DELAWARE'S 2012 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 2012 Greenhouse Gas (GHG) emissions inventory and account for GHG emissions and sinks[1] in the State of Delaware. The inventory includes Delaware GHG emissions from 1990 to 2012 as well as emission projections from 2013 to 2030. In addition to the emissions data, this report provides information on emission sources and activities, as well as inventory methods.

Delaware's anthropogenic[2] 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 (CO_2e), 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 CO_2 equivalents ($MmtCO_2e$).

To develop the annual emissions of GHGs from Delaware for the period of 1990 to 2012 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 activities[5] 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 model[6]. 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,

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[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 efficiency[7]. This data has been updated for all years and will be used in future reports.

SOURCES OF GHG EMISSIONS AND TRENDS

The 2012 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 2012, GHG emissions from Delaware added a cumulative amount of 417 million metric tons of carbon dioxide equivalents ($MmtCO_2e$) to the atmosphere. In 2012, Delaware's gross[8] total GHG emission was equivalent to 14.86 $MmtCO_2e$. Also in 2012, Delaware's net[9] GHG emission was equivalent to 13.68 $MmtCO_2e$. From 1990 to 2012, gross GHG emissions decreased by approximately 24%, while net emissions decreased by approximately 31%[10]. Delaware's gross GHG emission in 2012 made up approximately 0.2% of gross U.S GHG emissions in 2012 (6,526 $MmtCO_2e$)[11].

Figure ES-1 presents a breakdown[12] of GHG emissions in 2012 by Delaware's economic sectors. The largest source of GHG emissions in 2012 was the electric power sector. The power sector represented 31% of GHG emissions in 2012 as presented in Figure ES-1. This was followed by the transportation sector with approximately 30%. The industrial sector was the third largest emitter of GHG emissions in 2012 representing approximately 23% of gross emissions that year, while the other sectors including residential, commercial, agriculture and waste management each represented approximately 5%, 5%, 3% and 3%, respectively, as presented in Figure ES-1.

Figure ES-2 presents Delaware's gross[13] GHG emissions profile from 1990 to 2012, showing that in general, GHG emissions in Delaware's economic sectors trended downwards from 1990 to 2012 with some fluctuations. Gross GHG emissions decreased from 19.68 $MmtCO_2e$ in 1990 to 14.86 $MmtCO_2e$ in 2012, a decrease of approximately 24%. This decrease occurred at the rate of 0.25 $MmtCO_2e$ 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 CO_2 from 1999 to 2012 because it generated negative CO_2 emission.
[10] In 1990, gross emission was equivalent to net emission (19.68 $MmtCO_2e$) because there was no negative emission.
[11] U.S. EPA: 2014 Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990 -2012
[12] Figure ES-1 percentages are based on Delaware's gross emissions of 14.86 $MmtCO_2e$ and not the net emissions of 13.68 $MmtCO_2e$.
[13] Gross emissions includes all positive emissions and excludes all negative emissions from 1990 to 2012

FIGURE ES-1. 2012 DELAWARE GHG EMISSIONS BY ECONOMIC SECTOR

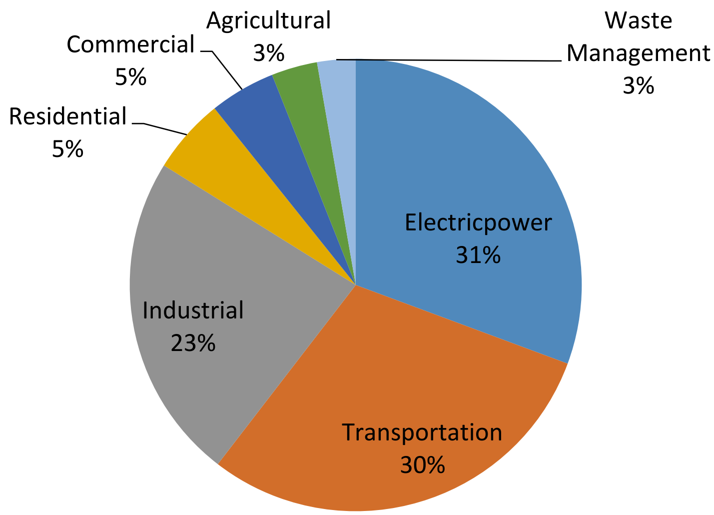


FIGURE ES-2.DELAWARE'S GROSS GHG EMISSION FROM 1990 TO 2012

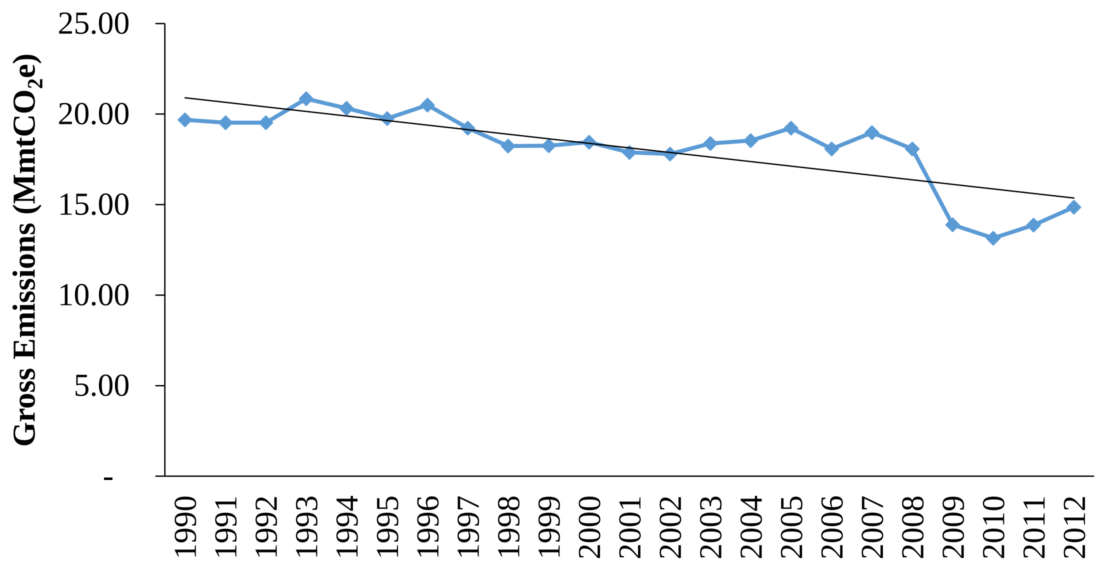


Figure ES-3 presents net[14] GHG emissions from 1990 to 2012. Emissions decreased from 19.68 $MmtCO_2e$ in 1990 to 13.68 $MmtCO_2e$ in 2012 as presented by Figure ES-3. This was a decrease of approximately 31% at the rate 0.32 $MmtCO_2e$ per year.

