IOWA DEPARTMENT OF
NATURAL RESOURCES

2010 Iowa Greenhouse Gas Inventory Report

Iowa Code 455B.104
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Iowa Department of Natural Resources
502 E. 9th Street
Des Moines, IA 50319

Table of Contents

List of Tables

List of Figures

Acronyms and Key Terms

AEO	Annual Energy Outlook
AFOLU	agriculture, forestry, and land use
BOD	biochemical oxygen demand
BOF	blast oven furnace
CH_4	methane
CCS	Center for Climate Strategies
CCT	Carbon Control Tool
CEEE	Center for Energy & Environmental Education
CGRER	Center for Global and Regional Environmental Research
CO_2	carbon dioxide
CRP	Conservation Reserve Program
DNR	Iowa Department of Natural Resources
DOE	United States Department of Energy
DOT	United States Department of Transportation
EAF	electric arc furnace
EIA	United States Energy Information Administration
EIIP	Emission Inventory Improvement Program
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Agency
FHWA	Federal Highway Administration
GHG	greenhouse gas
HDGV	heavy duty gas vehicle
HDDV	heavy duty diesel vehicle
IDALS	Iowa Department of Agriculture and Land Stewardship
IDOT	Iowa Department of Transportation
IEA	International Energy Agency
ILPA	Iowa Limestone Producers Association
IPCC	Intergovernmental Panel on Climate Change
LDC	local distribution company
LDDT	light duty diesel truck
LDDV	light duty diesel vehicle
LDGT	light duty gasoline truck
LDGV	light duty gasoline vehicle
LFGTE	landfill gas to energy
LMOP	Landfill Methane Outreach Program
LULUCF	land use, land use change, and forestry
MC	motorcycle
MMtC	million metric tons carbon

Acronyms and Key Terms (Continued)

MtCE	metric tons carbon equivalent
$MtCO_2e$	metric tons carbon dioxide equivalent
$MMtCO_2e$	million metric tons carbon dioxide equivalent
MRO	Midwest Reliability Organization
MROW	Midwest Reliability Organization West
MSW	municipal solid waste
N	nitrogen
NERC	North America Electric Reliability Corporation
NIFC	National Interagency Fire Center
NRCS	Natural Resources and Conservation Service
N_2O	nitrous oxide
OECD	Organization for Economic Co-operation and Development
PET	polyethylene terephthalate
PHMSA	Pipeline and Hazardous Materials Safety Administration
PS	polystyrene
PVC	polyvinyl chloride
SERC	SERC Reliability Corporation
SMRW	SERC Midwest
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VMT	vehicle miles traveled

Executive Summary

Background

This report is required by Iowa Code 455B.104 which states that "by December 31 of each year, the department shall submit a report to the governor and the general assembly regarding the greenhouse gas emissions in the state during the previous calendar year and forecasting trends in such emissions…." This report updates Iowa's 2005 Statewide Greenhouse Gas (GHG) Emission Inventory that was developed by the Center for Climate Strategies (Strait et al. 2008) for the Iowa Climate Change Advisory Council (ICCAC).

This is a "top-down" inventory based on statewide activity data from agriculture, fossil fuel combustion, industrial processes, natural gas transmission and distribution, transportation, solid waste, and wastewater treatment. It also includes carbon sequestered from land use, land use change, and forestry (LULUCF). GHG emissions were calculated using the State Inventory Tool (SIT), the standard GHG inventory method developed for states by the United States Environmental Protection Agency (EPA). The calculation method, results, and uncertainty for each sector are discussed in detail in their associated chapter. A majority of states have recently completed GHG inventories utilizing the same methodologies. Benefits of reports like this include the evaluation of emissions trends, development of a baseline to track progress in reducing emissions, and comparison with national trends (EPA 2011c). EPA also annually conducts a nationwide GHG inventory. The most recent was conducted for years 1990 – 2009 (EPA 2011b).

2010 Statewide GHG Emissions

In 2010, total Iowa *gross* greenhouse gas emissions (i.e. excluding carbon sinks) were 136.52 million metric tons carbon dioxide equivalents (MMtCO_2e). Table 1 and Figure 1 on the next page present the GHG emissions from each sector.

Table 1: Iowa GHG Emissions 2005 – 2010, by Sector[1,2]

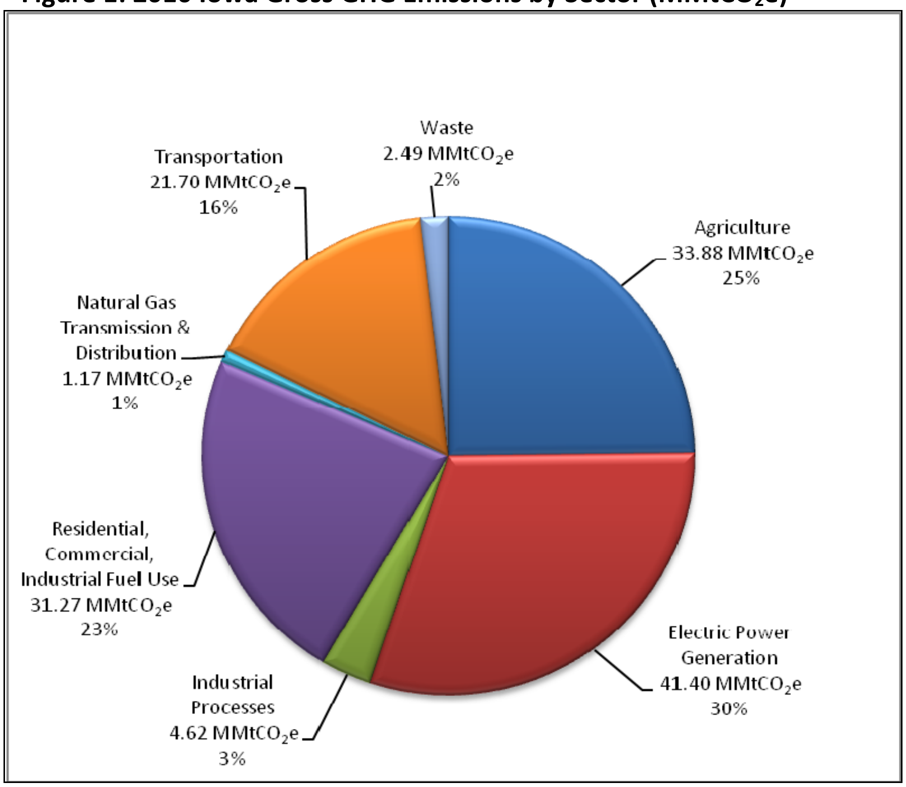
Emissions (MMtCO_2e)	2005	2006	2007	2008	2009	2010
Agriculture	32.14	34.25	38.73	34.81	34.63	33.88
Enteric Fermentation	5.95	6.35	6.62	6.77	6.74	6.50
Manure Management	6.77	6.80	7.48	8.19	8.25	7.93
Agricultural Soil Management	19.42	21.10	24.63	19.85	19.63	19.45
Burning of Agricultural Crop Waste	0.01	0.01	0.01	0.01	0.01	0.01
Fossil Fuel Combustion	60.90	60.68	66.26	69.53	65.38	72.67
Electric Power Fuel Use	36.84	36.35	40.04	41.78	37.71	41.40
Residential, Commercial, and Industrial (RCI) Fuel Use	24.07	24.32	26.21	27.75	27.66	31.27

[1] Totals may not equal the exact sum of subtotals in this table due to independent rounding.
[2] Numbers in parentheses are negative numbers.

Table 1 (continued)

Emissions ($MMtCO_2e$)	2005	2006	2007	2008	2009	2010
Industrial Processes	4.67	4.81	4.83	4.93	4.22	4.62
Land Use, Land Use Change, and Forestry (LULUCF)	(16.97)	(16.93)	(16.96)	(17.09)	(17.15)	(16.96)
Natural Gas and Oil Transmission and Distribution	1.15	1.15	1.16	1.07	1.17	1.17
Transportation	21.88	22.38	22.81	21.97	21.42	21.70
Waste	2.62	2.56	2.60	2.62	2.59	2.49
Municipal Solid Waste (MSW)	2.17	2.11	2.14	2.15	2.12	2.03
Wastewater	0.45	0.45	0.46	0.47	0.47	0.46
Gross Emissions	**123.37**[3]	**125.83**	**136.39**	**134.94**	**129.41**	**136.52**
Sinks	**(16.97)**	**(16.93)**	**(16.96)**	**(17.09)**	**(17.15)**	**(16.96)**
Net Emissions	**106.40**	**108.90**	**119.43**	**117.84**	**112.26**	**119.56**
% change in Gross from Previous Year		2.00%	8.40%	(1.07)%	(4.10)%	5.50%
% change in Gross from 2005		2.00%	10.56%	9.38%	4.90%	10.67%

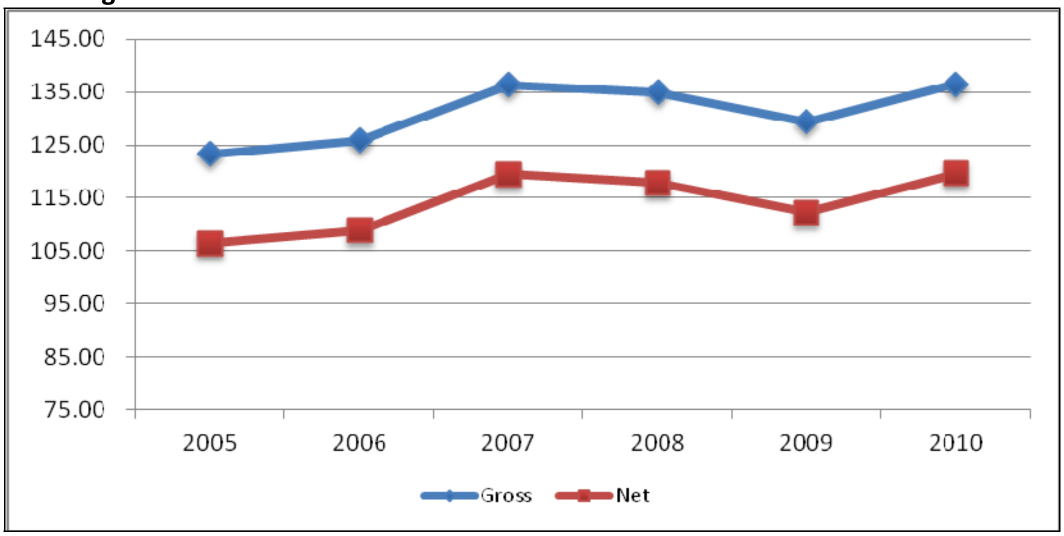
Figure 1: 2010 Iowa Gross GHG Emissions by Sector ($MMtCO_2e$)



[3] The 2005 value is as revised by the Department. The 2005 GHG emissions presented in this inventory are slightly higher (3.87 $MMtCO_2e$) than the emissions in the previous 2005 inventory conducted by Strait et al. The difference can be attributed to improved activity data and emissions factors since the inventory was conducted. The Department also determined that the SIT had been over-estimating emissions from both agricultural soils and agricultural burning. This is further discussed in *Chapter 2–Agriculture.*

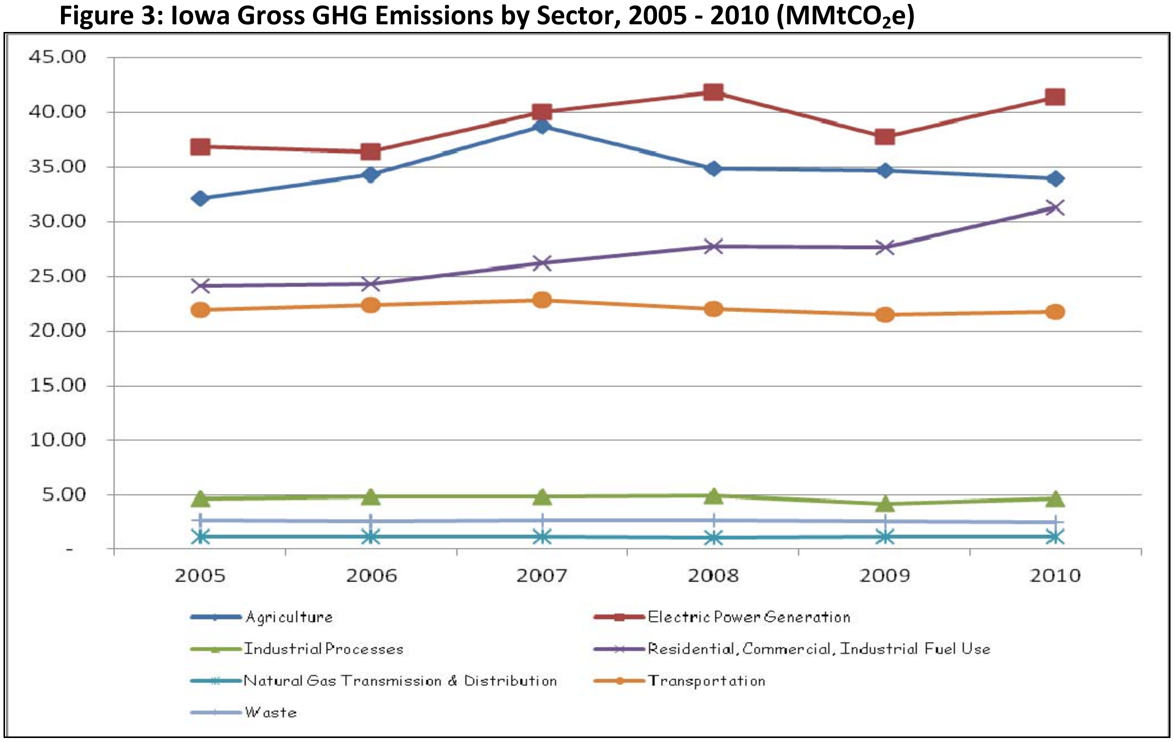
Total 2010 statewide gross GHG emissions increased 5.5% from 2009 and 10.7% from 2005 as shown in Figure 2 partially due to increases in the amount of fossil fuel combusted in the electric power and residential, commercial, industrial (RCI) sectors. Gross GHG emissions decreased 5.1% from 2007 – 2009, mostly due to the economic downturn. Net GHG emissions followed the same trend, as the amount of carbon sequestered remained stable.

