a GHG emissions inventory and are identifying action items to reduce the municipality's emissions.

To achieve significant overall reductions, the Centre Region COG strives to have a bold vision, equitable process, effective implementation, and excellent communication with the public. Active support of key stakeholders and inclusive community engagement will be necessary to design an effective climate action and adaptation plan. It's vitally important to have collaborations with governmental entities, businesses, community organizations, and residents. Through these efforts and others, the Centre Region can achieve additional benefits beyond reducing emissions, including saving money and improving Centre Region's economic vitality and its quality of life.

Climate Action and Adaptation Plan - Project Timeline



APPENDIX A: COMMUNITY INVENTORY DETAILS

Table A-1 provides a summary of the activity sources and emissions data included in the community GHG emissions inventory.

A-1: 2016 GHG EMMISSIONS INVENTORY FOR THE CENTRE REGION

Sector	Fuel or Source	Usage	Usage Units	CO2e Emissions
Residential Energy	Electricity	378,425,323	kWh	214,796
	Natural Gas	752,122	MMBtu	40,003
	Natural Gas - Fugitive emissions			1,308
	Propane	55,685	MMBtu	3,456
	Distillate Fuel Oil No. 2	361,999	MMBtu	26,953
			Residential Stationary Energy Total	**286,516**
Commercial Energy	Electricity	394,093,095	kWh	223,690
	Natural Gas	660,226	MMBtu	35,117
	Natural Gas - Fugitive emissions			1,148
	Distillate Fuel Oil No. 2	647,723	Gallons	6,655
			Commercial Stationary Energy Total	**266,610**
Transportation & Mobile Sources	CNG - Clean Energy	878,834	VMT	1,120
	Passenger Vehicles - gas	341,522,426	VMT	128,422
	Freight & Service Trucks - diesel	50,260,106	VMT	25,974
	Transit (CATA & other buses)			5,868
	Fugitive emissions from CNG			291
			Transportation & Mobile Sources Total	**161,675**
Solid Waste	Waste Sent to Landfill	65,148	Tons	46,858
	Transport, Equipment, composting			3,343
			Solid Waste Total	**50,201**
Water & Wastewater	Water Supply Energy - electricity	5,692,360	kWh	3,231
	Water Supply Energy - propane	11,599	Gallons	66
	Wastewater Energy - electricity	11,898,219	kWh	7,528
	Wastewater Energy - natural gas	145,670	Therms	
	Wastewater Biogenic Emissions			3,872
	Septic Tanks Biogenic Emissions			938
			Water & Wastewater Total	**15,635**
Agriculture & Parkland	Enteric Fermentation	9,266	Cattle	24,936
	Manure Management	10,164	Livestock	14,239
	Fertilizer Application	532	Metric Tons	4,250
	Parkland Management - gas	10,341	Gallons	56
	Parkland Management - diesel	5,498	Gallons	91
			Agriculture & Parkland Total	**43,572**
			TOTAL 2016 CENTRE REGION GHG EMISSIONS	**824,209**

Table A-2 provides a summary of the emissions sources and activities that are included in the community inventory, as well as those potential sources that are excluded.

SI – Local Government Significant Influence | CA – Community-Wide Activities | HC – Household Consumption

