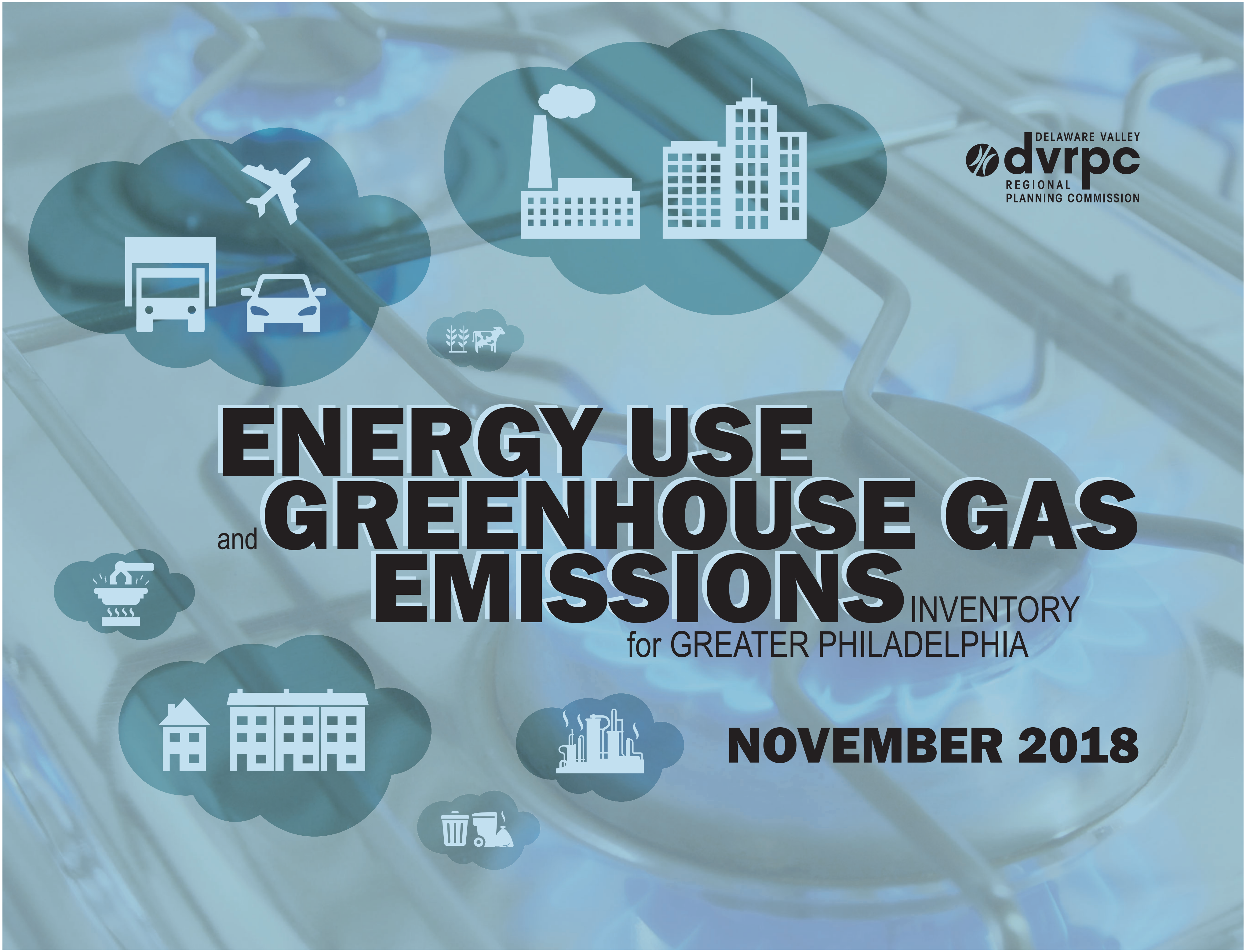

DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION

ENERGY USE and GREENHOUSE GAS EMISSIONS INVENTORY for GREATER PHILADELPHIA

NOVEMBER 2018

The Delaware Valley Regional Planning Commission is the federally designated Metropolitan Planning Organization for a diverse nine-county region in two states: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey.

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

DVRPC's vision for the Greater Philadelphia Region is a prosperous, innovative, equitable, resilient, and sustainable region that increases mobility choices by investing in a safe and modern transportation system; that protects and preserves our natural resources while creating healthy communities; and that fosters greater opportunities for all.

DVRPC's mission is to achieve this vision by convening the widest array of partners to inform and facilitate data-driven decision-making. We are engaged across the region, and strive to be leaders and innovators, exploring new ideas and creating best practices.

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DVRPC is funded through a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

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Executive Summary

This document provides the 2018 overview of energy use and greenhouse gas (GHG) emissions in Greater Philadelphia. It is based on data from calendar year 2015, the most recent year for which complete information is available. The Delaware Valley Regional Planning Commission (DVRPC) performs a regional energy use and GHG emissions inventory every five years. Our previous inventory, for 2010 (released in 2014), followed an initial, baseline inventory for 2005. DVRPC expects to release an inventory for 2020 in 2023.

DVRPC's inventory estimates energy use and GHG emissions in the nine-county Greater Philadelphia region (see Figure 1). DVRPC calculates energy use and GHG emissions associated with the residential, commercial, and industrial sectors as well as transportation sectors (on-road transportation, passenger and freight rail, aviation, marine transportation, and off-road vehicles). DVRPC also includes non-energy GHG emissions resulting from waste management (solid waste and wastewater), agriculture processes (animal and plant related), non-energy-related emissions from industrial processes, and fugitive and process emissions from fuel refining, transmission, and distribution. These categories are similar to those used in the U.S. Environmental Protection Agency's *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

Figure 1: Nine-County Greater Philadelphia Region

Source: DVRPC 2018

In 2015, activities in the region used about 1,174 trillion British Thermal Units (BTUs) of fossil fuel, biomass, and nuclear energy either through direct consumption, such as for home heating, or for the generation of electricity used in the region.[1] That's comparable to about 18 times the 2016 net generation output of Exelon's nuclear Limerick Generating Station in Montgomery County, Pennsylvania.[2] Fossil fuel combustion, both direct consumption and for electricity generation, along with non-energy sources of GHGs, resulted in GHG emissions equivalent to the release of 75 million metric tons of carbon dioxide (MMTCO$_2$e). When carbon dioxide absorbed by growth of trees or released as a result of forest loss is taken into account, net emissions from the region in 2015 were about 74 MMTCO$_2$e.

[1] In the case of electricity, due to conversion losses, the energy contained in a fuel does not equate to the energy delivered to the end-user. For instance, it takes about 10 cubic feet of natural gas containing 9,319 BTUs of energy to generate 1 kilowatt hour (kWh) of electricity, which contains 3,412 BTUs of energy. Between the generation plant and the point of use, an average five percent of this energy is lost, meaning only 3,251 BTUs are delivered.
[2] Exelon Corporation, *Limerick Generating Station*, Accessed July 2018. www.exeloncorp.com/locations/Documents/ Limerick%20Fact%20Sheet%20-%202017.pdf.

These estimated net annual regional GHG emissions are about 10 percent lower than the 81.7 $MMTCO_2e$ estimated for 2010.[3] The region's 2015 GHG emissions make up about 1.1 percent of the United States' total 2015 GHG emissions. Greater Philadelphia, with roughly 1.8 percent of the nation's population, has a per capita net emissions rate of 12.9 metric tons of carbon dioxide equivalents ($MTCO_2e$)—about 38 percent below the national average of about 21 $MTCO_2e$ per capita.[4] Yet, globally, the Greater Philadelphia region's total emissions are comparable to those of Austria, a nation with roughly 1.5 times the population of Greater Philadelphia. For further comparison, China and India, the world's most populous countries, have per capita GHG emissions rates of about 8.5 $MTCO_2e$ and 2.5 $MTCO_2e$, respectively.[5]

It's important to note that DVRPC's accounting for GHGs emitted due to activity in the region does not account for energy and emissions resulting from the manufacture of goods imported into the region, nor does it discount from regional emissions the GHGs associated with the manufacture of goods exported from the region. Such an accounting is beyond the scope of DVRPC's current inventory.

[3] Application of more accurate estimation methods used in the 2015 regional energy use and GHG emissions inventory and applied to 2010 data resulted in an adjustment of net emissions estimated for 2010 from 81.1 $MMTCO_2e$ (previously published) to 81.7 $MMTCO_2e$. DVRPC adopted new methods when improved estimates or new data sources became available or where new estimation methods offered a more reliable estimation of energy use and GHG emissions. See *Energy Use and Greenhouse Gas Emissions Inventory for Greater Philadelphia: Methods and Sources* for additional details.

[4] Due to variability in the methods used, economic sectors included, and geographies covered, comparisons between large cities and major metropolitan areas within the United States are difficult to make. However, denser cities, with smaller homes, shorter driving distances, and more extensive public transportation networks, tend to have lower emissions per capita. In its *Inventory of New York City Greenhouse Gas Emissions in 2015*, New York City reported a per capita emissions rate of 6.1 $MTCO_2e$. Washington, DC reported an 11.9 $MTCO_2e$ per capita emissions rate in 2013 in its *District of Columbia Greenhouse Gas Inventory Update, 2012–2013*.

[5] World Resources Institute. *Climate Watch: Data for Climate Action*, accessed July 2018. www.climatewatchdata.org/.

Connections 2045: Plan for Greater Philadelphia, DVRPC's long-range plan for future growth and development, sets a target of reducing GHG emissions by 60 percent from 2005 levels by 2040. The 10 percent reduction in GHG emissions between 2010 and 2015 helps continue to move the region toward this goal. However, additional reductions are likely to be increasingly challenging to achieve, and will require sustained, concerted, and aggressive action at the household, firm, community, regional, state, national, and global level as well as continued technical advancement.

DVRPC's analysis shows that the greatest reductions in regional greenhouse gas emissions from 2010 to 2015 were due to decreased emissions per kWh of electricity generated (a cleaner grid due in part to a shift from coal to natural gas in generation), decreased on-road emissions per mile traveled (cleaner vehicles due in part to federal corporate average fuel economy [CAFE] standards), and decreased electricity consumption per household, perhaps due to more efficient appliances and lighting.

There were also some factors that placed upward pressure on emissions. The most significant of these were: 1) an increase in the consumption of fuels other than electricity, natural gas, distillate fuel oil, and propane in the non-residential sector (such as gasoline, residual fuel oil, etc.); (2) an increase in employment; and (3) increased natural gas consumption per household.

Many of the actions taken to continue to increase energy efficiency and reduce GHG emissions will not only reduce energy costs and our region's contribution to global climate change. They will also make the transportation network more efficient, improve air quality, bolster public health, and make the region's communities more livable. An energy-efficient regional economy producing low GHG emissions will not only protect our regional environment but will also be more competitive in a world where climate change and energy efficiency are important concerns.

What Is an Energy Use and GHG Emissions Inventory?

An energy use and GHG emissions inventory is an accounting of energy use and GHGs emitted to or removed from the atmosphere over a period of time (e.g., one year) within particular geographic or organizational boundaries. Inventories often cover a variety of sectors and sources of emissions. Combustion of fuels either for direct use or to generate electricity to supply a given geography's or organization's energy needs is often the primary source of emissions. However, non-energy sources, such as industrial processes and agricultural practices, also produce GHG emissions.