Figure 2: Total Statewide GHG Emissions 2005 – 2010



The total gross GHG emissions increased from 2005 – 2010 in each sector except in the industrial processes, transportation, and waste sectors as shown in Figure 3.

Figure 3: Iowa Gross GHG Emissions by Sector, 2005 - 2010 (MMtCO_2e)



While the emissions from each sector are discussed in more detail in the chapter for each category, they can be summarized as follows:

- ***Agriculture*** – Includes GHG emissions from livestock and crop production such as enteric fermentation, manure management, agricultural soils, and agricultural burning. GHG emissions from fossil-fuel fired agricultural equipment are included in the transportation sector. Agricultural emissions increased 5.4% from 2005 – 2010, due to increases in both animal and crop production. This is further discussed in *Chapter 2 – Agriculture.*

- ***Fossil Fuel Combustion*** – Includes GHG emissions from fossil fuel consumption in two categories – electric power and residential, commercial, industrial (RCI). A 12.4% increase in electric power GHG emissions and a 30.0% increase RCI GHG emissions can be directly attributed to increases in the amount of fossil fuel consumed in each sector. This is further discussed in *Chapter 3 – Fossil Fuel Consumption*. GHG emissions from fossil fuels consumed by mobile sources are discussed in *Chapter 6 – Transportation.*

- ***Industrial Processes*** – Includes non-combustion GHG emissions from a variety of processes including cement production, lime manufacture, limestone and dolomite use, soda ash use, iron and steel production, ammonia production, nitric acid production, substitutes for ozone depleting substances (ODS), and electric power and distribution. GHG emissions trends in each sector vary, but overall GHG emissions from this sector decreased 1.1% from 2005 – 2010. This is further discussed in *Chapter 4 – Industrial Processes.*

- ***Natural Gas Transmission and Distribution*** – includes GHG emissions from natural gas transmission and distribution networks.GHG emissions increased 1.6% from 2005 – 2010 partly due to an increase in the miles of transmission lines in the state. This is further discussed in *Chapter 5 – Natural Gas Transmission & Distribution.*

- ***Transportation*** – includes GHG emissions from both highway and non-highway vehicles such as aviation, boats, locomotives, tractors, other utility vehicles, and alternative fuel vehicles. Transportation GHG emissions decreased 0.8% from 2005 – 2010, partly due to a decrease in the amount of gasoline combusted by motor vehicles. This is further discussed in *Chapter 6 – Transportation.*

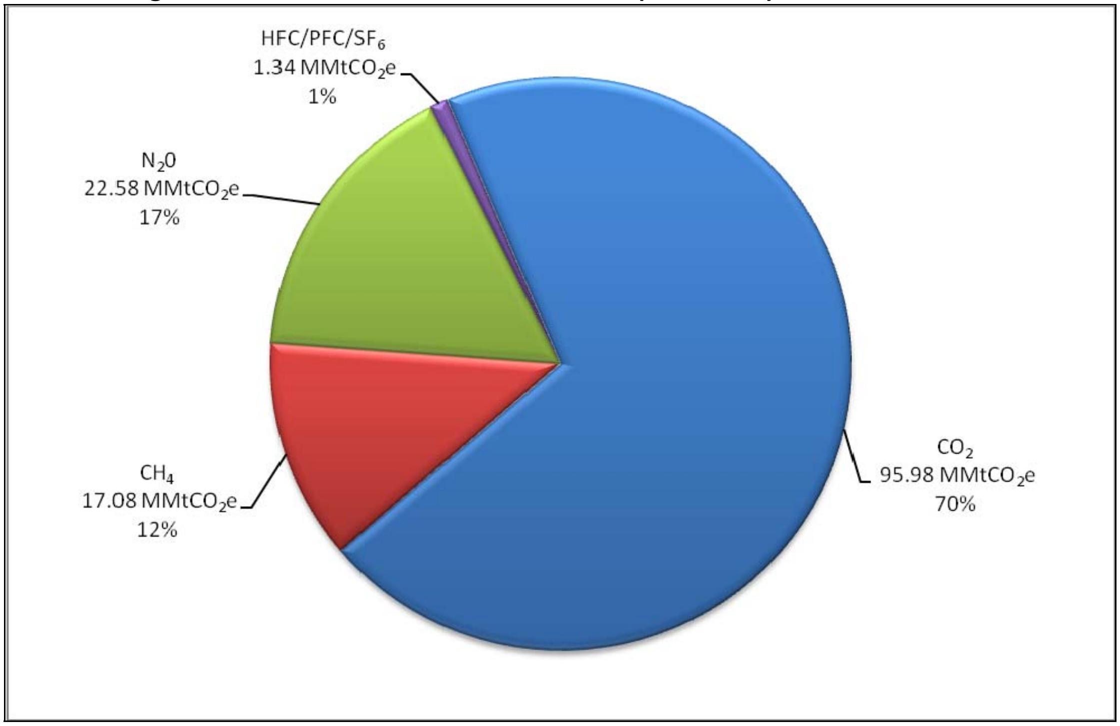
- ***Waste*** – includes GHG emissions from municipal solid waste (MSW) landfills and the treatment of municipal and industrial wastewater. GHG emissions from waste decreased 5.0% from 2005 – 2010, largely due to decreases in the amount of MSW both landfilled and combusted, as well as increases in the amount of methane emissions avoided by flaring and landfill gas to energy (LFGTE) projects. This is further discussed in *Chapter 7 – Waste: Solid Waste and Chapter 8 – Waste: Wastewater Treatment.*

- ***Land Use, Land Use Change, and Forestry (LULUCF****)* – includes emissions from liming of agricultural soils and fertilization of settlement soils, as well as carbon sequestered by forests, urban trees, and yard waste and food scraps that are sent to the landfill. The amount of CO_2 sequestered remained stable from 2005 – 2010, decreasing 0.02%. This is mostly due to a lack of more current forest carbon flux data. This is further discussed in *Chapter 9 – Land Use, Land Use Change, and Forestry (LULUCF).*

<u>Greenhouse Gases Emitted</u>

Greenhouse gases (GHG) included in the inventory are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC), hydrofluorocarbons (HFC), and sulfur hexafluoride (SF_6). Figure 4 shows the distribution of GHG emissions in 2010. The high percentage of CO_2 emissions is due to the high amount of CO_2 emissions (72.32 MMtCO_2e) from fossil fuel combustion. The majority of N_2O emissions (19.45 MMtCO_2e) are from agricultural soils, and the majority of CH_4 emissions (13.74 MMtCO_2e) are from enteric fermentation and manure management in the agricultural sector. More detail on the individual GHGs emitted from each sector is available in *Appendix A – Iowa GHG Emissions 2005 – 2010, by Pollutant.*

Figure 4: 2010 Iowa Gross GHG Emissions (MMtCO_2e)



EPA's Greenhouse Gas Equivalencies Calculator (2011a) estimates that the quantity of gross GHG emissions (i.e. excluding carbon sinks) emitted in Iowa in 2010 is equivalent to:

- Annual GHG emissions from 26.8 million passenger vehicles
- CO_2 emissions from the electricity use of 17.0 million homes for one year
- CO_2 emissions from the energy use of 11.8 million homes for one year
- The carbon sequestered by 3.5 billion tree seedlings grown for ten years
- GHG emissions avoided by recycling 47.6 million tons of waste instead of sending it to the landfill

<u>Comparison with National Emissions</u>

Figure 5 and Figure 6 compare Iowa and national GHG emissions by sector. For comparison purposes and to be consistent with the sectors in the national GHG inventory, the fossil fuel combustion, natural gas distribution and transmission, and transportation sectors have been combined into one sector called "Energy". Emissions from 2009 are used for this comparison as the 2010 national GHG inventory has not yet been published. Overall, Iowa emits 2.0% of U.S. GHG emissions. (EPA 2011b).

Figure 5: 2009 Iowa GHG Emissions by Sector

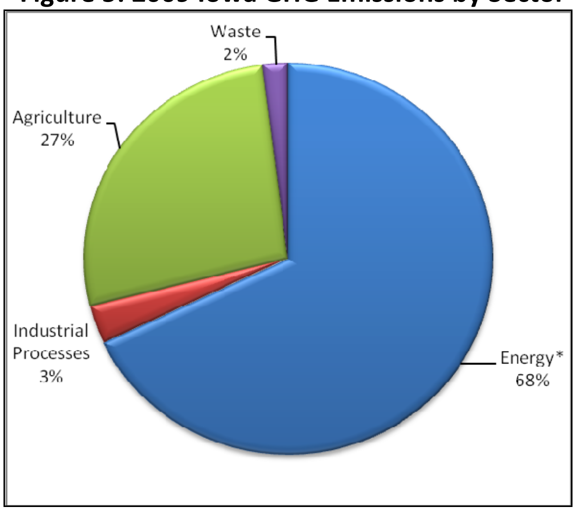
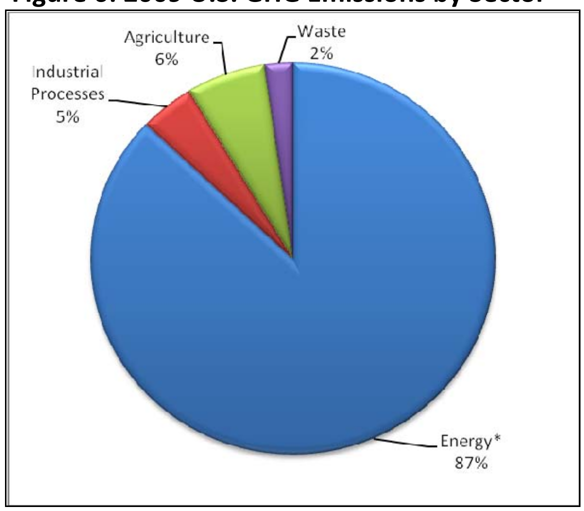


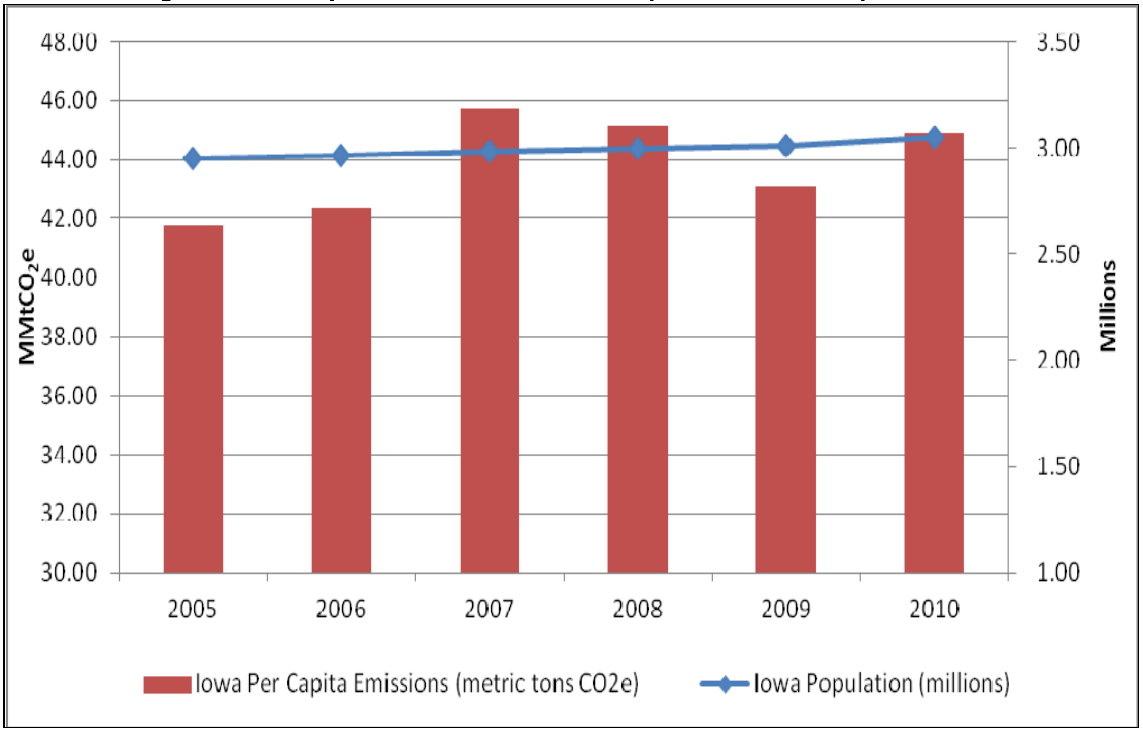
Figure 6: 2009 U.S. GHG Emissions by Sector



** The energy sector includes fossil fuel combustion, natural gas transmission and distribution, and transportation emissions.*

Iowa's population increased by 3.1% from 2005 – 2010. Per capita gross GHG emissions increased 6.7% during the same time period to 44.82 metric tons CO_2e per person in 2010 (43.02 metric tons in 2009) as shown in Figure 7. 2009 U.S. per capita emissions were 21.71 metric tons CO_2e per person.