A-2: SUMMARY OF INCLUDED AND EXCLUDED COMMUNITY EMISSIONS

Emissions Type		Source or Activity?	Required Activities	Included under reporting frameworks:			Excluded (IE, NA, NO, or NE)	Explanatory Notes	Emissions (MTCO2e)
				SI	CA	HC			
Stationary Energy - Built Environment									
Use of fuel in residential and commercial stationary combustion equipment		Source & Activity	x	x	x				114,639
Industrial stationary combustion sources		Source					NO	No industrial facilities in the community	
Electricity	Power generation in the community	Source					NO	No power plants in the community	
	Use of electricity by the community	Activity	x	x	x				438,487
District Heating/ Cooling	District heating/cooling facilities in the community	Source					NO	No sources in the community	
	Use of district heating/cooling by the community	Activity					NO	No sources in the community	
Industrial process emissions in the community		Source					NO	No industrial facilities in Centre Region	
Refrigerant leakage in the community		Source					NE	No data available	
Transportation and Other Mobile Sources									
On-road Passenger Vehicles	On-road passenger vehicles operating within the community boundary	Source	x	x	x				128,422
	On-road passenger vehicle travel associated with community land uses	Activity					IE	Obtained data for alternate method TR.1.B (source data, not activity)	
On-road Freight Vehicles	On-road freight and service vehicles operating within the community boundary	Source	x	x	x				29,989
	On-road freight and service vehicle travel associated with community land uses	Activity					IE	Obtained data for alternate method TR.1.B (source data, not activity)	
On-road transit vehicles operating within the community boundary		Source		x				Included CATA data	3,264
Transit Rail	Transit rail vehicles operating within the community boundary	Source					NO	No rail transit in Centre Region	
	Use of transit rail travel by the community	Activity					NE	No data available	
Inter-city passenger rail vehicles operating within the community boundary		Source					NO	No passenger rail in Centre Region	
Freight rail vehicles operating within the community boundary		Source					NE	No data available	

IE – Included Elsewhere | NE – Not Estimated | NA – Not Applicable, | NO – Not Occurring

SI – Local Government Significant Influence | CA – Community-Wide Activities | HC – Household Consumption

Emissions Type		Source or Activity?	Required Activities	Included under reporting frameworks:			Excluded (IE, NA, NO, or NE)	Explanatory Notes	Emissions (MTCO2e)
				SI	CA	HC			
Transportation and Other Mobile Sources (continued)									
Marine	Marine vessels operating within the community boundary	Source					NO	No transit waterways in Centre Region	
	Use of ferries by the community	Activity					NO	No transit waterways in Centre Region	
Off-road surface vehicles and other mobile equipment operating within the community boundary		Source					NE	No data available	
Use of air travel by the community		Activity					NE	No data available	
Solid Waste									
Solid Waste	Operation of solid waste disposal facilities in the community	Source					IE	Included our portion of the operations	
	Generation and disposal of solid waste by the community	Activity	x	x	x				50,201
Water and Wastewater									
Potable Water - Energy Use	Operation of water delivery facilities in the community	Source	x	x	x			SCBWA, CTWA in Centre Region	3,297
	Use of energy associated with use of potable water by the community	Activity					IE	Included in source data	
Use of energy associated with generation of wastewater by the community		Activity	x	x	x				7,528
Centralized Wastewater Systems - Process Emissions	Process emissions from operation of wastewater treatment facilities located in the community	Source		x				UAJA in Centre Region – biogenic emissions	3,872
	Process emissions associated with generation of wastewater by the community	Activity					NE		
Use of septic systems in the community		Source & activity		x	x				938
Agriculture and Parkland Management									
Domesticated animal production		Source			x			Includes enteric fermentation	22,264
Fertilizer application (Ag & Parks)		Activity			x				4,250
Manure decomposition and treatment		Source			x				14,239
Parkland Fuel Consumption		Activity			x				147

IE – Included Elsewhere | NE – Not Estimated | NA – Not Applicable, | NO – Not Occurring

SI – Local Government Significant Influence | CA – Community-Wide Activities | HC – Household Consumption

Emissions Type	Source or Activity?	Required Activities	Included under reporting frameworks:			Excluded (IE, NA, NO, or NE)	Explanatory Notes	Emissions (MTCO2e)
			SI	CA	HC			
Upstream Impacts of Community-Wide Activities								
Upstream impacts of fuels used in stationary applications by the community	Activity					NE		
Upstream and transmission and distribution (T&D) impacts of purchased electricity used by the community	Activity					NE		
Upstream impacts of fuels used for transportation in trips associated with the community	Activity					NE		
Upstream impacts of fuels used by water and wastewater facilities for water used and wastewater generated within the community boundary	Activity					IE	Included in water and wastewater operations	
Upstream impacts of select materials (concrete, food, paper, carpets, etc.) used by the whole community	Activity					NE		

IE – Included Elsewhere | NE – Not Estimated | NA – Not Applicable, NO – Not Occurring

Table A-3 provides details on calculation methods and data sources for each included activity and source.