Inventories can be performed at multiple scales, from the local to the global. In the United States, some of the most prominent inventories are carried out by large cities, states, and the federal government. Many corporations also publish inventories in order to track their own progress toward sustainability goals.

In order to measure progress toward energy use and GHG emissions reduction goals and to help identify the best opportunities to reduce both energy use and GHG emissions, inventories should be performed at regular intervals starting with a baseline year. Such periodic inventories can reveal long-term trends.

Types of Inventories

Energy use and GHG emissions inventories can be area-based ("in-boundary"), consumption-based, or life-cycle based.

> ***Area-based inventories*** measure all energy use and/or GHG emissions within a specified area, whether or not that energy use or those emissions result from consumption by that area's residents. For instance, in an area-based inventory a municipality hosting a regional electricity generation facility would be allocated all the emissions generated by that facility, even for the portion of that electricity consumed by customers outside the municipality.
>
> ***Consumption-based inventories*** measure energy use and/or GHG emissions associated with the consumption of resources by a specified population, whether or not that energy use or those emissions occur where that population lives. For example, in a consumption-based inventory, a municipality would be allocated emissions resulting from the electricity consumed by residents, whether that electricity was produced inside or outside the municipality.
>
> ***Life-cycle based inventories*** seek to quantify and add indirect sources of emissions and energy use, such as emissions and energy use associated not only with the use of a vehicle, but also with its manufacture and disposal. Life-cycle inventories can be combined with consumption-based inventories to provide a comprehensive assessment of a given population's impact.

DVRPC employs a hybrid inventory type, using consumption-based estimates for activities such as electricity generation and automobile travel, and area-based estimates for activities such as petroleum refining and iron and steel manufacturing. DVRPC's inventory does not include energy use or GHG emissions associated with production of goods imported to the region, other than electricity.

Why Inventory Energy Use and GHG Emissions?

An energy use and GHG emissions inventory provides the information required to track energy use and GHG emissions trends, develop and prioritize strategies and policies to reduce energy use and GHG emissions, and assess progress toward goals to reduce energy use and GHG emissions. An inventory can help policymakers and citizens better understand how energy is used in the region and the sources of GHG emissions to help effectively decrease both.

Through its energy use and GHG emissions inventory for 2015, DVRPC calculates and documents estimates of regional energy use and GHG emissions as well as estimates or allocations for each of the counties and municipalities in Greater Philadelphia. This data can be found in this document, *Energy Use and Greenhouse Gas Emissions in Greater Philadelphia, 2015: Summary* and in detailed municipal energy use and GHG emissions profiles found at www.dvrpc.org/webmaps/municipalenergy.

DVRPC's Office of Energy and Climate Change Initiatives works to reduce regional, county, and local energy use and GHG emissions through regional data-sharing, cooperation, and planning, and is available to assist counties and municipalities with their own efforts.

DVRPC's Regional Energy Use and GHG Emissions Inventory

DVRPC's *Energy Use and Greenhouse Gas Emissions Inventory for Greater Philadelphia* tracks energy use and GHG emissions in three major use and emissions categories and 12 major sectors. These use and emissions categories are:

- stationary energy use: use of energy in buildings and other stationary applications;
- mobile energy use: use of energy by vehicles and other mobile equipment; and
- other non-energy emissions/sequestration sources.

The sectors within each of these categories are shown to the right. These categories and sectors are similar to those used in the U.S. Environmental Protection Agency's *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

DVRPC's inventory estimates emissions of the three major GHGs: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). DVRPC uses a blend of "top-down" data (e.g., state fuel consumption estimates), "bottom-up" data (e.g., local consumption data from utilities), and modeling (e.g., DVRPC's regional travel demand model) to develop estimates of energy use and GHG emissions. The mix of data and other inputs used in this inventory was dictated by availability, existing protocols, and resource limitations. DVRPC's inventory methods and sources are described in detail in *Energy Use and Greenhouse Gas Emissions in Greater Philadelphia, 2015: Methods and Sources*.

GHG Emissions—Categories, Sectors, and Sub-Sectors

Stationary Energy Use

- Residential
- Non-Residential

Mobile Energy Use

- On-Road Motor Vehicles
- Rail
  - Transit
  - Freight
  - Intercity
- Aviation
  - Commercial
  - General
- Marine and Port-Related
- Off-Road Vehicles and Equipment

Non-Energy Emissions/Sequestration

- Fuel Refining, Transmission, and Distribution
- Industrial Processes
- Waste Management
- Agriculture
- Land Use, Land Use Change, and Forestry

Energy Use and GHG Emissions in Greater Philadelphia

Energy Use

DVRPC estimates that activity in the nine-county Greater Philadelphia region in 2015 resulted in the use of 1,174 trillion BTUs of energy, equivalent to about 18 times the 2016 net generation output of Exelon's nuclear Limerick Generating Station in Montgomery County, PA.[6] This energy use estimate includes energy from fuel consumed within or outside the region to provide electricity to users in Greater Philadelphia; fuels consumed within the region to heat homes and businesses; fuels consumed by motor vehicles, including trips starting in the region and ending outside of it or vice versa; and fuels consumed by other transportation modes (e.g., rail, aviation). About 74 percent of this energy was used by the region's homes, businesses, schools, and other stationary applications. Mobile energy use by motor vehicles, trains, planes, ships, and other vehicles and equipment accounted for the remaining 26 percent.

BTU

A BTU or British thermal unit is the amount of energy needed to heat one pound of water by one degree Fahrenheit. A kilowatt hour of electricity contains about 3,412 BTUs, and a gallon of gasoline contains about 114,000 BTUS. One Therm equals 100,000 BTUs.

[6] Exelon Corporation, *Limerick Generating Station*, Accessed July 2018. www.exeloncorp.com/locations/Documents/ Limerick%20Fact%20Sheet%20-%202017.pdf.

GHG Emissions

Activity in Greater Philadelphia also resulted in the emission of GHGs equivalent to 75 MMTCO_2e, not including emissions and sequestration from land use, land use change, and forestry. If the net sequestration due to land use change and forestry is considered, emissions decrease to a net total of about 74 MMTCO_2e.

Of the 75 MMTCO_2e of gross GHG emissions, about 88 percent were associated with energy use, comprising stationary energy use by the residential, commercial, and industrial sectors and mobile energy use by the transportation sectors (see Figure 2). Fugitive and process emissions from fuel refining, transmission, and distribution (primarily leaks from natural gas transmission and distribution infrastructure and leaks and evaporation from petroleum refining) accounted for four percent of total emissions. Industrial processes and waste management each accounted for an additional four percent and three percent, respectively. Agricultural processes accounted for less than one percent of total emissions. Net sequestration of CO_2 due to land use and forestry reduced overall emissions by about two percent.

Carbon Dioxide Equivalent (CO_2e)

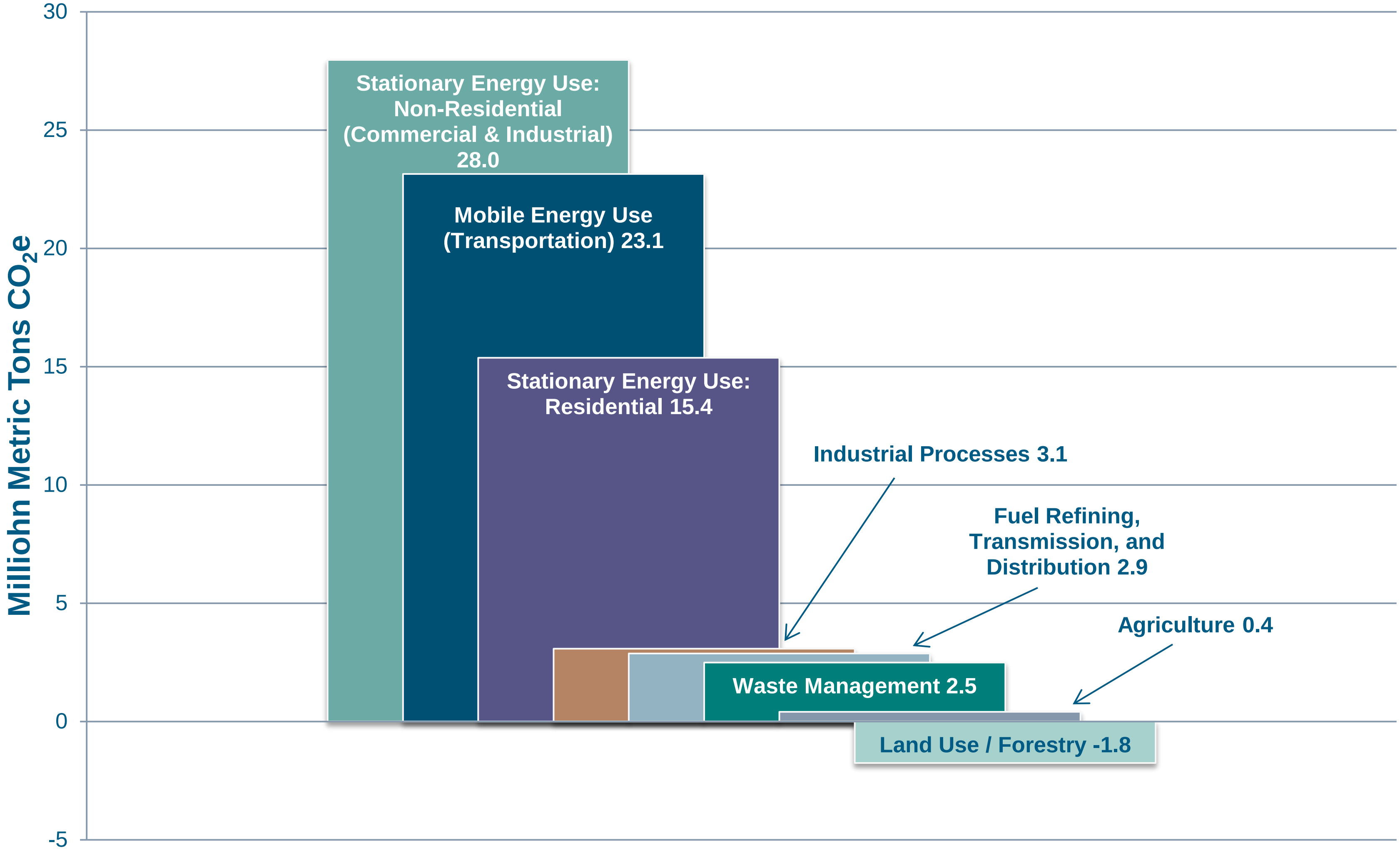
GHG emissions are generally reported in metric tons or million metric tons of carbon dioxide equivalent (CO_2e) units. A metric ton is 1,000 kilograms (2,205 pounds), equivalent to approximately 1.102 U.S. short tons. CO_2e units provide a measure of a gas's global warming potential (GWP) compared to a unit of CO_2. The GWP takes into account the fact that many gases are more powerful GHGs than CO_2, per unit mass. For instance, one metric ton of methane has the same global warming effect as 25 metric tons of CO_2 over the course of 100 years. The equivalencies, or global warming potentials (GWP), used in this inventory are identical to those used in the U.S. Environmental Protection Agency's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016*. Table 1 below shows the relative GWPs—expressed in CO_2e—for the GHGs included in this inventory.

