

**DELAWARE'S 2014 GREENHOUSE GAS
EMISSIONS INVENTORY**

**PREPARED BY:
DIVISION OF AIR QUALITY
JANUARY 2019**

EXECUTIVE SUMMARY

This inventory was prepared by the Department of Natural Resources and Environmental Control (DNREC), Division of Air Quality (DAQ) for Delaware to present the findings of the 2014 Greenhouse Gas (GHG) emissions inventory and account for GHG emissions and sinks¹ in the State of Delaware. The inventory includes Delaware GHG emissions from 1990 to 2014 as well as emission projections from 2015 to 2030. In addition to the emissions data, this report provides information on emission sources and activities, as well as inventory methods.

Delaware's anthropogenic² GHG emissions were developed using a set of generally accepted principles and guidelines as well as protocols for State GHG emissions inventories established by the U.S. Environmental Protection Agency (EPA) and International Organization for Standardization (ISO). The General Methodology and Assumptions section of this report describes the principles and general methods applied to this GHG inventory process.

GHG emissions from Delaware's sources are presented in this report by using a common metric, carbon dioxide equivalents (CO₂e), which accounts for the relative contributions of each gas to global average radiative forcing on a Global Warming Potential (GWP) weighted basis. The emissions estimates in this report are represented in million metric tons of CO₂ equivalents (MmtCO₂e).

To develop the annual emissions of GHGs from Delaware for the period of 1990 to 2014 with projections, emissions estimations were performed by using the U.S.EPA's State Inventory Tool (SIT) as well as the projection tool (PT). The SIT and the PT consists of MSEXcel® spread sheets, which facilitate the collection of activity data (Information on the extent to which human activity takes place)³ and emission factors (coefficients which quantify emissions or removal per unit activity)⁴ that are based on economic activities⁵ in Delaware. Projection of GHG emissions are estimated by utilizing the U.S. Energy Information Administration Annual Energy Outlook data as well as other economic data that are used to predict GHG emissions.

An important change from the 2010 GHG emissions inventory report was performed in this update. Calculations for the waste management sector, specifically municipal solid waste, were updated to avoid misrepresentation of the sector as an emissions sink. Per the IPCC 2006 guidelines for the waste sector, methane generation from solid waste is calculated using a first order decay model⁶. However, in some cases, state data may show that more methane is recovered for beneficial use and/or flared than is modeled using the first order decay method. In such cases, negative emissions can be realized. In this case, per 40 CFR 98, Subpart HH,

¹ Sinks: Removal or sequestration of greenhouse gases from the atmosphere.

² The term "anthropogenic", in this context, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities (IPCC/UNEP/OECD/IEA 1997)

³ 2006 IPCC Guidelines for National Greenhouse Gas Inventories

⁴ 2006 IPCC Guidelines for National Greenhouse Gas Inventories

⁵ This includes fossil fuel combustion, industrial processes, agricultural activities and waste management

⁶ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste

methane emissions from municipal solid can be calculated based on the methane recovered and a collection efficiency⁷. This data has been updated for all years and will be used in future reports.

SOURCES OF GHG EMISSIONS AND TRENDS

The 2014 GHG inventory estimated GHG emissions from various sources. Data collection was performed by characterizing the sources into eight economic sectors of Delaware including electric power, transportation, industrial, residential, commercial, agricultural, waste management and land-use, land-use change & forestry (LULUCF). To estimate GHG emissions, each economic sector was subdivided based on subsectors and economic activities, as well as methodologies.

Between 1990 and 2014, GHG emissions from Delaware added a cumulative amount of 447.8 million metric tons of carbon dioxide equivalents (MmtCO_{2e}) to the atmosphere. In 2014, Delaware's gross⁸ total GHG emission was equivalent to 15.23 MmtCO_{2e}. Also in 2014, Delaware's net⁹ GHG emission was equivalent to 14.04 MmtCO_{2e}. From 1990 to 2014, gross GHG emissions decreased by approximately 22.6%, while net emissions decreased by approximately 28.6%¹⁰. Delaware's gross GHG emission in 2014 made up approximately 0.2% of gross U.S GHG emissions in 2014 (6,870 MmtCO_{2e})¹¹.

Figure ES-1 presents a breakdown¹² of GHG emissions in 2014 by Delaware's economic sectors. The largest source of GHG emissions in 2014 was the industrial sector. The industrial sector represented 29% of GHG emissions in 2014 as presented in Figure ES-1. This was followed by the transportation sector with approximately 28%. The electric power sector was the third largest emitter of GHG emissions in 2014 representing approximately 24% of gross emissions, while all other sectors including residential, commercial, agriculture and waste management each represented approximately 7%, 5%, 4% and 3% respectively as presented in Figure ES-1.

Figure ES-2 presents Delaware's gross¹³ GHG emissions profile from 1990 to 2014. It shows that in general, GHG emissions in Delaware's economic sectors trended downwards from 1990 to 2014 with some fluctuations. Gross GHG emissions decreased from 19.68 MmtCO_{2e} in 1990 to 15.23 MmtCO_{2e} in 2014, a decrease of approximately 22.6%. This decrease occurred at the rate of 0.24 MmtCO_{2e} per year with GHG emissions peaking at 20.85 MmtCO_{2e} in 1993.

⁷ 40 CFR 98 – Mandatory Greenhouse Gas Reporting, Subpart HH – Municipal Solid Waste Landfills

⁸ Gross GHG emissions accounts for only positive emissions and excluded metric tons of CO_{2e} removed from the atmosphere (sink)

⁹ The land-use category was a sink for the removal CO₂ from 1999 to 2014 because it generated negative CO₂ emission.

¹⁰ In 1990, gross emission was equivalent to net emission (19.34 MmtCO_{2e}) because there was no negative emission.

¹¹ U.S. EPA: 2016 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 -2014

¹² Figure ES-1 percentages are based on Delaware's gross emissions of 14.60 MmtCO_{2e} and not the net emissions of 13.75 MmtCO_{2e}.

¹³ Gross emissions includes all positive emissions and excludes all negative emissions from 1990 to 2014

FIGURE ES-1. 2014 DELAWARE GHG EMISSIONS BY ECONOMIC SECTOR

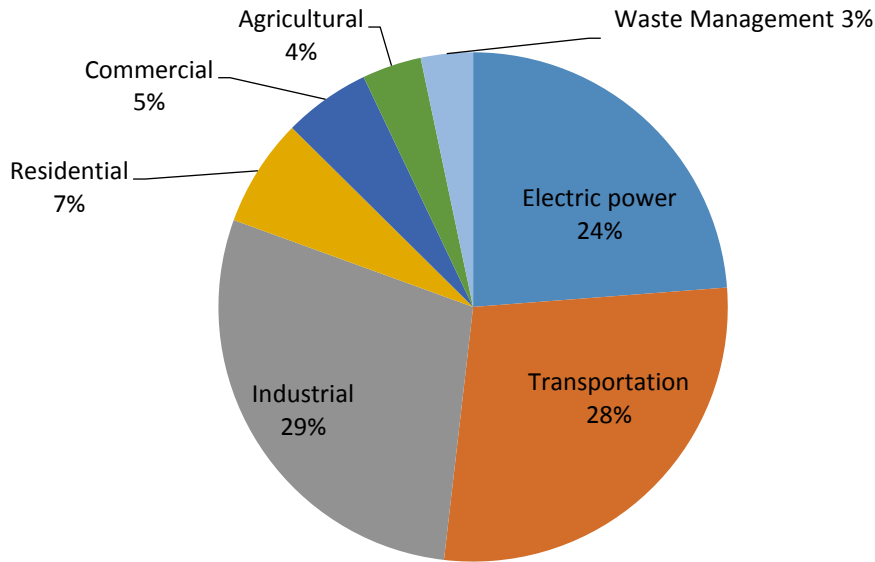


FIGURE ES-2. DELAWARE'S GROSS GHG EMISSION FROM 1990 TO 2014

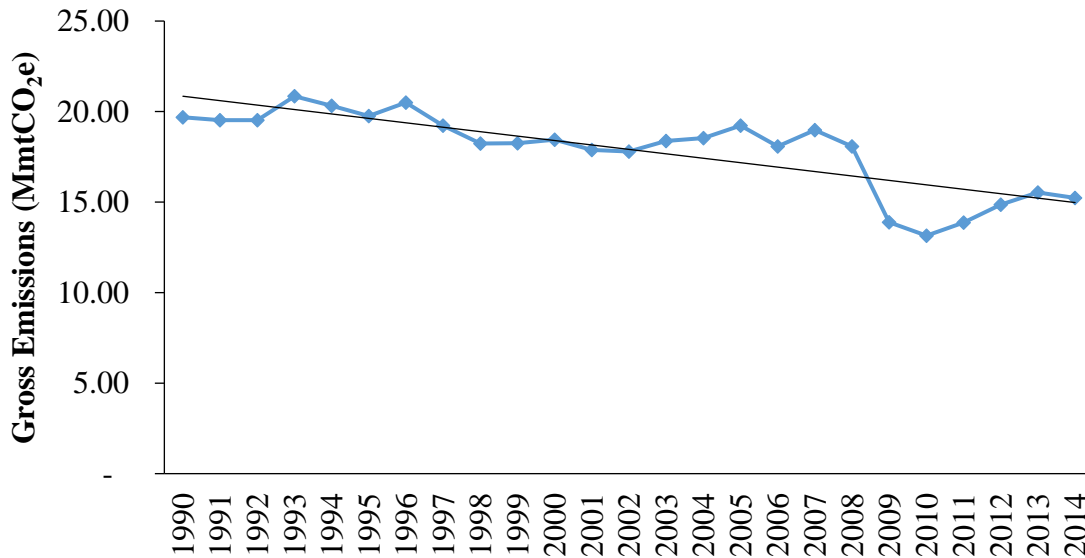


Figure ES-3 presents net¹⁴ GHG emissions from 1990 to 2014. Emissions decreased from 19.68 MmtCO₂e in 1990 to 14.04 MmtCO₂e in 2014 as presented by Figure ES-3. This was a decrease of approximately 28.7% at the rate 0.31 MmtCO₂e per year.

¹⁴ Net GHG emissions include all emissions including negative and positive emissions from 1990 to 2010. There were no negative emissions (i.e. emissions sinks) from 1990 through 1998, and thus, the net and gross GHG emission totals for each of those years are equivalent.

