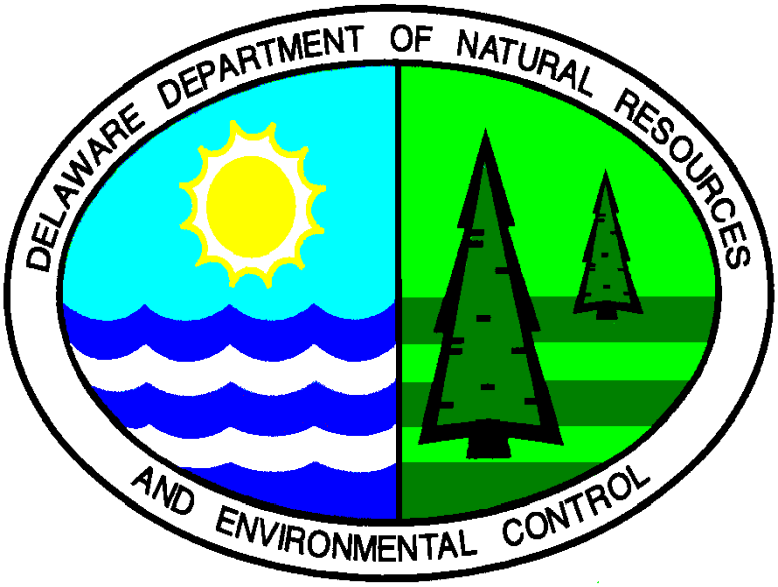


DELAWARE'S 2008 GREENHOUSE GAS EMISSIONS INVENTORY

PREPARED BY:

DIVISION OF AIR QUALITY

AUGUST 2012

EXECUTIVE SUMMARY

This report 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 2008 Greenhouse Gas (GHG) emissions inventory. The inventory was prepared to account for GHG emissions and sinks[1] in the State of Delaware. The inventory includes Delaware GHG emissions from1990 to 2008. In addition to 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 2008, emissions estimations were performed by using the U.S.EPA's State Inventory Tool (SIT). The SIT 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.

SOURCES OF GHG EMISSIONS

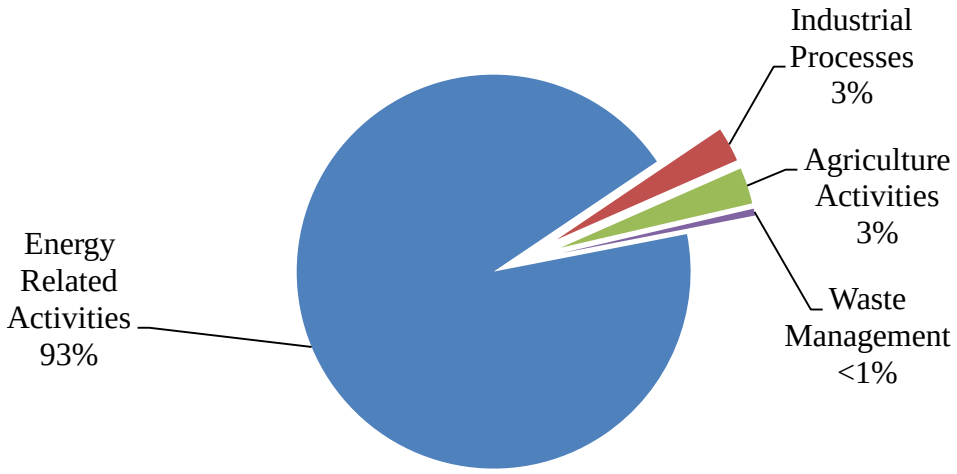
[1] Sinks: Removal or sequestration of greenhouse gases from the atmosphere.
[2] The term "anthropogenic", in this context, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities (IPCC/UNEP/OECD/IEA 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

The 2008 GHG inventory estimated GHG emissions from various sources. Data collection was performed by characterizing the sources into four categories including energy related activities, non-energy related industrial processes, agricultural activities, land-use, land-use change & forestry (LULUCF) and waste management[6]. Each source category was subdivided based on economic activities, as well as methodologies for estimating emissions. In 2008, Delaware's gross[7] GHG emission was equivalent to 18.88 million metric tons of carbon dioxide equivalents ($MmtCO_2e$). Also in 2008, net[8] GHG emission was equivalent to 16.14 $MmtCO_2e$ emitted. This was approximately a 21% decrease when compared to 1990 net emission of 20.55 $MmtCO_2e$. Delaware's gross GHG emission in 2008 made up approximately 0.3% of gross U.S GHG emissions (7,048 $MmtCO_2e$)[9]. Figure ES-1 provides the breakdown[10] of the 2008 GHG emissions by Delaware source category.