Table 1: Global Warming Potentials

GHG	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous Oxide (N_2O)	298
Hydroflourocarbons (HFCs)	124 – 14,800
Perflourocarbons (PFCs)	7,390 – 12,200

Source: U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016, April 12, 2018, accessed July 27, 2018. www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

Figure 2: Greater Philadelphia's 2015 GHG Emissions ($MMTCO_2e$)



Source: DVRPC 2018

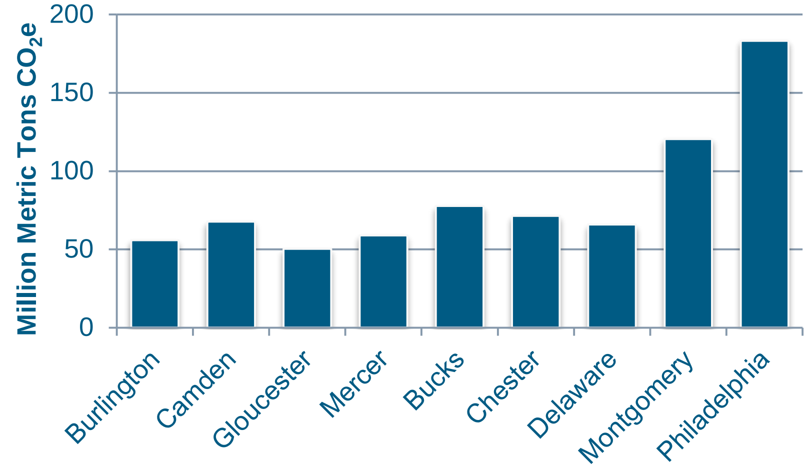
Energy Use by County

At the county level, activity in Philadelphia used the most energy in 2015, with 183 trillion BTUs (see Figure 3).[7] Activity in Gloucester County used the least energy, with 50 trillion BTUs. Philadelphia had the lowest energy use per "capita" with 78 million BTUs used per person/job (see Figure 4).[8] Delaware, Burlington, and Bucks counties used 79, 81 and 82 million BTUs per person/job, respectively. Gloucester County had the highest energy use per "capita" at 122 million BTUs per person/job. Higher per capita energy use in Gloucester County results, in part, from substantial energy use by the county's non-residential sector, the fifth highest in the region, and a residential population that is lower than other counties in the region. Dispersed residential development with little access to transit, resulting in longer commutes and more driving, also plays a role.

[7] For county and municipal allocations, energy use is defined as the billion British thermal units (BBTU) equivalent of energy used by end point users. For electricity and district steam, this is the BBTU equivalent of the electricity or steam at point of consumption, not the heat content of fuels used to produce electricity or district steam. This is different from how energy use is estimated for the region as a whole.

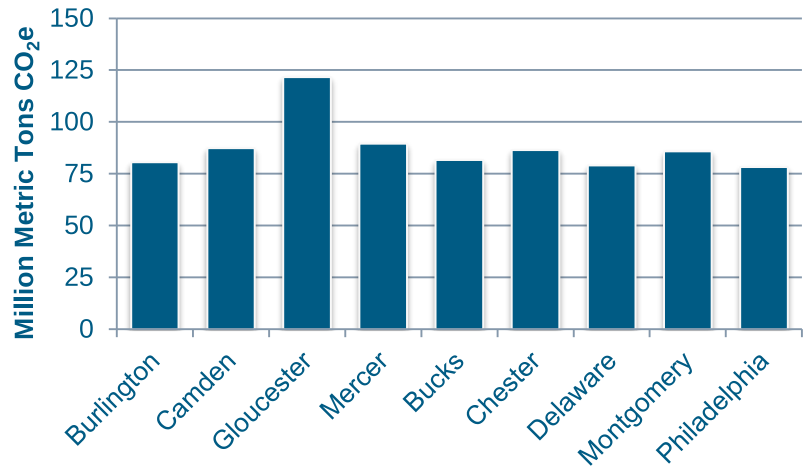
[8] DVRPC combines population and jobs to serve as the basis for a modified per capita calculation that reflects the energy demands of both households and businesses.

Figure 3: 2015 Energy Use by County (Trillion BTUs)



Source: DVRPC 2018

Figure 4: 2015 Energy Use per Capita by County (Million BTUs per Person/Job)

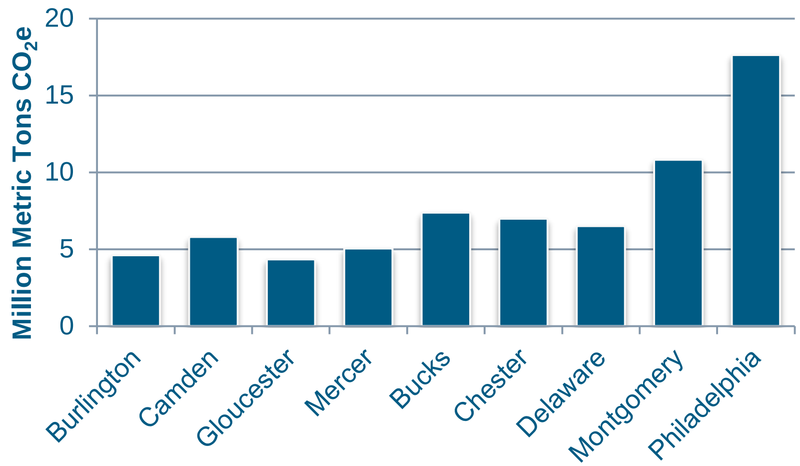


Source: DVRPC 2018

GHG Emissions by County

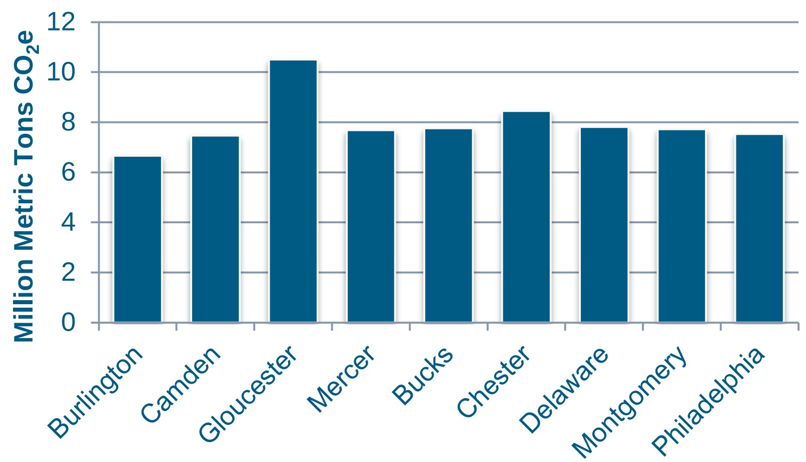
Activity in Philadelphia resulted in the highest GHG emissions,[9] with 17.6 MMTCO$_2$e (see Figure 5).[10] Activity in Gloucester County resulted in the lowest emissions, with 4.3 MMTCO$_2$e. Burlington County had the lowest emissions per capita, with 6.7 MTCO$_2$e per person/job, while Gloucester County had the highest emissions per capita, with 10.5 metric tons of CO$_2$e per person/job (see Figure 6). Again, higher per capita GHG emissions in Gloucester County result in part from energy use by the county's non-residential sector and emissions resulting from that use, but it is further increased by industrial process and fugitive (non-energy) emissions from petroleum refining facilities located in the county. Dispersed development again also plays a role in driving up per "capita" emissions in the transportation sector.

Figure 5: 2015 GHG Emissions by County (MMTCO$_2$e)



Source: DVRPC 2018

Figure 6: 2015 GHG Emissions per Capita by County (MTCO$_2$e per Person/Job)



Source: DVRPC 2018

[9] In this section, emissions reported take into account carbon sequestered (stored) in urban and forest trees.

[10] In *Greenworks: 2014 Progress Report*, the City of Philadelphia estimates that activity in the city resulted in the emission of 20.89 tons of CO$_2$e in 2012. Differing estimation and allocation methods and data availability contribute to this difference. DVRPC uses methods that can be replicated with data available across the region, whereas the City of Philadelphia, in some cases, uses methods and data that are available only for the city.

Changes in Energy Use and GHG Emissions

Connections 2045: Plan for Greater Philadelphia, DVRPC's long-range plan for future growth and development, sets a target of reducing GHG emissions by 60 percent from 2005 levels by 2040. DVRPC estimates that net GHG emissions decreased 10 percent from 2010 to 2015, from about 82 $MMTCO_2e$ to about 74 $MMTCO_2e$ (see Table 3). By 2015, emissions were down about 21 percent from their 2005 levels. Such reductions continue to move the region toward meeting the 2040 goal. However, further and continued reductions will require sustained, concerted and aggressive action at the household, firm, community, regional, state, national, and global level, as well as continued technical advancement.

The decrease in GHG emissions from 2010 to 2015 reflects decreases in most major source sectors, including a decrease of over 10 percent in GHG emissions from both the stationary and mobile energy use sectors, which together account for 88 percent of all emissions. GHG emissions from fuel refining, transmission, and distribution also decreased. However, emissions from waste management and industrial processes rose.

Regional energy use decreased about 9 percent, from 1,291 trillion BTUs to 1,174 trillion BTUs (see Table 2). Stationary energy use decreased about eight percent, with reductions in both the residential and non-residential sectors. Mobile energy use decreased about 12 percent, the bulk of which came from decreased energy use by motor vehicles traveling the regions roadways.

Table 2: Regional Energy Use

	Energy Use (Trillion BTUs)	
	2010	2015
Stationary Energy Use: Non-Residential	582	542
Mobile Energy Use	347	306
Stationary Energy Use: Residential	363	326
Total Energy Use (Gross)	1,291	1,174

Source: DVRPC 2018 (items may not add to totals due to rounding)

Table 3: Regional GHG Emissions

	GHG Emissions ($MMTCO_2e$)	
	2010	2015
Stationary Energy Use: Non-Residential	30.0	28.0
Mobile Energy Use	26.4	23.1
Stationary Energy Use: Residential	18.5	15.4
Industrial Processes	2.7	3.1
Fuel Refining, Transmission, and Distribution	4.0	2.9
Waste Management	2.1	2.5
Agriculture	0.4	0.4
Total Emissions (Gross)	84.0	75.3
Land Use, Land Use Change, and Forestry	-2.3	-1.8
Total Emissions (Net)	81.7	73.6

Source: DVRPC 2018 (items may not add to totals due to rounding)

Contribution Analysis

With funding from the U.S. Department of Energy's Cities Leading through Energy Analysis and Planning (Cities-LEAP) program, the City of Bellevue, Washington and ICLEI—Local Governments for Sustainability led a group of leaders in the field of municipal and regional GHG emission inventories, including DVRPC, in developing a methodology and tool to quickly identify and communicate the most significant factors contributing to changes in GHG emissions from one time period to the next.[11] DVRPC used this methodology and tool to identify the largest drivers of change between our 2010 and 2015 GHG emissions inventories.

Some of the drivers impact multiple sectors. For example, the overall change in electricity generation mix (less coal, more natural gas) was the most significant factor impacting GHG emissions across the region. It applied downward pressure on GHG emissions in the residential and non-residential energy use sectors, as well as some mobile energy use sectors where electric propulsion plays a prominent role (e.g., transit rail).

Overall, the top three drivers of reductions in 2015 were, in decreasing levels of significance, change in electricity generation mix (i.e., a cleaner electricity grid due to the continued switch from coal to natural gas), decreased on-road emissions per mile traveled,[12] and decreased electricity consumption per household (see Figure 7).