[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 2012

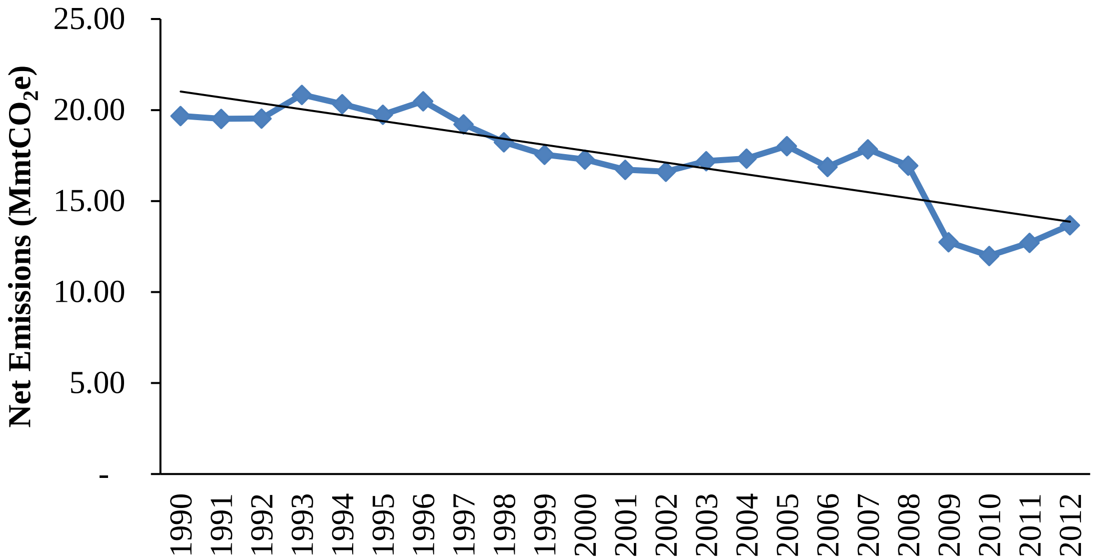
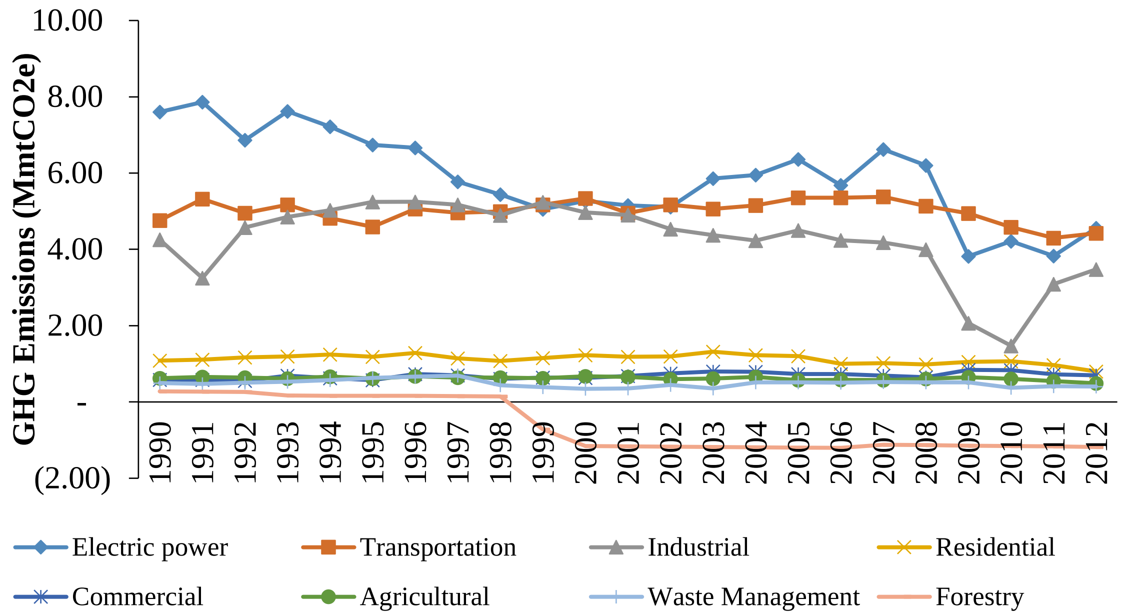


Figure ES-4 presents GHG emissions by economic sectors. Figure ES-4 shows that the largest emissions sources in Delaware included the electric power, transportation and industrial sectors.

In this report, the collection of these three sectors is known as the *Big Three* because their combined GHG emissions represented approximately 84% of Delaware's emissions in 2012. As Figure ES-4 presents, GHG emissions from the *Big Three* intersected between 2000 and 2002; however, for most of the years between 1990 and 2012, 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. The transportation sector emissions remained fairly constant and became the greatest emitting sector until 2011, as demonstrated by Figure ES-4. In 2012, the electric power sector had the highest GHG emissions at 4.55 $MmtCO_2e$, while the transportation sector followed closely behind at 4.43 $MmtCO_2e$. The industrial sector reclaimed some of the emission losses from 2009 – 2010 and had GHG emissions of 3.48 $MmtCO_2e$, more than doubling its 2010 total.

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 2012 as they represented 90% of gross GHG emissions from Delaware. The overall fuel consumption in Delaware declined in 2012 relative to 1990, and the fuel mix shifted more towards natural gas and away from coal; as such, gross GHG emissions decreased.

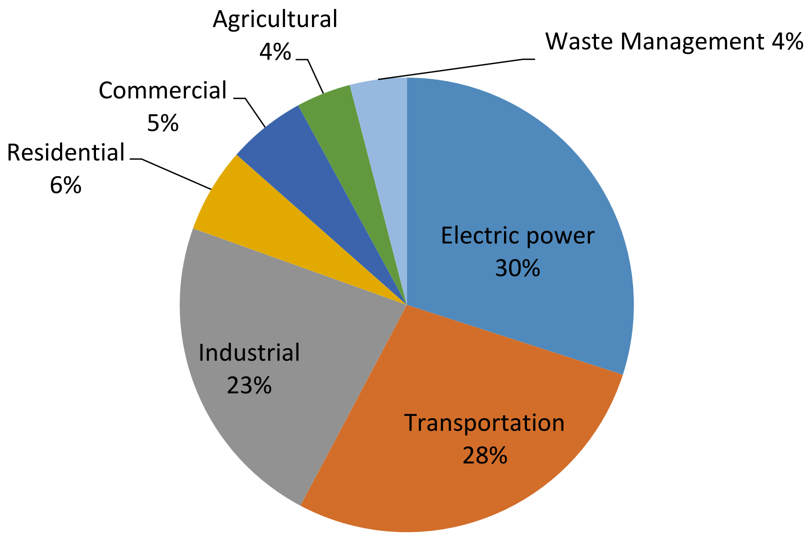
Reference Case GHG Emissions projections

The overall decline in historical GHG emissions is not projected to continue over time. Projection analysis[16] shows that gross GHG emissions from Delaware are expected to remain fairly constant over time. 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 remain the greatest contributor at 30% in 2030. The transportation sector is projected to remain the second largest emitter of GHGs representing approximately 28% in 2030, representing a relative decrease in contribution of 2% when compared to 2012. Industrial GHG emissions are projected to maintain a constant percentage of gross GHG emissions representing approximately 23% in 2030. The commercial sector is projected to remain at 5% of gross GHG emissions in 2030. The agricultural, residential, and waste management sectors are each projected to increase by one percentage relative to their respective shares in 2012 of the total GHG emissions in 2030.

[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 255.2 $MmtCO_2e$ to the atmosphere between 2013 and 2030. Figure ES-6 presents projected gross GHG emissions from Delaware from 2013 to 2030. GHG emissions are projected to increase slightly from 13.47 $MmtCO_2e$ in 2013 to 14.63 $MmtCO_2e$ in 2030, which represents an increase of approximately 8.6% or at an annual rate of 0.059 $MmtCO_2e$. However, 2030 gross GHG emissions are nearly equal to 2012 gross GHG emissions and are decreased by only 1.6%.

Cumulative net GHG emissions between 2013 and 2030 are projected to be 233.9 $MmtCO_2e$. Figure ES-7 presents projected net GHG emissions from 2013 to 2030. Net GHG emissions are projected to slightly increase from 12.29 $MmtCO_2e$ in 2013 to 13.45 $MmtCO_2e$ in 2030, which represents an increase of approximately 9.4% or at an annual rate of 0.059 $MmtCO_2e$. Similar to gross GHG emissions, the 2030 net GHG emissions are near those of 2012, decreasing by just 1.7%.