As Figure ES-1 presents, GHG emissions from energy related activities in Delaware had the largest CO_2e contribution to gross GHG emissions with approximately 93%. This was followed by agricultural source categories with approximately 3%, non-energy related industrial process sources with approximately 3% and waste management sources with less than1% (approximately 0.58%).

FIGURE ES-1. 2008 DELAWARE CO_2e EMISSIONS BY SOURCE CATEGORY

[6] IPCC, 2006 Guidelines for National Greenhouse Gas Inventories, Vol. 1
[7] Gross GHG emissions excluded metric tons of CO_2e removed from the atmosphere (sink)
[8] The land-use category was a sink for the removal CO_2. This produced negative CO_2e in the inventory results.
[9] U.S. EPA: 2012 Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990 -2008
[10] Figure 1 percentages are based on Delaware's gross emissions of 18.88 and not the net emissions of 16.14.



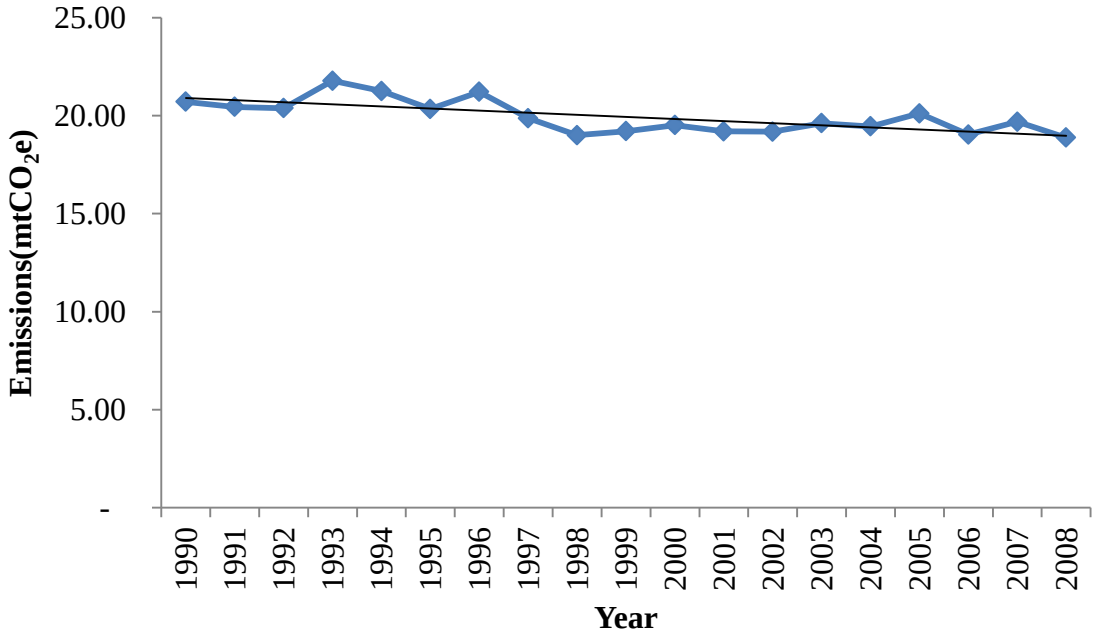
GROSS GHG EMISSION TREND

Delaware's gross GHG emissions trended down from 1990 to 2008 as shown in Figure ES-2. Gross GHG emissions decreased by approximately 8.8% from1990 to 2008. Though fluctuations where observed in the emissions trend as Figure ES-2 show, overall GHG emission levels declined from 1990 to 2008 at the rate of 0.11 $MmtCO_2e$ per year.

There were many factors that contributed to the downward trend of Delaware's gross GHG emissions. Energy related activities[11] affected all sectors of Delaware's economy and was the largest contributor to GHG emissions. Fossil fuel combustion was the greatest driver of GHG emissions from energy related activities. As the overall amount of fossil fuel combusted declined from 1990 to 2008, GHG emissions from energy related activities also declined. This decline in GHG emissions from energy related activities was the greatest driver of reductions in GHG emissions between 1990 and 2008.