The top three discrete drivers putting upward pressure on emissions in 2015 were, in decreasing levels of significance: (1) an increase in the consumption of fuels other than electricity, natural gas, distillate fuel oil, and propane in the non-residential sector (such as gasoline, residual fuel oil, etc.); (2) an increase in employment; and (3) increased natural gas consumption per household.

It is important to note that decreased electricity consumption and increased heating fuel consumption per household due to changes other than weather are isolated from changes resulting from weather by this analysis. Weather, treated separately, exerted downward pressure on overall emissions. Electricity demand, though still higher than an expected weather normalized estimate, was closer to that estimate than in 2010. And natural gas demand dipped even lower below an expected weather normalized estimate.

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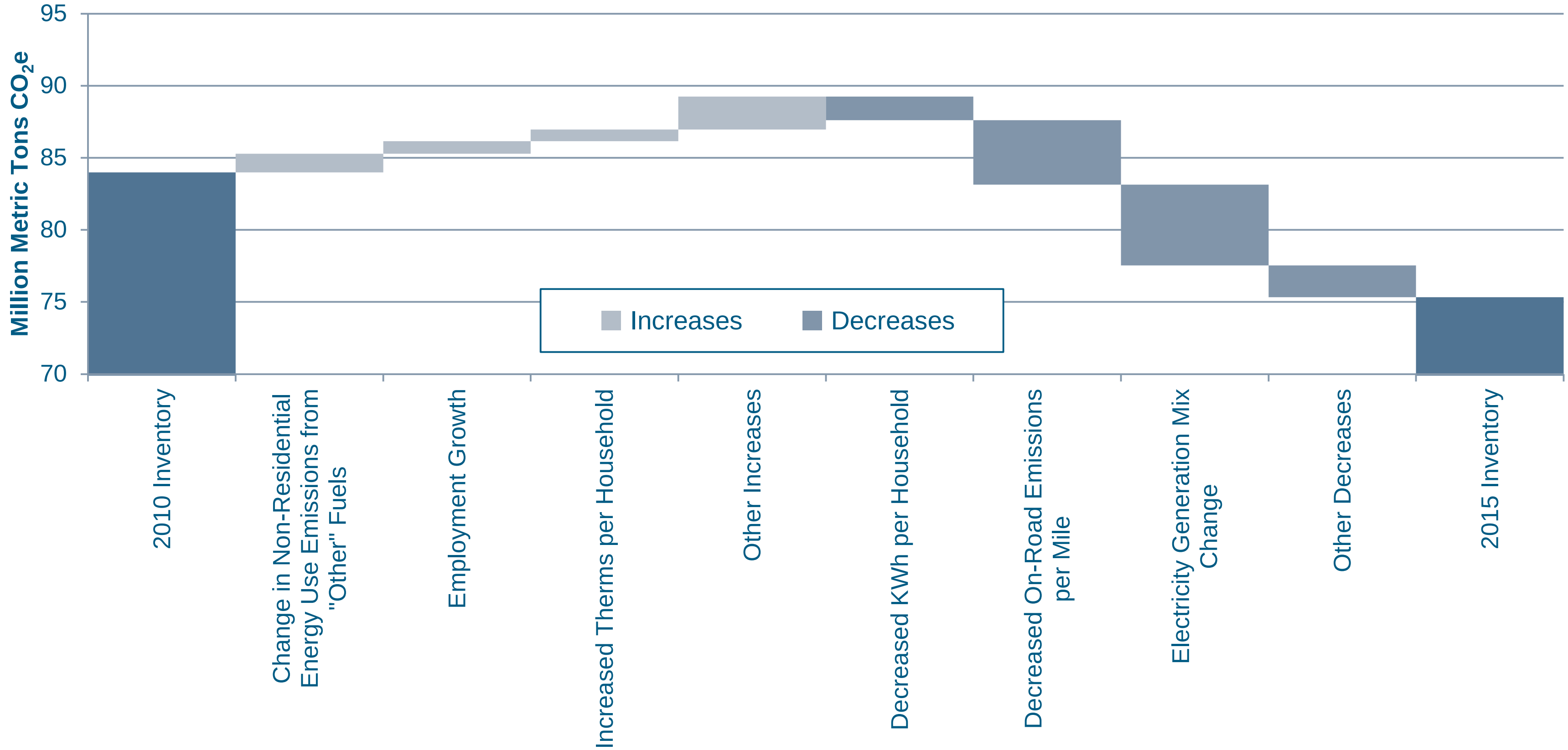
[11] More information about the project and tool can be found at: http://icleiusa.org/ghg-contribution-analysis/. More information about Cities-LEAP can be found at: www.energy.gov/eere/cities-leading-through-energy-analysis-and-planning.

[12] DVRPC updated its travel demand model and the U.S. Environmental Protection Agency updated its Motor Vehicle Emissions Simulator between DVRPC's 2010 and 2015 inventory. Some change in on-road emissions per mile traveled is likely due to these model changes, while some is likely due to an overall more efficient vehicle fleet.

Figure 7: Top Three Positive and Negative Drivers of Change: DVRPC Regional GHG Emissions Summary, 2010 vs. 2015

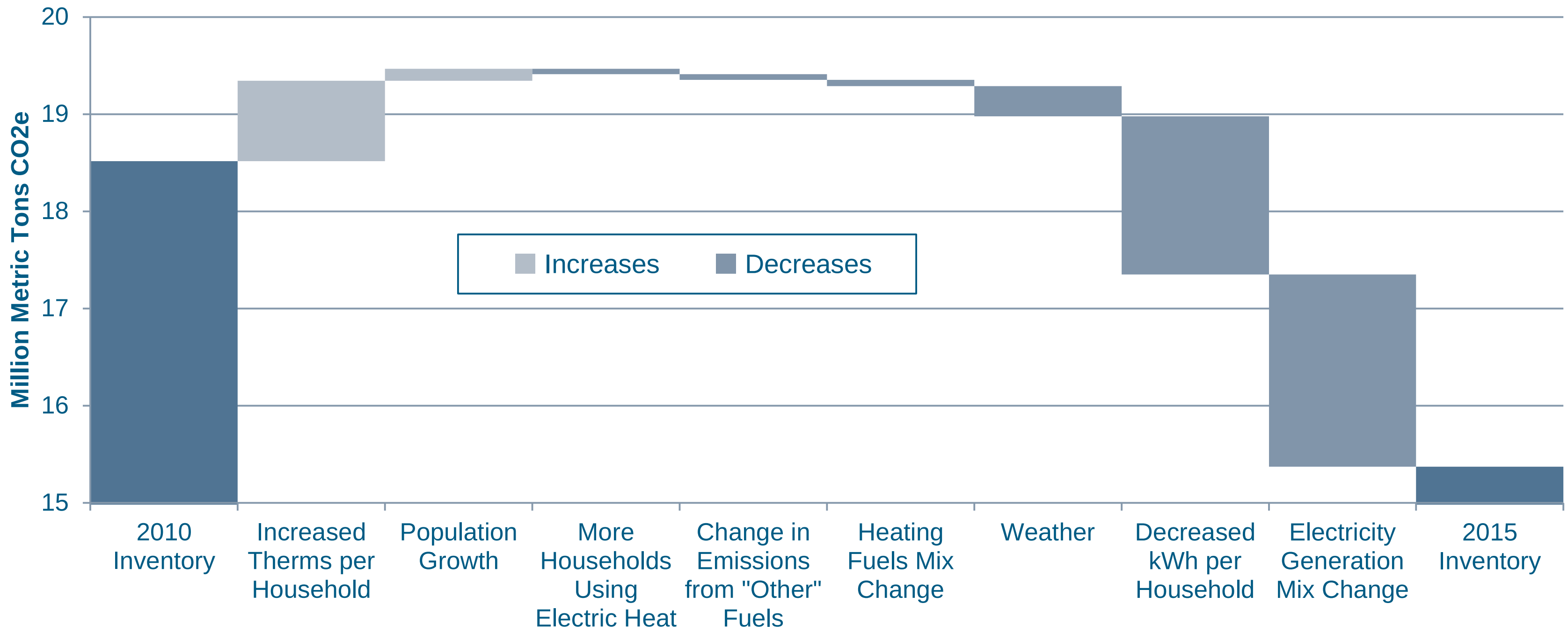


Source: DVRPC 2018

Residential Sector

Figure 8 illustrates the drivers of change in GHG emissions from the residential sector resulting from stationary energy. These emissions decreased 17 percent, from about 19 $MMTCO_2e$ to 15 $MMTCO_2e$. As illustrated in the right side of the figure, the bulk of this decrease was due to the change in electricity generation mix, but decreased electricity consumption per household also played a strong role. Other factors contributing to the decrease were weather, a change in heating fuel mix (e.g., fuel switching from heating oil to natural gas), households converting to electric heat (such as heat pumps), and a decrease in emissions from fuels other than electricity, natural gas, distillate fuel oil, and propane. On the other hand, increased heating fuel demand and population growth applied upward pressure on emissions.

Figure 8: Drivers of Change in the Residential Sector: DVRPC Regional GHG Emissions Summary, 2010 vs. 2015

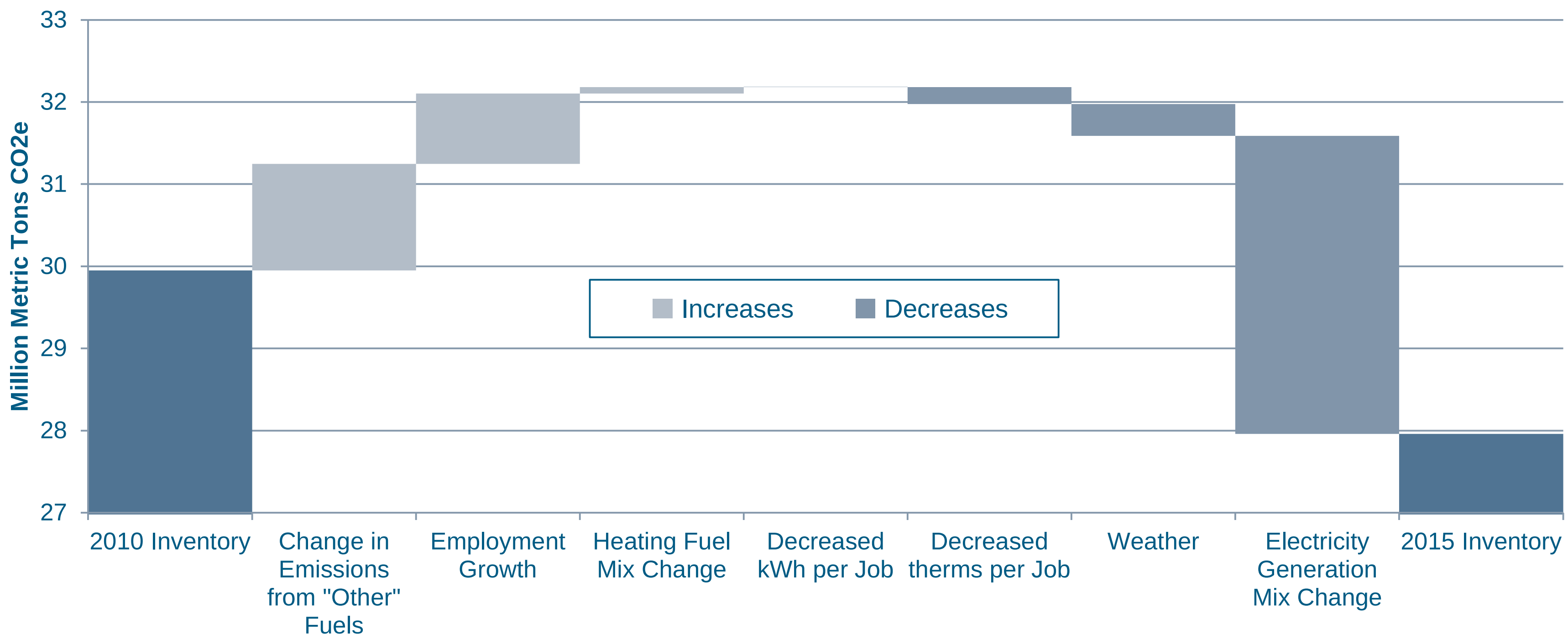


Source: DVRPC 2018

Non-Residential Sector

GHG emissions resulting from stationary energy use in the non-residential sector decreased seven percent, from about 30 $MMTCO_2e$ to 28 $MMTCO_2e$. Again, the bulk of this decrease was due to the change in electricity generation mix (see Figure 9). Weather and decreased natural gas and a very small decline in electricity consumption per job also contributed to the decrease. However, an increase in the use of fuels other than electricity, natural gas, distillate fuel oil, and propane placed significant upward pressure on emissions. Employment growth, heating fuel mix, and weather also pushed emissions higher than they otherwise would have been.