FIGURE ES-6. DELAWARE'S PROJECTED GROSS GHG EMISSIONS FROM 2013 TO 2030

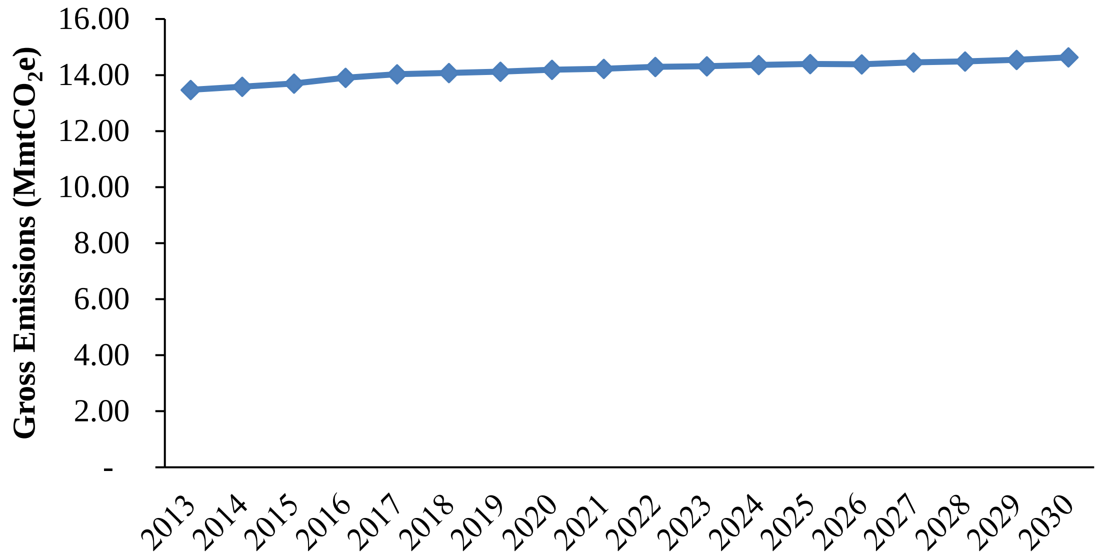


FIGURE ES-7. DELAWARE'S PROJECTED NET GHG EMISSIONS FROM 2013 TO 2030

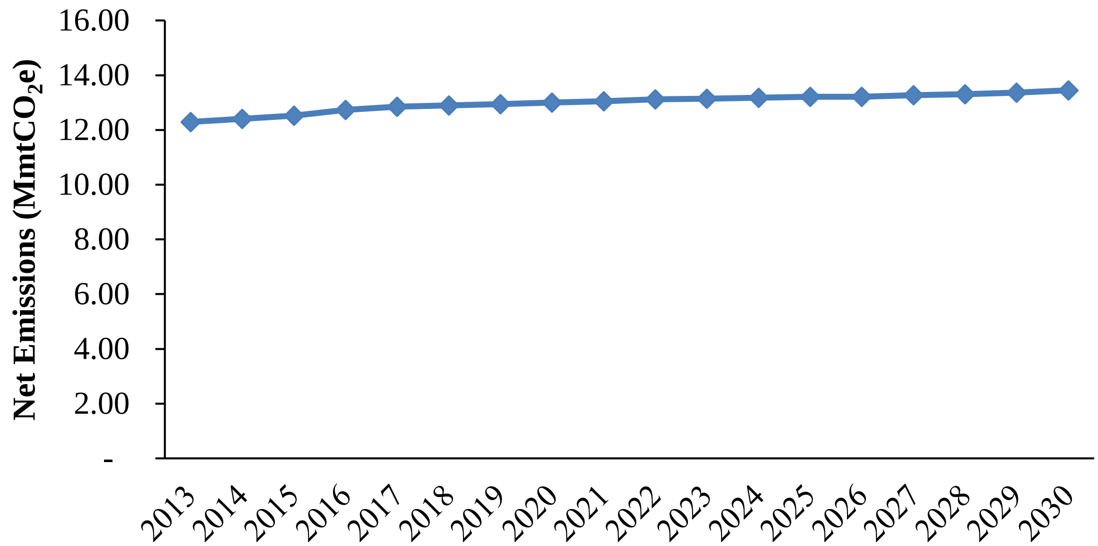
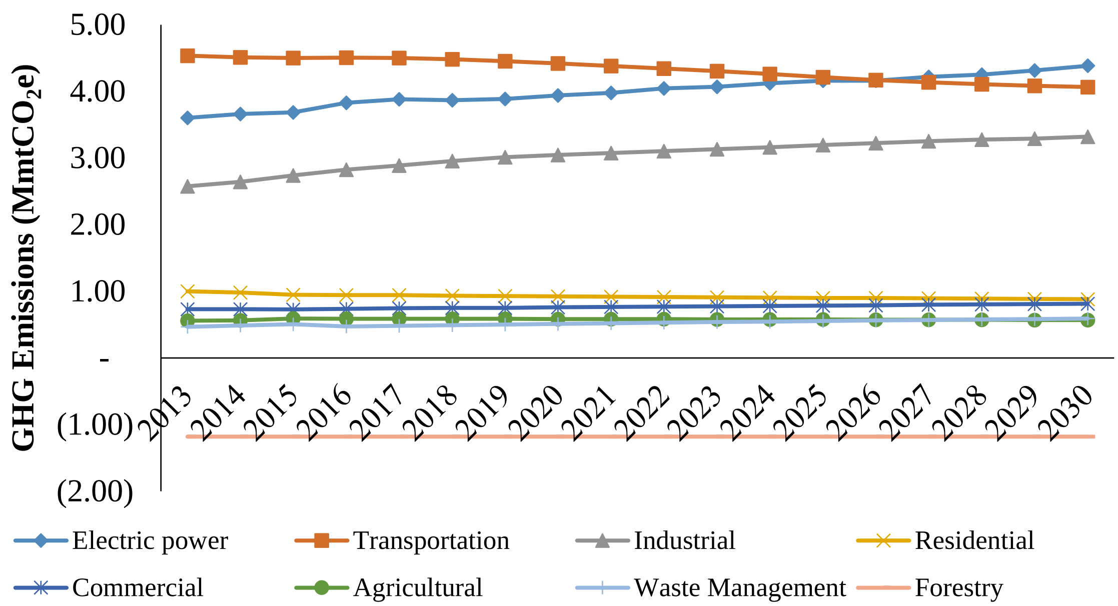


Figure ES-8 presents projected GHG emissions by sector from 2013 to 2030. Projection analysis shows that most of the economic sector emissions are projected to increase slightly over time, relative to modelled 2013 emissions. As Figure ES-8 presents, the *Big Three* sectors are expected to continue to 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 transportation sector and industrial sector as shown in Figure ES-8. The residential sector is projected to remain fairly constant with a slight decrease through 2030. The commercial, agricultural, 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 2012 GHG emisssions inventory characterized GHG emissions into eight econmic sectors of Delaware. The emssion trends and analytical findings of those sectors are summerized below:

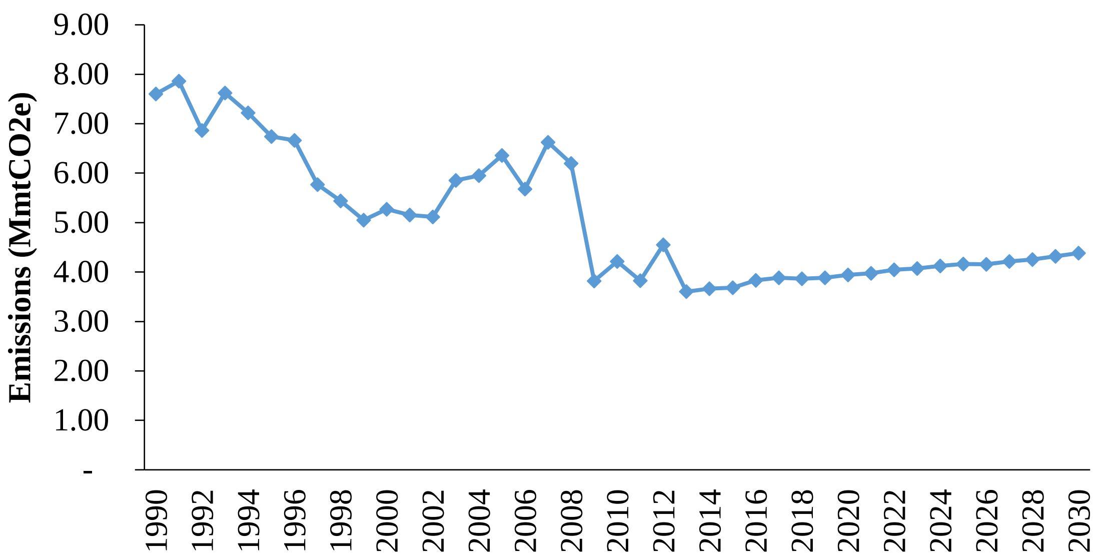
Electric Power Sector

The electric power sector added a cumulative amount of approximately 135.5 $MmtCO_2e$ in GHG emissions to the atmosphere between 1990 and 2012. 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 $MmtCO_2e$ in 1990 to 4.55 $MmtCO_2e$ in 2012, a decrease of approximately 40%. However, emissions increased in 2012 from 2011 by approximately 19%, largely due to increased generation from natural gas fired plants. Projection analysis shows that this sector is expected to add a total of 72 $MmtCO_2e$ in GHG emissions from 2013 to 2030. This trend is similar to that projected in the 2012 load forecast by PJM, which shows increases in peak demand for the DPL zone[17]. Electric power GHG emission is projected to moderately decrease from 2012 to 2013, then stabilize with a slight increase through 2030, as Figure ES-9 shows.

[17] PJM Load Forecast Report January 2012; DPL zone also includes parts of Maryland and Virginia.

Annual emissions are projected to increase by approximately 21.7% from 2013 (3.60 $MmtCO_2e$) to 2030 (4.38 $MmtCO_2e$).

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



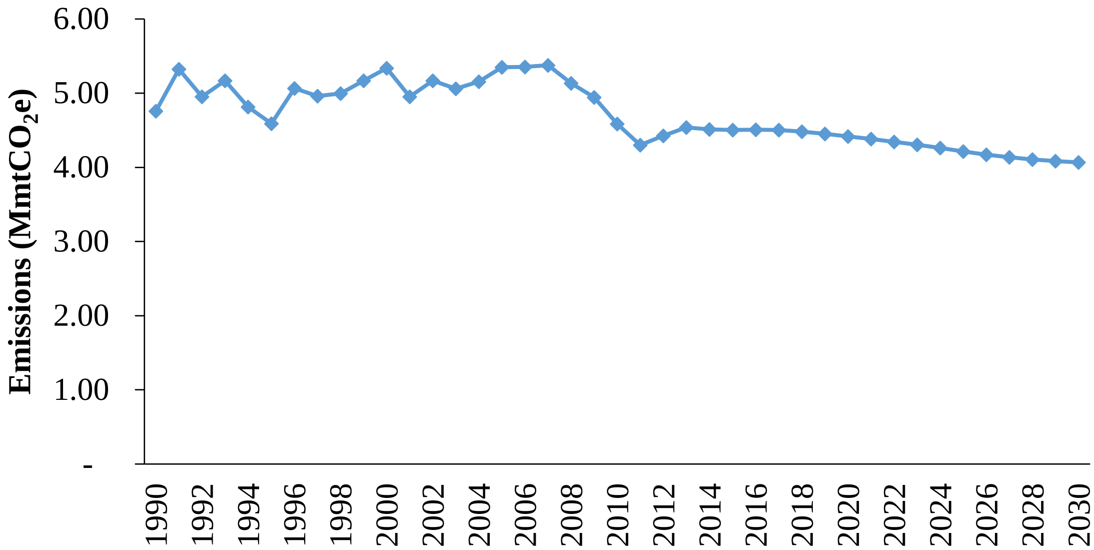
Transportation Sector

Between 1990 and 2012, the transportation sector added approximately 114.95 $MmtCO_2e$ to the atmosphere. Approximately 98% of GHG emission was CO_2 emission from gasoline and diesel combustion in vehicle – both highway and non-highway – engines. Figure ES-10 shows that GHG emission from the transportation sector was 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 prices[18].