FIGURE ES-2. DELAWARE'S GROSS GHG EMISSION FROM 1990 TO 2008

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



Energy Related Activities

The GHG emission trends by source category in Figure ES-3 shows that emissions from the energy source category have the largest share in gross GHG emissions from 1990 to 2008. Energy related activities resulted in an average annual emission of 18.42 $MmtCO_2e$ from 1990 to 2008. As shown in Table ES-1, GHG emissions from energy related activities decreased from 1990 to 2008 due to decreased fossil fuel consumption.

Agricultural Activities

The agricultural activities[12] were a distant second with respect to overall GHG emissions from 1990 to 2008. It had an average annual emission of 0.62 $MmtCO_2e$. GHG emissions from agricultural activities decreased slightly from 1990 to 2008 as presented by Table ES-1. This decrease was partly due Delaware's shrinking agricultural base as a result of land development, as well as improved agricultural practices that minimize emissions as well as increase carbon storage and sequestration.

Non-energy Related Activities

[12] Agricultural activities are activities that involve the cultivation of animals and plants for food.

Emissions from agricultural activities were followed by non-energy related industrial processes, which resulted in an average emission of 0.43 $MmtCO_2e$ per year. Table ES-1 showed that GHG emissions from non-energy industrial process emissions increased emissions increased from 1990 to 2008. This increase was driven primarily by emissions from the consumption of substitutes of ozone depleting substances (ODS)[13]. Emissions from the consumption of ODS substitutes increased drastically by approximately 36,533% from 1990 to 2008, representing the largest emissions rate increase of any source category.

Waste management Activities[14]

Waste management had the least impact with an average emission of 0.31 $MmtCO_2e$ per year. On the other hand, land use, land-use change and forestry (LULUCF) had an opposite impact on gross GHG emissions because it was a major sink for CO_2, removing an average amount of 1.50 $MmtCO_2e$ per year from 1990 to 2008.

FIGURE ES-3. GHG EMISSIONS BY SOURCE CATEGORIES

[13] Ozone depleting substances are gases that catalyzes the decomposition the ozone gas in the stratosphere

[14] Waste management activities are activities include recycling, combustion for energy recovery, treatment (treatment includes treatment for destruction and waste stabilization), and release, including disposal