Figure 7: Per Capita Gross GHG Emissions (metric tons CO_2e), 2005 – 2010



Chapter 1 - General Calculation Method

Iowa's GHG emissions for 2005 - 2010 were calculated using the most recent version of the United States Environmental Protection Agency's (EPA) State Greenhouse Gas Inventory Tool (SIT) and using available Iowa-specific activity data. The calculation methods in the SIT are based on the August 2004 version of EPA's Emission Inventory Improvement Program (EIIP) guidance for greenhouse gases (ICF Consulting 2004a and 2004b). The individual modules for each sector are Excel workbooks populated with emission factors and default activity data[4] for years 1990 – 2008, but allow the user to enter better state-specific activity data when it is available. Detailed information on the activity data used is provided in the corresponding chapter for each sector, under the "Method" heading. The individual modules then auto-calculate the resulting GHG emissions from each sector. The Synthesis Tool then collects the results of each individual module and organizes them into a final statewide emissions summary. The SIT modules and their corresponding chapters in this inventory report are:

Table 2: Inventory Chapters and Corresponding SIT Modules

Inventory Chapter	SIT Module[5]	Release Date	Pollutants Addressed
Executive Summary	Synthesis Tool	01/03/11	CO_2, CH_4, N_2O, SF_6
Agriculture	Ag	01/03/11, updated on 05/04/11	CH_4, N_2O
Energy	CO_2FFC	08/03/11	CO_2
	Stationary Combustion	08/03/11[6]	CH_4, N_2O
Industrial Processes	IP	01/03/11	CO_2, N_2O, SF_6
Natural Gas Transmission and Distribution	Natural Gas and Oil	01/03/11	CH_4
Transportation	CO_2FFC	08/03/11	CO_2
	Mobile Combustion[7]	08/03/11	CH_4, N_2O
Waste	Solid Waste	01/03/11	CO_2, CH_4
	Wastewater	01/03/11	CH_4
Land Use, Land Use Change, and Forestry (LULUCF)	LULUCF	01/03/11	CH_4
Indirect Emissions from Electricity Consumption	Electricity Consumption	01/03/11	CO_2

[4] The Department's calculation worksheets are available upon request.
[5] The coal module was not used as there are no coal mines currently operating in Iowa.
[6] The stationary combustion module used is the 08/03/11 version, although the front screen of the module still reads 01/03/11.
[7] The front screen of the mobile combustion module says 1/3/11 but the module was updated with 2009 data and re-released EPA on 8/23/11.

Chapter 2 - Agriculture

This chapter includes non-energy greenhouse gas (GHG) emissions from livestock and crop production in Iowa. GHG emissions from fossil fuel-fired agricultural equipment are discussed in *Chapter 6 – Transportation* and carbon sinks from agriculture are discussed in *Chapter 9 – LULUCF* of this report.

GHG emissions are emitted from four agricultural sectors in Iowa – enteric fermentation, manure management, agricultural soils, and agricultural burning. The GHGs emitted are methane (CH_4) and nitrous oxide (N_2O). Table 3 below summarizes the source of GHG emissions in each sector.[8] N_2O emissions from rice cultivation were not included as rice is not grown in Iowa (USDA 2009).

Table 3: Sources of Agricultural GHG Emissions in Iowa

Sector		GHGs Emitted	Source of Emissions
Enteric Fermentation		CH_4	Microbial activity in the digestive systems of dairy cattle, beef cattle, sheep, goats, swine, and horses.
Manure Management		CH_4 N_2O	Decomposition of manure during storage and treatment of livestock manure.
Agricultural Soils	Residues, legumes, and histosols	N_2O	Biological nitrogen fixation by crops, crop residues remaining on fields, and cultivation of high organic content soils (histosols).
	Fertilizers	N_2O	Application of manure, fertilizers, etc. to soils and leaching/runoff of nitrogen into ground or surface water.
	Animals	N_2O	Animal excretions directly on to soils such as pastures.
Agricultural Burning		CH_4 N_2O	Burning of crop residues.

Method

GHG emissions from agriculture for 2005 - 2010 were calculated using the United States Environmental Protection Agency's (EPA) State Greenhouse Gas Inventory Tool (SIT)[9] agriculture module dated January 3, 2011. ICF International on behalf of EPA issued a software patch on May 4, 2011 to correct formulas in the agricultural soils sector (Pederson 2011). This is further discussed in this chapter under "*Revisions*".

2005 GHG emissions in this inventory differ from the values in the 2005 inventory developed for the Iowa Climate Change Advisory Council, *Iowa Greenhouse Gas Inventory and Reference Case Projections*

[8] For more detailed information on the source of GHG emissions in each agricultural sector, please see Chapter 3 and Appendix B of the *Year 2000 Iowa Greenhouse Gas Emissions Inventory*.
[9] The SIT is available by filling out a request form at < http://www.epa.gov/statelocalclimate/resources/tool.html>.

1990 – 2005 (Strait et al. 2008) because of updates made by EPA to the SIT worksheets for enteric fermentation and manure management since the 2005 inventory was completed. Specifically, EPA updated emission factors in the SIT for the amount of CH_4 emitted per head of cattle and the daily amount of volatile solids produced by cattle (ICF 2011a).

Enteric Fermentation

The SIT calculates CH_4 emissions from enteric fermentation by multiplying various livestock populations by an annual CH_4 emission factor (kilograms CH_4 per head). Iowa-specific 2009 and 2010 livestock populations were used when available, as shown in Table 4. In addition, the Department updated the 2007 and 2008 goat population values in SIT with the 2007 value of 55,950 head (USDA 2009) which is a significant increase from the 18,898 default value in SIT.

Table 4: Livestock Populations Updated in Enteric Fermentation Worksheet

Year(s)	Animal Type	Source
2009, 2010	Sheep, swine, dairy cattle, and beef cattle except feedlot heifers and steers[10]	(USDA 2010a)
2009, 2010	Feedlot heifers and steers	No value available – used 2008 value already in SIT.[11]
2007	Goats	(USDA 2009)
2008	Goats	Used 2008 value (USDA 2009)
2009, 2010	Goats	(USDA 2010a)
2009, 2010	Horses	No value available – used 2008 value already in SIT.[12]

Manure Management

This sector includes CH_4 and N_2O emissions from manure when it is being stored and treated in a manure management system. In general, CH_4 emissions increase in more anaerobic (lacking oxygen) conditions while N_2O emissions increase under aerobic conditions (Strait et al. 2008). For consistency, the same sheep, swine, horse, goat, dairy cattle, and beef cattle populations were used as in the enteric fermentation sector. In addition, animal populations for swine subcategories, sheep subcategories, and poultry were added as shown in Table 5.

[10] Value used is the number of animals on farms on January 1. The 2010 value for feedlot heifers and feedlot steers was not available.

[11] USDA does not publish animal populations for these categories.

[12] USDA does not track horse populations on an annual basis (Cowles 2011a).

Table 5: Livestock Populations Updated in Manure Management Worksheets

Year(s)	Animal Type	Source
2009	Hens, pullets, and chickens[13]	(USDA 2010a)
2010	Hens, pullets, and chickens	No value available – used 2009 value from USDA.
2009, 2010	Sheep (On Feed/ Not on Feed)	No value available – used 2008 value already in SIT.
2009, 2010	Swine (breeding and various market weights)	(USDA 2010a)
2009, 2010	Turkeys	No value available – used 2008 value already in SIT.

Agricultural Residue Burning

The SIT assumes that 3% of Iowa corn, soybean, and wheat field residue are burned annually. However, burning of cropland is not a typical agricultural practice in Iowa. Previous Iowa greenhouse gas inventories (Ney et al. 1996 and Strait et al. 2008) have noted that the SIT over-estimates emissions from agricultural residue burning in Iowa, but did not include Iowa-specific data to refine the SIT estimate. The *Year 2000 Iowa Greenhouse Gas Emissions Inventory* notes that **"**According to expert opinion, even this lower estimate [3%] is thought to be too large in Iowa because burning is mostly a maintenance tool for conservation plantings, which are not extensive" (Wollin and Stigliani 2005).

In 2004, Sonoma Technology, Inc. conducted a planned burning emissions inventory for the Central States Regional Air Planning Association. As part of the inventory, Sonoma surveyed the extension offices in 56 of Iowa's 99 counties regarding agricultural burning practices in each county. Sonoma found that in 2002, only 2,247 acres, or 0.009% of agricultural land was burned. 1,660 acres were classified as hay or alfalfa and 587 acres were classified as "other". None of the 54 responding county extension offices reported burning of corn, oat, soybean, or wheat fields (Reid et al. 2004).

<u>Improvement</u>

Noting this overestimation, the Department chose to calculate GHG emissions from burning of agricultural residues using a more refined method used in EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009 (EPA 2011). This method uses data on the area burned in each state by crop type from a study by McCarty (2010) in which remote sensing data from Moderate Resolution Imaging Spectroradiometer (MODIS) was used to approximate the area burned by crop. The method combined changes in surface reflection with locations of ongoing burning from active fire discoveries (McCarty 2011). The study also used improved combustion efficiencies, emission factors, and fuel loads to calculate emissions.

The state-level area burned was then divided by state-level crop area harvested data from USDA to estimate the percent of crop area burned by crop and by state for 2003 – 2007 (EPA 2011). EPA provided

[13] Value used is the state inventory from December 1, 2008 – 2009.

the Iowa-specific data from McCarty (2010) to the Department (Wirth 2011). For this Iowa inventory, the Department assumed that the percent area burned for 2008 – 2010 was equal to the average percent area burned from 2003 – 2007.

McCarty found that EPA consistently overestimated cropland burned area by a factor of two and national EPA estimates of CH_4 emissions from agricultural residue burning were overestimated by 78% (McCarty 2011). Specifically for Iowa, the average percentage of harvested agricultural areas burned was found to be 0.1% (McCarty 2009) and total GHG emissions were found to be significantly lower than estimated by SIT as shown in Table 6.

Table 6: Emissions from Ag Residue Burning (MMtCO$_2$e)

Year	McCarty	SIT	% Overestimation
2003	0.003	0.147	+5,576%
2004	0.005	0.191	+3,719%
2005	0.008	0.192	+2,194%
2006	0.011	0.184	+1,612%
2007	0.011	0.189	+1,558%
Total	0.038	0.903	+2,270%

Agricultural Soils

N_2O emissions in the agricultural soils sector occur when the natural processes of denitrification and nitrification interact with agricultural practices that add or release nitrogen (N) in the soil profile. Denitrification is the process of converting nitrate to nitrogen gas. It is carried out by microorganisms in an oxygen-lacking environment. Nitrification occurs when ammonia is converted to nitrites (NO_2-) and then nitrates (NO_3-). It is carried out by specialized bacterial and naturally occurs in the environment

Direct N_2O emissions occur at the site of application of both synthetic and organic fertilizers to the soil, production of N-fixing crops, and integration of crop residues into the soil by practices such as cultivation. Indirect emissions occur when N is made available or is transported to another location following volatilization, leaching or runoff, and is then converted to N_2O (EPA 2011).

<u>Plant Residues and Legumes</u>

2009 and 2010 crop production data for alfalfa, corn for grain, oats, soybeans, and wheat (USDA 2010a and Cowles 2011b) were entered into the SIT. N_2O emissions were calculated for N-fixing crops, including alfalfa and soybeans, and were calculated for N returned to soils during the production of corn for grain, wheat, oats, and soybeans.

<u>Soil Cultivation - Nitrous Oxide (N_2O)</u>

N_2O is also emitted during the cultivation of highly organic soils called histosols. May 2011 Soil survey data from NRCS (NRCS 2011) shows there are just over 70,000 acres of histosols in Iowa (Sucik 2011a and 2011b). The quantity of histosols that are cultivated is not currently available, so the Department estimated the number of cultivated histosol acres by multiplying the acres of histosols by the annual percentages of Iowa cropland that are corn and soybeans (USDA 2010c) and by the average percentage of each crop that is tilled (USDA 2010b). However, this may be an overestimation as according to NRCS Soil Scientist, Michael Sucik, "…all Histosols are listed as hydric soils and are eligible for the Wetland Restoration Program as CRP [Conservation Reserve Program] practices that require wetlands. Also, a Histosol would require some type of artificial drainage in order to be consistently row cropped" (Sucik 2011a).