FIGURE ES-3. DELAWARE’S NET GHG EMISSIONS FROM 1990 TO 2014

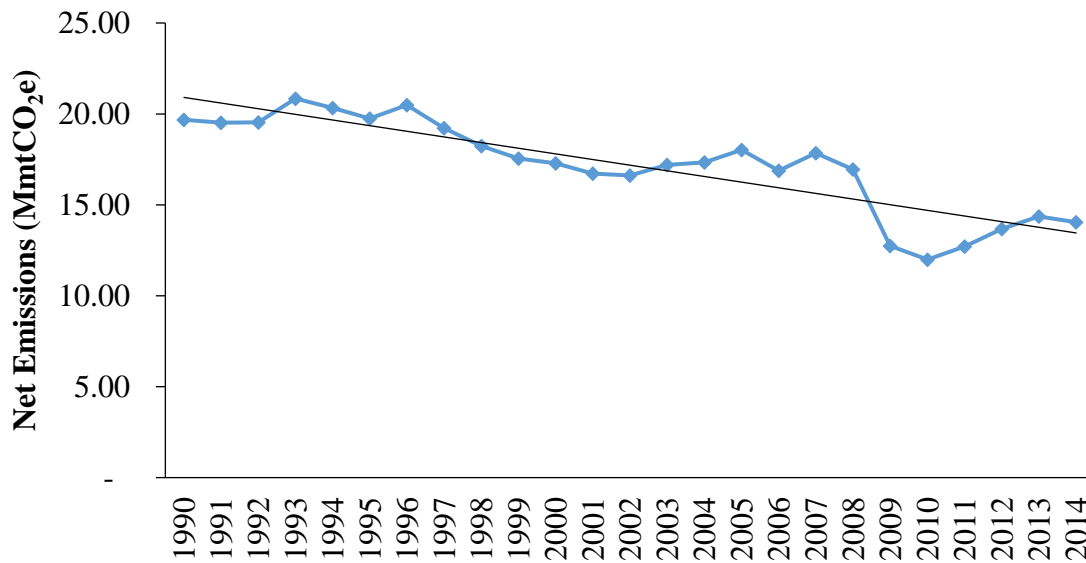
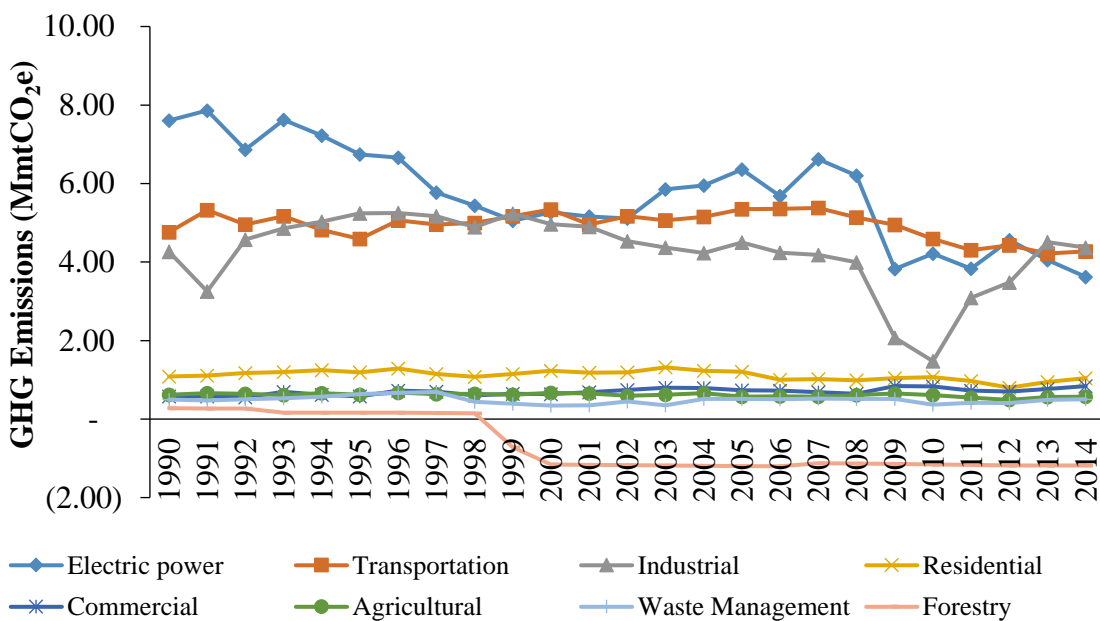


Figure ES-4 presents GHG emissions by economic sectors. Figure ES-4 shows that the largest emissions sources in Delaware included the electric power, transportation and industrial sectors.

In this report, the collection of these three sectors is known as the *Big Three* because their combined GHG emissions represented approximately 80% of Delaware’s emissions in 2014. As Figure ES-4 presents, GHG emissions from the *Big Three* intersected between 2000 and 2002, and again between 2012 and 2013. For most of the years between 1990 and 2014, electric power GHG emissions exceeded emissions from the other two sectors.

From 2004 through 2008, GHG emissions from the electric power sector began to pull away from the other two sectors. Emissions from the electric power and industrial sector had a sharp decline in 2009 and 2010 caused primarily by the economic recession. Transportation sector GHG emissions remained fairly constant and became the greatest emitting sector until 2011, as demonstrated by Figure ES-4. In 2014, the transportation and industrial sectors GHG emissions were each greater than the electric power sector GHG emissions. The decline in GHG emissions in the electric power sector can be attributed to fuel shifting from coal to natural gas for generation. The transportation sector remained constant with previous emission levels, while the industrial sector saw an increase in from 2011 due to refinery processes restarting.

FIGURE ES-4. DELAWARE’S GHG EMISSIONS BY ECONOMIC SECTOR



As the analysis indicates, the driving force for GHG emissions is largely energy consumption in all economic sectors.¹⁵ Energy related activities, specifically fossil fuel combustion, were the largest source of GHG emissions in 2014 as they represented 88% of gross GHG emissions from Delaware. The overall fuel consumption in Delaware declined in 2014 relative to 1990, and the fuel mix shifted more towards natural gas and away from coal; as such, gross GHG emissions decreased.

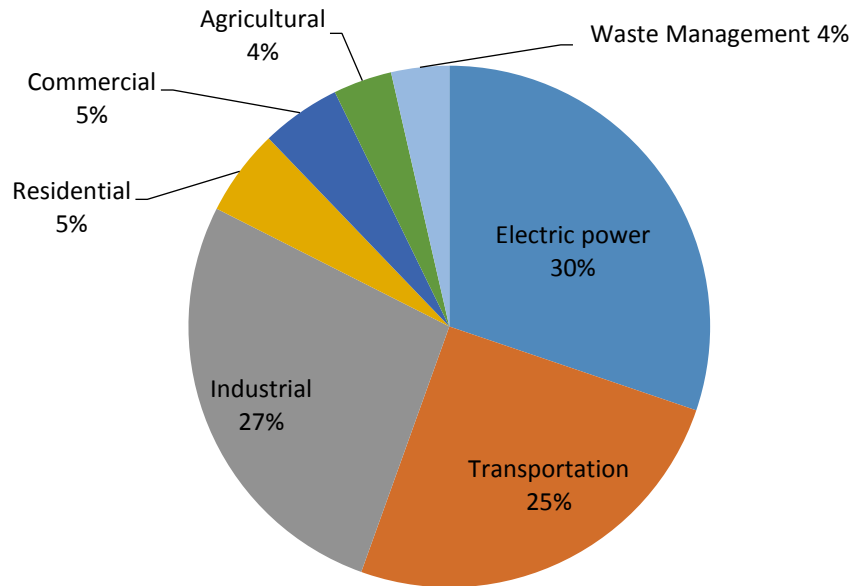
Reference Case GHG Emissions projections

The overall decline in historical GHG emissions is not projected to continue over time. Projection analysis¹⁶ shows that gross GHG emissions from Delaware are expected to trend upwards overtime. Figure ES-5 presents projected GHG emissions by economic sectors in 2030. GHG emissions, by sector, are projected to remain consistent with minor fluctuations. GHG emissions from the electric power sector are projected to become the top emitting sector again at 30% in 2030. Industrial GHG emissions are projected to represent approximately 27% in 2030, decreasing by a 2% of the share as compared to 2014. The transportation sector is projected to be the third largest emitter of GHGs representing approximately 25% in 2030, representing a relative decrease in contribution of 3% when compared to 2014. The residential and commercial sectors are projected to each represent 5% of the total 2030 GHG emissions. The waste management and agricultural sectors each are projected to represent 4% of the 2030 total.

¹⁵ Energy related activities are activities that involve fossil fuel combustion for energy use.

¹⁶ Projection analyses for all economic sectors are discussed in from Section 4.1 through 4.7.

FIGURE ES-5. DELAWARE'S 2030 GROSS GHG EMISSIONS BY ECONOMIC SECTOR



Cumulative gross GHG emissions from Delaware are projected to add approximately 261.5 MmtCO₂e to the atmosphere between 2015 and 2030. Figure ES-6 presents projected gross GHG emissions from Delaware from 2015 to 2030. GHG emissions are projected to increase slightly from 15.43 MmtCO₂e in 2015 to 17.14 MmtCO₂e in 2030, which represents an increase of approximately 11% or at an annual rate of 0.10 MmtCO₂e.

Cumulative net GHG emissions between 2015 and 2030 are projected to be 242.5 MmtCO₂e. Figure ES-7 presents projected net GHG emissions from 2015 to 2030. Net GHG emissions are projected to slightly increase from 14.25 MmtCO₂e in 2013 to 15.95 MmtCO₂e in 2030, which represents an increase of approximately 12% or at an annual rate of 0.10 MmtCO₂e.