Figure 9: Drivers of Change in the Non-Residential Sector: DVRPC Regional GHG Emissions Summary, 2010 vs. 2015

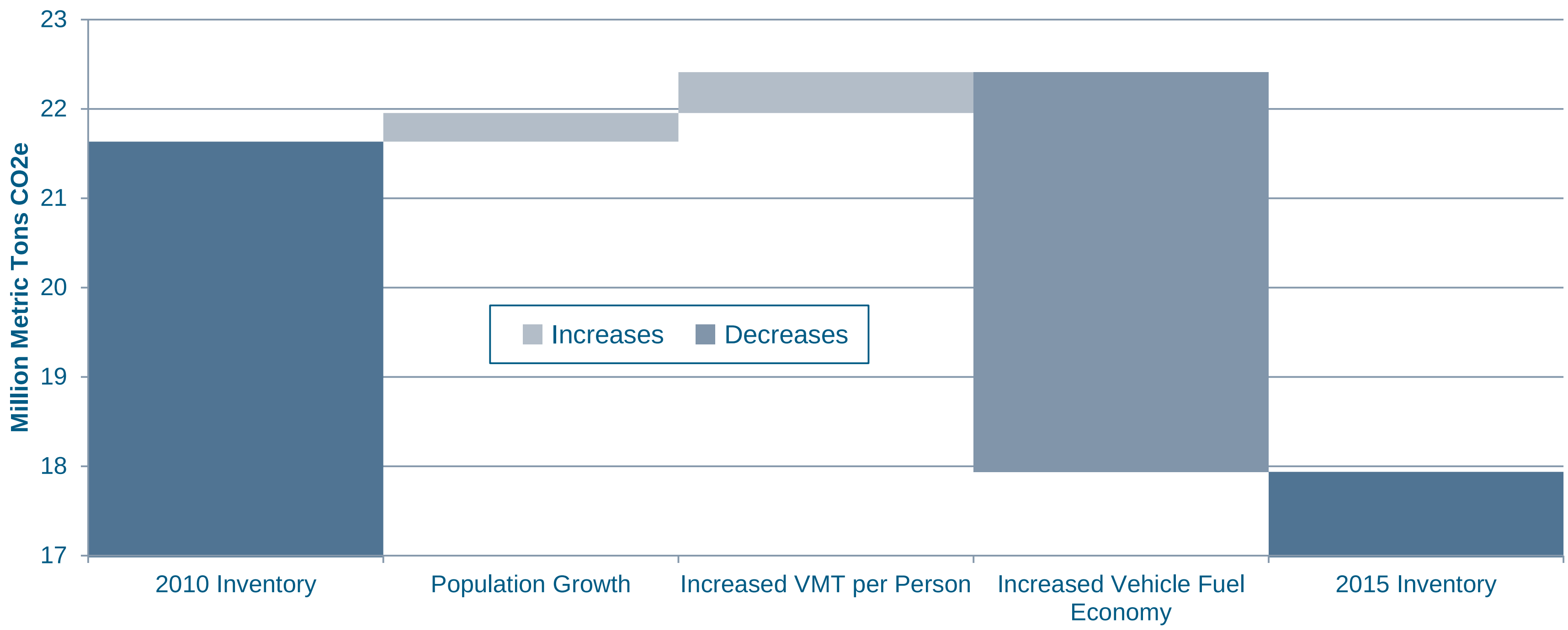


Source: DVRPC 2018

On-Road Transportation Sector

Emissions resulting from mobile energy use in the on-road transportation sector decreased about 17 percent, from about 22 $MMTCO_2e$ to about 18 $MMTCO_2e$. Decreased on-road emissions per mile traveled, due to increased fuel economy in the vehicle fleet, overwhelmed upward pressure from increased vehicle miles traveled per person and population growth (see Figure 10).

Figure 10: Drivers of Change in On-Road Transportation: DVRPC Regional GHG Emissions Summary, 2010 vs. 2015



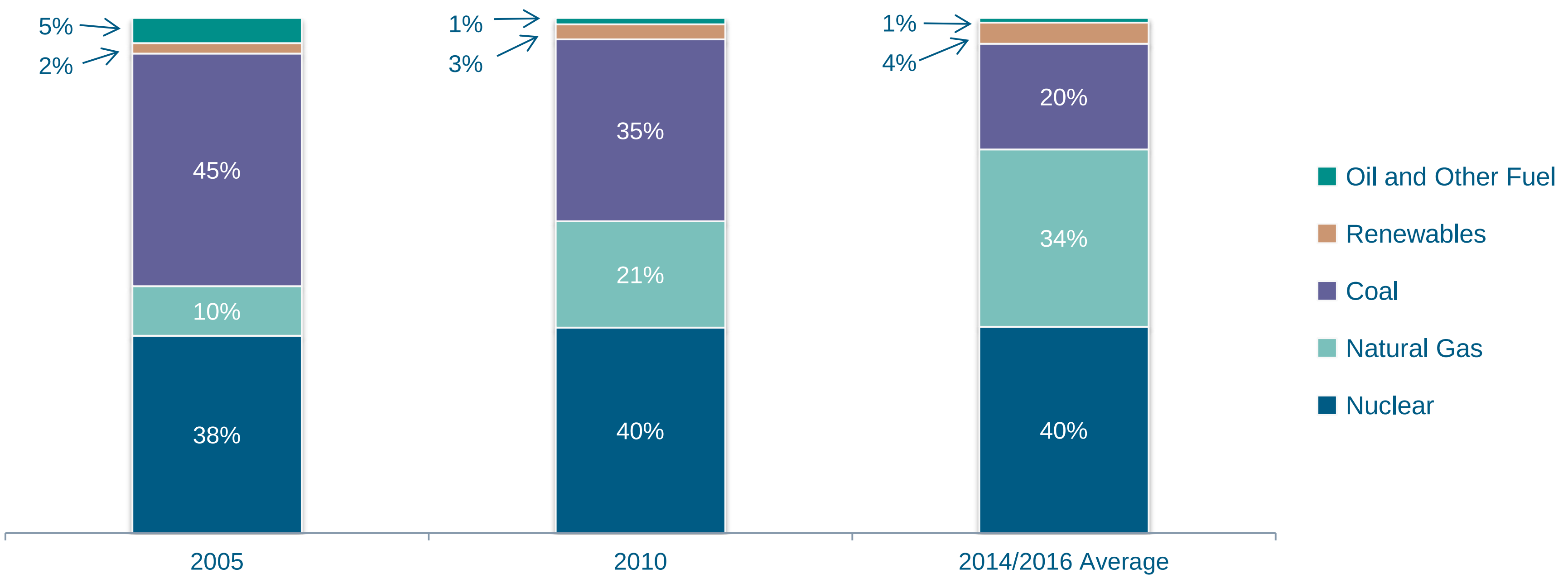
Source: DVRPC 2018

Electricity Generation Mix

The mix of fuels used to generate electricity plays a significant role in regional GHG emissions. If the region had met its 2015 electricity demand across all sectors with its 2010 electricity generation mix, GHG emissions from electricity generation would have been about five $MMTCO_2e$ higher. Using the 2005 mix would have resulted in about nine $MMTCO_2e$ of additional emissions. The reduction in emissions over the last decade was due mostly to generation from coal-fired generating plants being replaced by generation from natural gas plants (see Figure 11). However, natural gas, though it has a lower emissions rate than coal, is a fossil fuel and does release GHGs when combusted. Thus, the emissions reductions that can be achieved through switching to natural gas generation are limited.

Renewables, such as hydropower, wind, and solar photovoltaics, continue to expand their contribution to the electricity generation mix, but still account for only about four percent of electricity generated. Nuclear, which produces no GHG emissions, continues to account for about 40 percent of generation.

Figure 11: Electricity Generation Mix in 2005, 2010, and 2015



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). DVRPC falls within the RFC East subregion used by the U.S. Environmental Protection Agency to classify emission rates and generation mixes. RFC East is the eastern part of the ReliabilityFirst Corporation's territory and contains much of Pennsylvania and New Jersey, and several other Mid-Atlantic states. Because eGRID did not produce a report for 2015, DVRPC used the average of the 2014 and 2016 reports. Note: eGRID emissions factors only account for emissions at the point of electricity generation and do not include lifecycle emissions resulting from extraction and transportation of fuels or disposal of waste products.

Municipal Allocation

The following maps (see Figures 12–17), placed on facing pages, present per acre and per capita[13] energy use and GHG emissions at the municipal level. Higher density communities—those with a greater number of residents and jobs per acre—tend to use less energy and produce lower GHG emissions per person/job (See Table 4). These communities tend to be characterized by walkable, mixed-use neighborhoods served by transit. Homes and commercial spaces tend to be more compact. These communities tend to be located in the region's historic core and in its transit-connected suburbs. *Connections 2045: Plan for Greater Philadelphia* calls for continued investment in already-established communities or "Centers" such as these. As the region continues to grow, focusing new development in these areas and ensuring communities are walkable, transit-accessible, and comprising energy efficient buildings will be essential to achieving energy use and GHG emissions reduction goals.

When the sequestration of carbon dioxide by forests is taken into account, sparsely populated, heavily-forested municipalities also have lower net per capita GHG emissions, pointing to the importance of conservation of the region's rural and urban forests and natural areas as embodied in *Connection 2045's* Greenspace Network and Conservation Focus Areas.

DVRPC has developed an online tool that provides detailed municipal-level reports of energy use and GHG emissions allocations. Just as with the overall inventory, energy use and GHG emissions in these reports are sometimes based on reported data, but in other cases reflect estimates based on population, economic data, and other factors. Not all categories of emissions estimated at the regional level have been allocated to the municipal level. Though in some cases additional local data may support a more accurate local analysis, the allocated emissions and energy use are all done to a very high standard, and can be useful in prioritizing local strategies to reduce energy use and GHG emissions.

DVRPC's tool for producing detailed municipal-level energy use and GHG emissions profiles is available at www.dvrpc.org/webmaps/municipalenergy.