GHG emissions decreased from 4.76 $MmtCO_2e$ in 1990 to 4.43 $MmtCO_2e$ in 2012, a decrease of approximately 7%. Projected transportation sector GHG emissions show that a cumulative amount of approximately 77.99 $MmtCO_2e$ in GHG emissions is expected to be added to the atmosphere from 2013 to 2030. Projection analysis shows that emissions are expected to stabilize with a slight decrease from 2013 to 2030 as presented by Figure ES-10. Emissions are projected to average approximately 4.33 $MmtCO_2e$ annually between 2013 and 2030. While population is expected to increase nearly 11% from 2012 to 2030, the transportation sector will realize net 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



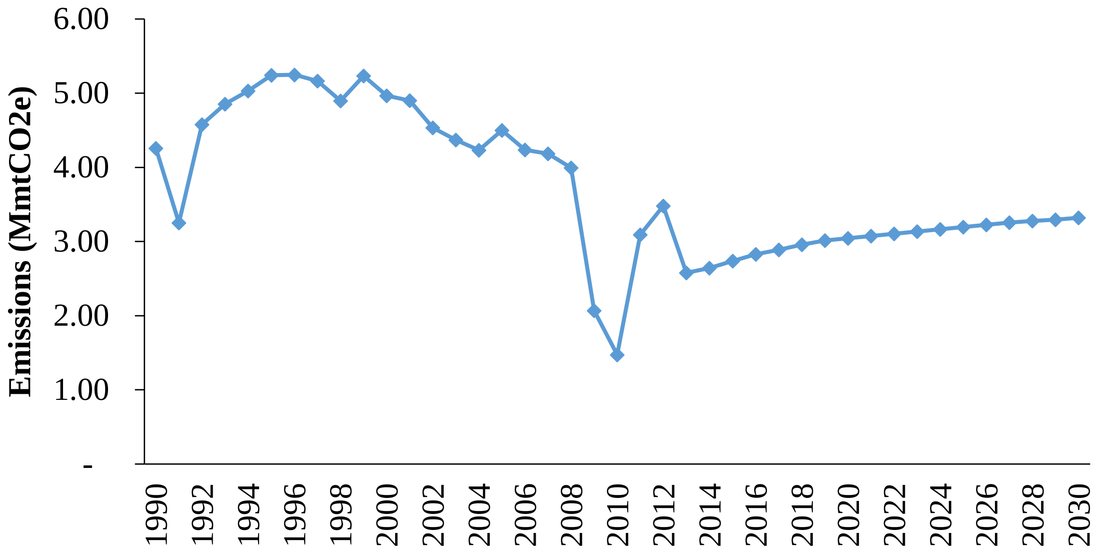
Industrial Sector

The industrial sector added a cumulative amount of approximately 97.78 $MmtCO_2e$ in GHG emissions to the atmosphere between 1990 and 2012. As Figure ES-11 presents, GHG emissions from this sector had a concave profile peaking at 5.25 $MmtCO_2e$ in 1996 and decreasing significantly to 1.47 $MmtCO_2e$ 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 2011[19].

Cumulative GHG emission from this sector is projected to be 54.7 $MmtCO_2e$ from 2013 to 2030. Projected emissions presented in Figure ES-11 predict a steadily increasing annual GHG emission from this sector, relative to 2013. Emissions are projected to increase from 2.58 $MmtCO_2e$ in 2013 to 3.32 $MmtCO_2e$ in 2030, an increase of approximately 29%.

[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



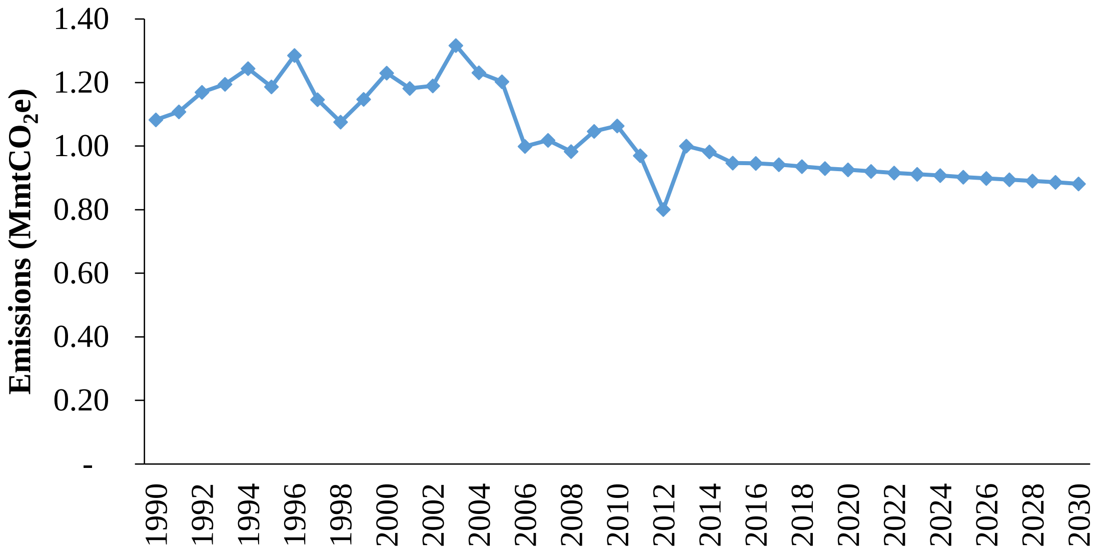
Residential Sector

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 2012 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 25.88 $MmtCO_2e$ in GHG emissions to the atmosphere from 1990 to 2012. As Figure ES-12 shows, historical emissions from 1990 to 2012 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 1990-2012[20]. 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. Emissions peaked at 1.32 $MmtCO_2e$ in 2003 and fluctuated downward to 0.80 $MmtCO_{2e}$ in 2012, a decrease of approximately 39%.

Cumulative GHG emission from the residential sector is projected to add 16.62 $MmtCO_2e$ to the atmosphere from 2013 to 2030. Projected emissions show that from 2013 to 2030, GHG emissions are expected to stabilize with a slight decrease from 1.00 $MmtCO_{2e}$ in 2013 to 0.88 in 2030, a decrease of approximately 12%. Over time, GHG emissions from the residential sector are not expected to decrease significantly but remain fairly constant with the potential of minor fluctuations depending on future weather patterns and fuel prices.

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

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

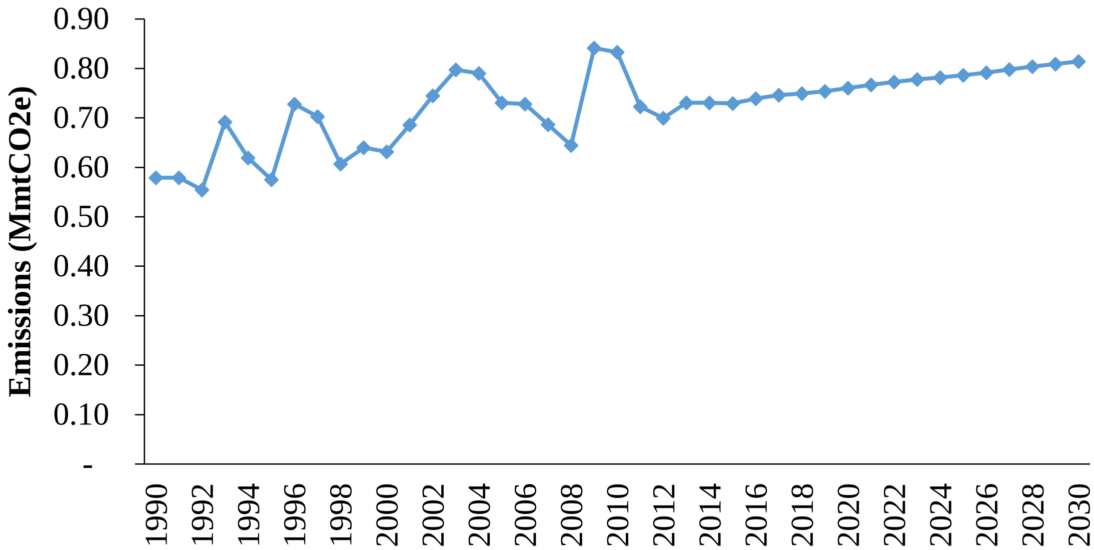


Commercial Sector

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 15.8 $MmtCO_2e$ in GHG emissions to the atmosphere from 1990 to 2012. As Figure ES-13 presents, historical GHG emissions fluctuated upwards from 1990 to 2012, 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 $MmtCO_2e$ in 1990 to 0.70 $MmtCO_2e$ in 2012, an increase of approximately 21%.