FIGURE ES-6. DELAWARE'S PROJECTED GROSS GHG EMISSIONS FROM 2015 TO 2030

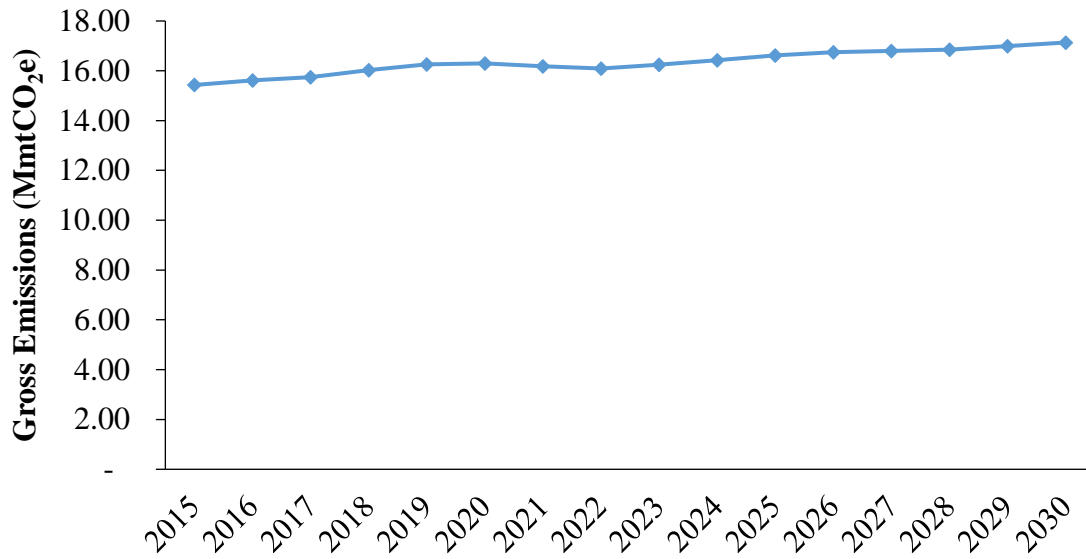


FIGURE ES-7. DELAWARE'S PROJECTED NET GHG EMISSIONS FROM 2015 TO 2030

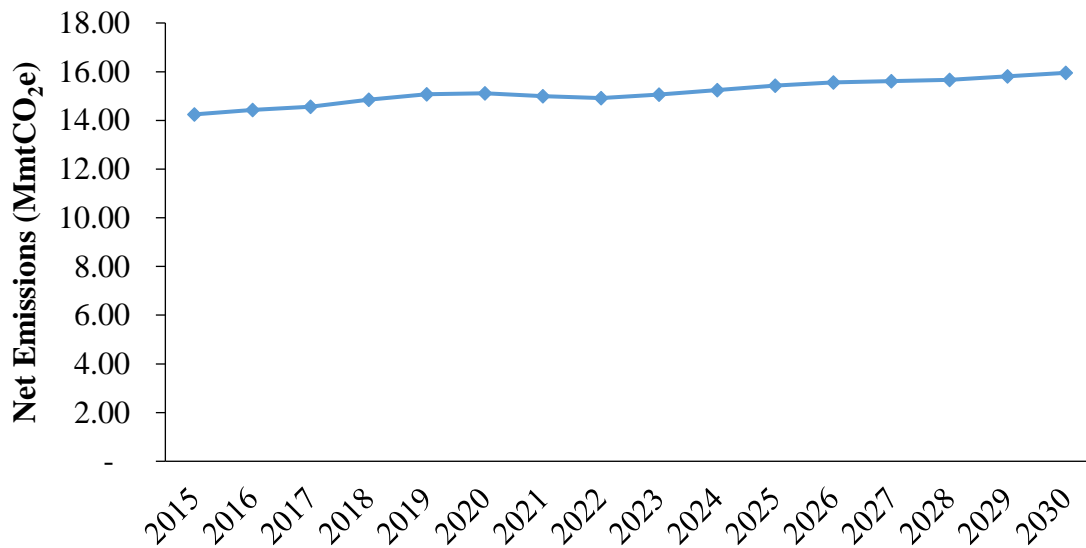
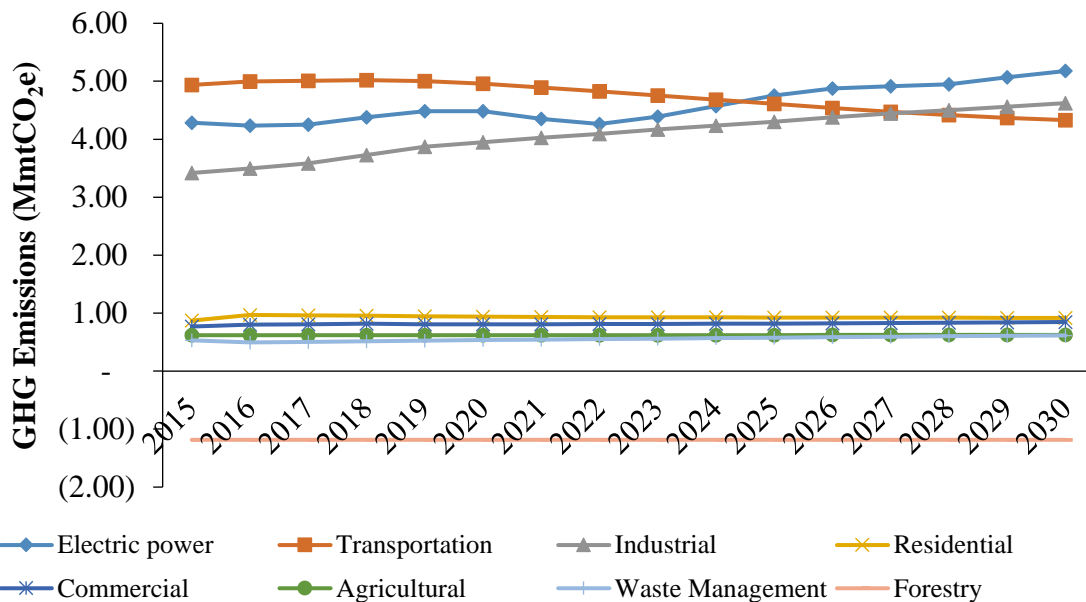


Figure ES-8 presents projected GHG emissions by sector from 2015 to 2030. Projection analysis shows that most of the economic sector emissions are projected to increase slightly over time. As Figure ES-8 presents, the *Big Three* sectors are expected to continue to exceed all other sectors in terms of GHG emissions. The electric power sector is projected to become the largest source of GHG emissions by 2030, followed by the industrial sector and transportation sector, as shown in Figure ES-8. The residential and agricultural sectors are projected to remain fairly constant with a slight decrease through 2030. The commercial and waste management sectors are projected to remain fairly constant with a slight increase in emissions over time. Finally, the

forestry sector is projected to remain constant with negative emissions, representing the sector as an emissions sink through 2030.

FIGURE ES-8. DELAWARE’S PROJECTED GHG EMISSIONS BY SECTOR



GHG Emission Trends by Economic sectors

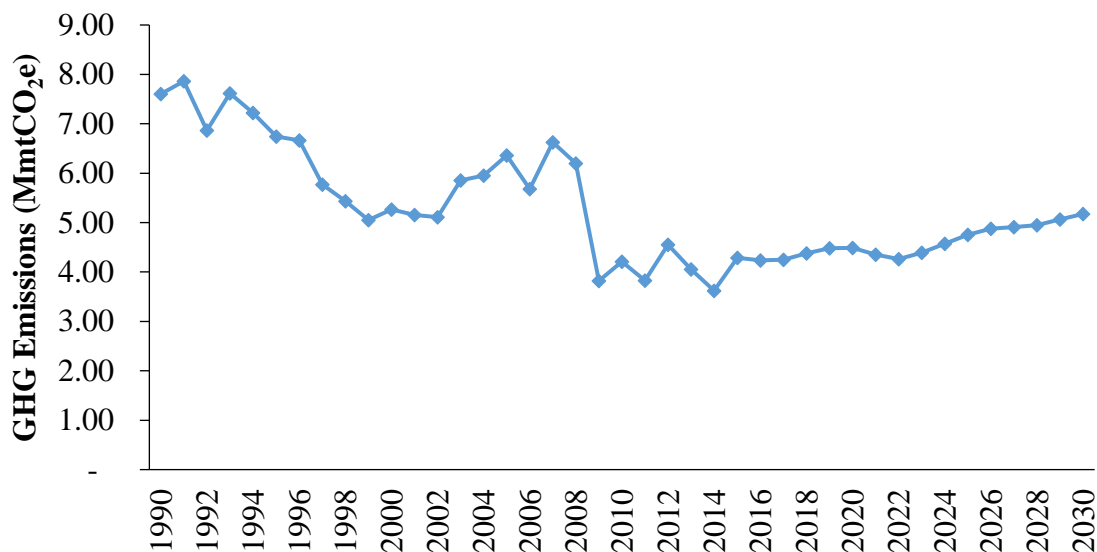
The 2014 GHG emissions inventory characterized GHG emissions into eight economic sectors of Delaware. The emission trends and analytical findings of those sectors are summarized below:

Electric Power Sector

The electric power sector added a cumulative amount of approximately 143.1 MmtCO₂e in GHG emissions to the atmosphere between 1990 and 2014. The emission of GHGs in this sector was driven primarily by the combustion of fossil fuels such as coal, natural gas and petroleum products in order to generate electricity. Figure ES-9 shows that emissions decreased significantly from 7.60 MmtCO₂e in 1990 to 3.62 MmtCO₂e in 2014, a decrease of approximately 52.4%. Projection analysis shows that this sector is expected to add a total of 73.4 MmtCO₂e in GHG emissions from 2015 to 2030. This trend is similar to that projected in the 2014 load forecast by PJM, which shows increases in peak demand for the DPL zone¹⁷. Electric power GHG emission is projected to increase from 2014 to 2015, then continue to increase through 2030, as Figure ES-9 shows. Annual emissions are projected to increase by approximately 21.7% from 2015 (4.28 MmtCO₂e) to 2030 (5.18 MmtCO₂e).

¹⁷ PJM Load Forecast Report January 2014; DPL zone also includes parts of Maryland and Virginia.