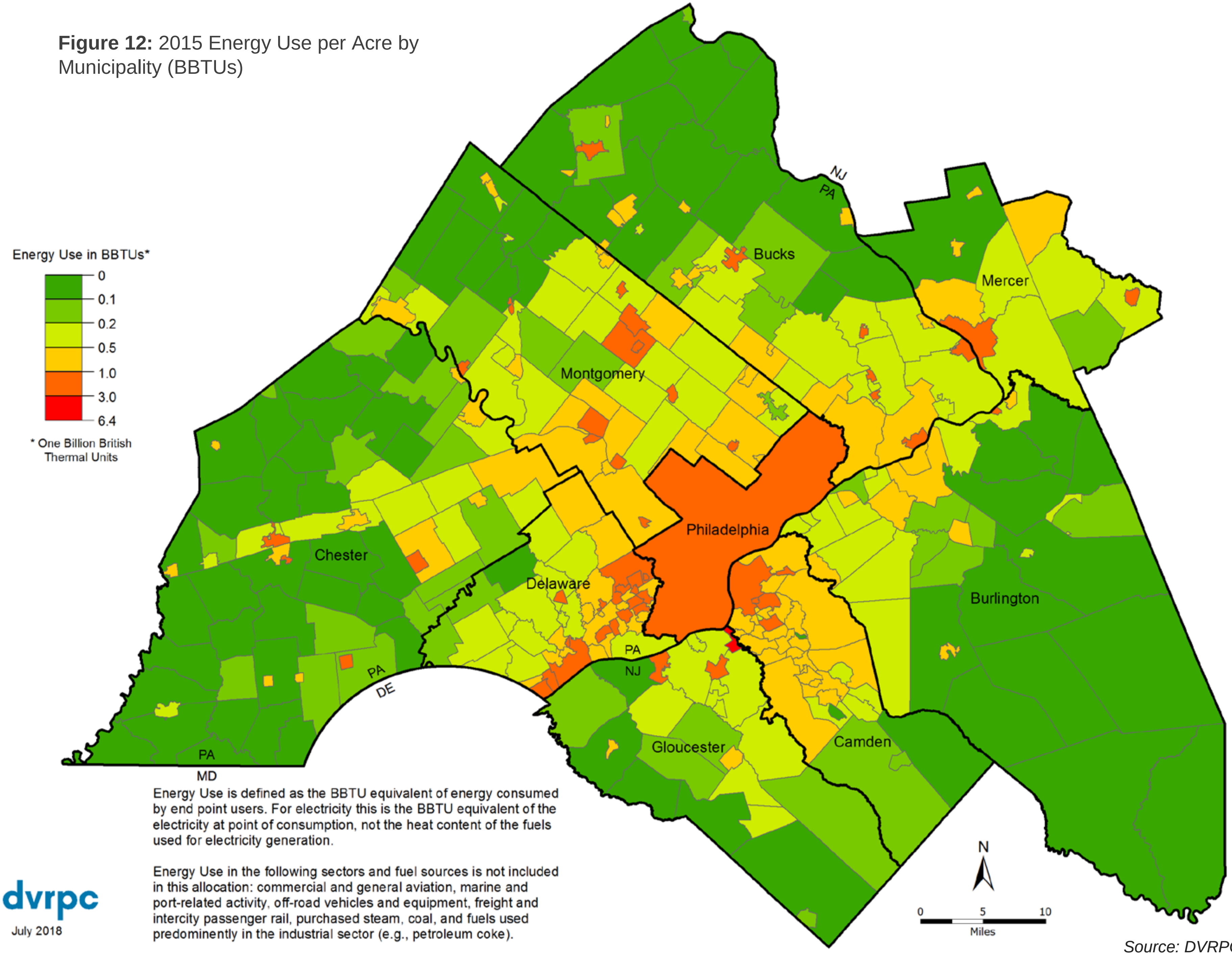
Table 4: Energy Use and GHG Emissions and Density

Density	Energy Use per Person + Job (Million BTUs)	Gross GHG Emissions per Person + Job ($MTCO_2e$)	Net GHG Emissions per Person + Job ($MTCO_2e$)
<1 Person + Job per Acre	83.8	7.6	6.4
1 to <5 People + Jobs per Acre	89.3	8.0	7.7
5 to <10 People + Jobs per Acre	85.1	7.1	7.0
≥10 People + Jobs per Acre	77.7	6.9	6.9

Source: DVRPC 2018

[13] As noted elsewhere, DVRPC combines population and jobs to serve as the basis for a modified per capita calculation that reflects the energy demands of households and businesses in any particular municipality.

Figure 12: 2015 Energy Use per Acre by Municipality (BBTUs)



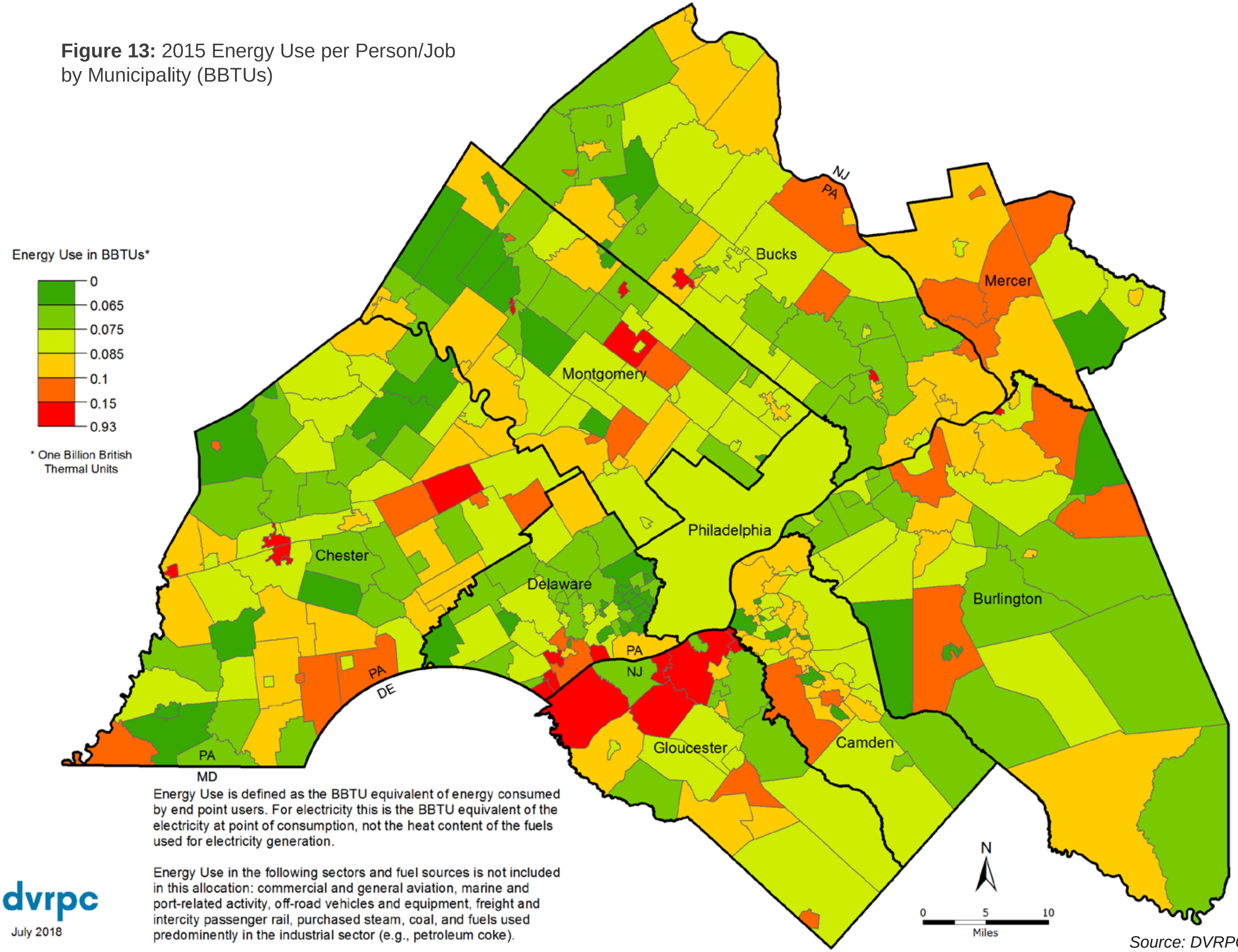
Energy Use is defined as the BBTU equivalent of energy consumed by end point users. For electricity this is the BBTU equivalent of the electricity at point of consumption, not the heat content of the fuels used for electricity generation.

Energy Use in the following sectors and fuel sources is not included in this allocation: commercial and general aviation, marine and port-related activity, off-road vehicles and equipment, freight and intercity passenger rail, purchased steam, coal, and fuels used predominently in the industrial sector (e.g., petroleum coke).

dvrpc July 2018

Source: DVRPC 2018

Figure 13: 2015 Energy Use per Person/Job by Municipality (BBTUs)



Energy Use is defined as the BBTU equivalent of energy consumed by end point users. For electricity this is the BBTU equivalent of the electricity at point of consumption, not the heat content of the fuels used for electricity generation.

Energy Use in the following sectors and fuel sources is not included in this allocation: commercial and general aviation, marine and port-related activity, off-road vehicles and equipment, freight and intercity passenger rail, purchased steam, coal, and fuels used predominently in the industrial sector (e.g., petroleum coke).