Soil Tillage - Carbon Dioxide (CO_2)

CO_2 may be emitted when soils are tilled. However, CO_2 may also be sequestered when soils are not tilled or are converted to CRP land, grass, trees or wetlands. This balance between emissions and sequestration is called the soil carbon flux. The SIT does not include a calculation method for agricultural soil carbon flux.

Recent scientific studies and literature reviews such as those by Baker et al. (2007) and Blanco-Canqui and Lal (2008) have created uncertainty in this area, while other studies such as those by Franzluebbers (2009) and Boddey et. al (2009) dispute them. According to the USDA's "*'No-Till" Farming is a Growing Practice",* "Many uncertainties remain in scientists' understanding of the relationship between tillage, soil carbon, and other greenhouse gases" (USDA 2010b). Therefore, the Department did not include CO_2 sequestration or emissions from agricultural tillage practices in this inventory. The Department plans to quantify the emissions and sequestration in future inventories as more scientific research becomes available.

Fertilizer Utilization

The Department calculated fertilizer emissions for 2005 – 2007 using the default values in the SIT. For 2008 – 2010, emissions were calculated using fertilizer tonnages from the Iowa Department of Agriculture and Land Stewardship's (IDALS) *Fertilizer Tonnage Distribution in Iowa* website (IDALS 2011). The IDALS fertilizer data is provided per growing season, which is from July – June. The SIT then converts it to calendar year data, which is from January – December. So although the Department was able to obtain the total amount of fertilizer applied during the 2010 growing season (July 2009 – June 2010), the amount of fertilizer applied from July 2010 – December 2010 was not available. Therefore, Department used the amount applied from July 2009 – December 2009 as a surrogate.

Revisions

The Department found that the SIT was over-estimating GHG emissions from fertilizer utilization by 10% due to a conversion error in the SIT. The 1/3/2011 version of the tool provided annual state fertilizer usage on the "FertilizerData" worksheet in units of short tons of nitrogen (N). This value is then converted on the "Ag Soils-Plant-Fertilizers" worksheet from short tons of N to kilograms of N. However, the SIT calculation formula used a conversion value of 1000, which is the conversion rate from *metric* tons to kilograms, instead of *short* tons to kilograms. The correct conversion is one short ton equals 906 kilograms. This conversion error resulted in annual GHG emissions from fertilizers being over-estimated by approximately 10%. The Department contacted the U.S. EPA Climate Change Division on April 25, 2011, regarding the conversion issue; the issue was confirmed by EPA on May 3, 2011 (Denny 2011). On May 4, 2011, ICF International provided a SIT software patch on May 4, 2011, to make the necessary correction.

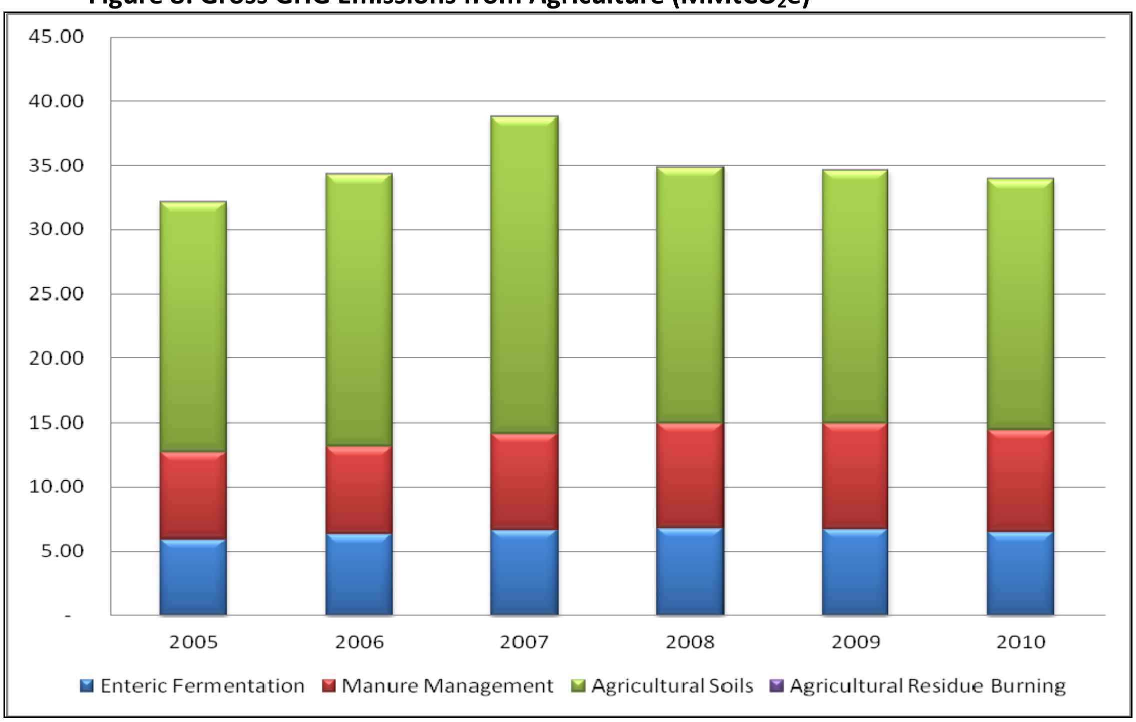
Results

GHG missions from agriculture increased 5.4% from 2005 – 2010 and increased overall in all agricultural categories, except agricultural residue burning, which is a small fraction of agricultural emissions. Total *gross* GHG emissions from agriculture were 33.88 MMtCO_2e in 2010, or nearly 24.8% of Iowa's total gross GHG emissions. This total does not account for any carbon sinks from agriculture. Sinks are discussed in *Chapter 8 – Land Use, Land Use Change, and Forestry*. The majority of emissions (57.4%) are from agricultural soils as shown in Table 7 and Figure 8 below.

Table 7: Gross GHG Emissions from Agriculture (MMtCO_2e)[14]

Sector	2005	2006	2007	2008	2009	2010
Enteric Fermentation	5.95	6.35	6.62	6.77	6.74	6.50
Manure Management	6.77	6.80	7.48	8.19	8.25	7.93
Agricultural Soils	19.42	21.10	24.63	19.85	19.63	19.45
Agricultural Residue Burning	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	**32.14**	**34.25**	**38.74**	**34.81**	**34.63**	**33.88**

Figure 8: Gross GHG Emissions from Agriculture (MMtCO_2e)



[14] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

Enteric Fermentation

CH_4 emissions from enteric fermentation were 6.50 $MMtCO_2e$ in 2010 and increased 9.3% from 2005 – 2010. This increase can be attributed a 10% increase in animal population during the same time period. While the poultry and swine make up the greatest percentages of total livestock in Iowa as shown in Figure 9, enteric fermentation emissions are primarily driven by the cattle population. This is because cattle emit more CH_4 than other ruminant animals due to their unique stomachs. The amount of methane emitted from each animal type is shown in Figure 9.

Figure 9: 2010 Animal Populations (USDA)[15]

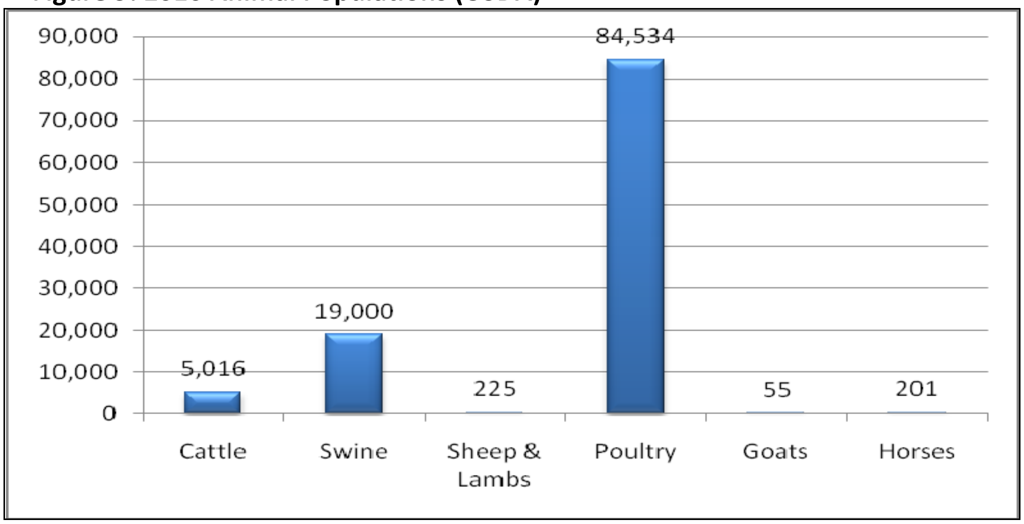


Table 8: Methane Emitted per Animal

Animal Type	kg/head CH_4 Emitted (ICF 2011a)
Beef Cattle	33.1 – 93.8
Dairy Cattle	65.3 – 131.3
Goats	5.0
Horses	18.0
Sheep	8.0
Swine	1.5

Manure Management

Factors influencing CH_4 and N_2O emissions include the animal type, animal population, animal mass, the type of manure management system, etc. GHG emissions from manure management increased 17.2% from 2005 – 2010 and accounted for 23.4% of agricultural GHG emissions.

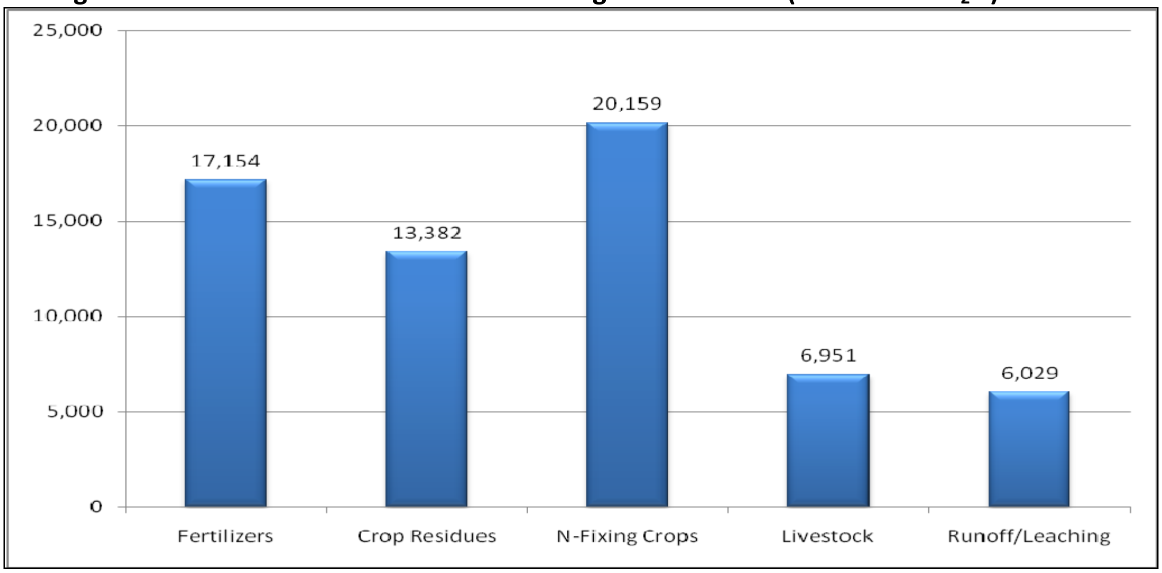
Agricultural Soils

N_2O emissions from agricultural soils accounted for 57.4% of all agricultural GHG emissions and 14.2% of total statewide GHG emissions in 2010. The majority of GHG emissions from agricultural soils can be

[15] See Table 4 and Table 5 for the specific USDA publication.

attributed to crop production (fertilizers, crop residues, and nitrogen fixing) as shown in Figure 10 below.

Figure 10: 2010 Gross GHG Emissions from Agricultural Soils (metric tons N_2O)



Agricultural Residue Burning

While the estimation of GHG emissions from agricultural residue has been improved, it had little impact on total Iowa statewide GHG emissions, accounting for 0.02% of Iowa agricultural GHG emissions and less than 0.01% of total Iowa GHG emissions in 2010.

Uncertainty

Excerpted from SIT Agriculture Module (ICF 2011a):

Enteric Fermentation

The quantity of methane (CH_4) emitted from enteric fermentation from livestock is dependent on the estimates of animal populations and the emission factors used for each animal type. Therefore, the uncertainty associated with the emission estimate stems from those two variables. Uncertainty is also introduced as animal populations vary throughout the year. There is also uncertainty associated with the original population survey methods used by USDA. Emission factors vary in each animal, depending on its production and diet characteristics, as well as genetics (ICF 2011a).

Manure Management

As with enteric fermentation, uncertainty occurs in animal populations and the emission factors used for each animal. However, the largest contributor to uncertainty in manure management emissions is the lack of Iowa –specific data describing manure management systems in the SIT and the CH_4 and N_2O emission factors used for these systems. Specifically, the N_2O emission factors used are from a limited set of global data (ICF 2011a).

In addition, there is uncertainty in the maximum CH_4 producing potential (B_0) used for each animal group. This value varies with both animal and diet characteristics, so estimating an average across an entire population introduces uncertainty. While the B_0 values used in the SIT vary by animal subcategory to attempt to represent as many of these differences as possible, there is not sufficient data available at this time to estimate precise values that accurately portray the B_0 for all animal types and feeding circumstances (EPA 2004).