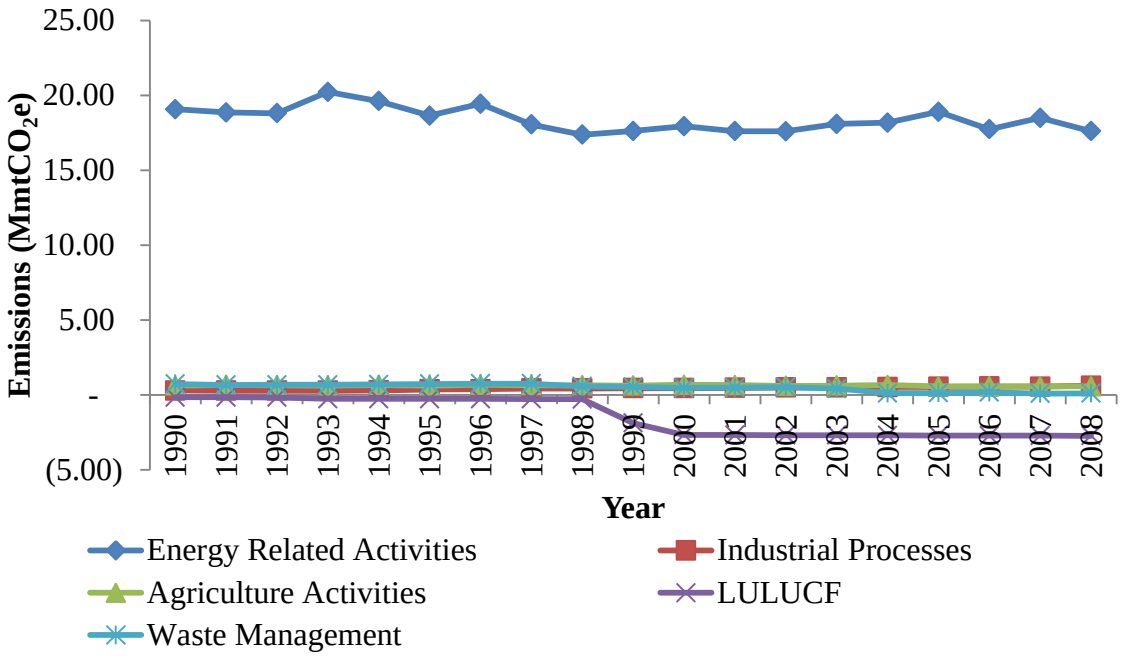


Table ES-1 provides a list of categories and sub-categories of sources with corresponding emissions estimates based on CO_2e. In 2008, energy related activities emitted 17.61 $MmtCO_2e$ into the atmosphere. This was followed by industrial processes with 0.60 $MmtCO_2e$, agricultural activities with 0.56 $MmtCO_2e$ and waste management with 0.11 $MmtCO_2e$. LULUCF removed 2.74 $MmtCO_2e$ from the atmosphere.

TABLE ES-1. GHG EMISSION ESTIMATES BY SOURCE CATEGORY

Source Categories	1990	1995	2000	2005	2008
Energy Related Activities	**19.08**	**18.64**	**17.94**	**18.90**	**17.61**
CO_2 from Fossil Fuel Combustion	18.78	18.30	17.62	18.66	17.43
Stationary Combustion	0.06	0.06	0.06	0.06	0.06
Mobile Combustion	0.24	0.28	0.27	0.19	0.12
Industrial Processes	**0.29**	**0.36**	**0.45**	**0.53**	**0.60**
Agriculture Activities	**0.62**	**0.61**	**0.67**	**0.57**	**0.56**
Enteric Fermentation	0.05	0.05	0.05	0.04	0.04
Manure Management	0.18	0.21	0.20	0.19	0.19

TABLE ES-1. GHG EMISSION ESTIMATES BY SOURCE CATEGORY					
Source Categories	**1990**	**1995**	**2000**	**2005**	**2008**
Agricultural Soil Management	0.38	0.35	0.42	0.33	0.32
Waste Management	**0.73**	**0.73**	**0.46**	**0.12**	**0.11**
Municipal Solid Waste	0.66	0.66	0.38	0.04	0.02
Wastewater	0.06	0.07	0.08	0.08	0.09
LULUCF	**(0.16)**	**(0.27)**	**(2.68)**	**(2.72)**	**(2.74)**
Gross Emissions	**20.71**	**20.34**	**19.52**	**20.12**	**18.88**
Sinks	**(0.16)**	**(0.27)**	**(2.68)**	**(2.72)**	**(2.74)**
Net Emissions	**20.55**	**20.07**	**16.84**	**17.40**	**16.14**
Indirect CO_2 from Electricity Consumption	**0.00**	**0.00**	**6.26**	**6.74**	**6.55**

NET GHG EMISSIONS TREND

In addition to estimating GHG emissions from various sources, DAQ also estimated the amount of GHGs in metric tons sequestered or removed from the atmosphere by sinks. The land-use, land-use change and forestry (LULUCF) category was identified as a sink. LULUCF mitigates the atmospheric build-up of GHGs by removing CO_2 from the atmosphere and then storing it in forest at a rate greater than emission back to the atmosphere through human and natural disturbances. The GHG emissions removed as a result of LULUCF from 1990 to 2008 were subtracted from gross GHG emissions to obtain net GHG emissions as presented in Figure ES-4.