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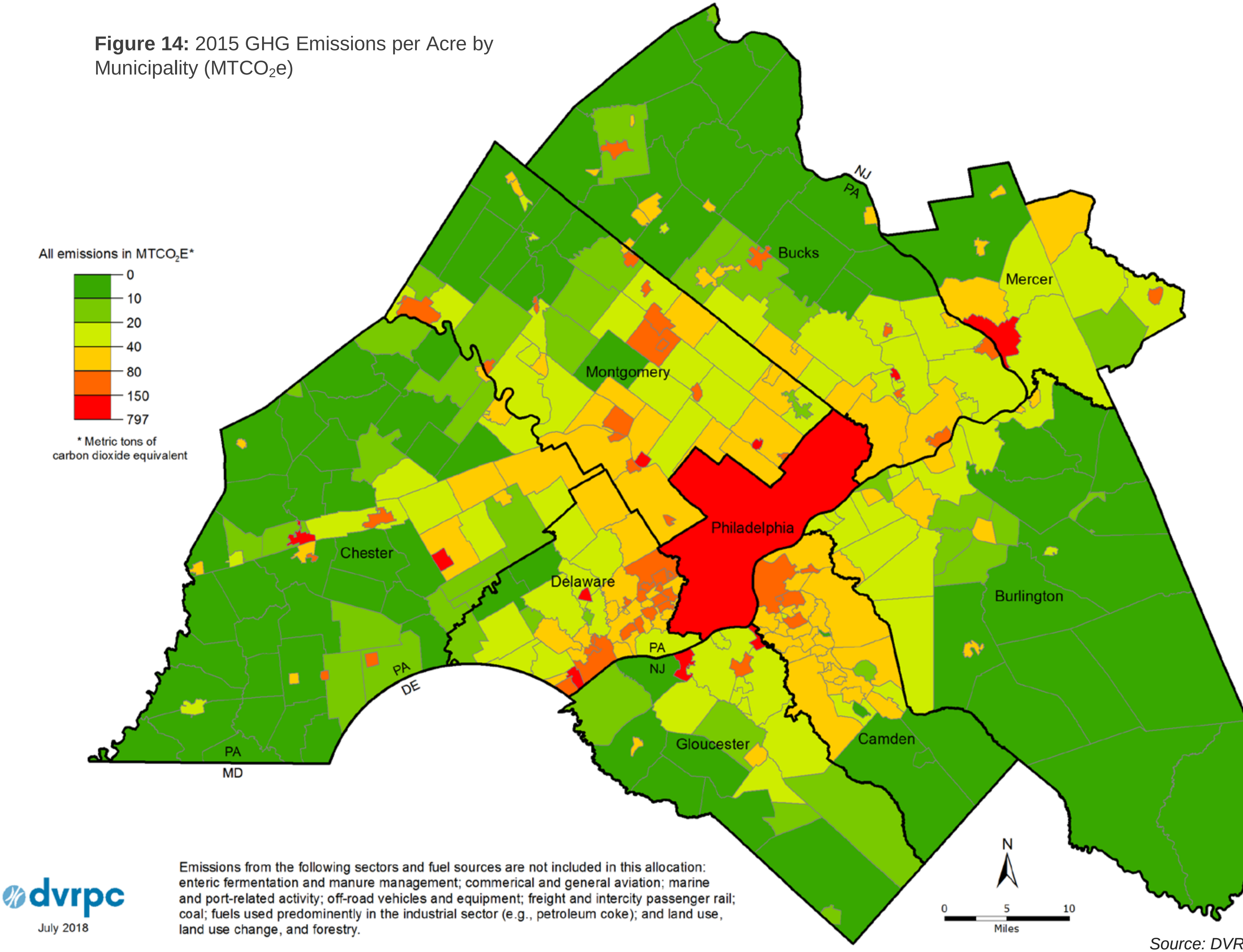
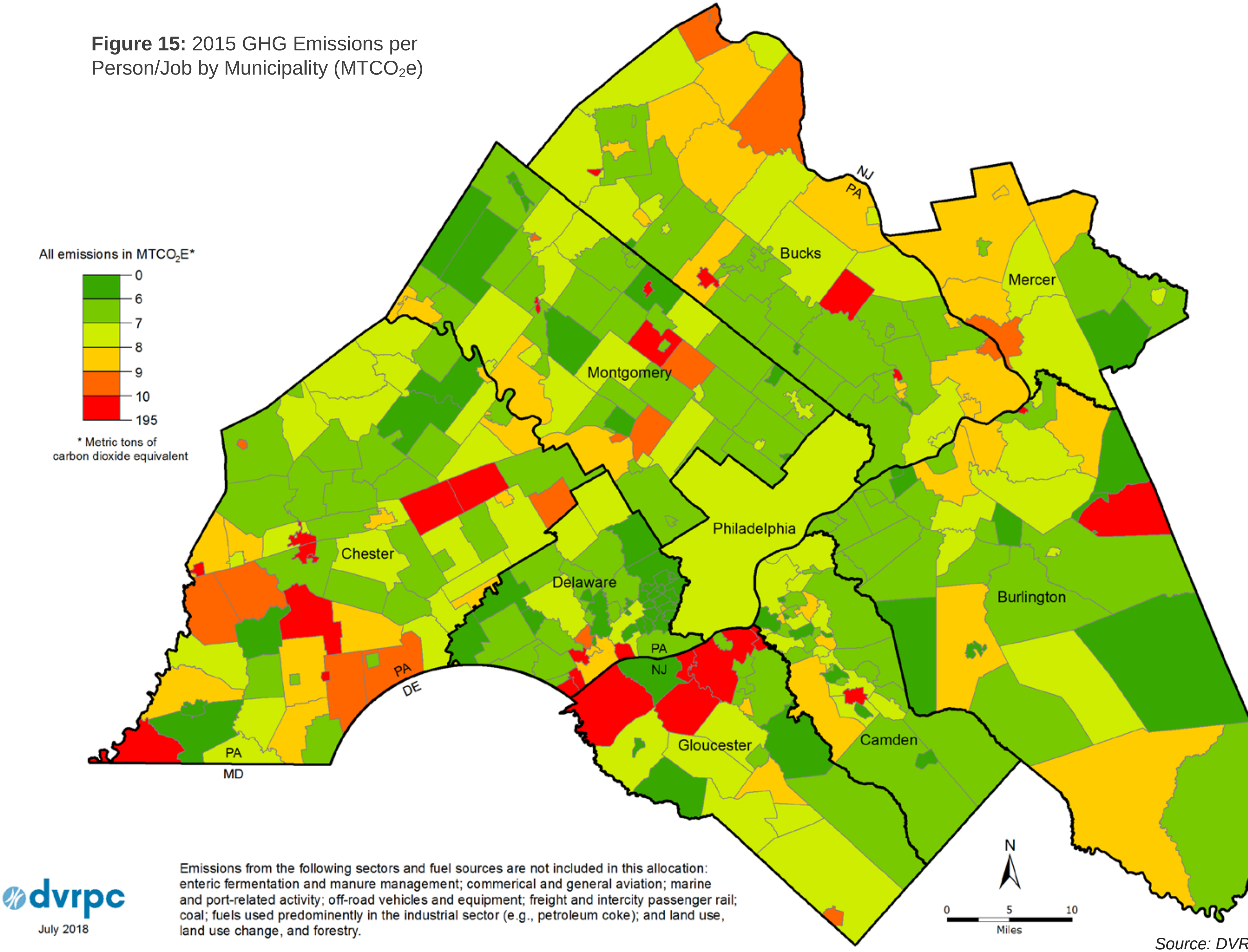
Source: DVRPC 2018

Figure 14: 2015 GHG Emissions per Acre by Municipality ($MTCO_2e$)



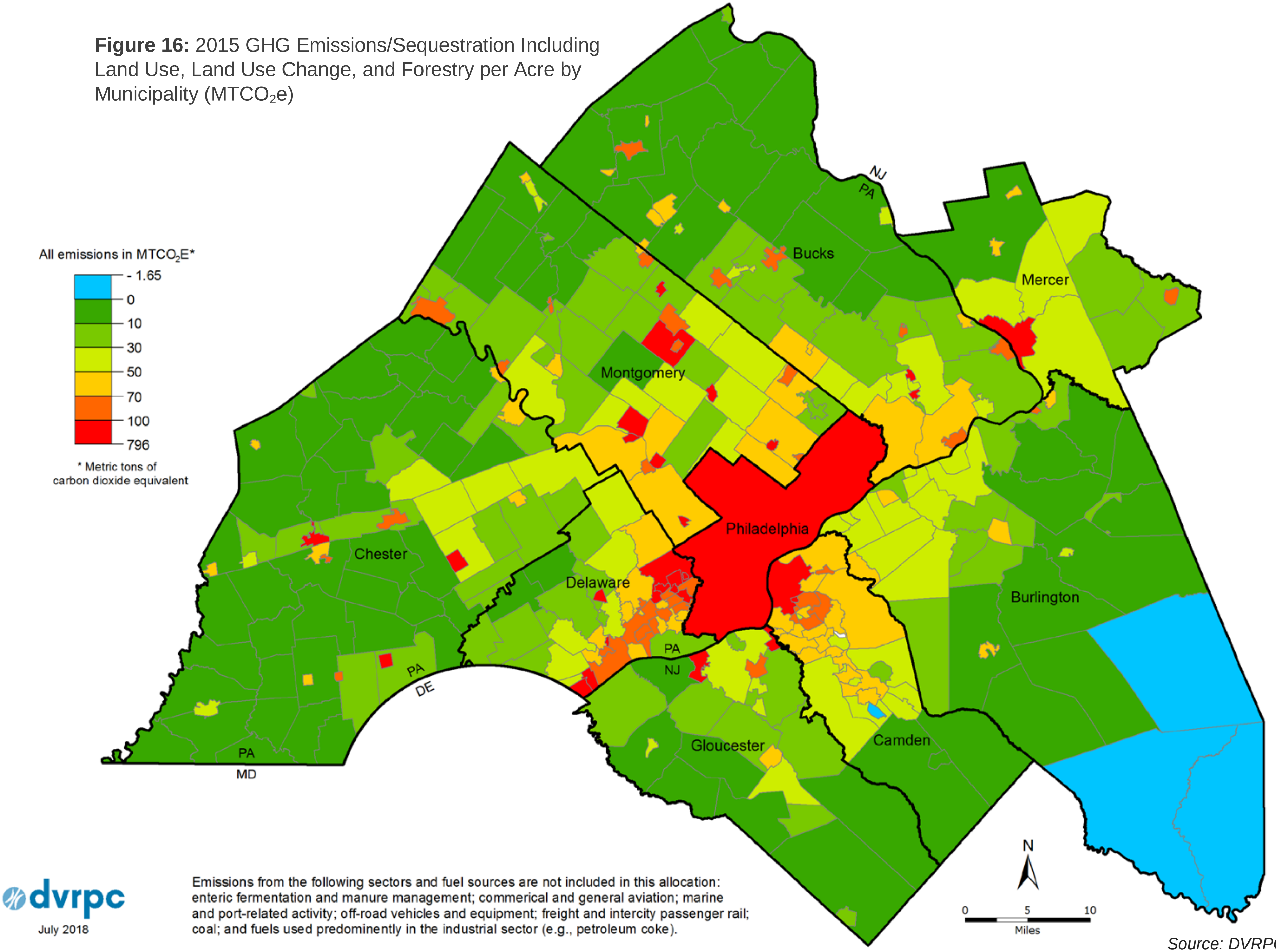
Source: DVRPC 2018

Figure 15: 2015 GHG Emissions per Person/Job by Municipality ($MTCO_2e$)