Agricultural Soils
The amount of N_2O emission from managed soils is dependent on a large number of variables other than N inputs. They include soil moisture, pH, soil temperature, organic carbon availability, oxygen partial pressure, and soil amendment practices. The effect of the combined interaction of these variables on N_2O flux is complex and highly uncertain. The methodology used in the SIT is based only on N inputs, does not include other variables and treats all soils, except histosols, equally. In addition, there is limited knowledge regarding N_2O productions from soils when N is added to soils. It is not possible to develop emission factors for all possible combinations of soil, climate, and management conditions.

Uncertainties also exist in fertilizer usage calculations. The fertilizer usage does not include non-commercial fertilizers other than manure and crop residues, and site-specific conditions are not considered in determining the amount of N excreted from animals. Additional uncertainty occurs due to lack of Iowa-specific data for application of sewage sludge and cultivation of histosols (ICF 2011a).

Agricultural Residue Burning
The quantity of emissions is dependent on the number of crop acres burned, and the emission factor, fuel load, and combustion efficiency used for each crop type. Therefore, the uncertainty associated with the emission estimate stems from those four variables. In many cases, the emission factors, fuel load, and combustion efficiencies were derived from expert knowledge and laboratory studies using limited samples. Emission factors also do not provide for seasonal differences in crop burning (McCarty 2011).

Chapter 3 – Fossil Fuel Consumption

This chapter includes GHG emissions from fossil fuel consumption in four sectors – residential, commercial, industrial, and electric power. Emissions from the transportation sector are discussed later in this report in *Chapter 6 – Transportation*.

Method

2005 – 2009 Emissions

GHG emissions were calculated using two SIT modules – the CO_2FFC module for carbon dioxide (CO_2) emissions and the Stationary Combustion module for CH_4 and N_2O emissions. These modules calculate energy emissions based on annual statewide consumption for the following sectors and fuels:

Table 9: Fuel Types Consumed by Energy Sector

Fuel Types	Residential	Commercial	Industrial	Electric Power
Coal	x	x	x	x
Coking coal, other coal			x	
Natural gas	x	x	x	x
Distillate fuel	x	x	x	x
Kerosene	x	x	x	
LPG	x	x	x	
Motor gasoline		x	x	
Residual fuel		x	x	
Lubricants			x	
Asphalt/Road oil			x	
Crude oil			x	
Feedstocks			x	
Misc. petroleum products			x	
Petroleum coke			x	x
Pentanes plus			x	
Still gas			x	
Special naphthas			x	
Unfinished oils			x	
Waxes			x	
Aviation gasoline blending components			x	
Motor gasoline blending components			x	

Emissions from the electric power sector include direct emissions resulting from the combustion of fossil fuels at the electric generating station. Indirect emissions from electricity consumed at the point of use (i.e. residential electric water heaters) are discussed in *Chapter 10 – Indirect Emissions from Electricity Consumption*.

Emissions in both the CO_2FFC and Stationary Combustion SIT modules were calculated using bulk energy consumption data from the U.S. Energy Information Administration's – State Energy Data System (EIA 2011b) that was preloaded in the SIT.[16] The corresponding amount of fuel ethanol (excluding denaturant) was subtracted from the motor gasoline categories in the SIT to avoid double-counting of ethanol emissions (ICF 2011a and 2011b). State-specific carbon content coefficients, amount of carbon stored in products, and percentage of carbon oxidized during combustion were not available, so the SIT default values were used.

Calculated CO_2 emissions for 2005 – 2010 from the electric power sector were replaced with actual CO_2 emissions values measured by continuous emission monitors (CEMS) at electric generating units subject to the federal Acid Rain Program[17] (CAMD 2011). While the CEMS emissions values are more accurate than calculating emissions using the SIT, they may be under-estimated as not every electric generating unit is subject to the Acid Rain Program.

2010 Emissions
State-specific 2010 energy consumption data will not be published by EIA until 2012, so the Department projected 2010 energy emissions for every sector except electric power using the reference case in EIA's *Annual Energy Outlook (AEO) 2011 with Projections to 2035* (EIA 2011a). To make the projections, the Department first calculated the state's percent energy consumption for each sector in 2009 relative to the energy consumption of the region. Iowa is in the West North Central U.S. Census region. The Department then applied Iowa's proportion of consumption to the projected 2011 consumption for the West North Central region. As discussed earlier, CEMS data was used for 2010 CO_2 emissions from the electric power sector. CH_4 and N_2O emissions from that sector were calculated using the fuel consumption data reported by the Acid Rain-affected sources.

Results

Total GHG emissions from energy consumption in 2010 were 72.67 $MMtCO_2e$, an increase of 19.3% from 2005. Total GHG emissions from the electric power and residential, commercial, and industrial (RCI)sectors accounted for 53.2% of statewide GHG emissions in 2010. Of these four sectors, the electric power sector was the largest-emitting sector, accounting for 57.0% emissions from fossil fuel combustion as shown in Table 10 and Figure 11 on the next pages.

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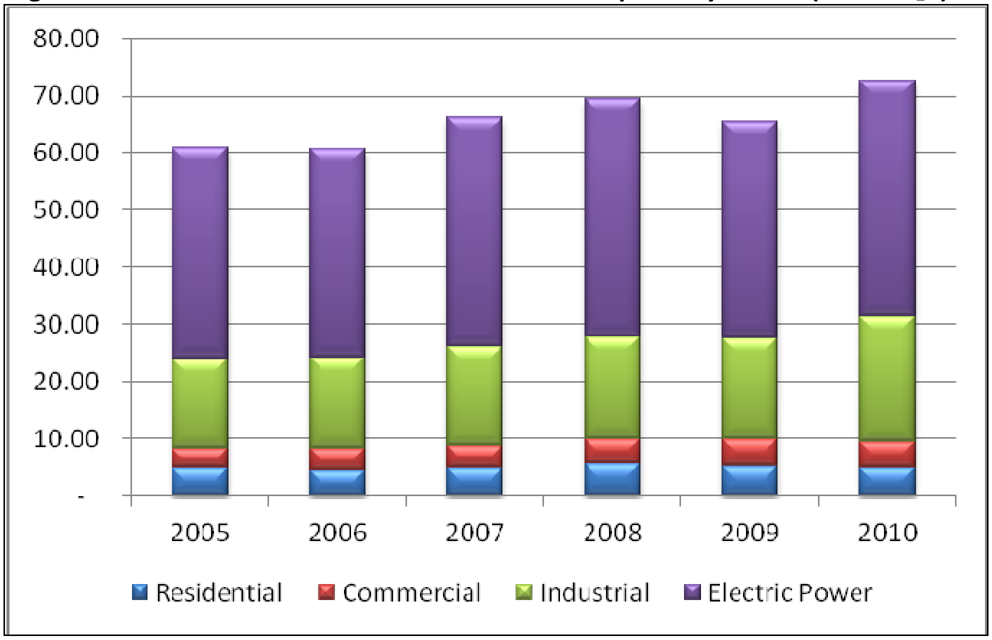
[16] The front screen of the Stationary Combustion module says 1/3/11 but the module was updated with 2009 data and re-released EPA on 8/23/11.
[17] 40 CFR Part 75.

Table 10: GHG Emissions from Energy Consumption ($MMtCO_2e$)[18]

Category/Fuel Type	2005	2006	2007	2008	2009	2010
Residential	**4.82**	**4.48**	**4.81**	**5.52**	**5.16**	**5.01**
Coal	0.05	0.06	0.08	0.06	0.06	0.06
Petroleum	1.14	1.06	1.07	1.38	1.32	1.16
Natural Gas	3.60	3.33	3.64	4.05	3.75	3.75
Wood	0.03	0.03	0.03	0.03	0.03	0.03
Commercial	**3.48**	**3.84**	**3.95**	**4.35**	**4.64**	**4.55**
Coal	0.55	0.60	0.63	0.50	0.51	0.51
Petroleum	0.51	0.90	0.82	0.83	1.09	1.09
Natural Gas	2.41	2.34	2.49	3.01	3.03	2.94
Wood	0.00	0.00	0.00	0.01	0.01	0.01
Industrial	**15.76**	**16.00**	**17.45**	**17.88**	**17.86**	**21.72**
Coal	5.61	5.77	5.77	5.45	4.99	4.99
Petroleum	5.19	4.98	4.38	4.00	4.35	6.77
Natural Gas	4.96	5.25	7.30	8.43	8.51	9.96
Wood	0.00	0.00	0.00	0.00	0.00	0.00
Electric Power	**36.84**	**36.35**	**40.04**	**41.78**	**37.71**	**41.40**
Coal	35.92	35.41	38.83	40.96	37.31	40.97
Petroleum	0.04	0.04	0.04	0.01	0.00	0.00
Natural Gas	0.89	0.91	1.17	0.82	0.40	0.42
Wood	-	-	-	0.00	0.00	0.00
TOTAL	**60.90**	**60.68**	**66.26**	**69.53**	**65.38**	**72.67**
Coal	42.13	41.84	45.31	46.97	42.88	46.54
Petroleum	6.88	6.98	6.31	6.22	6.77	9.02
Natural Gas	11.86	11.82	14.60	16.31	15.69	17.07
Wood	0.04	0.03	0.04	0.04	0.04	0.04

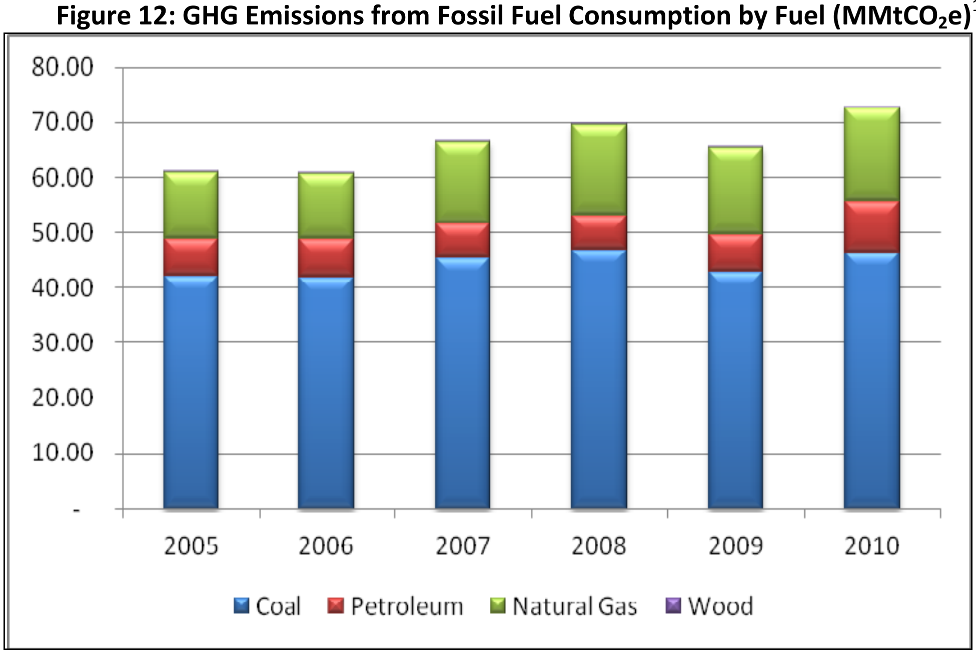
[18] Values do not include emissions from the transportation sector. Totals may not equal the sum of subtotals shown in this table due to independent rounding.

Figure 11: GHG Emissions from Fossil Fuel Consumption by Sector (MMtCO_2e)



GHG emissions increased from 2005 – 2010 in all four sectors, with the residential sector increasing the least (3.9%) and the industrial sector increasing the most (37.8%). The quantity of emissions attributed to each fuel type is shown in Figure 12.

Figure 12: GHG Emissions from Fossil Fuel Consumption by Fuel (MMtCO_2e)[19]



[19] Values do not include emissions from the transportation sector.

Uncertainty -

CO_2 Emissions - Excerpted from SIT CO_2FFC Module (ICF 2011a):

The amount of CO_2 emitted from energy consumption depends on the type and amount of fuel that is consumed, the carbon content of the fuel, and the fraction of the fuel that is oxidized. Therefore, the more accurate these parameters are, the more accurate the estimate of direct CO_2 emissions will be. Nevertheless, there are uncertainties associated with each of these parameters.

National total energy consumption data is fairly accurate, but there is more uncertainty in the state-level data, especially when allocating consumption to the individual end-use sectors (i.e. residential, commercial, and industrial). The amount or rate at which carbon is emitted to the atmosphere can vary greatly depending on the fuel and use, and may vary at the state-level compared to the national default levels in the SIT. Uncertainty is also introduced by using CEMS data from the Clean Air Markets Division's Acid Rain database for the electric power sector because not every electrical generating unit in Iowa is subject to the Acid Rain program.

The uncertainty in carbon content and oxidation are much lower than with fuel consumption data. Carbon contents of each fuel type are determined by EIA by sampling and the assessment of market requirements, and, with the exception of coal, do not vary significantly from state to state. EIA takes into account the variability of carbon contents of coal by state; these coefficients are also provided in the SIT.