Projected emissions show that between 2013 and 2030, the commercial sector is expected to add a total of approximately 13.84 $MmtCO_2e$ to the atmosphere. As Figure ES-13 presents, GHG emissions are projected to increase from 0.73 $MmtCO_2e$ in 2013 to 0.81 $MmtCO_2e$ in 2030, an increase of approximately 11%, or a modest 0.08 $MmtCO_2e$.

Figure ES-13. Commercial Sector GHG Emissions from 1990 to 2030

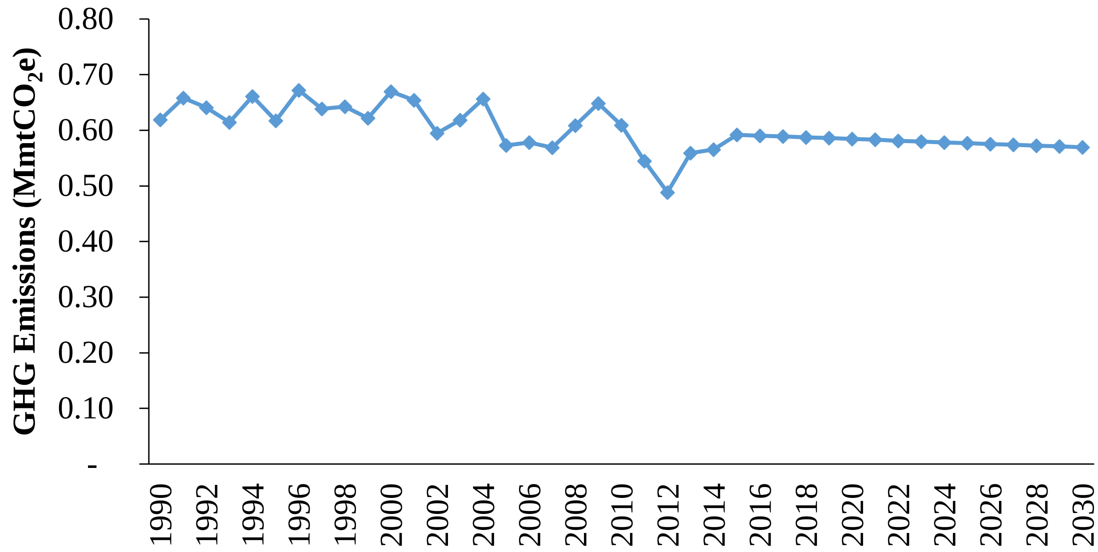


Agricultural Sector

Agricultural sector GHG emissions added a total of 14.20 MmtCO_2e in GHG emissions to the atmosphere from 1990 to 2012. The GHG emissions from this sector fluctuated downward from 0.62 MmtCO_2e in 1990 to 0.49 MmtCO_2e in 2012, a decrease of approximately 21%. 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 be constant with a marginal increase from 0.56 MmtCO_2e in 2013 to 0.57 MmtCO_2e in 2030. The cumulative GHG emissions projected to be added to the atmosphere is 10.41 MmtCO_2e between 2013 and 2030.

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



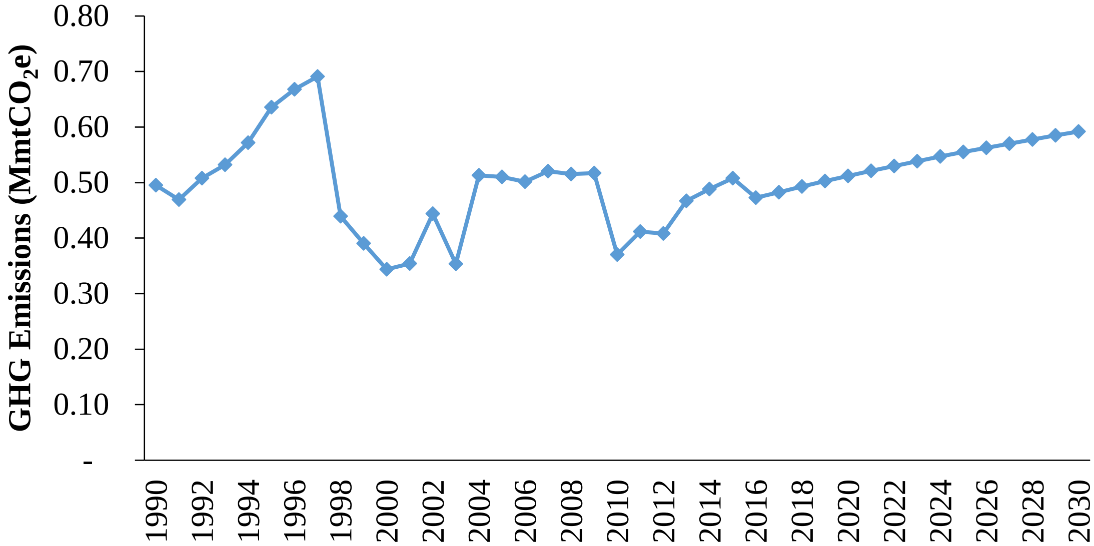
Waste Management Sector

Greenhouse gas emission from the waste management sector includes wastewater treatment methane (CH_4) and nitrous oxide (N_2O) emissions and municipal solid waste (landfills) CH_4 emissions. This sector added a total of approximately 11.16 $MmtCO_2e$ in GHG emissions to the atmosphere from 1990 to 2012. GHG emissions from wastewater treatment were fairly constant from 1990 to 2012 and are based mainly on municipal wastewater and industrial wastewater generated from poultry processing.

As Figure ES-15 presents, emissions fluctuated from 1990 to 2012. 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. LFTGE 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) have decreased by 18% from 0.50 $MmtCO_2e$ in 1990 to 0.41 $MmtCO_2e$ in 2012.

Projected emissions in the waste management sector are on pace to increase from 2013 to 2030, adding a cumulative 9.5 $MmtCO_2e$. GHG emissions from the waste management sector are projected to increase by 25.5% from 0.47 $MmtCO_2e$ in 2013 to 0.59 $MmtCO_2e$ in 2030.

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



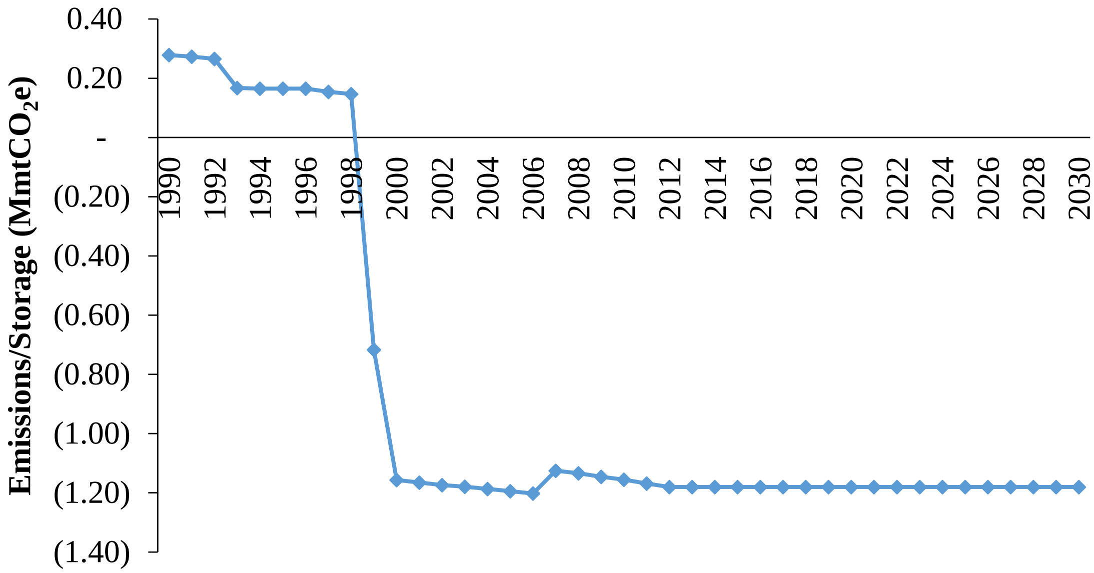
Land-use, Land Use Change and Forestry Emission Analysis

The 2012 GHG emissions inventory identified the land-use sector as a major sink[21] 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 $MmtCO_2e$. However, despite some losses in forest acreage, increased forest management practices and trees reaching maturity have enhanced carbon sequestration from 1999 to the present[22, 23]. In 2012, GHG emission for land-use was -1.18 $MmtCO_2e$. Meaning 1.18 $MmtCO_2e$ 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 2012. The removal of GHGs in this sector peaked in 2006 with a net GHG removal of 1.20 $MmtCO_2e$ as indicated in Figure ES-16. Net GHG removed from Delaware's forest pool totaled 15.88 $MmtCO_2e$ from 1999 and 2012.