A-3: CALCULATION METHODS AND DATA SOURCES						
Residential use of electricity	**Activity data**		**Emissions factor**			**Method[4]**
	Value	**Unit**	**CO2 lbs/ MWh**	**CH4 lbs/ GWh**	**N2O lbs. GWh**	
	378,425,323	kWh	1243.4	108.19	18.59	Community Protocol Method BE.2.1
Method and data source notes: West Penn Power provided electricity consumption for the 6 municipalities. Emissions factors from the EPA eGRID 2016 for RFCW region[7]						

Commercial use of electricity	**Activity data**		**Emissions factor**			**Method[4]**
	Value	**Unit**	**CO2 lbs/ MWh**	**CH4 lbs/ GWh**	**N2O lbs.GWh**	
	394,093,095	kWh	1243.4	108.19	18.59	Community Protocol Method BE.2.1
Method and data source notes: West Penn Power provided electricity consumption for the 6 municipalities. Emissions factors from the EPA eGRID 2016 for RFCW region[7] Includes the consumption from commercial, institutional governmental & industrial entities, and street/stop lighting categories.						

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2 kg/ MMBtu	CH4 kg/ MMBtu	N2O kg/ MMBtu	
Residential use of stationary combustion equipment	752,122 natural gas	MMBtu	53.02	0.005	0.0001	Community Protocol Method BE.1.1
	361,999 Distillate Fuel 2	MMBtu	73.96	0.01087	0.000724	Community Protocol Method BE.1.1
	55,685 propane	MMBtu	61.46	0.01099	0.001099	Community Protocol Method BE.1.1

Method and data source notes:
Columbia Gas provided natural gas consumption for Centre County and it was scaled down to the 6 municipalities.
Propane and distillate fuel estimates were obtained using the US Energy Information Administration (EIA) data for PA and scaled down to the 6 municipalities using the US Census – American Community Survey data[5].

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2 kg/ MMBtu	CH4 kg/ MMBtu	N2O kg/ MMBtu	
Commercial use of stationary combustion equipment	660,266 natural gas	MMBtu	53.02	0.005	0.0001	Community Protocol Method BE.1.1
	647,723 Distillate Fuel 2	MMBtu	73.96	0.01087	0.000724	Community Protocol Method BE.1.1

Method and data source notes:
Columbia Gas provided natural gas consumption for Centre County and it was scaled down to the 6 municipalities.
Distillate fuel estimates were obtained using the US Energy Information Administration (EIA) data for PA and scaled down to the 6 municipalities using the Centre Region Code Agency data.

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	CH4 kg/ MMBtu	N2O kg/ MMBtu	
Public Transit CATABUS CATARIDE	49,359,634 CNG	SCF	.0544 kg/ SCF	1.966	.0175	Community Protocol Method TR.4.a-b
	27,625 diesel	gallons	10.28 kg/ gal	0.0010	0.0015	Community Protocol Method TR.4.a-b

Method and data source notes:
CATA provided fuel consumption, revenue miles and data to calculate % of routes in Centre Region. Excluded routes for Penn State commuters (included in PSU emissions) and routes outside the Centre Region. CATACOMMUTE not included since all rides originate outside of the Centre Region boundary.
Emission factors are from EPA GHG inventory guidance – Appendix B[16]

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2 kg/gal	CH4 g/mi	N2O g/mi	
On-road passenger vehicle travel associated with community land uses	7,767,877 autos	gallons	8.01	0.0173	0.0036	Community Protocol Method TR.1.b
	7,829,868 LDT	gallons	8.01	0.0163	0.0066	Community Protocol Method TR.1.b
	359,684 Motorcycles	gallons	8.01	0.0672	0.0069	Community Protocol Method TR.1.b