Uncertainty is also introduced by the complexity in calculating emissions from the import/export of electricity. The precise fuel mix used to generate the power crossing state lines is very difficult to determine, so, an average fuel mix for all electricity generation within a specific region of the grid must usually be used. Moreover, these emissions factors are generated by emission monitors (rather than carbon contents of fuels), which may overestimate CO_2 emissions to a small extent (ICF 2011a).

CH_4 and N_2O Emissions - Excerpted from SIT Stationary Combustion Module (ICF 2011b):

The amount of CH_4 and N_2O emitted depends on the amount and type of fuel used, the type of technology in which it is combusted (e.g., boilers, water heaters, furnaces), and the type of emission control used. In general, the more detailed information available on the combustion activity, the lower the uncertainty. However, as noted in the Revised 1996 IPCC Guidelines (IPCC/UNEP/OECD/IEA 1997), the contribution of CH_4 and N_2O to overall emissions is small and the estimates are highly uncertain.

Uncertainties also exist in both the emission factors and the EIA energy consumption data used to calculate emissions. For example, the EIA state data sets do not fully capture the wood used in fireplaces, wood stoves, and campfires. As with CO_2, uncertainty is also introduced with allocating energy consumption data to the individual end-use sectors and estimation of the fraction of fuels used for non-energy (ICF 2011b). Uncertainty is also introduced by using heat input data from the Clean Air Markets Division's Acid Rain database for the electric power sector because not every electrical generating unit in Iowa is subject to the Acid Rain program.

Chapter 4 - Industrial Processes

This chapter includes non-combustion GHG emissions from a variety of industrial processes. The processes and GHG pollutants emitted from each sector include:

Table 11: Industrial Processes and GHG Emissions

Sector	GHGs Emitted
Cement Production	CO_2
Lime Manufacture	CO_2
Limestone and Dolomite Use	CO_2
Soda Ash Use	CO_2
Iron and Steel Production	CO_2
Ammonia Production & Urea Consumption	CO_2
Nitric Acid Production	N_2O
Ozone Depleting Substances (ODS) Substitutes	HFCs, PFCs, and SF_6
Electric Power Transmission and Distribution	SF_6

Cement Production

Carbon Dioxide (CO_2) is emitted during a process called calcining when limestone is heated in a cement kiln to form lime and CO_2. The CO_2 is vented to the atmosphere and the lime is then mixed with silica-containing materials such as clay to form clinker, an intermediate product that is made into finished Portland cement (ICF 2004). Two facilities currently manufacture Portland cement in Iowa.[20]

Lime Manufacture

Similar to cement manufacturing, lime is produced by heating limestone in a kiln, creating lime and CO_2. The CO_2 is typically released to the atmosphere, leaving behind a product known as quicklime, which can then be used to produce other types of lime (ICF 2004). One facility currently manufactures lime in Iowa.

Limestone and Dolomite Use

Limestone and dolomite are used in industrial processes such as glass making, flue gas desulfurization, acid neutralization, etc.

Soda Ash Use

Soda ash is currently only produced in three states – Wyoming, Colorado, and California (ICF 2011b). However, commercial soda ash is used as a raw material in a variety of industrial processes and in many familiar consumer products such as glass, soap and detergents, paper, textiles, and food (EPA 2011). In Iowa it is commonly used by corn wet millers for pH control, in ion exchange regeneration, and in other operations (DNR 2010).

[20] Historically, three facilities produced cement in Iowa. One of the facilities has not operated since the fall of 2009.

Iron and Steel

Iron and steel production is an energy-intensive process that also generates process-related GHG emissions. Steel is produced from pig iron or scrap steel in a variety of specialized steel-making furnaces, including electric arc furnaces (EAFs) and basic oxygen furnaces (BOFs) (EPA 2010). There are currently no pig iron mills operating in Iowa. All three steel production facilities currently operating in Iowa use EAFs to produce steel from scrap. These furnaces use carbon electrodes, coal, natural gas, and other substances such as limestone and dolomite to aid in melting scrap and other metals, which are then improved to create the preferred grade of steel. In EAFs, CO_2 emissions result primarily from the consumption of carbon electrodes and also from the consumption of supplemental materials used to augment the melting process (EPA 2010).

Ammonia Production and Urea Consumption

CO_2 is released during the manufacture of ammonia. The chemical equations to calculate the release of CO_2 are fairly complicated, but in general anhydrous ammonia is synthesized by reacting nitrogen with hydrogen. The hydrogen is typically acquired from natural gas. The majority of direct CO_2 emissions occur when the carbon in the natural gas is then eliminated from the process by converting it to CO_2. Other emissions of CO_2 can occur during condensate stripping or regeneration of the scrubbing solution. CO_2 emissions may also be captured for use in urea synthesis or carbon sequestration and storage (WRI 2008a). Three facilities in Iowa currently produce ammonia.

Nitric Acid Production

Nitrous Oxide (N_2O) is produced when ammonia is oxidized to produce nitric acid. Two facilities in Iowa currently produce nitric acid.

Consumption of ODS Substitutes

Ozone Depleting Substances (ODS) are often used in refrigeration, air conditioning, aerosols, solvent cleaning, fire extinguishers, etc. However, ODS are being phased out per the Montreal Protocol and the 1990 Clean Air Act Amendments. The most common ODS is HFCs, but PFCs and SF_6 may also be used (ICF 2011b).

Electric Power Transmission and Distribution

SF_6 is used as an insulator in electricity transmission and distribution in equipment such as transformers, high-voltage circuit breakers, substations, and transmission lines (ICF 2011b).

Other Industry Types

GHG emissions from soda ash manufacturing, adipic acid production, (primary) aluminum production, HCFC-22 production, semiconductor manufacture, and magnesium production and processing were not calculated as the Department is not aware of any of these facilities currently operating in Iowa.

Method

GHG emissions from industrial processes were calculated using a variety of methods, depending on the type of industry and activity data available. The calculation method and activity data for each industry type is summarized in Table 12 below. GHG emissions were calculated for each industrial process category using Iowa-specific or facility-specific activity data where available.

For several categories (cement production, lime manufacture, iron and steel production, nitric acid production, and ammonia production and urea consumption) emissions for 2005 – 2009 were calculated using either *The GHG Protocol* or the SIT and facility –specific activity data that was submitted to the Department by the affected facilities on their annual criteria and hazardous air pollutant air emissions inventories, or on the GHG inventories required by the Department for 2008 and 2009 (DNR 2009 – 2010). The World Resource Institute's *The GHG Protocol* and associated worksheets (WRI 2005 – 2008d) is a more accurate method of calculating GHG emissions from industrial processes than the SIT (ICF 2011a) because *The GHG Protocol* worksheets require more detailed activity data than the SIT. If the higher-level activity data was available, the Department used *The GHG Protocol.* If only basic activity data was available, the Department used the SIT.

For 2010, GHG emissions from these categories were calculated by the affected facilities themselves using the method required by the new federal GHG reporting program (40 CFR 98). The facilities then provided their total GHG emissions from each category to the Department for this report (Bertie 2011, Berry 2011, Dean 2011, Kluss 2011, Looman 2011, Maas 2011, Sanicola 2011, and Van Hall 2011).

Table 12: Industrial Processes Calculation Methods and Activity Data

Category	Inputs	2005 - 2007	2008	2009	2010
Cement Production	Calculation Method	SIT	*The GHG Protocol*	*The GHG Protocol*	40 CFR 98 Subpart H
	Activity Data	Facility-specific data	Facility-specific data	Facility-specific data	Facility-specific data
Lime Manufacture[21]	Calculation Method	*The GHG Protocol*	*The GHG Protocol*	*The GHG Protocol*	40 CFR 98 Subpart S
	Activity Data	Facility-specific data	Facility-specific data	Facility-specific data	Facility-specific data
Limestone and Dolomite Use	Calculation Method	SIT	SIT	SIT	SIT
	Activity Data	SIT defaults	SIT defaults	2009 US consumption x 2009 Iowa/US population ratio	2009 US consumption x 2010 Iowa/US population ratio

[21] In instances where the ratio of high calcium lime or dolomitic lime was unavailable, the Department assumed 50% was high calcium lime and 50% was dolomitic lime.

Table 12 (continued)

Category	Inputs	2005 - 2007	2008	2009	2010
Soda Ash Use	Calculation Method	SIT	SIT	SIT	SIT
	Activity Data	SIT defaults	SIT defaults	2009 US consumption x 2009 Iowa/US population ratio	2009 US consumption x 2010 Iowa/US population ratio
Iron and Steel	Calculation Method	SIT	*The GHG Protocol*	*The GHG Protocol*	40 CFR 98 Subpart Q and *The GHG Protocol*[22]
	Activity Data	Facility-specific data	Facility-specific data	Facility-specific data	Facility-specific data
Ammonia and Urea[23]	Calculation Method	*The GHG Protocol*	*The GHG Protocol*	*The GHG Protocol*	40 CFR 98 Subpart G
	Activity Data	Facility-specific data	Facility-specific data	Facility-specific data	Facility-specific data
Nitric Acid	Calculation Method	The GHG Protocol	The GHG Protocol	*The GHG Protocol*	40 CFR 98 Subpart V
	Activity Data	Facility-specific data	Facility-specific data	Facility-specific data	Facility-specific data
ODS Substitutes	Calculation Method	SIT	SIT	SIT	SIT
	Activity Data	SIT defaults	SIT defaults	2009 US consumption x 2009 Iowa/US population ratio	2009 US consumption x 2010 Iowa/US population ratio
Electric Power Transmission and Distribution	Calculation Method	SIT	SIT	SIT	SIT
	Activity Data	SIT defaults	SIT defaults	2009 US consumption x 2009 Iowa/US population ratio	2009 US consumption x 2010 Iowa/US population ratio

Improvements

2010 GHG missions calculated by the affected facilities using the methods in 40 CFR 98 are an improvement over the SIT as they are calculated using facility-specific activity data. Other improvements in 2005 – 2009 emissions include:

[22] Emissions for the two facilities subject to the federal GHG reporting program were calculated using 40 CFR 98 Subpart Q. The Department calculated emissions from the two smaller facilities not subject to the federal GHG reporting program using *The GHG Protocol*.

[23] 2005 – 2007 and 2010 values may be overestimates as they do not account for CO_2 that was recovered for urea or carbon capture.

Cement Production

The facility-specific activity data used by the Department to calculate emissions for 2005 - 2009 is an improvement over the default Iowa production data in the SIT, which underestimated cement production in Iowa by 76-80% depending on the year.

Lime Manufacture

The facility-specific activity data used by the Department to calculate emissions for 2005 - 2009 is an improvement over the default Iowa production data in the SIT, which is underestimated by approximately 50% (ICF 2011a).

Iron and Steel

The facility-specific activity data used by the Department to calculate emissions for 2005 - 2009 is an improvement over both the default Iowa production data in the SIT, which overestimated production from BOFs and underestimated production from EAFs. It is also an improvement of the estimates in the Department's 2008 and 2009 inventories which included production from steel mills (SIC 3312), but not from steel foundries (3325).

Results

GHG emissions from industrial processes in 2010, were 4.62 $MMtCO_2e$, or 3.4% of total statewide GHG emissions. Emissions from this sector decreased 1.1% from 2005 – 2010 as shown in Table 13. Ammonia and urea production, ODS substitutes, nitric acid production, and cement manufacture were the highest contributors to industrial process emissions in 2010 as shown in Table 13. All other categories individually contributed less than 10% each.