The projection analysis for this sector was based on the assumption that Delaware's change in carbon storage will remain constant from 2012 to 2030. Therefore, the sequestration of 1.18 $MmtCO_2e$ in 2012 is constant from 2013 to 2030.

[21] A sink is the removal of GHG from the atmosphere
[22] Delaware Forest Resource Assessment, Delaware Forest Service, 2010
[23] 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 CO_2 emissions are CO_2 emissions that are estimated based on the amount of kilowatt-hours consumed by end-users of electricity. Indirect GHG estimates were included in the 2012 GHG inventory to show how electricity demand in Delaware impacts GHG emissions. Direct GHG emissions from in-state electricity generation were separated from indirect CO_2 emissions to avoid the double counting of emissions estimates.

Between 1990 and 2012, the total indirect GHG emission from Delaware was estimated at approximately 129.9 MmtCO_2e. As Figure ES-17 presents, indirect GHG emissions increased from 4.40 MmtCO_2e in 1990 to 5.95 MmtCO_2e in 2012, an increase of approximately 35%. Indirect GHG emissions are expected to continue to increase linearly as Figure ES-17 shows. Projected indirect GHG emissions are expected to increase from 6.80 MmtCO_2e in 2013 to 8.23 MmtCO_2e in 2030, an increase of approximately 21%. The rate of annual increase was determined to be 0.090 MmtCO_2e per year from 1990 to 2030.

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

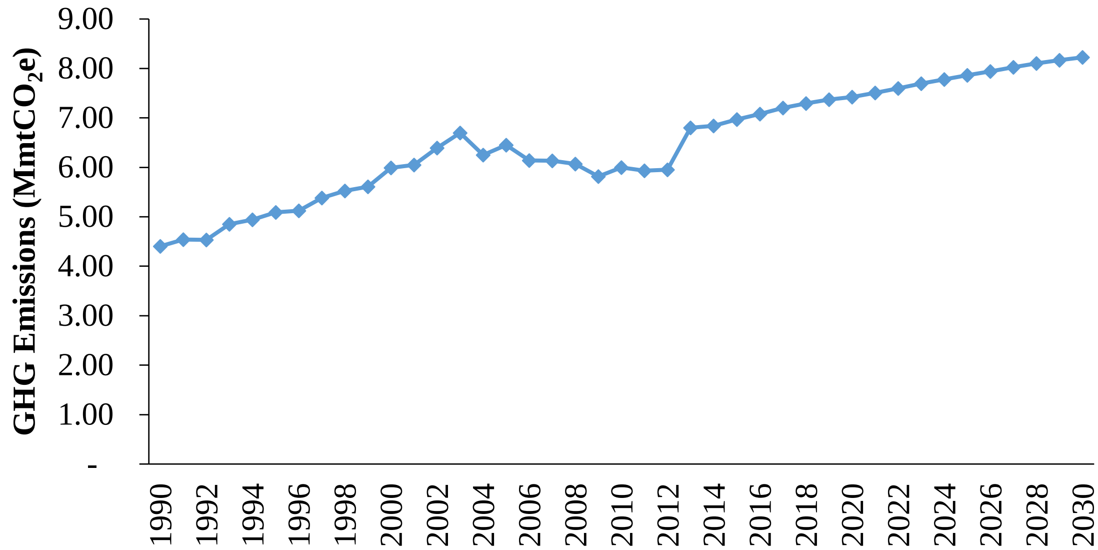


TABLE ES-1. GHG EMISSION ESTIMATES BY SECTORS

Economic Sectors	1990	2000	2012	2020	2030
Electric Power	**7.60**	**5.27**	**4.55**	**3.94**	**4.38**
CO_2 from FFC	7.49	5.20	4.53	3.93	4.36
N_2O from FFC	0.03	0.02	0.01	0.01	0.01
CH_4 from FFC	0.003	0.002	0.001	0.001	0.001
SF_6 from T&D	0.08	0.05	0.01	0.01	0.01
Transportation	**4.76**	**5.34**	**4.43**	**4.42**	**4.07**
CO_2 from FFC	4.53	5.08	4.36	4.35	4.00
N_2O from FFC	0.21	0.24	0.06	0.07	0.06
CH_4 from FFC	0.02	0.02	0.01	0.01	0.01
Industrial	**4.26**	**4.96**	**3.48**	**3.04**	**3.32**
CO_2 from FFC	4.04	4.58	2.86	2.23	2.33
N_2O from FFC	0.01	0.01	0.01	0.002	0.002
CH_4 from FFC	0.003	0.004	0.002	0.001	0.001
CH_4 from IP	0.20	0.16	0.14	0.14	0.10
CO_2 from IP	0.01	0.001	0.11	0.14	0.17
HFC, PFC Emissions	0.001	0.21	0.35	0.54	0.71
Residential	**1.08**	**1.23**	**0.80**	**0.93**	**0.88**
CO_2 from FFC	1.07	1.22	0.79	0.92	0.88
N_2O from FFC	0.003	0.004	0.002	0.001	0.001
CH_4 from FFC	0.01	0.01	0.01	0.002	0.002
Commercial	**0.58**	**0.63**	**0.70**	**0.76**	**0.81**

TABLE ES-1. GHG EMISSION ESTIMATES BY SECTORS					
Economic Sectors	**1990**	**2000**	**2012**	**2020**	**2030**
CO_2 from FFC	0.58	0.63	0.70	0.76	0.81
N_2O from FFC	0.001	0.001	0.001	0.001	0.001
CH_4 from FFC	0.002	0.003	0.002	0.002	0.002
Agricultural	**0.62**	**0.67**	**0.49**	**0.40**	**0.37**
Enteric Fermentation	0.05	0.05	0.04	0.04	0.04
Manure Management	0.19	0.20	0.19	0.22	0.23
Ag Soils	0.38	0.42	0.26	0.32	0.29
Ag Residue Burning	0.002	0.003	0.001	0.002	0.002
Waste Management	**0.50**	**0.34**	**0.41**	**0.51**	**0.59**
Wastewater Treatment	0.11	0.13	0.15	0.17	0.19
MSW	0.38	0.21	0.26	0.34	0.40
Land Use/Forestry	0.28	(1.16)	(1.18)	(1.18)	(1.18)
Gross GHG Emissions	**19.68**	**18.44**	**14.86**	**14.19**	**14.63**
Net GHG Emissions	**19.68**	**17.29**	**13.68**	**13.01**	**13.45**
Electricity Consumption	4.40	5.99	5.95	7.42	8.23

GHG EMISSIONS BY GAS

The 2012 GHG inventory estimated emissions for the six Kyoto GHGs. They include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

Figure ES-18 presents gross GHG emissions by gas in 2012. Carbon dioxide emissions represent the largest type of GHGs with approximately 90% of gross emissions from Delaware which is followed by N_2O and CH_4, each representing approximately 4%. The combined emission of HFC, PFC and SF_6 represent approximately 2% of gross GHG emissions from Delaware.