FIGURE ES-9. ELECTRIC POWER SECTOR GHG EMISSIONS FROM 1990 TO 2030



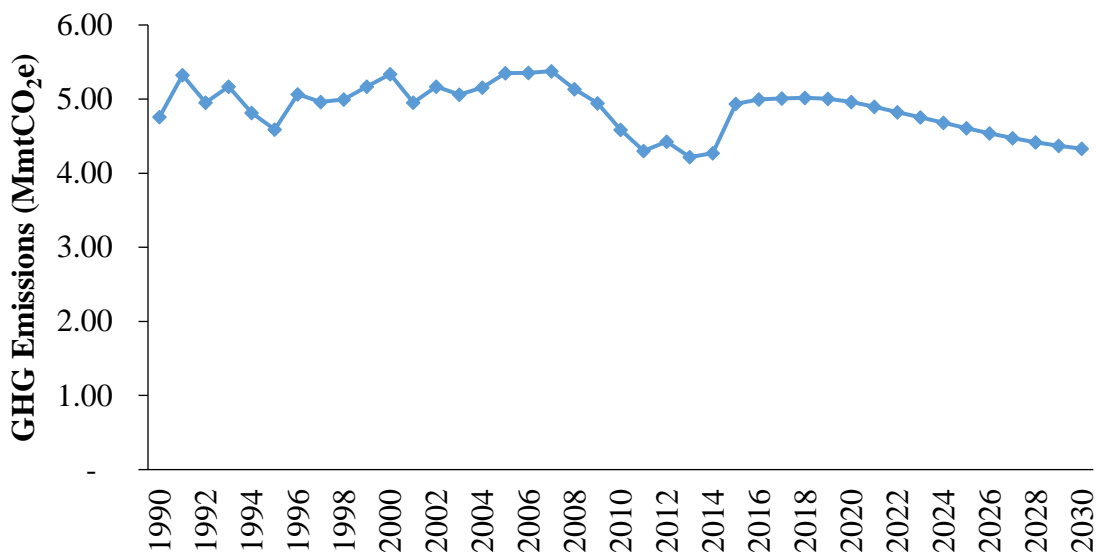
Transportation Sector

Between 1990 and 2014, the transportation sector added approximately 123.4 MmtCO₂e to the atmosphere. Over 98% of GHG emissions were CO₂ emissions from gasoline and diesel combustion in vehicle – both highway and non-highway – engines. Figure ES-10 shows that GHG emissions from the transportation sector were relatively constant between 1990 and 2007, but saw a decrease from 2008 to 2011, which could be attributed to the economic recession and rising gas prices¹⁸.

GHG emissions decreased from 4.76 MmtCO₂e in 1990 to 4.27 MmtCO₂e in 2014, a decrease of approximately 10%. Projected transportation sector GHG emissions show that a cumulative amount of approximately 75.8 MmtCO₂e in GHG emissions is expected to be added to the atmosphere from 2015 to 2030. Projection analysis shows that emissions are expected to stabilize with a slight decrease from 2015 to 2030 as presented by Figure ES-10. Emissions are projected to average approximately 4.74 MmtCO₂e annually between 2015 and 2030. While population is expected to increase about 8% from 2014 to 2030, the transportation sector is projected to realize overall decreases in emissions due to lower fuel economy standards.

¹⁸ EIA State Energy Data System (SEDS) 1960-2014

FIGURE ES-10. TRANSPORTATION SECTOR GHG EMISSIONS FROM 1990 TO 2030



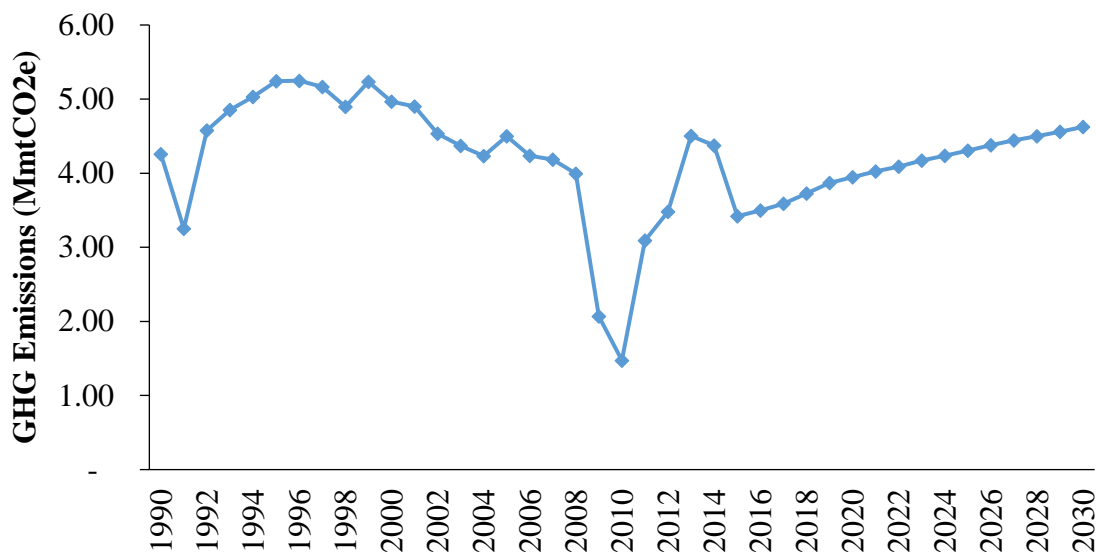
Industrial Sector

The industrial sector added a cumulative amount of approximately 106.7 MmtCO₂e in GHG emissions to the atmosphere between 1990 and 2014. As Figure ES-11 presents, GHG emissions from this sector had a concave profile peaking at 5.25 MmtCO₂e in 1996 and decreasing significantly to 1.47 MmtCO₂e in 2010, a decrease of approximately 72%. This decrease in industrial sector emissions was influenced by declining productivity in this sector was due to a slowing economy and loss of heavy industry as represented by the significant decrease observed from 2008 to 2009 presented in Figure ES-11. In addition, operations at the Delaware City Refinery were shut down at the end of 2009 and restarted at the end of 2011¹⁹.

Cumulative GHG emission from this sector is projected to be 65.4 MmtCO₂e from 2015 to 2030. Projected emissions presented in Figure ES-11 predict a steadily increasing annual GHG emission from this sector. Emissions are projected to increase from 3.42 MmtCO₂e in 2015 to 4.62 MmtCO₂e in 2030, an increase of approximately 35%.

¹⁹ “PBF Celebrates Successful Restart of its Delaware City Refinery” Delaware News, Office of the Governor, October 2011

FIGURE ES-11. INDUSTRIAL SECTOR GHG EMISSIONS FROM 1990 TO 2030



Residential Sector

Residential sector emissions are calculated using energy consumption data and carbon content of each fuel type used. The primary fuel type in the residential sector in 2014 and more recent years is natural gas, for which it is mainly used in heating and cooling applications. The residential sector added a cumulative amount of approximately 27.9 MmtCO₂e in GHG emissions to the atmosphere from 1990 to 2014. As Figure ES-12 shows, historical emissions from 1990 to 2014 show some fluctuations that can be attributed to weather and fuel shifting. For example, a local peak in the emissions data in 1996 can be linked to temperature data at the Dover station, which had the most days with a maximum temperature below 32°F from 1990-2014²⁰. A sharp decrease in emissions was observed from 2005 to 2006, as natural gas became the major type of fuel used over petroleum. Petroleum use in the residential sector decreased even more from 2010 to 2012, thus, further reductions in emissions. However, residential sector emissions increased in 2013 and 2014 as petroleum use increased due to high natural gas prices during the December of 2013 through February of 2014²¹. Emissions peaked at 1.32 MmtCO₂e in 2003 and fluctuated downward to 1.05 MmtCO₂e in 2014, a decrease of approximately 20%.

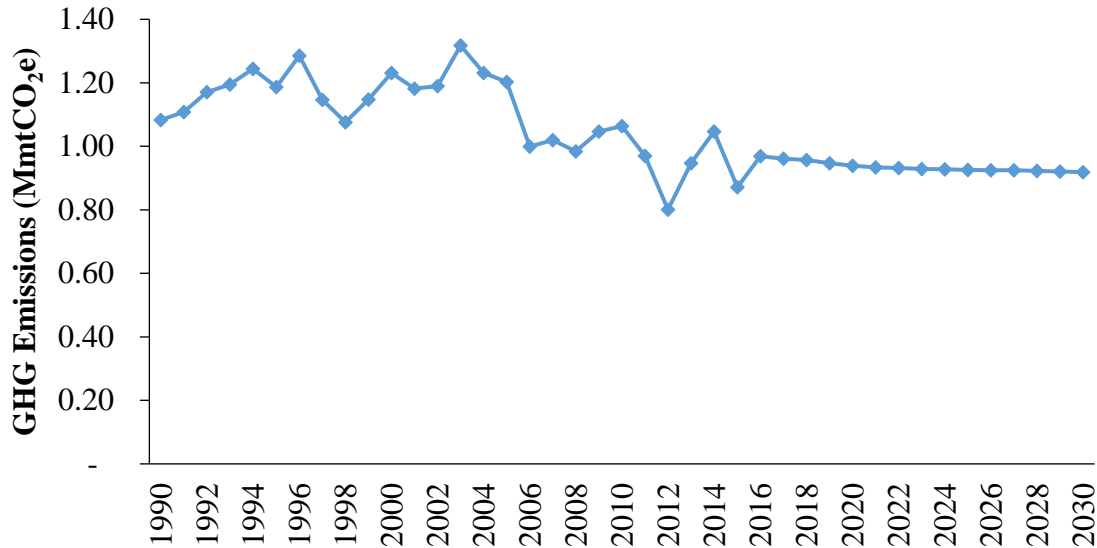
Cumulative GHG emission from the residential sector is projected to add 14.90 MmtCO₂e to the atmosphere from 2015 to 2030. Projected emissions show an increase from 2015 to 2016 in residential emissions, followed by a slight, steady decrease. Residential GHG emissions are projected to decrease from 0.97 MmtCO₂e in 2016 to 0.92 MmtCO₂e in 2030, or a decrease of 5%. As seen in Figure ES-12, GHG emissions from the residential sector are not expected to

²⁰ National Oceanic and Atmospheric Administration, National Centers for Environmental Information – Climate Data Online

²¹ U.S. Energy Information Administration, Henry Hub Natural Gas Spot Price

decrease significantly but remain fairly constant with the potential of minor fluctuations depending on future weather patterns and fuel prices.