Table 13: GHG Emissions from Industrial Processes ($MMtCO_2e$)[24]

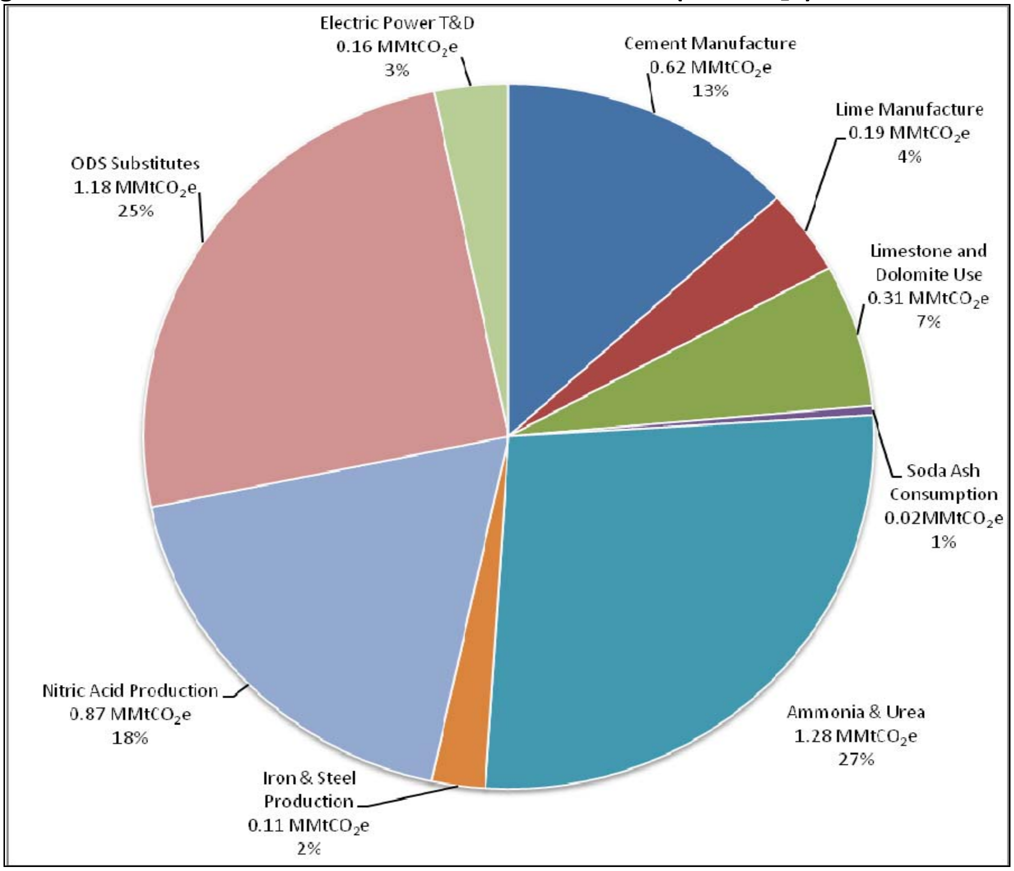
Category	2005	2006	2007	2008	2009	2010
Cement Manufacture	1.27	1.29	1.27	1.31	0.84	0.72
Lime Manufacture	0.18	0.17	0.16	0.17	0.13	0.18
Limestone & Dolomite Use	0.19	0.31	0.24	0.26	0.31	0.31
Soda Ash Consumption	0.03	0.03	0.02	0.02	0.02	0.02
Ammonia & Urea[25]	1.01	0.91	0.95	0.87	0.60	0.84
Iron & Steel Production	0.13	0.13	0.13	0.12	0.09	0.23
Nitric Acid Production	0.68	0.75	0.81	0.90	0.90	0.99
ODS Substitutes	1.03	1.07	1.09	1.11	1.18	1.18
Electric Power T&D	0.16	0.16	0.15	0.16	0.16	0.16
Total Emissions	**4.67**	**4.81**	**4.83**	**4.93**	**4.22**	**4.62**

[24] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

[25] 2005 – 2007 values may be overestimates as they do not account for CO_2 that was recovered for urea or carbon sequestration and storage.

GHG emissions from cement manufacture decreased 36.2% from 2008 – 2009 and 14.4% from 2009 – 2010. One reason for this is the closure of one of the three Portland cement plants in late 2009.

Figure 13: 2010 GHG Emissions from Industrial Processes (MMtCO$_2$e)



Uncertainty

Uncertainty is introduced in several categories in which emissions were calculated using different calculation methods in different years (cement manufacture and iron and steel production). Uncertainty is also increased in categories where SIT default activity data was used instead of Iowa-specific activity data (limestone and dolomite use, soda ash use, ODS substitutes, and electric power transmission and distribution). Other sources of uncertainty include:

Cement Manufacture:

Uncertainty occurs in the SIT default emission factor for cement manufacture because it does not account for variation ratios of clinker-to-cement, raw material per ton of clinker, and calcium carbonate to raw material.

Lime Manufacture

Emissions reported from lime manufacturing do not account for any CO_2 that could have been re-absorbed when the lime was used in the steel industry (ICF 2011a).

Limestone and Dolomite Use

The main source of uncertainty in soda ash consumption is the lack of Iowa-specific data and variety in possible end-uses. The variable composition of limestone also introduces uncertainty (ICF 2011a).

Soda Ash Consumption

The main source of uncertainty in soda ash consumption is the lack of Iowa-specific data and variety in possible end-uses (ICF 2011a).

Iron & Steel Production

The SIT default emission factor does not account for variation in the carbon contents of the materials used to produce steel.

Nitric Acid Production

2005 – 2007 and 2010 emissions are over-estimated as they do not account for any CO_2 that was recovered for urea or CSS. Uncertainty may also occur because emissions are dependent on site-specific characteristics such as plant design and process conditions (WRI 2008d).

Consumption of ODS Substitutes

As with soda ash consumption, the main source of uncertainty is the lack of Iowa-specific data (ICF 2011a).

Electric Power Transmission and Distribution

Apportioning national emissions based on electricity sales down to the state level is uncertain because it is not based on state-specific data and assumes that SF_6 reduction practices are the same nation-wide (ICF 2011a).

Chapter 5 - Natural Gas Transmission & Distribution

This chapter includes GHG emissions from natural gas transmission and distribution (T & D) in Iowa. In this sector, methane (CH_4) is emitted from leaks, vents, regulators, valves, compressors, accidents, and other devices located along the natural gas transmission and distribution networks. Carbon dioxide (CO_2) may also be emitted from venting and flaring, but was not calculated due to lack of data. GHG emissions from coal mining, natural gas production, oil production, oil transmission, and oil transportation are not included as those industries are currently not active in Iowa.

Method

Natural Gas Transmission

Natural gas is transmitted in Iowa through large, high-pressure lines. These lines transport natural gas from production fields and processing plants located out-of-state to Iowa storage facilities, then to local distribution companies (LDCs) and high volume customers. Compressor stations, metering stations, and maintenance facilities are located along the transmission system. CH_4 is emitted from leaks, compressors, vents, and pneumatic devices (ICF 2011).

The number of miles of transmission pipeline in Iowa was obtained from the United States Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration's (PHMSA) Office of Pipeline Safety for 2005 – 2009 (DOT 2011). Due to lack of 2010 transmission line data at time of publication, the 2009 estimate was used as a surrogate for 2010.[26]

The number of natural gas compressor and gas storage stations was obtained from the Iowa Utilities Board (Stursma 2011). This is a refinement of previous inventories that have calculated GHG emissions using a default ratio of 0.0060 natural gas transmission compressor stations per miles of transmission pipeline and 0.0015 gas storage compressor stations per mile of transmission pipeline. Previous methods overestimate emissions because it estimated 43-50 transmission compressor stations and 11 – 13 storage compressor stations, when there are only 18 transmission compressor stations and 4 storage compressor stations currently in Iowa (Stursma 2011).

Natural Gas Distribution

Natural gas is distributed through large networks of small, low-pressure pipelines. Natural gas flows from the transmission system to the distribution network at municipal gate stations, where the pressure is reduced for distribution within municipalities. CH_4 is emitted from leaks, meters, regulators, and accidents (ICF 2011). Activity data from the DOT PHSMA's Office of Pipeline Safety was used for calculating 2005 – 2010 emissions (DOT 2011). Data entered included miles of steel and cast iron

[26] The annual variation in miles of transmission line from 2007 – 2009 was 1%.

distribution pipeline, unprotected and protected; number of services; and number of steel services, unprotected and protected.

Natural Gas Venting and Flaring

The Department is unable to find data on the annual amount of natural gas vented and flared from natural gas transmission pipelines. This data is not tracked by the EIA (Little 2011).The Department has requested this information from the Federal Energy Regulatory Agency (FERC). Therefore, no GHG emissions were calculated from natural gas venting and flaring.

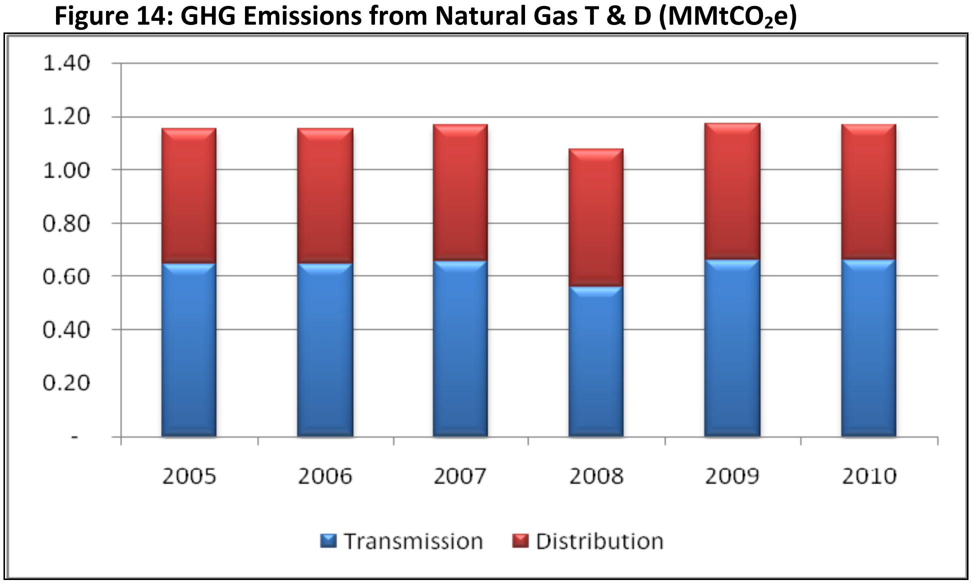
Results

Total GHG emissions from natural gas transmission and distribution were 1.17 $MMtCO_2e$ in 2010, an increase of 1.6% from 2005 as shown in Table 14 and Figure 14. GHG emissions from this sector account for 0.9% of 2010 statewide GHG emissions.

Table 14: GHG Emissions from Natural Gas T & D ($MMtCO_2e$)

Category	2005	2006	2007	2008	2009	2010
Transmission	0.65	0.65	0.66	0.56	0.66	0.66
Distribution	0.50	0.50	0.50	0.51	0.51	0.51
Total Emissions	**1.15**	**1.15**	**1.16**	**1.07**	**1.17**	**1.17**

Figure 14: GHG Emissions from Natural Gas T & D ($MMtCO_2e$)



Uncertainty

Excerpted from SIT Natural Gas and Oil Systems Module (ICF 2011a):

The main source of uncertainty in the SIT calculation methods is the emission factors. The emission factors used are based on a combination of statistical reporting, equipment design data, engineering calculations and studies, surveys of affected facilities and measurements. In the process of combining these individual components, the uncertainty of each individual component is pooled to generate a larger uncertainty for the overall emission factor. In addition, statistical uncertainties arise from natural variation in measurements, equipment types, operational variability, and survey and statistical methodologies. The method also does not account for regional differences in natural gas infrastructure and activity levels (ICF 2011a).

Chapter 6 - Transportation

This chapter includes GHG emissions from both highway and non-highway vehicles such as aviation, boats, locomotives, tractors, other utility vehicles, and alternative fuel vehicles.

Method

An important distinction to make in the transportation category is that carbon dioxide (CO_2) emissions from all vehicle categories are calculated based on fossil fuel consumption, as are methane (CH_4) and nitrous oxide (N_2O) emissions from non-highway vehicles. However, CH_4 and N_2O emissions from highway vehicles are calculated based on vehicle miles traveled (VMT).

GHG emissions from transportation were calculated using two SIT modules – the CO_2FFC module for CO_2 emissions and the Mobile Combustion module for CH_4 and N_2O emissions. The CO_2FFC SIT module also calculates emissions from the residential, commercial, industrial, and electric power sectors, but for this report those emissions are discussed in *Chapter 3 – Fossil Fuel Combustion*. Emissions from international bunker fuels were not calculated due to a lack of state-level data. Bunker fuels are fuels used in international aviation and marine transportation that originates in the United States. It is a standard inventory practice to subtract emissions from bunker fuels if they are included in state energy consumption totals because the pollutants may not be emitted within the state (IFC 2011a).

2005 - 2009 CO_2 Emissions

CO_2 emissions from 2005 – 2009 were calculated using bulk energy consumption data from the U.S. Energy Information Administration's State Energy Data System (EIA 2011c) that was preloaded in the SIT. The SIT avoids double-counting ethanol emissions in these categories by subtracting the corresponding amount of fuel ethanol (excluding denaturant) in that sector. Emissions were calculated for the fuel types shown in Table 15**.**

Table 15: Fuel Types Consumed in the Transportation Sector

Fuel	Sub-Fuels
Natural gas	
Petroleum	Distillate fuel (diesel)
	Kerosene
	LPG
	Motor gasoline
	Residual fuel
	Lubricants
	Aviation gasoline
	Jet fuel, kerosene
	Jet fuel, naphtha

2010 CO_2 Emissions

State-specific 2010 energy consumption data will not be published by EIA until 2012, so the Department projected 2010 transportation CO_2 emissions using the reference case in EIA's *Annual Energy Outlook 2011 with Projections to 2035* (EIA 2011b). To project 2010 energy consumption data, the Department first calculated the state's percent energy consumption for each transportation fuel in 2009 relative to the energy consumption of the region. Iowa is in the West North Central U.S. Census region. The Department then multiplied Iowa's proportion of consumption by the projected 2011 consumption for the West North Central region.

Highway Vehicles (CH_4 and N_2O)

Highway vehicles include passenger cars, truck, motorcycles, and heavy-duty vehicles. CH_4 and N_2O emissions from highway vehicles were calculated using the SIT as follows:

1. The vehicle miles traveled (VMT) for each vehicle type was calculated.
   The total annual Iowa VMT for 2005 – 2009 is available from both the Iowa Department of Transportation (IDOT 2011) and the Federal Highway Administration's (FHWA) *Highway Statistics Series Reports* (FHWA 2005-2009). However, the values published by IDOT and FHWA differ because the FHWA adjusts the VMT data after they receive it from the state (Carlson 2011b). The Department was unable to determine what adjustments were made by FHWA. This should be noted as an area for improvement in the future. While the IDOT VMT data is more conservative,[27] the FHWA VMT values were used to calculate emissions to be consistent with the federal age and vehicle type distributions used. At the time of publication, the FHWA had not published its 2010 report, so the IDOT's 2010 VMT value (Carlson 2011c) was used.