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

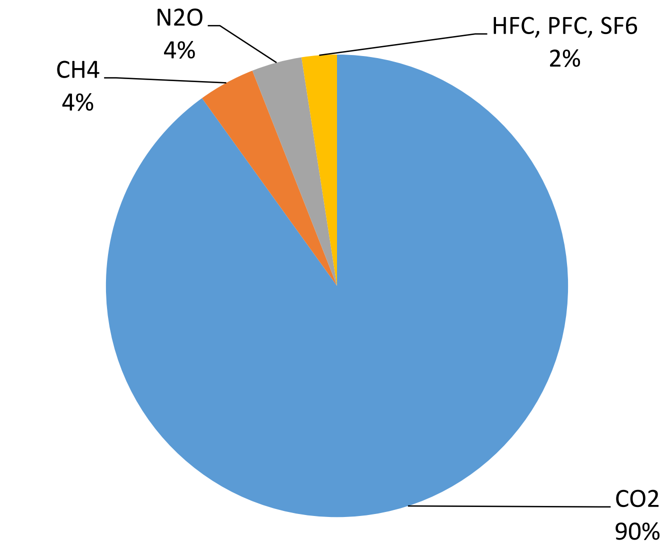
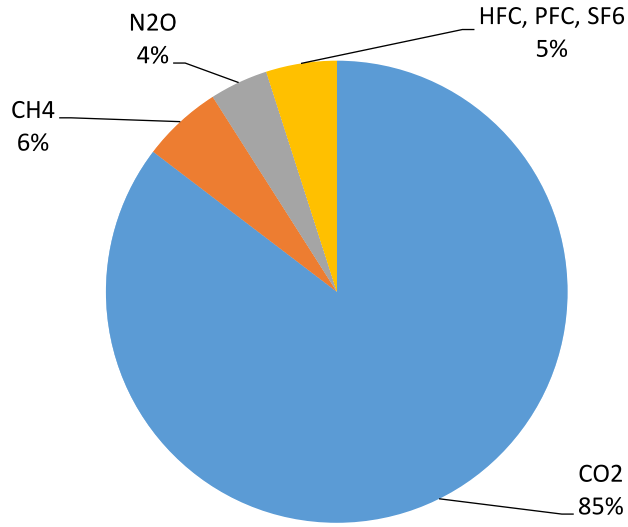


Figure ES-19 presents gross GHG emissions by gas in 2030. Carbon dioxide is projected to remain the most emitted GHG representing approximately 85% of gross GHGs emitted in 2030. CH_4 emissions are projected to be the next most abundant GHG in 2030 at 6%. The combined emissions of HFC, PFC and SF_6 is projected to be approximately 5% of gross emissions. N_2O emissions are projected to represent approximately 4% of gross GHG emissions as presented by Figure ES-19.

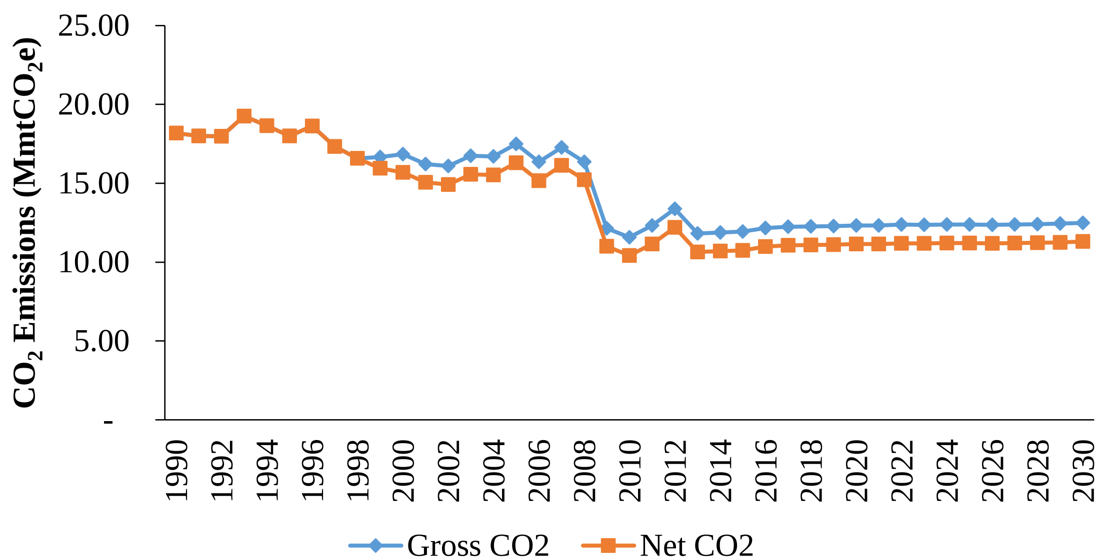
FIGURE ES-19. 2030 DELAWARE'S GHG EMISSIONS BY GAS



Carbon Dioxide: The emission of CO_2 was driven by fossil fuel combustion in all sectors of Delaware's economy. Approximately 99% of CO_2 came from fossil fuel combustion. Between 1990 and 2012, approximately 378.77 $MmtCO_2e$ in emissions were directly added to the atmosphere. Carbon dioxide was the largest contributor to GHG emissions representing approximately 90% in 2012, and is projected to represent approximately 85% in 2030. Historical CO_2 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 CO_2 emissions from 1990 to 2030. Gross CO_2 emissions are the sum of emissions excluding CO_2 sequestration or sinks. A key CO_2 sink is the land-use or forestry sector, which stores large amounts of CO_2 annually. Gross CO_2 emissions decreased from 18.18 $MmtCO_2e$ in 1990 to 13.38 $MmtCO_2e$ in 2012, a decrease of approximately 26%. However, gross CO_2 emissions are projected to increase from 11.82 $MmtCO_2e$ in 2013 to 12.49 $MmtCO_2e$ in 2030, a slight increase of approximately 6%. Net CO_2 emissions include sinks and which are calculated by subtracting annual CO_2 sequestration by Delaware's forest resource. Net CO_2 emissions decreased from 18.18 $MmtCO_2e$ in 1990 to 12.20 $MmtCO_2e$ in 2012, a decrease of approximately 33%. Net CO_2 emissions are projected to increase from 10.64 $MmtCO_2e$ in 2013 to 11.31 $MmtCO_2e$ in 2030, a slight increase of approximately 6%.

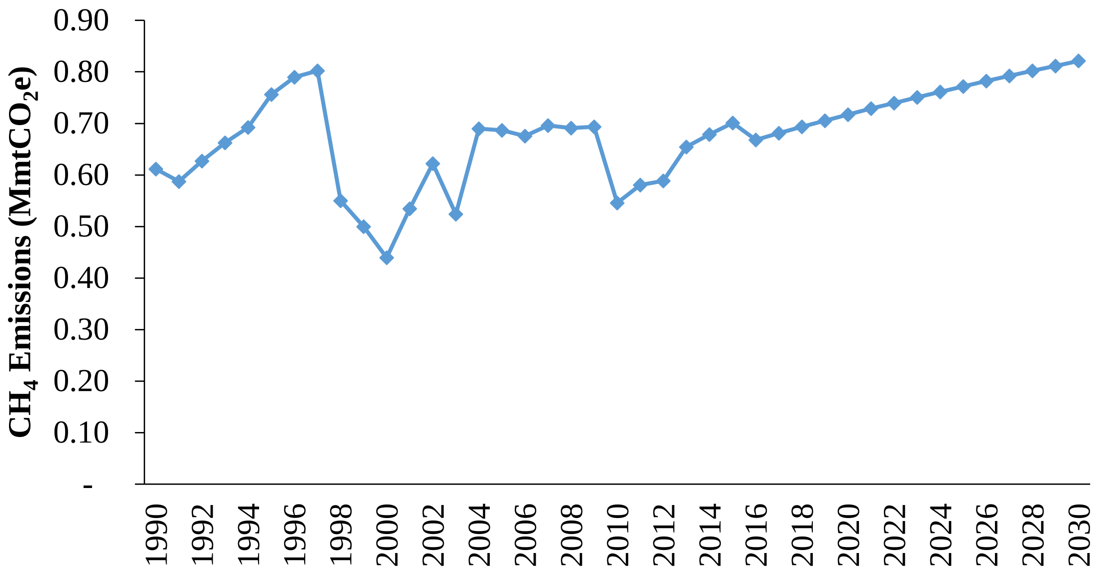
FIGURE ES-20. CO_2 EMISSIONS FROM 1990 TO 2030



Methane: From 1990 to 2012, approximately 14.55 $MmtCO_2e$ in CH_4 emissions was added to the atmosphere. Figure ES-21 presents CH_4 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, CH_4

emissions are projected to increase from 0.65 $MmtCO_2e$ in 2013 to 0.82 $MmtCO_2e$ in 2030, an increase of approximately 26%.