FIGURE ES-4. NET GHG EMISSION FROM DELAWARE

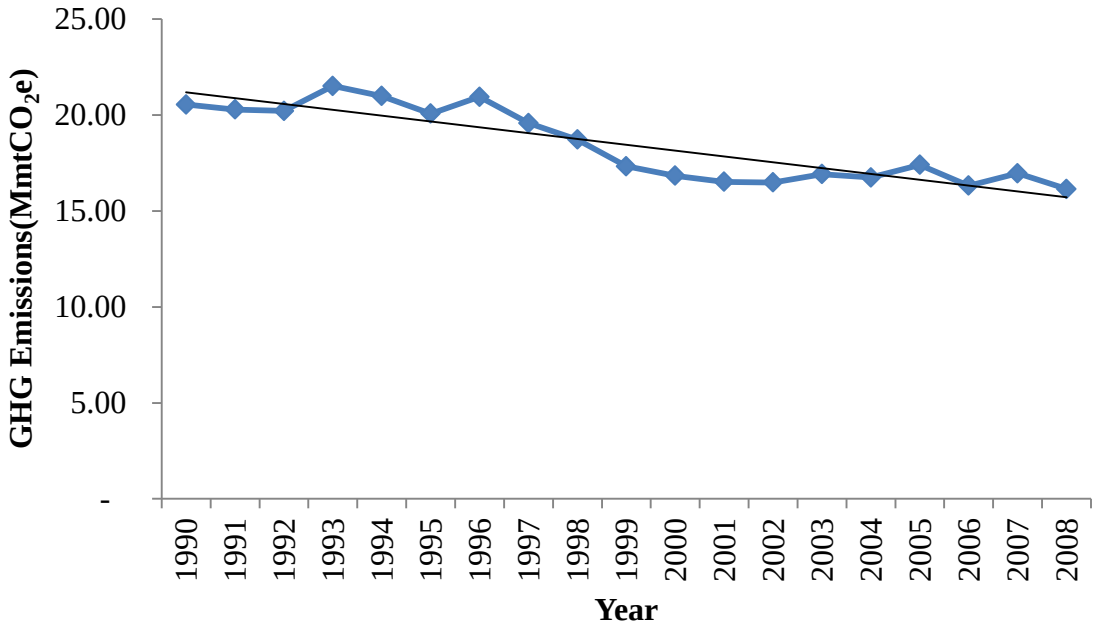


Table ES-1 shows that net GHG emissions decreased from 20.55 $MmtCO_2e$ in 1990 to 16.14 $MmtCO_2e$ in 2008. This was a decrease of approximately 21%. The overall decrease in net GHG emissions was at the rate of 0.30 $MmtCO_2e$ per year.

According to Table ES-1, indirect CO_2 emission from electricity consumption resulted in the emission of 6.55 $MmtCO_2e$. Indirect CO_2 emission is CO_2 emission that is estimated based on the amount of kilowatt-hour consumed by end-users of electricity. Estimates of indirect CO_2 emissions do not include electricity generated from fossil combustion. Indirect CO_2 estimates were included in the 2008 GHG inventory to show how electricity demand in Delaware impacts CO_2 emissions. Indirect CO_2 emissions were estimated from 2000 to 2008 because the available data was limited to those years. Direct CO_2 emissions from electricity generation were separated from indirect CO_2 emissions to avoid the double counting of emissions estimates. According to the 2008 GHG inventory, overall indirect CO_2 emissions increased as electricity demands increased from 2000 to 2008.

GHG EMISSIONS BY GAS

The 2008 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-5. 2008 DELAWARE'S GHG EMISSIONS BY GAS

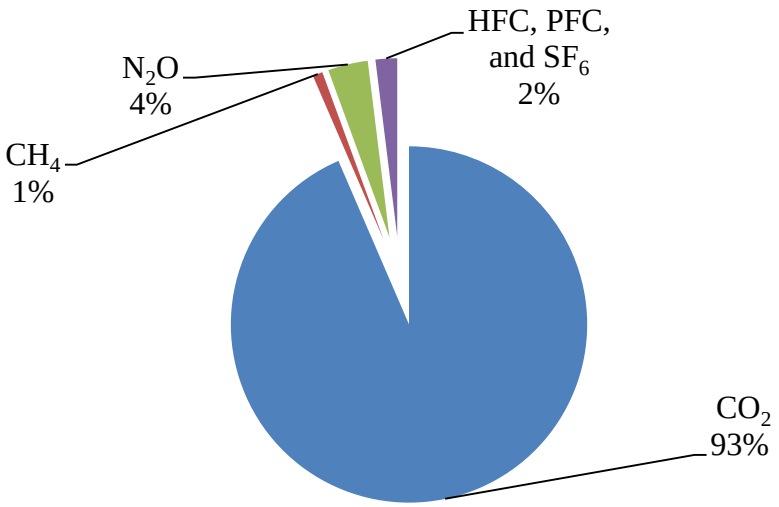


Figure ES-5 provides the percent breakdown for each GHG emitted in 2008. According to Figure ES-5, CO_2 emission represented the largest share of gross GHG emissions in 2008 with approximately 93% of the emissions. N_2O emission was a distant second representing only 4% of gross emissions. The combined emission of SF_6, HFC and PFC represented 2% of gross emissions, while CH_4 emission represented 1% in 2008.