Method and data source notes:
Includes automobiles, light duty trucks (LDT) and motorcycles
Emission factors are from EPA GHG inventory guidance – Appendix B[16]

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	CH4 g/mi	N2O g/mi	
On-road freight and service vehicle travel associated with community land uses	1,946,453 LDT-diesel	gallons	10.28 kg/gal	0.0009	0.0014	Community Protocol Method TR.1.b
	854,871 HDT-diesel	gallons	10.28 kg/gal	0.0051	0.0048	Community Protocol Method TR.1.b
	19,360,321 CNG	SCF	0.0539 kg/SCF	1.66	.014	Community Protocol Method TR.1.b

Method and data source notes:
Includes diesel powered (1) Light duty trucks (LDT), (2) medium and heavy duty trucks (HDT) and buses, i.e. private and school and (3) CNG service vehicles (includes both heavy duty – refuse – trucks and light duty trucks/vans)
Emission factors are from EPA GHG inventory guidance – Appendix B[16]

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	MT CH4 / ton	MT N2O / ton	
Generation of solid waste by the community	65,148 MSW	tons	Factor different for each waste type (see notes)			Community Protocol Method SW.4
			Collection: 0.014 MTCO2e/ton Transportation: 0.0001 MTCO2e/ton Processing: 0.0164 MTCO2e/ton			Community Protocol Method SW.6 and SW.5
	7,752 Compost	Tons	n/a	.00022	.000133	Community Protocol Method SW.3

Method and data source notes:
MSW landfilled - used waste characteristics from 2003 PA State Wide Waste Composition Study. Emissions factors are from Exhibit 6-6 of US EPA, "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM) ", revised March 2018[16].

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	CH4	N2O	
Use of energy associated with use of potable water	5,692,360	kWh	1243.4 lbs/MWh	108.19 lbs/GWh	18.59 lbs/GWh	Community Protocol BE.2.1
	1,055 propane	MMBtu	61.46 kg/MMBtu	0.01099 kg/MMBtu	0.001099 kg/MMBtu	Community Protocol BE 1.1

Method and data source notes:
Electricity and propane consumption provided by State College Borough and College Water Authorities. It is not included in the commercial electricity data. Emissions factors from the EPA eGRID 2016 for RFCW region[7].

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	CH4	N2O	
Use of energy associated with generation of wastewater	11,898,219	kWh	1243.4 lbs/MWh	108.19 lbs/GWh	18.59 lbs/GWh	Community Protocol WW.15
	14,567	MMBtu	53.02 kg/MMBtu	0.005 kg/MMBtu	0.0001 kg/MMBtu	Community Protocol WW.15

Method and data source notes:
Electricity and natural gas consumption provided by University Area Joint Authority. This electricity data is not included in the commercial electricity data.
Emissions factors from the EPA eGRID 2016 for RFCW region[7]

	Activity data		Emissions factor			Method
	Value	Unit	CO2	CH4	N2O	
Biogenic Emissions from septic tanks and wastewater treatment	7,724	people	n/a	0.0482 MT CH4 / daily kg BOD5	n/a	Community Protocol WW.11 (alt)[4]
	wastewater treatment		3,872 MT CO2e			Direct report from UAJA GHG inventory

Method and data source notes:
Population served: 3,102 septic tanks in Centre Region (Source: COG Code Agency--POC Kathy Woods) x 2.49 people (Source: 2016 US Census American Community Survey average household size in township) =7,723.98 people