Source: DVRPC 2018

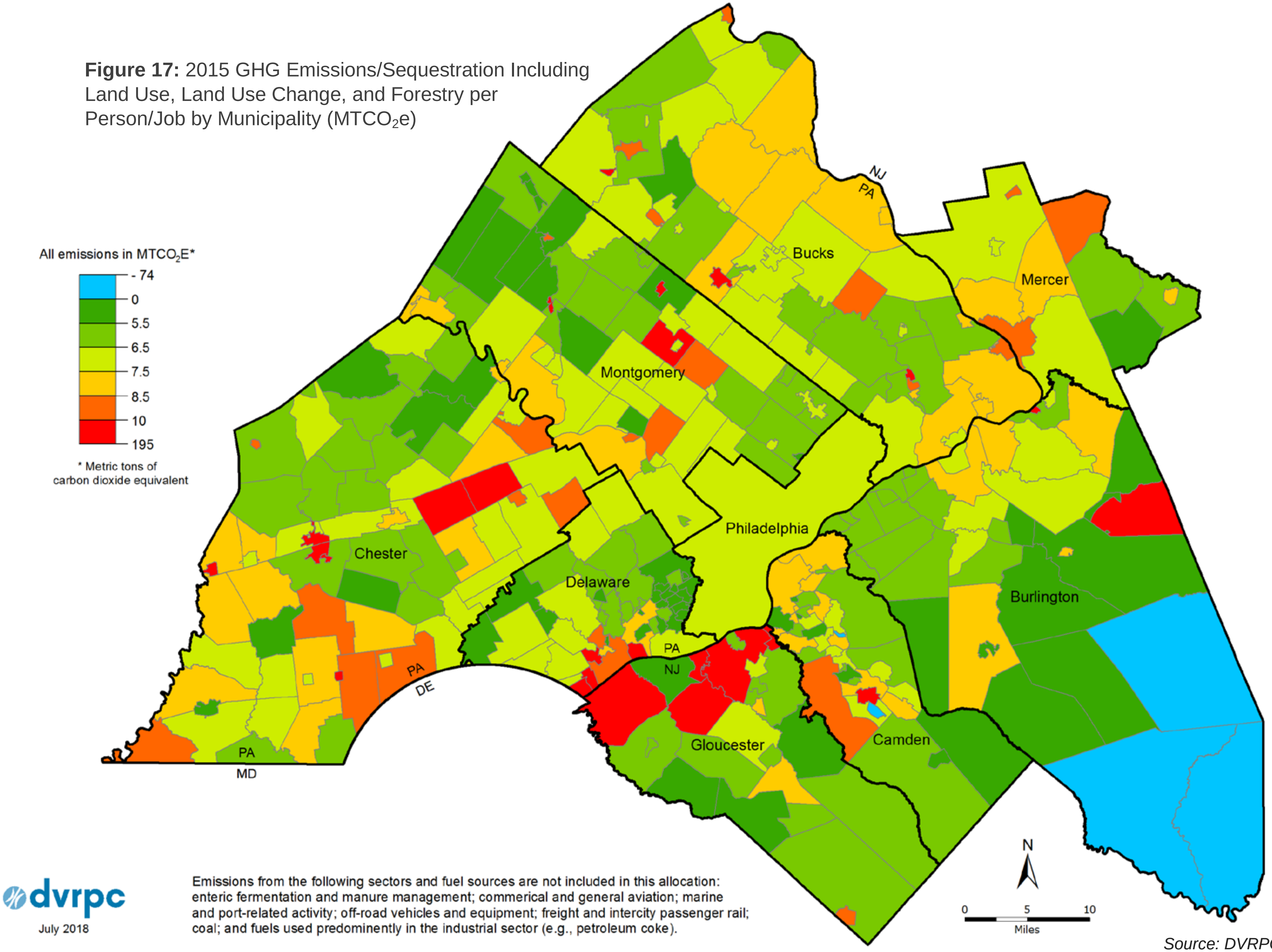
Figure 16: 2015 GHG Emissions/Sequestration Including Land Use, Land Use Change, and Forestry per Acre by Municipality ($MTCO_2e$)



Emissions from the following sectors and fuel sources are not included in this allocation: enteric fermentation and manure management; commerical and general aviation; marine and port-related activity; off-road vehicles and equipment; freight and intercity passenger rail; coal; and fuels used predominently in the industrial sector (e.g., petroleum coke).

Source: DVRPC 2018

Figure 17: 2015 GHG Emissions/Sequestration Including Land Use, Land Use Change, and Forestry per Person/Job by Municipality ($MTCO_2e$)



Source: DVRPC 2018

The Role of Federal, State, and Local Policy

The most significant factors contributing to emissions reductions in Greater Philadelphia, such as electricity generation mix and vehicle efficiency, are largely beyond the scope of local government control. They reflect a mix of national and international economic realities coupled with federal and state policies. For instance, the large shift in electricity generation from coal to natural gas reflects natural gas's cost advantage over coal in recent years, due to increased supplies as a result of hydraulic fracturing ("fracking"). State and multi-state regulatory regimes, such as Pennsylvania's Alternative Energy Portfolio Standard and the multi-state Regional Greenhouse Gas Initiative, also play a role in fostering the development of lower carbon electricity generation. With vehicles, the federal government has largely been responsible for setting vehicle efficiency standards and historically has allowed states to adopt California's more stringent standard. This has contributed to a steadily cleaner fleet and the continued adoption of emissions reduction technologies (e.g., regenerative braking, start-stop systems, hybrid and electric technology). Backpedaling on these policies could slow or reverse these gains.

Local policies to encourage renewable generation (such as use-by-right zoning for rooftop solar) or adoption of more efficient vehicles (such as encouraging or requiring multifamily buildings to allow electric vehicle charging) can play an important role in this larger context. But focus should also be given to local policies that directly or indirectly impact other drivers of emissions. For instance, land use ordinances that encourage smart growth can play a role in reducing single-occupancy vehicle miles traveled and thus overall emissions from the transportation sector.

Firm and household level decisions, such as choosing transit over private vehicles or upgrading to energy efficient heating and cooling equipment can also play a role in this larger context. Governmental policies at all levels—national, state, and local—can encourage these choices.

Net Metering

Net metering is a way of compensating customers with distributed energy generation systems, such as solar panels or wind turbines, for the excess electricity they sometimes generate. Under this regulatory framework, a customer generator has the ability to "sell" electricity back to the grid when their generation exceeds their demand. This results in credits on their electricity bill. Because these credits allow customer generators to offset periods of high demand and low generation, net metering has been seen as an important mechanism for encouraging the installation of roof-top solar photovoltaic panels. On the other hand, some utilities have argued that reduced revenue from net-metered customers does not adequately offset costs required to maintain the electricity grid for those customers, without which they wouldn't be able to "buy" and "sell" power as needed or use electricity when their solar panels are not producing sufficient power.

Net metering has grown rapidly in both New Jersey and Pennsylvania. In Pennsylvania, the number of customer generators increased 74 percent between 2015 and 2017, from 9,258 customer generators to 16,130.[14] In New Jersey, the number of customer generators increased 86 percent, between 2015 and 2017, from 45,976 customer generators to 85,460.[15]

[14] Pennsylvania Public Utility Commission, *Net Metering & Interconnection Report, 2015-17*, accessed August 1, 2018. http://www.puc.state.pa.us/Electric/pdf/AEPS/net_metering-interconnection_report_2015-17.pdf.
[15] Compiled from net metering and interconnection reports provided to the New Jersey Bureau of Public Utilities by electric distribution companies. Accessed July 2018: www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection.

Electricity Supplier Choice Programs

In Pennsylvania and New Jersey, consumers have the ability to choose their electricity suppliers. Under these regulatory frameworks, while an electric distribution company (e.g., PECO Energy Company, PSE&G) continues to deliver electricity and charge for distribution, consumers have the option to shop for the portion of their bill referred to as supply or generation. This allows consumers to select a supplier that offers the cheapest prices or that provides a specific service, such as green or renewable energy. To help with consumer awareness, the Pennsylvania Public Utility Commission (PUC) and New Jersey Board of Public Utilities (BPU) have established online awareness and marketplace websites called PA Power Switch and NJ Power Switch.

According to the PUC and BPU data, these electricity power choice programs serve 67 percent and 39 percent of residential and non-residential load in Pennsylvania and New Jersey respectively.[16] Although both the PUC and BPU provide data on number of participating accounts and load served, they do not provide participation data for specific electricity supply plans, thus it is not possible to know the impact of these programs on emissions.

Power choice programs allow customers to select green or renewable electricity supply plans. However, it is important to note that a consumer is entering into a contract to support production of green or renewable electricity somewhere, not to have that electricity delivered to their home or business. Where that generation occurs and what portion of a customer bill it accounts for will be based on the stipulations in the plan.

A similar program is available for natural gas in both states.

Power Purchase Agreements (PPAs)

A PPA is similar to an electricity supply plan enrolled in under an electricity supply choice program. However, a PPA is a direct agreement between two entities (private or public) where one party agrees to supply the other with energy at an agreed upon rate. A common example of a PPA is a solar PPA. In a solar PPA, one party operates and maintains a solar power facility or otherwise procures solar-generated electricity and then sells the generated electricity to the other party. As with an electricity supply plan the generated electricity may or may not be delivered directly to the electricity consumer, but rather is delivered to the grid consistent with the agreement. However, some PPAs do include electricity generation at or near a buyer's facility.

PPA contracts tend to be long in duration. By providing a long-term contractual agreement, PPAs can provide benefits to both parties, including less electricity price volatility.

[16] Pennsylvania PUC, *PAPowerSwitch: Monthly Update, July 2018* and New Jersey BPU, *New Jersey Electric Switching Statistics—June 2018*.

Conclusion: Reducing Energy Use and GHG Emissions in Greater Philadelphia

The 13 percent reduction in GHG emissions between 2005 and 2010 followed by the 10 percent reduction between 2010 and 2015 have helped move Greater Philadelphia toward the *Connections 2045* target of reducing GHG emissions by 60 percent from 2005 levels by 2040. However, further reductions will require sustained, concerted, and aggressive action at the household, firm, community, regional, state, national, and global level as well as continued technology advancement.

The actions needed to increase energy efficiency and reduce GHG emissions do more than reduce energy costs and our region's contribution to climate change. They also make the transportation network more efficient, improve air quality, bolster public health, and make the region's communities more livable. An energy-efficient regional economy producing low GHG emissions will not only protect our regional environment, but it will also be more competitive in a world where climate change is an important concern.

DVRPC is committed to fostering sustainability, equity, and innovation in Greater Philadelphia. Increasing energy efficiency and decreasing the region's GHG emissions is a goal that motivates activities at DVRPC as varied as planning for transit-accessible, compact, mixed-use communities or administering the RideECO transit benefit program. For more information on DVRPC's activities, please visit DVRPC's website at www.dvrpc.org.

DVRPC's Office of Energy and Climate Change Initiatives leads the agency's energy efficiency, energy use and GHG emission, and climate change resiliency efforts. For more information or for assistance with local energy use and GHG emission reduction initiatives, please visit www.dvrpc.org/EnergyClimate.

Methods and Sources

Please refer to *Energy Use and Greenhouse Gas Emissions in Greater Philadelphia, 2015: Methods and Sources* for detailed descriptions of the methods used to calculate and estimate energy use and emissions in Greater Philadelphia, as well as a complete list of sources.

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Jersey Central Power & Light (FirstEnergy Corporation)
Maritime Exchange for the Delaware River and Bay
National Railroad Passenger Corporation (Amtrak)
PECO Energy Company (Exelon Corporation)
Philadelphia Gas Works
Philadelphia Office of Sustainability
Philadelphia Water Department
PPL Electric Utilities
Public Service Enterprise Group, Inc.
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U.S. Census Bureau

U.S. Department of Transportation
- Bureau of Transportation Statistics
- Federal Aviation Administration
- Federal Highway Administration
- Federal Transit Administration

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ENERGY USE AND GREENHOUSE GAS EMISSIONS INVENTORY FOR GREATER PHILADELPHIA

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Geographic Area Covered:

Nine-County Greater Philadelphia region, comprised of Bucks, Chester, Delaware, Montgomery, and Philadelphia counties in Pennsylvania, and Burlington, Camden, Gloucester, and Mercer counties in New Jersey.

Key Words:

Energy, Greenhouse Gas, GHG, CO_2. Carbon Dioxide, Emissions, Climate Change, Inventory

Abstract:

This document estimates energy use and greenhouse gas (GHG) emissions in DVRPC's nine-county Greater Philadelphia region. Data are for 2015. This is DVRPC's third such inventory. Earlier inventories were published using 2005 and 2010 data. DVRPC estimates that net GHG emissions decreased 10 percent from 2010 to 2015, from emissions equivalent to the release of 82 million metric tons of carbon dioxide ($MMTCO_2e$) to about 74 $MMTCO_2e$. GHG emissions were 21 percent lower in 2015 than in 2005. The top three drivers of reductions between 2010 and 2015 were, in decreasing levels of significance, change in electricity generation mix (a cleaner electricity grid due to the continued switch from coal to natural gas), decreased on-road emissions per mile traveled, and decreased electricity consumption per household. Continued reductions will require sustained, concerted and aggressive action at the household, firm, community, regional, state, national, and global level, as well as continued technical advancement. More information can be found at www.dvrpc.org/EnergyClimate/Inventory.htm.

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