FIGURE ES-12. RESIDENTIAL SECTOR GHG EMISSIONS FROM 1990 TO 2030

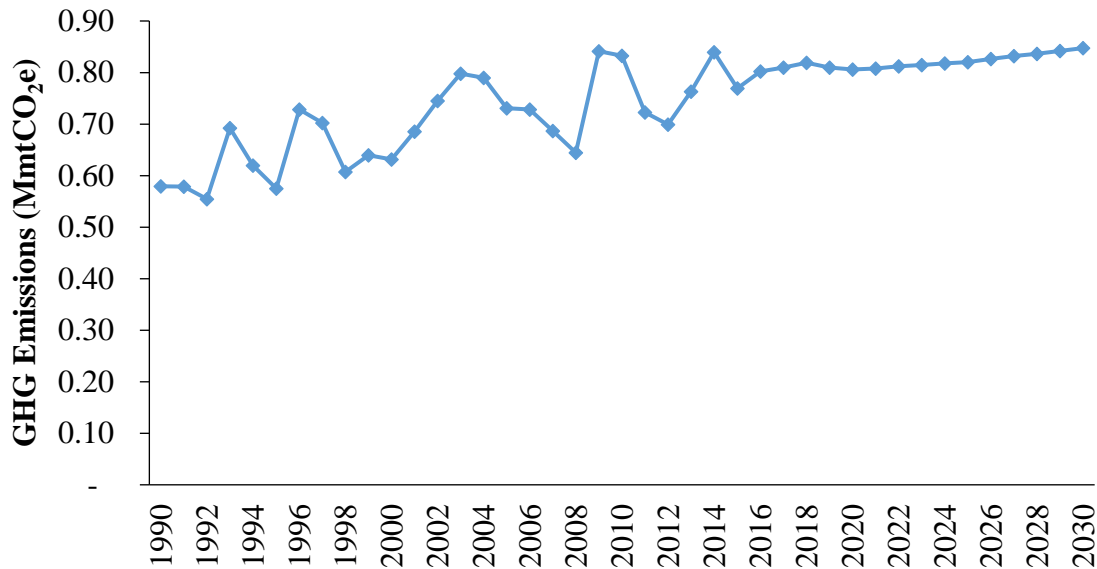


Commercial Sector

Commercial sector emissions are associated with fuel use among various applications such as heating, cooling, ventilation, lighting and refrigeration. Like the residential sector, natural gas is the most used fuel type in the commercial sector. The commercial sector added approximately 17.42 MmtCO₂e in GHG emissions to the atmosphere from 1990 to 2014. As Figure ES-13 presents, historical GHG emissions fluctuated upwards from 1990 to 2014, varying in relation to temperature conditions. No sharp decrease in emissions from fuel shifting is observed like in the residential sector because natural gas has been the major fuel type in commercial sector at least since 1990. GHG emissions from this sector increased from 0.58 MmtCO₂e in 1990 to 0.84 MmtCO₂e in 2014, an increase of approximately 45%. The increase in commercial sector GHG emissions in 2014, specifically, was most likely influenced by high natural gas prices from December of 2013 to February of 2014.

Projected emissions show that between 2015 and 2030, the commercial sector is expected to add a total of approximately 13.07 MmtCO₂e to the atmosphere. As Figure ES-13 presents, GHG emissions are projected to increase from 0.77 MmtCO₂e in 2015 to 0.85 MmtCO₂e in 2030, an increase of approximately 10%, or a modest 0.08 MmtCO₂e.

FIGURE ES-13. COMMERCIAL SECTOR GHG EMISSIONS FROM 1990 TO 2030

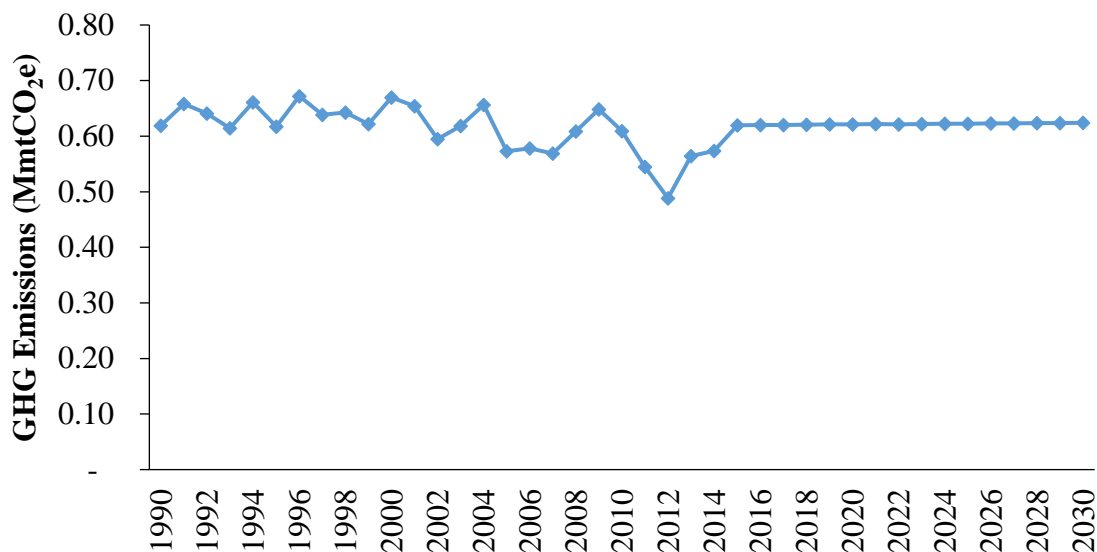


Agricultural Sector

Agricultural sector GHG emissions added a total of 15.33 MmtCO₂e in GHG emissions to the atmosphere from 1990 to 2014. The GHG emissions from this sector fluctuated downward from 0.62 MmtCO₂e in 1990 to 0.57 MmtCO₂e in 2014, a decrease of approximately 8%. This decrease was partly due to Delaware's shrinking agricultural base as a result of land development, as well as improved agricultural practices that minimize emissions by increasing carbon storage and sequestration.

Figure ES-14 shows that GHG emission from the agricultural sector is projected to increase in 2015 to 0.62 MmtCO₂e and remain constant through 2030. The cumulative GHG emissions projected to be added to the atmosphere is 10.0 MmtCO₂e between 2015 and 2030.

FIGURE ES-14. AGRICULTURAL SECTOR GHG EMISSIONS FROM 1990 TO 2030



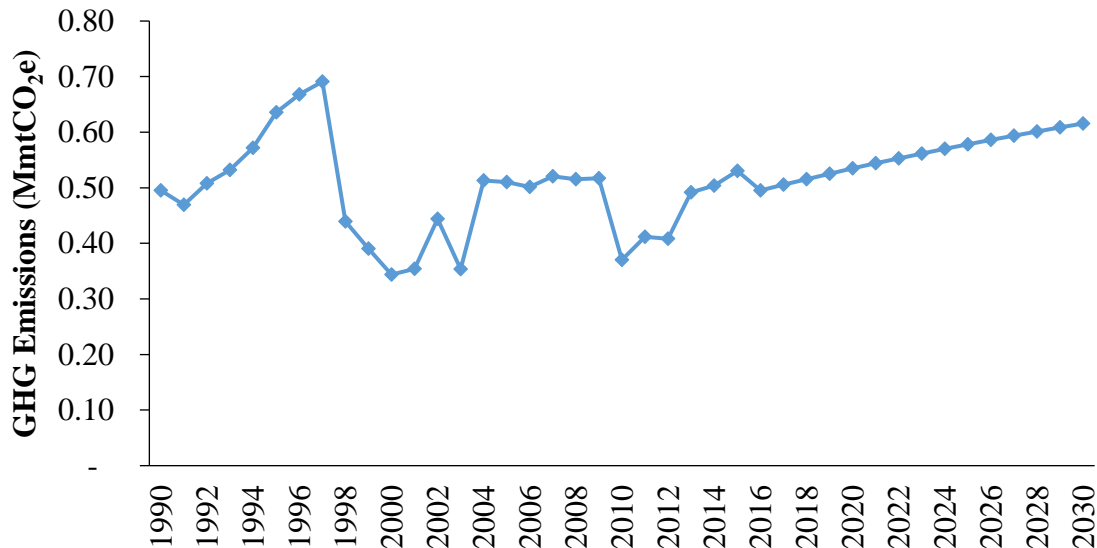
Waste Management Sector

Greenhouse gas emission from the waste management sector includes wastewater treatment methane (CH₄) and nitrous oxide (N₂O) emissions and municipal solid waste (landfills) CH₄ emissions. This sector added a total of approximately 12.16 MmtCO₂e in GHG emissions to the atmosphere from 1990 to 2014. GHG emissions from wastewater treatment were fairly constant from 1990 to 2014 and are based mainly on municipal wastewater and industrial wastewater generated from poultry processing.

As Figure ES-15 presents, emissions fluctuated from 1990 to 2014. Fluctuations in the waste management sector are largely based on changes in operation in the municipal solid waste sector. The first major change in emissions occurred between 1997 and 1998, when flaring began each of the three major landfills. In addition, land fill gas recovery for energy generation (landfill gas to energy, or LFGTE) started in 1997 at the Cherry Island Landfill site. LFGTE began in 2007 at the Central and Southern Solid Waste Management Centers; however, significant additional decreases in emissions were not observed because processes simply shifted from flaring to LFGTE. Overall, emissions from the waste management sector (including wastewater treatment) in 2014 are equal to those in 1990 at 0.50 MmtCO₂e.

Projected emissions in the waste management sector are on pace to increase from 2015 to 2030, adding a cumulative 8.92 MmtCO₂e. GHG emissions from the waste management sector are projected to increase by 17% from 0.53 MmtCO₂e in 2015 to 0.62 MmtCO₂e in 2030.

FIGURE ES-15. WASTE MANAGEMENT SECTOR GHG EMISSIONS FROM 1990 TO 2030



Land-use, Land Use Change and Forestry Emission Analysis

The 2014 GHG emissions inventory identified the land-use sector as a major sink²² for GHG emissions in Delaware. Carbon emissions and/or sequestration in the land-use sector is calculated as the annual change in carbon storage among different carbon pools of Delaware’s forest and croplands, as well as harvested wood products. Between 1990 and 1998, the land use sector had positive emissions totaling 1.78 MmtCO₂e. However, despite some losses in forest acreage, increased forest management practices and trees reaching maturity have enhanced carbon sequestration from 1999 to the present^{23, 24}. In 2014, GHG emission for land-use was - 1.18 MmtCO₂e. Meaning 1.18 MmtCO₂e in GHG emissions was sequestered from the atmosphere as a result of Delaware’s forest reserves. According to Figure ES-16, net GHG emissions from this sector were negative from 1999 to 2014. The removal of GHGs in this sector peaked in 2006 with a net GHG removal of 1.20 MmtCO₂e as indicated in Figure ES-16. Net GHG removed from Delaware’s forest pool totaled 18.25 MmtCO₂e from 1999 and 2014.