	Activity data		Emissions factor			Method[4]
	Value	Unit	CO2	CH4 / animal/ year	N2O / animal/year	
Emissions from Agriculture and Parkland Activities	3,460	Dairy cows		158.7 kg		Community Protocol Method A1 (Enteric Fermentation)
				137 kg	0.07 kg	Comm Protocol Method A2
	5,806	Other cows		58.8 kg		Comm Protocol Method A1 (Enteric Fermentation)
				2.4 kg	0.07 kg	Comm Protocol Method A2
	898	Swine		15 kg	0.108 kg	Comm Protocol Method A2
	1,805	Tons fertilizer			0.03 kg N2O/ton	IPCC 2006 Chapter 11[17]
	10,342	Gallons gas	8.01 kg/gal	0.0013 kg/ gal	0.000091 kg/ gal	Community Protocol Method BE.1.1
	5,498	Gallons diesel	10.28 kg/ gal			Community Protocol Method TR.1.b

Method and data source notes:
Obtained data from (a) 2012 and 2017 Census of Agriculture reported by the Department of Agriculture and (b) the PA Department of Agriculture Bureau of Plant Industry Fertilizer report. Emissions factors are from 2006 IPCC Guidelines for National Greenhouse Gas Inventories[17] and from current research updating the emission factors for livestock management (Revised methane emissions factors and spatially distributed annual carbon fluxes for global livestock' by Wolf et al. published in Carbon Balance and Management, 2017[18].)

Fugitive Emissions from Natural Gas	Activity data		Emissions factor			Method
	Value	Unit	CO2 kg/ MMBtu	CH4 kg/ MMBtu	N2O g/mi	
Local distribution	1,412,388	MMBtu	0.000664	0.062	n/a	
Pump to wheels	17,424	MMBtu	0.00111	0.1036	n/a	

Method and data source notes:
Accounts for leakage in the local natural gas distribution system. The leakage rate of 0.3% was used for the baseline leakage rates for the natural gas local distribution system based on EPA data. The leakage rate of 0.5% was used for the pump to wheels default for the Clean Energy and CATA fueling station. (Source: EDF User Guide for Natural Gas Leakage Rate Modeling Tool - ICLEI[19])

APPENDIX B: REFERENCE MATERIALS

B-1 provides a list of acronyms used throughout the report.

AADT Annual Average Daily Traffic
CATA Centre Area Transportation Authority
CCRRA Centre Region Recycling & Refuse Authority
CFC Chlorofluorocarbon
CH4 Methane
CNG Compressed Natural Gas
COG Council of Governments
CO2 Carbon Dioxide
CTWA College Township Water Authority
DVMT Daily Vehicle Miles Traveled
e-GRID Emissions & Generation Resource Integrated Database
EIA Energy Information Administration
EPA Environmental Protection Agency

GHG Greenhouse Gas Emissions
GWP Global Warming Potential
ICLEI Local Governments for Sustainability
IPCC Intergovernmental Panel on Climate Change
kWh Kilowatt-hour
MSW Municipal Solid Waste
MTCO2e metric tons of carbon dioxide equivalent
PA Pennsylvania
PA DEP Pennsylvania Department of Environmental Protection
PASA Pennsylvania Association of Sustainable Agriculture
PennDOT Pennsylvania Department of Transportation
PFC Perfluorocarbons
RFCW Reliability First Corporation West

SCBWA State College Borough Water Authority
SUV Sports Utility Vehicle
TAG Climate Action and Adaptation Technical Advisory Group
VMT Vehicle Miles Traveled
UAJA University Area Joint Authority
US United States

B-2 provides a summary of the references used to complete the GHG emissions inventory and referred to in this document.

1. IPCC, 2018: *Global Warming of 1.5°C*. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

2. K. Kunkel, R. Frankson (2017) *NOAA National Center for Environmental Information: State Climate Summaries*

3. K. Inhoff (2019) State College weather observing station on Penn State University Park campus. The data record is 1894 through 2018 for annual calculation of number of days per year with greater than or equal to 2" rain.

4. ICLEI-Local Governments for Sustainability (July 2019) *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, version 1.2*

5. US Census Bureau (2012-2016) *American Community Survey 5-Year Estimates*. CRPA compiled data

6. US Census Bureau (2008) Population Estimates Program. CRPA compiled data

7. US Environmental Protection Agency (February 2018) *eGRID Summary Tables 2016*, page 2 and 3

8. US Census Bureau (2012) *Economic Census of the U.S*. Economic Census of Island Areas, and Nonemployer Statistics data files released on a flow basis from March 2014 through June 2016. Retrieved from the American Fact Finder website.