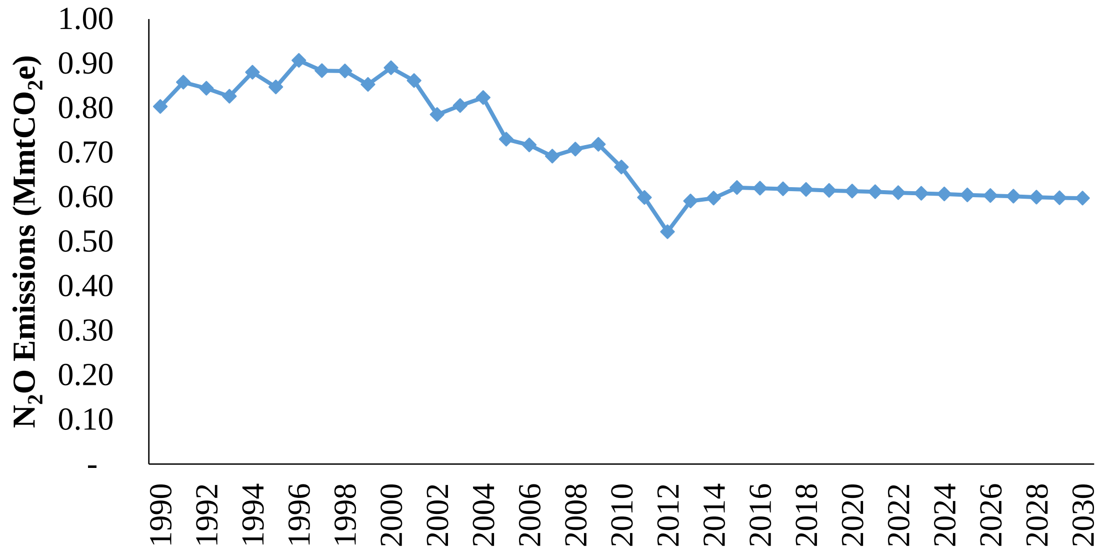
FIGURE ES-21. CH_4 EMISSIONS FROM 1990 TO 2030



Nitrous Oxide: From 1990 to 2012, approximately 18.10 $MmtCO_2e$ in N_2O emissions were added to the atmosphere. Figure ES-22 shows that N_2O emissions decreased gradually from 0.80 $MmtCO_2e$ in 1990 to 0.52 $MmtCO_2e$ in 2012, a decrease of approximately 35%. The decrease in N_2O 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 N_2O from Delaware's economy are projected to remain constant with a minimal increase from 0.59 $MmtCO_2e$ in 2013 to 0.60 $MmtCO_2e$ in 2030, or an increase of approximately 1.7%. Economic activities such as agriculture, transportation, and wastewater treatment in Delaware are projected to add approximately 10.93 $MmtCO_2e$ in N_2O emissions to the atmosphere from 2013 to 2030.

FIGURE ES-22. N_2O EMISSIONS FROM 1990 TO 2030



Hydrofluorocarbons, Perfluorocarbons, and Sulfur hexafluoride: The combined emission of HFC, PFC, and SF_6 added approximately 5.59 $MmtCO_2e$ to the atmosphere from 1990 to 2012. Though there was a significant increase in the emission of Ozone Depleting Substances (ODS)[24] substitutes, its impact to Delaware's gross GHG emissions was minimal because it was approximately only 2% of total GHG emissions in 2012 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 $MmtCO_2e$ in 1990 to 0.36 $MmtCO_2e$ in 2012, or an increase of approximately 350%.

The increasing emissions of this class of GHGs in Delaware was driven primarily by increasing consumption of ODS substitutes such as HFCs and PFCs. SF_6 emissions from power transmission and distribution in Delaware, however, have declined by approximately 87% from 1990 to 2012 and are projected to continue to decrease with time. Projection analyses show that this class of GHGs is expected to add approximately 10.29 $MmtCO_2e$ to the atmosphere from 2013 to 2030. It should be noted that 98.5% of the added emissions are HFC and PFC emissions. Emissions have been projected to increase from 0.42 $MmtCO_2e$ in 2013 to 0.72 $MmtCO_2e$ in 2030, a significant increase of approximately 71%.

[24] 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 SF_6 EMISSIONS FROM 1990 TO 2030

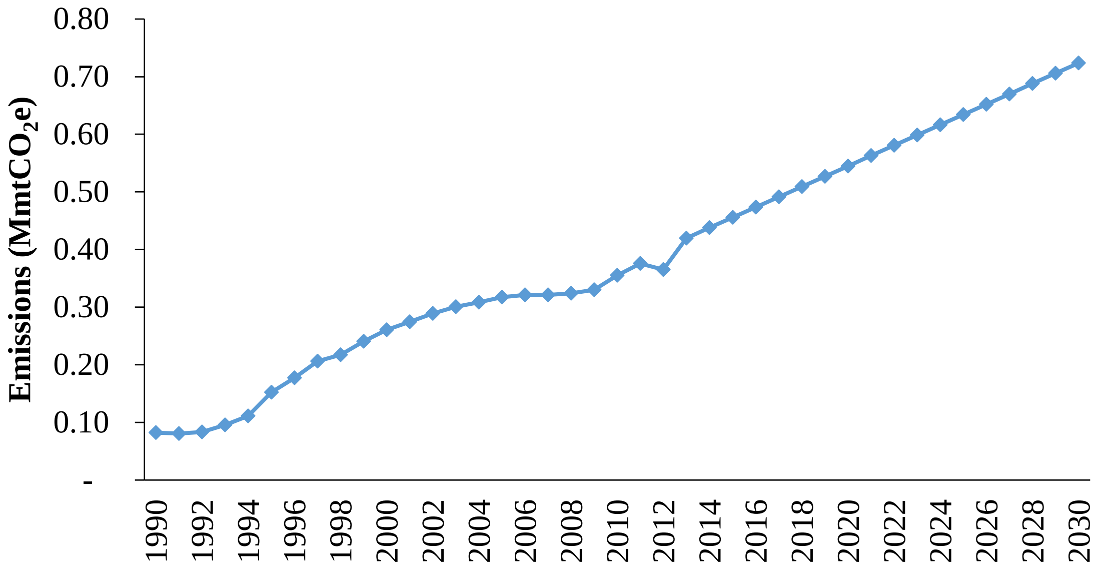


TABLE ES-2. GHG EMISSION ESTIMATES BY GAS (MMTCO2e)					
GHGs by Sources	**1990**	**2000**	**2012**	**2020**	**2030**
Gross CO_2	**18.18**	**16.85**	**13.38**	**12.32**	**12.49**
Net CO_2	**18.18**	**15.70**	**12.20**	**11.14**	**11.31**
Electric power FFC	7.49	5.20	4.53	3.93	4.36
Transportation FFC	4.53	5.08	4.36	4.35	4.00
Industrial FFC	4.04	4.58	2.86	2.23	2.33
CO_2 from IP	0.20	0.16	0.14	0.14	0.10
Residential FFC	1.07	1.22	0.79	0.92	0.88
Commercial FFC	0.58	0.63	0.70	0.76	0.81
Forestry	0.28	(1.16)	(1.18)	(1.18)	(1.18)
CH_4	**0.61**	**0.44**	**0.59**	**0.72**	**0.82**
Electric power	0.003	0.002	0.001	0.001	0.001
Transportation	0.02	0.02	0.01	0.01	0.01
Industrial	0.003	0.004	0.002	0.001	0.001
Industrial Processes	0.01	0.001	0.11	0.14	0.17
Residential FFC	0.01	0.01	0.01	0.002	0.002
Commercial FFC	0.002	0.003	0.002	0.002	0.002
MSW	0.38	0.21	0.31	0.34	0.40
Municipal wastewater treatment (WWT)	0.05	0.05	0.06	0.07	0.08

TABLE ES-2. GHG EMISSION ESTIMATES BY GAS (MMTCO$_2$e)					
GHGs by Sources	**1990**	**2000**	**2012**	**2020**	**2030**
Industrial WWT	0.05	0.06	0.06	0.08	0.08
Ag Enteric Fermentation	0.05	0.05	0.04	0.04	0.04
Ag Manure Management	0.03	0.03	0.04	0.04	0.04
Ag Burning of Crop Waste	0.001	0.002	0.002	0.001	0.001
N_2O	**0.80**	**0.89**	**0.52**	**0.43**	**0.40**
Electric power FFC	0.03	0.02	0.01	0.01	0.01
Transportation FFC	0.21	0.24	0.06	0.07	0.06
Industrial FFC	0.01	0.01	0.01	0.002	0.002
Residential FFC	0.003	0.004	0.002	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	0.16	0.18	0.19
Ag Soil Management	0.38	0.42	0.26	0.32	0.29
Ag Burning of Crop Waste	0.001	0.001	0.001	0.001	0.001
HFC, PFC &SF6	**0.08**	**0.26**	**0.36**	**0.53**	**0.72**
HFC, PFC Emissions	0.001	0.21	0.35	0.52	0.71
SF_6 from T&D	0.08	0.05	0.01	0.01	0.01
Gross Total GHG Emissions	**19.68**	**18.44**	**14.86**	**14.19**	**14.63**
Net total GHG Emissions	**19.68**	**17.29**	**13.68**	**13.01**	**13.45**

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 EPA[25], 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 2011, Delaware ranked 32nd in GHG emissions per capita according to the U.S Energy Information Administration[26]. As Figure ES-24 presents, per capita GHG emissions decreased from 29.41 mtonCO_2e/person in 1990 to 16.23 mtonCO_2e/person in 2012, a decrease of approximately 45%. The significant decrease in per capita GHG emissions from 1990 to 2012 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.

[25] State-Level Energy-Related Carbon Dioxide Emissions, 2000-2010
[26] EIA: http://www.eia.gov/environment/emissions/state/analysis/

Projected GHG emissions per capita are expected to remain essentially constant from 14.61 mtonCO_2e/person in 2013 to 14.45 mtonCO_2e/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