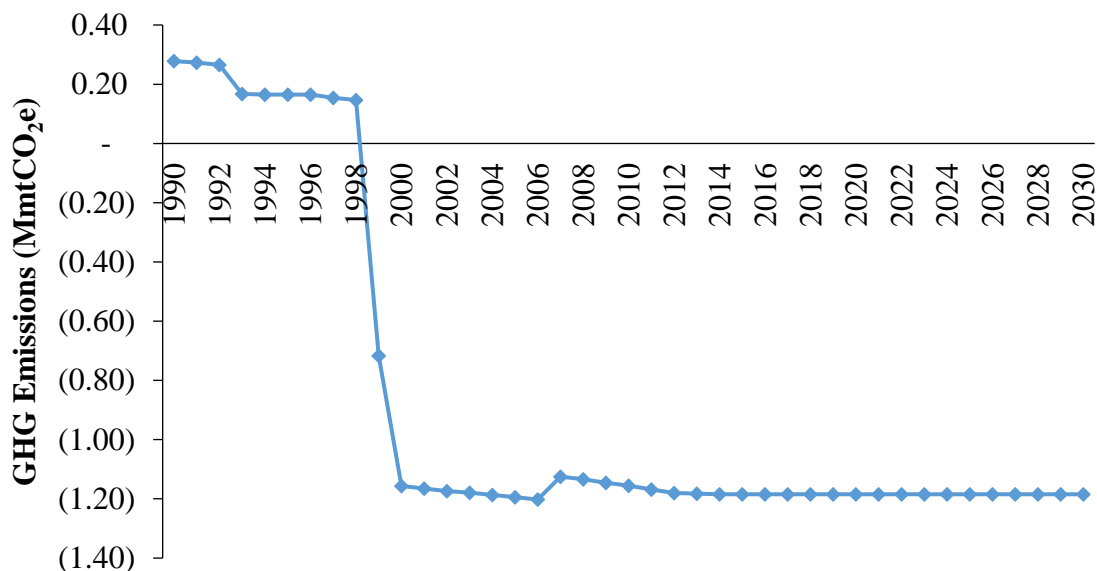
The projection analysis for this sector was based on the assumption that Delaware’s change in carbon storage will remain constant from 2014 to 2030. Therefore, the sequestration of 1.18 MmtCO₂e in 2014 is constant from 2015 to 2030.

²² A sink is the removal of GHG from the atmosphere

²³ Delaware Forest Resource Assessment, Delaware Forest Service, 2010

²⁴ Delaware Forests 2013, United States Forest Service, 2017

FIGURE ES-16. LAND-USE GHG SEQUESTRATION



Indirect GHG Emissions from Electricity Consumption

Indirect GHG are emissions associated with consuming electricity that is produced in Delaware as well as imported. This source category describes the electric power consumption pattern of Delawareans in terms of GHG emissions. Indirect CO₂ emissions are CO₂ emissions that are estimated based on the amount of kilowatt-hours consumed by end-users of electricity. Indirect GHG estimates were included in the 2014 GHG inventory to show how electricity demand in Delaware impacts GHG emissions. Direct GHG emissions from in-state electricity generation were separated from indirect CO₂ emissions to avoid the double counting of emissions estimates.

Between 1990 and 2014, the total indirect GHG emission from Delaware was estimated at approximately 143.5 MmtCO₂e. As Figure ES-17 presents, indirect GHG emissions increased from 4.40 MmtCO₂e in 1990 to 6.84 MmtCO₂e in 2014, an increase of approximately 55%. Indirect GHG emissions are expected to continue to increase linearly as Figure ES-17 shows. Projected indirect GHG emissions are expected to increase from 6.97 MmtCO₂e in 2015 to 8.23 MmtCO₂e in 2030, an increase of approximately 18%. The rate of annual increase was determined to be 0.090 MmtCO₂e per year from 1990 to 2030.

FIGURE ES-17. INDIRECT GHG EMISSIONS FROM 1990 TO 2030

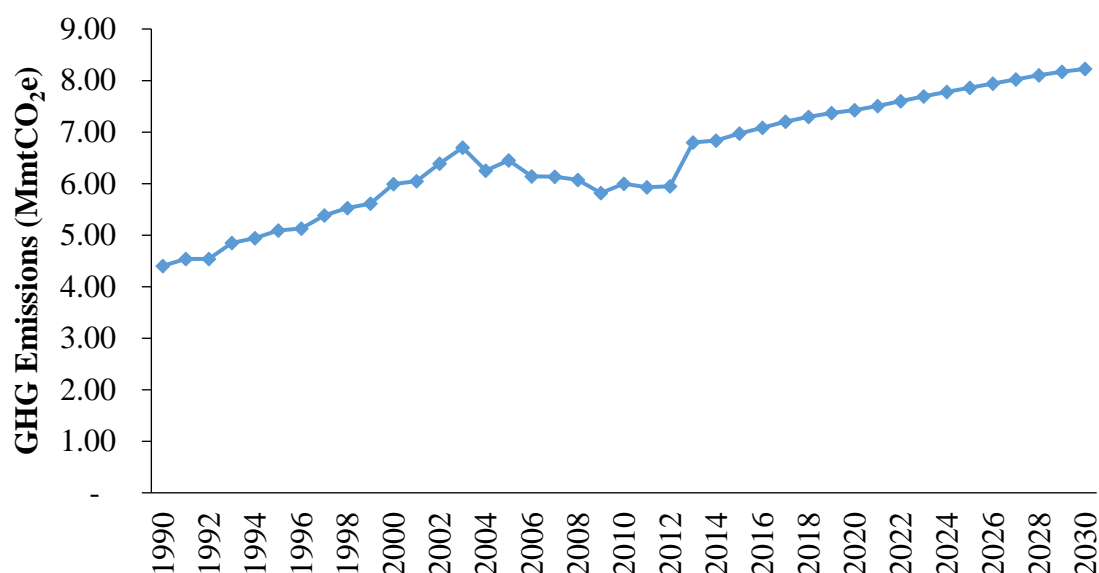


TABLE ES-1. GHG EMISSION ESTIMATES BY SECTORS					
Economic Sectors	1990	2000	2014	2020	2030
Electric Power	7.60	5.27	3.62	4.49	5.18
CO ₂ from FFC	7.49	5.20	3.60	4.47	5.16
N ₂ O from FFC	0.03	0.02	0.01	0.01	0.01
CH ₄ from FFC	0.003	0.002	0.001	0.002	0.002
SF ₆ from T&D	0.08	0.05	0.02	0.01	0.01
Transportation	4.76	5.34	4.27	4.96	4.33
CO ₂ from FFC	4.53	5.08	4.21	4.89	4.26
N ₂ O from FFC	0.21	0.24	0.05	0.07	0.06
CH ₄ from FFC	0.02	0.02	0.01	0.01	0.01
Industrial	4.26	4.96	4.37	3.95	4.62
CO ₂ from FFC	4.04	4.58	3.67	3.19	3.63
N ₂ O from FFC	0.01	0.01	0.01	0.003	0.004
CH ₄ from FFC	0.003	0.004	0.003	0.002	0.002
CH ₄ from IP	0.20	0.16	0.08	0.01	0.01
CO ₂ from IP	0.01	0.001	0.14	0.14	0.17
HFC, PFC Emissions	0.001	0.21	0.47	0.61	0.81
Residential	1.08	1.23	1.05	0.94	0.92
CO ₂ from FFC	1.07	1.22	1.03	0.94	0.92
N ₂ O from FFC	0.003	0.004	0.003	0.001	0.001
CH ₄ from FFC	0.01	0.01	0.01	0.003	0.002
Commercial	0.58	0.63	0.84	0.81	0.85
CO ₂ from FFC	0.58	0.63	0.84	0.80	0.84

TABLE ES-1. GHG EMISSION ESTIMATES BY SECTORS					
Economic Sectors	1990	2000	2014	2020	2030
N ₂ O from FFC	0.001	0.001	0.001	0.001	0.001
CH ₄ from FFC	0.002	0.003	0.003	0.002	0.002
Agricultural	0.62	0.67	0.57	0.62	0.62
Enteric Fermentation	0.05	0.05	0.04	0.05	0.05
Manure Management	0.19	0.20	0.18	0.23	0.24
Ag Soils	0.38	0.42	0.35	0.34	0.33
Ag Residue Burning	0.002	0.003	0.004	0.003	0.003
Waste Management	0.50	0.34	0.50	0.53	0.62
Wastewater Treatment	0.11	0.13	0.18	0.20	0.22
MSW	0.38	0.21	0.33	0.34	0.40
Land Use/Forestry	0.28	(1.16)	(1.18)	(1.18)	(1.18)
Gross GHG Emissions	19.68	18.44	15.23	16.29	17.14
Net GHG Emissions	19.68	17.29	14.04	15.11	15.95
Electricity Consumption	4.40	5.99	6.84	7.42	8.23

GHG EMISSIONS BY GAS

The 2014 GHG inventory estimated emissions for the six Kyoto GHGs. They include carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF₆).

Figure ES-18 presents gross GHG emissions by gas in 2012. Carbon dioxide emissions represent the largest type of GHGs with approximately 88% of gross emissions from Delaware which is followed by N₂O and CH₄, representing approximately 5% and 4%, respectively. The combined emission of HFC, PFC and SF₆ represent approximately 3% of gross GHG emissions from Delaware.