Carbon Dioxide: The emission of CO_2 was driven by fossil fuel combustion in all sectors of Delaware's economy. As Table ES-2 provides CO_2 emissions in Delaware decreased slightly by approximately 8% from 1990 to 2008.

Methane: Based on estimates provided by Table ES-2, CH_4 emissions decreased drastically by approximately 64% from 1990 to 2008. This decrease in CH_4 emissions was driven by landfill gas recovery activities that mitigate the impact of CH_4 emissions. These activities included flaring and landfill gas conversion to electricity.

Nitrous Oxide: Based on estimates provided by Table ES-2, N_2O emissions decreased gradually by approximately 16% from 1990 to 2008. This decrease in N_2O was driven by improved farming activities as well as Delaware shrinking agricultural base due to land use change.

Hydrofluorocarbons), Perfluorocarbons and Sulfur hexafluoride: The combined emission of HFC, PFC and SF_6 increased drastically by approximately 363% from 1990 to 2008. This increase was driven by the increasing consumption of ODS substitutes. Though there was a significant increase in the emission of ODS substitutes, its impact to Delaware's gross GHG emissions was minimal because it was approximately only 2 % of total GHG emissions.

TABLE ES-2. GHG EMISSION ESTIMATES BY GAS ($MMTCO_2e$)

	1990	**1995**	**2000**	**2005**	**2008**
Gross CO_2	**19.12**	**18.60**	**17.81**	**18.84**	**17.59**
Net[15] CO_2	18.95	18.31	15.12	16.11	14.85
CO_2 from FFC	18.78	18.30	17.62	18.66	17.43
Industrial Processes	0.20	0.20	0.19	0.18	0.16
Waste	0.14	0.09	0	0	0
LULUCF	(0.17)	(0.28)	(2.69)	(2.72)	(2.75)
CH_4	**0.69**	**0.75**	**0.56**	**0.21**	**0.25**
Stationary Combustion	0.02	0.02	0.02	0.02	0.02
Mobile Combustion	0.02	0.02	0.02	0.01	0.01
Oil Refining	0.01	0.01	0.01	0.01	0.01
Enteric Fermentation	0.05	0.05	0.05	0.04	0.04
Manure Management	0.03	0.03	0.03	0.03	0.03
MSW	0.52	0.56	0.38	0.04	0.02
Wastewater Treatment	0.05	0.05	0.05	0.06	0.06

[15] Net CO_2 is determined by subtracting total CO_2 removed from the atmosphere by LULUCF (sink).

TABLE ES-2. GHG EMISSION ESTIMATES BY GAS ($MMTCO_2e$)					
	1990	**1995**	**2000**	**2005**	**2008**
N_2O	**0.82**	**0.86**	**0.90**	**0.74**	**0.68**
Stationary Combustion	0.04	0.04	0.04	0.04	0.04
Mobile Combustion	0.21	0.26	0.25	0.18	0.11
Manure Management	0.15	0.17	0.16	0.16	0.16
Agricultural Soil Management	0.38	0.35	0.42	0.33	0.32
Burning of Ag Crop Residue	0.00	0.00	0.00	0.00	0.00
N_2O from Settlement Soils	0.01	0.01	0.01	0.01	0.01
MSW	0.01	0.00	0	0	0
Wastewater Treatment	0.02	0.02	0.02	0.02	0.03
HFC, PFC, and SF_6	**0.08**	**0.15**	**0.26**	**0.34**	**0.37**
Industrial Processes	0.08	0.15	0.26	0.34	0.37
Gross Emissions	**20.71**	**20.34**	**19.52**	**20.12**	**18.88**
Sinks	**(0.17)**	**(0.28)**	**(2.69)**	**(2.72)**	**(2.75)**
Net Emissions (Sources and Sinks)	**20.55**	**20.35**	**16.84**	**17.40**	**16.14**
Indirect CO_2 from Electricity Consumption	**0**	**0**	**6.26**	**6.74**	**6.55**