9. Department of Energy: Alternative Fuels Data Center (November 28, 2018) *Average Fuel Economy of Major Vehicle Categories*. https://afdc.energy.gov/data/10310

10. Centre Area Transportation Authority (2016/2017) *Annual Report*

11. R.W. Beck (April 2003) *Statewide Waste Composition Study* completed on behalf of the Pennsylvania Department of Environmental Protection. Data pulled from Section 7, Northcentral Region MSW Composition.

12. US Department of Agriculture (2012 and 2017) *Census of Agriculture*. Table 1: County Highlights, Table 11: Cattle and Calves, and Table 12: Hogs and Pigs

13. PA Department of Agriculture (2016) *Fertilizer Tonnage Report by County* Jan – Jun 2016 and Jul – Dec 2016

14. Centre County Government (2019) Agricultural Security Areas. Data retrieved from website in fall of 2019: https://centrecountypa.gov/610/Agricultural-Security-Areas-ASA

15. US Environmental Protection Agency Center for Corporate Climate Leadership (January 2016) *GHG Inventory Guidance: Direct Emissions from Mobile Combustion Sources* Appendix A and B

16. US Environmental Protection Agency (March 2018) *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)*

17. IPCC (2006) *Guidelines for National Greenhouse Gas Inventories* Volume 4: Agriculture, Forestry, and other Land Use, Chapter 11

18. J. Wolf, G. Asrar, and T. West (2017) *Revised methane emissions factors and spatially distributed annual carbon fluxes for global livestock*. Carbon Balance and Management 12:16

19. Environmental Defense Fund *What Influence Will Switching to Natural Gas have on Climate? User Guide for Natural Gas Leakage Rate Modeling Tool* ICLEI ClearPath software used page 4 for leakage data

Global Warming of 1.5°C

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

Headline Statements from the Summary for Policymakers*

Understanding Global Warming of 1.5°C

Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (*high confidence*)

Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are unlikely to cause global warming of 1.5°C (*medium confidence*).

Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*).

Projected Climate Change, Potential Impacts and Associated Risks

Climate models project robust differences in regional climate characteristics between present-day and global warming of 1.5°C, and between 1.5°C and 2°C. These differences include increases in: mean temperature in most land and ocean regions (*high confidence*), hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*).

By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (*medium confidence*). Sea level will continue to rise well beyond 2100 (*high confidence*), and the magnitude and rate of this rise depend on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (*medium confidence*).

On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans (*high confidence*).

Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems (*high confidence*).

Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.

Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*). The number and availability of adaptation options vary by sector (*medium confidence*).

* Headline statements are the overarching conclusions of the approved Summary for Policymakers which, taken together, provide a concise narrative.

ipcc INTERGOVERNMENTAL PANEL ON climate change

Emission Pathways and System Transitions Consistent with 1.5°C Global Warming

In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C CO_2 emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range). Non-CO_2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (*high confidence*)

Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (*high confidence*). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (*medium confidence*).

All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (*high confidence*). CDR deployment of several hundreds of $GtCO_2$ is subject to multiple feasibility and sustainability constraints (*high confidence*). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred $GtCO_2$ without reliance on bioenergy with carbon capture and storage (BECCS) (*high confidence*).

Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty

Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions in 2030 of 52–58 $GtCO_2eq\ yr^{-1}$ (*medium confidence*). Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*). Avoiding overshoot and reliance on future large-scale deployment of carbon dioxide removal (CDR) can only be achieved if global CO_2 emissions start to decline well before 2030 (*high confidence*).

The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (*high confidence*).

Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (*high confidence*).

Mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (*high confidence*)

Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes (*high confidence*).

Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (*high confidence*).

Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C (*high confidence*). International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions (*high confidence*).