FIGURE ES-18. 2012 DELAWARE'S GHG EMISSIONS BY GAS

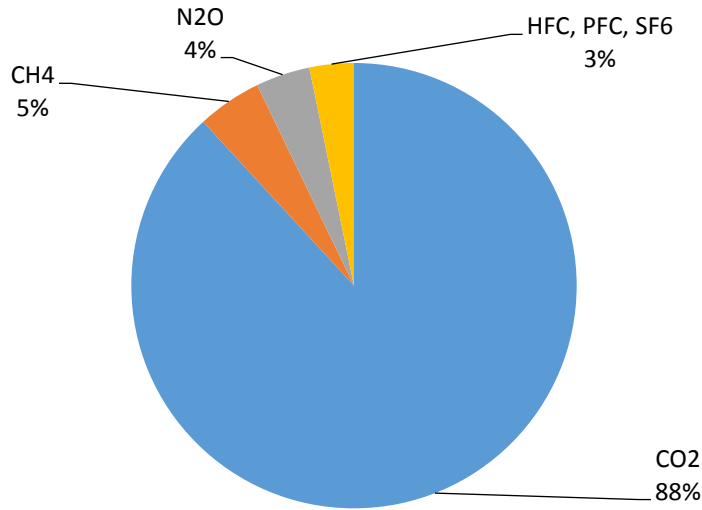
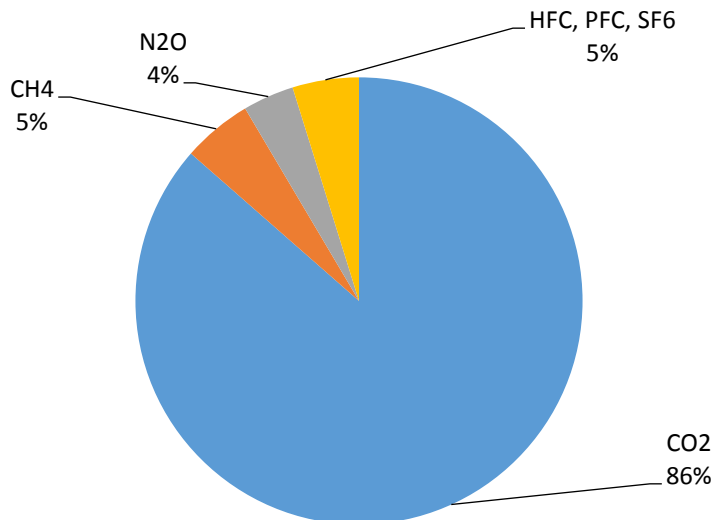


Figure ES-19 presents gross GHG emissions by gas in 2030. Carbon dioxide is projected to remain the most emitted GHG representing approximately 86% of gross GHGs emitted in 2030. CH₄ emissions are projected to be the next most abundant GHG in 2030 at 5%. The combined emissions of HFC, PFC and SF₆ is projected to be approximately 5% of gross emissions. N₂O emissions are projected to represent approximately 4% of gross GHG emissions as presented by Figure ES-19.

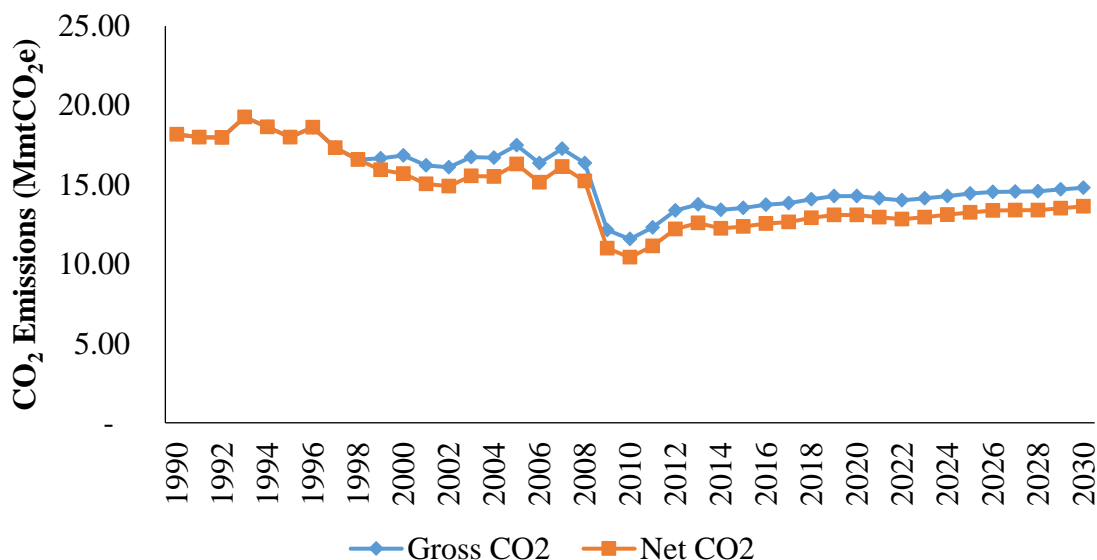
FIGURE ES-19. 2030 DELAWARE'S GHG EMISSIONS BY GAS



Carbon Dioxide: The emission of CO₂ was driven by fossil fuel combustion in all sectors of Delaware’s economy. Approximately 99% of CO₂ came from fossil fuel combustion. Between 1990 and 2012, approximately 405.97 MmtCO₂ in emissions were directly added to the atmosphere. Carbon dioxide was the largest contributor to GHG emissions representing approximately 88% in 2014, and is projected to represent approximately 86% in 2030. Historical CO₂ emissions continue to trend downwards from 1990 levels with a minor increase as the economy rebounded from the 2008 recession as Figure ES-20 demonstrates.

Figure ES-20 presents both gross and net CO₂ emissions from 1990 to 2030. Gross CO₂ emissions are the sum of emissions excluding CO₂ sequestration or sinks. A key CO₂ sink is the land-use or forestry sector, which stores large amounts of CO₂ annually. Gross CO₂ emissions decreased from 18.18 MmtCO₂e in 1990 to 13.43 MmtCO₂e in 2014, a decrease of approximately 26%. However, gross CO₂ emissions are projected to increase from 13.54 MmtCO₂e in 2013 to 14.82 MmtCO₂e in 2030, an increase of approximately 9.5%. Net CO₂ emissions include sinks and which are calculated by subtracting annual CO₂ sequestration by the Delaware’s forest resource. Net CO₂ emissions decreased from 18.18 MmtCO₂e in 1990 to 12.24 MmtCO₂e in 2014, a decrease of approximately 33%. Net CO₂ emissions are projected to increase from 12.36 MmtCO₂e in 2013 to 13.63 MmtCO₂e in 2030, an increase of approximately 10%.

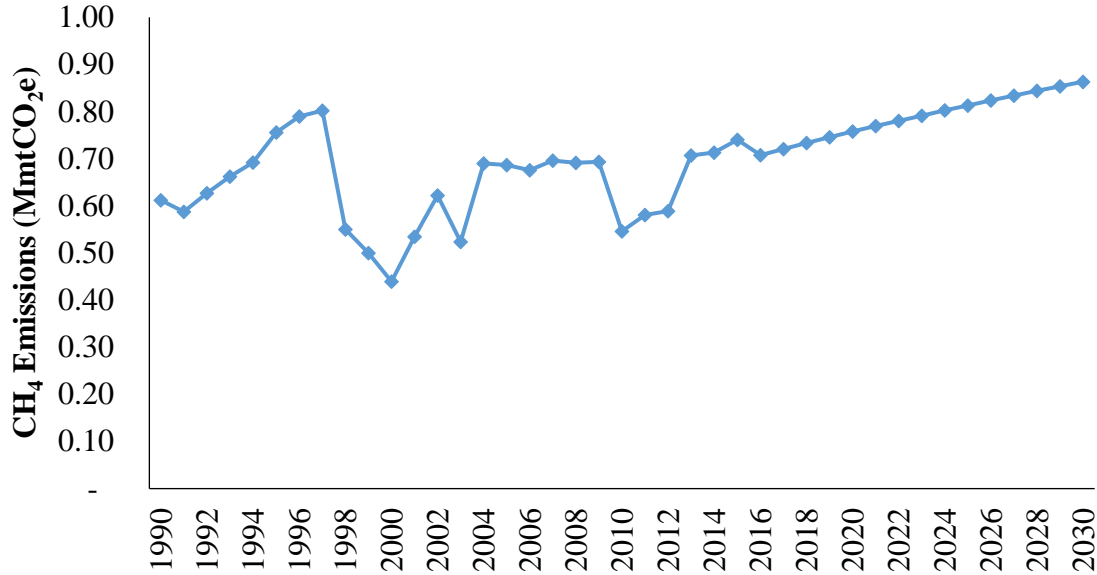
FIGURE ES-20. CO₂ EMISSIONS FROM 1990 TO 2030



Methane: From 1990 to 2014, approximately 15.97 MmtCO₂e in CH₄ emissions was added to the atmosphere. Figure ES-21 presents CH₄ emissions from 1990 to 2030. Methane emissions include emissions from fossil fuel combustion, agricultural processes, industrial processes, and waste management. Within waste management, methane recovered for energy use or that is flared are subtracted from the overall landfill emissions. As presented by Figure ES-21, CH₄

emissions are projected to increase from 0.74 MmtCO₂e in 2015 to 0.86 MmtCO₂e in 2030, an increase of approximately 16%.

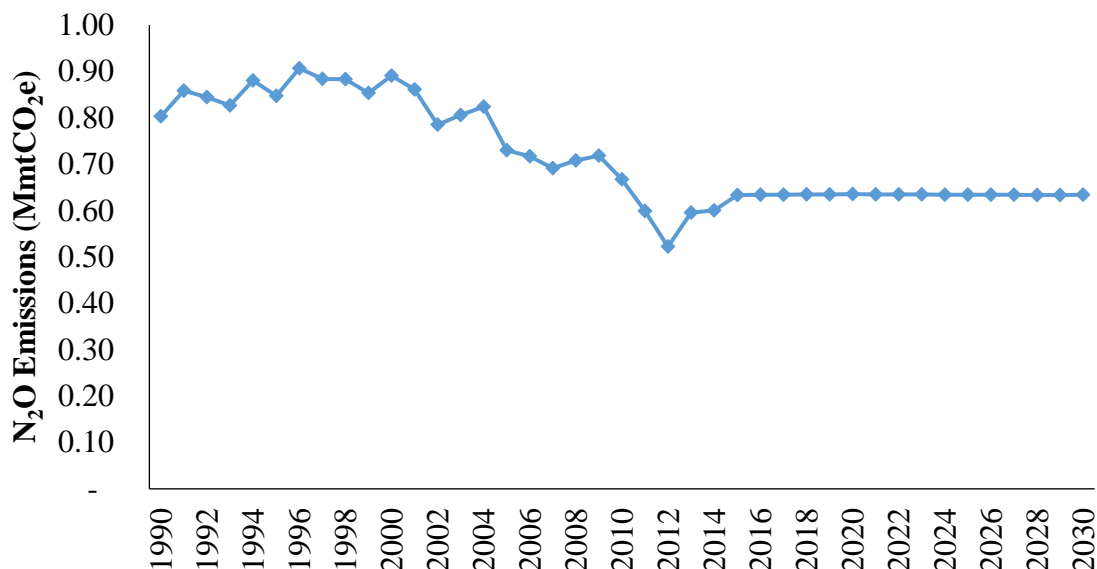
FIGURE ES-21. CH₄ EMISSIONS FROM 1990 TO 2030



Nitrous Oxide: From 1990 to 2014, approximately 19.30 MmtCO₂e in N₂O emissions were added to the atmosphere. Figure ES-22 shows that N₂O emissions decreased gradually from 0.80 MmtCO₂e in 1990 to 0.60 MmtCO₂e in 2012, a decrease of approximately 25%. The decrease in N₂O emissions can be attributed to increased emission standards for vehicles and improved farming activities, as well as Delaware shrinking agricultural base due to land use change.

Projected emissions of N₂O from Delaware's economy are projected to remain constant at approximately 0.63 MmtCO₂e from 2015 through 2030. Economic activities such as agriculture, transportation, and wastewater treatment in Delaware are projected to add approximately 10.15 MmtCO₂e in N₂O emissions to the atmosphere from 2015 to 2030.

FIGURE ES-22. N₂O EMISSIONS FROM 1990 TO 2030



Hydrofluorocarbons, Perfluorocarbons, and Sulfur hexafluoride: The combined emission of HFC, PFC, and SF₆ added approximately 6.55 MmtCO₂e to the atmosphere from 1990 to 2014. Though there was a significant increase in the emission of Ozone Depleting Substances (ODS)²⁵ substitutes, its contribution to Delaware’s overall gross GHG emissions was approximately only 3% of total GHG emissions in 2014 as Figure ES-18 presents. However, it is projected to represent approximately 5% of gross GHG emissions in 2030 as presented by Figure ES-19. The annual emissions from this class of GHGs increased significantly from 0.08 MmtCO₂e in 1990 to 0.49 MmtCO₂e in 2012, or an increase of approximately 612%.

The increasing emissions of this class of GHGs in Delaware were driven primarily by increasing consumption of ODS substitutes such as HFCs and PFCs, which have become the fastest growing GHG emissions in the country. SF₆ emissions from power transmission and distribution in Delaware, however, have declined by approximately 80% from 1990 to 2014 and are projected to continue to decrease with time. Projection analyses show that this class of GHGs is expected to add approximately 10.69 MmtCO₂e to the atmosphere from 2015 to 2030. It should be noted that 98.6% of the added emissions are HFC and PFC emissions. Emissions have been projected to increase from 0.51 MmtCO₂e in 2015 to 0.82 MmtCO₂e in 2030, a significant increase of approximately 61%.

²⁵ Ozone depleting substances (ODS) break down when exposed to intense ultraviolet light in the stratosphere and release chlorine or bromine atoms, which deplete the stratospheric ozone layer. ODS substitutes (such as HFCs and PFCs) do not break down the ozone layer but have been found to be potent GHGs.

FIGURE ES-23. HFC, PFC AND SF₆ EMISSIONS FROM 1990 TO 2030

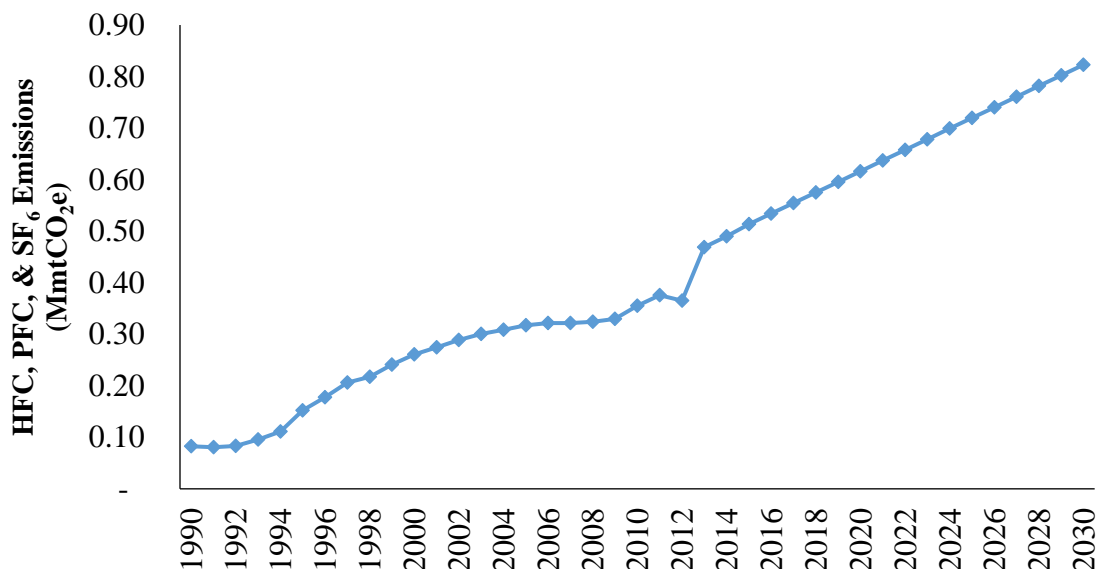


TABLE ES-2. GHG EMISSION ESTIMATES BY GAS (MMTCO₂e)					
GHGs by Sources	1990	2000	2014	2020	2030
Gross CO₂	18.18	16.85	13.43	14.28	14.82
Net CO₂	18.18	15.70	12.24	13.10	13.63
Electric power FFC	7.49	5.20	3.60	4.47	5.16
Transportation FFC	4.53	5.08	4.21	4.89	4.26
Industrial FFC	4.04	4.58	3.67	3.19	3.63
CO ₂ from IP	0.20	0.16	0.08	0.01	0.01
Residential FFC	1.07	1.22	1.03	0.94	0.92
Commercial FFC	0.58	0.63	0.84	0.80	0.84
Forestry	0.28	(1.16)	(1.18)	(1.18)	(1.18)
CH₄	0.61	0.44	0.71	0.76	0.86
Electric power	0.003	0.002	0.001	0.002	0.002
Transportation	0.02	0.02	0.01	0.01	0.01
Industrial	0.003	0.004	0.003	0.002	0.002
Industrial Processes	0.01	0.001	0.14	0.14	0.17
Residential FFC	0.01	0.01	0.01	0.002	0.002
Commercial FFC	0.002	0.003	0.003	0.002	0.002
MSW	0.38	0.21	0.33	0.34	0.40
Municipal wastewater treatment (WWT)	0.05	0.05	0.07	0.08	0.09

TABLE ES-2. GHG EMISSION ESTIMATES BY GAS (MMTCO₂e)					
GHGs by Sources	1990	2000	2014	2020	2030
Industrial WWT	0.05	0.06	0.07	0.08	0.09
Ag Enteric Fermentation	0.05	0.05	0.04	0.05	0.05
Ag Manure Management	0.03	0.03	0.03	0.04	0.05
Ag Burning of Crop Waste	0.001	0.002	0.002	0.002	0.002
N₂O	0.80	0.89	0.60	0.64	0.63
Electric power FFC	0.03	0.02	0.01	0.01	0.01
Transportation FFC	0.21	0.24	0.05	0.07	0.06
Industrial FFC	0.01	0.01	0.01	0.003	0.004
Residential FFC	0.003	0.004	0.003	0.001	0.001
Commercial FFC	0.001	0.001	0.001	0.001	0.001
Municipal WWT	0.02	0.02	0.03	0.03	0.03
Ag Manure Management	0.15	0.16	0.15	0.18	0.19
Ag Soil Management	0.38	0.42	0.35	0.34	0.33
Ag Burning of Crop Waste	0.001	0.001	0.001	0.001	0.001
HFC, PFC & SF₆	0.08	0.26	0.49	0.62	0.82
HFC, PFC Emissions	0.001	0.21	0.47	0.61	0.81
SF ₆ from T&D	0.08	0.05	0.02	0.01	0.01
Gross Total GHG Emissions	19.68	18.44	15.23	16.29	17.14
Net total GHG Emissions	19.68	17.29	14.04	15.11	15.95

GHG EMISSIONS PER PERSON

Another way to present Delaware's GHG emissions is to analyze the data by state population and a per capita basis. This is useful when comparing emissions from one state to another. Many factors contribute to the amount of emissions per capita. According to the EPA²⁶, factors such as climate, the structure of the economy, population density, energy sources, building standards and explicit state policies to reduce emissions can impact GHG emissions. In 2013, Delaware ranked 30th in GHG emissions per capita according to the U.S Energy Information Administration²⁷. As Figure ES-24 presents, per capita GHG emissions decreased from 29.41 mtonCO₂e/person in 1990 to 16.28 mtonCO₂e/person in 2014, a decrease of approximately 49.7%. The significant decrease in per capita GHG emissions from 1990 to 2014 can be attributed to a number of factors including; the economic recession, which lead to a decline in the industrial sector emissions; energy efficiency in the power, commercial and residential sectors; and switching from a more carbon intensive fuel such as coal to a less carbon intensive fuel such as natural gas.

²⁶ State-Level Energy-Related Carbon Dioxide Emissions, 2000-2010

²⁷ EIA: <http://www.eia.gov/environment/emissions/state/analysis/>

Projected GHG emissions per capita are expected to remain essentially constant from 16.64 mtonCO₂e/person in 2015 to 16.92 mtonCO₂e/person in 2030. GHG emissions and population increases are projected to occur at similar rates, which explains why there is not a significant decrease or increase in emissions per capita through 2030.

FIGURE ES-24. DELAWARE’S GHG EMISSIONS PER-CAPITA FROM 1990 TO 2030