The VMT was then distributed among seven vehicle/fuel classes using the national distribution percentages from the Table A-89 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011), which are derived from historical estimates of fuel shares reported in the Appendix to the *Transportation Energy Data Book* (DOE 1993-2010). Neither the IDOT nor FHWA track state-level VMT by the seven classes used in the SIT. The classes and the 2010 national distribution are shown in Table 16.

Table 16: VMT Vehicle/Fuel Classes and Distribution

Class	Acronym	National Distribution
Heavy duty diesel vehicle	HDDV	6.32%
Heavy duty gas vehicle	HDGV	0.76%
Light duty diesel truck	LDDT	1.51%
Light duty diesel vehicle	LDDV	0.27%
Light duty gasoline truck	LDGT	36.08%
Light duty gasoline vehicle	LDGV	54.57%
Motorcycle	MC	0.49%

[27] The IDOT values are 0.73% – 1.64% higher than the values published by the FHWA.

2. VMT was converted for use with existing emission factors.
   Iowa-specific emission factors were not available, so the SIT default emission factors were used. These factors are consistent with those used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011).

3. VMT was allocated by model year.
   Iowa-specific VMT data by model year was not available, so the VMT was allocated for 2005 – 2008 using the default values in the SIT. 2009 and 2010 VMT were allocated using the 2009 on-road age distribution by vehicle/fuel type from Table A-93 the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011).

4. Control technology was allocated by model year.
   Iowa-specific control technologies by model year were not available, so the SIT default values for 2005 – 2008 were used. 2009 control technology values from Tables A-97, A-98, A-99, and A-100 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011) were used for both 2009 and 2010.

Non-highway Vehicles (CH_4 and N_2O)
Non-highway vehicles include aviation, marine vessels, locomotives, and tractors. In general, CH_4 and N_2O emissions from non-highway vehicles were calculated for 2005 – 2008 using the default emission factors and activity data provided in the SIT. State-specific activity data for 2009 was added when available as shown in Table 17 below.

Table 17: Iowa-specific Non-highway Activity Data Used

Category	Year(s)	Data Element	Source
Non-highway	2009	Aviation gas, locomotive diesel, farm diesel	(EIA 2011a)
	2009	Jet fuel kerosene	(EIA 2011c)
	2009	Boat gasoline, construction gasoline, construction diesel, farm gasoline, gasoline HD utility, diesel HD utility	(FHWA 2011)
	2009	Alternative fuel vehicles VMT	See below.

Emissions from snowmobiles were not calculated because fuel consumption data was not available. Due to a lack of 2010 consumption data at the time of publication, the 2009 consumption values for boat gasoline, locomotive diesel, and farm equipment fuel were used as surrogates for 2010. However, the Department was able to project the 2010 consumption values for aviation gasoline and jet fuel kerosene value using EIA's *Annual Energy Outlook 2011* (EIA 2011a).

Alternative Fuel Vehicles (CH_4 and N_2O)
Alternative fuel vehicles include vehicles that combust methanol, ethanol, compressed natural gas, liquefied natural gas, and liquefied petroleum gas. Iowa-specific VMT for alternative fuel vehicles were

not available, so 2005 – 2008 emissions were calculated using existing data in the SIT. 2009 VMT were derived from the national alternative vehicle VMT in Table A-92 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011). The Department assumed Iowa VMT was 0.77% of federal VMT as the SIT assumed for 2008 (ICF 2011b). The VMT from alternative fuel vehicles were subtracted from the highway VMT in SIT to avoid double-counting. Because the 2010 VMT value was not available, the 2009 value was used as a surrogate.

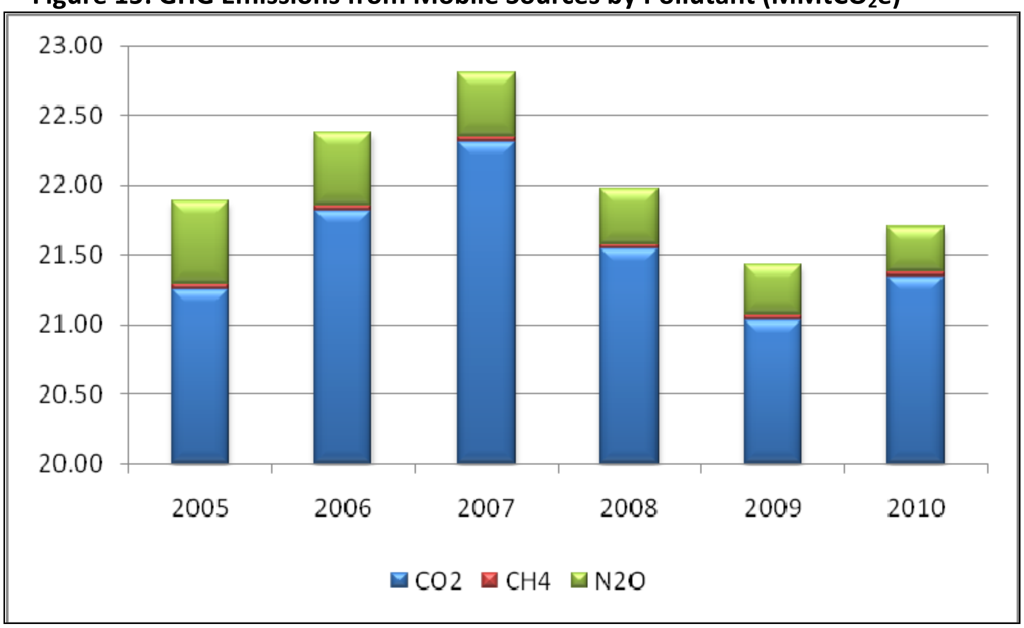
Results

Total GHG emissions from transportation were 21.70 MMtCO$_2$e in 2010, a decrease of 0.8% from 2005 as shown in Table 18 and Figure 15. GHG emissions from this sector account for 15.9% of 2010 statewide GHG emissions. CO_2 is the most prevalent GHG, accounting for 98.3% of GHG emissions from the transportation sector.

Table 18: GHG Emissions from Transportation (MMtCO$_2$e)[28]

Pollutant	2005	2006	2007	2008	2009	2010
CO_2	21.25	21.82	22.31	21.54	21.03	21.34
CH_4	0.04	0.04	0.04	0.03	0.03	0.03
N_2O	0.59	0.52	0.46	0.40	0.36	0.32
TOTAL	**21.88**	**22.38**	**22.81**	**21.97**	**21.42**	**21.70**

Figure 15: GHG Emissions from Mobile Sources by Pollutant (MMtCO$_2$e)



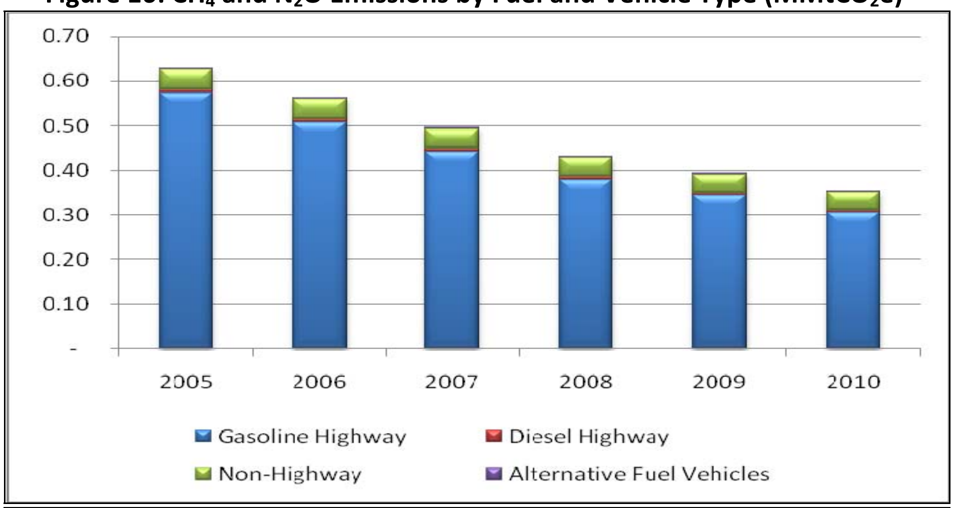
[28] Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

Of the 0.35 $MMtCO_2e$ of CH_4 and N_2O emitted from mobile sources, 86.2% is from gasoline highway vehicles, mainly passenger cars and light-duty trucks. CH_4 and N_2O emissions from mobile sources have decreased every year since 2005 as shown in Table 19 as vehicles have become more efficient (EPA 2011).

Table 19: Total CH_4 and N_2O Emissions from Mobile Sources ($MMtCO_2e$)[29]

Fuel Type/Vehicle Type	2005	2006	2007	2008	2009	2010
Gasoline Highway	0.57	0.51	0.44	0.38	0.34	0.31
Diesel Highway	0.01	0.01	0.01	0.01	0.01	0.01
Non-Highway	0.05	0.05	0.04	0.04	0.04	0.04
Alternative Fuel Vehicles	2.6E-03	2.5E-03	3.1E-03	2.9E-03	3.0E-03	3.0E-03
Total	**0.63**	**0.56**	**0.50**	**0.43**	**0.39**	**0.35**

Figure 16: CH_4 and N_2O Emissions by Fuel and Vehicle Type ($MMtCO_2e$)



Uncertainty

CO_2 Emissions - Excerpted from SIT CO_2FFC Module (ICF 2011a):

The amount of CO_2 emitted from energy consumption depends on the type and amount of fuel consumed, the carbon content of the fuel, and the fraction of the fuel that is oxidized. Therefore, the more accurate these parameters are in the equations, the more accurate the estimate of direct CO_2 emissions will be. Nevertheless, there are uncertainties associated with each of these parameters.

National total energy consumption data is fairly accurate, but there is more uncertainty in the state-level data, especially when allocating consumption to the transportation end-use sector. The amount or rate at which carbon is emitted to the atmosphere can vary greatly depending on the fuel and use and may

[29] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

vary at the state-level compared to the national default levels in the SIT. Uncertainty is also introduced by not subtracting emissions from international bunker fuel (ICF 2011a).

The uncertainty in carbon content and oxidation is much lower than with fuel consumption data. Carbon contents of each fuel type are determined by EIA by sampling and the assessment of market requirements, and, with the exception of coal, do not vary significantly from state to state. EIA takes into account the variability of carbon contents of coal by state and these coefficients are also provided in the SIT.

CH_4 and N_2O Emissions:
Uncertainty in CH_4 and N_2O emissions occurs because national vehicle/fuel type, age distributions, and emission factors, which may not be reflective of Iowa conditions, were applied to Iowa-specific VMT data. The annual VMT value used also has some uncertainty because the values provided by the federal DOT differed from the value provided by the state DOT. There is also some uncertainty in the method EPA used to develop the national vehicle/fuel type distributions and to develop emission factors (EPA 2011). The VMT used for alternative fuel vehicles has a higher level of uncertainty because the Department was unable locate Iowa-specific VMT data.

Since CH_4 and N_2O emissions from non-highway vehicles are calculated in a fairly straightforward calculation by multiplying fuel consumption data by an emission factor, uncertainty may be introduced if the fuel consumption data or emission factors used do not reflect Iowa scenarios, such as using default national emission factors. In addition, it is assumed that all fuel purchased is consumed in the same year (ICF 2011b).

Aviation CH_4 and N_2O emissions have a higher level of uncertainty because the jet fuel and aviation gasoline fuel data used is the total quantity of those fuels purchased in Iowa and includes fuel that may be consumed during interstate or international flights (Strait et al. 2008).

Chapter 7 – Waste: Solid Waste

This chapter includes methane (CH_4) emissions from municipal solid waste (MSW) landfills and carbon dioxide (CO_2) and nitrous oxide (N_2O) emitted from the combustion of MSW. It also accounts for CH_4 that is flared or captured for energy production. CH_4 emissions from landfills are a function of several factors, including the total quantity of waste in MSW landfills; the characteristics of the landfills such as composition of the waste, size, climate; the quantity of CH_4 that is recovered and either flared or combusted in landfill-gas-to-energy (LFGTE) projects; and the quantity of CH_4 oxidized in landfills instead of being released into the atmosphere. Fluctuations in CH_4 emissions can be caused by changes in waste composition, the quantity of landfill gas collected and combusted, the frequency of composting, and the rate of recovery of degradable materials such as paper and paperboard (EPA 2011).

Method

MSW Landfills

CO_2 and CH_4 are produced in landfills from anaerobic decomposition of organic matter. The resulting GHG emissions are approximately 50% CO_2 and 50% CH_4. Some landfills collect and flare landfill gas, and there are also landfills that collect and burn landfill gas for landfill-gas-to-energy (LFGTE) projects. CH_4 emissions were determined by estimating the amount of CH_4 generated by landfills and subtracting any CH_4 that was flared or combusted in LFGTE projects. Previous Iowa statewide greenhouse gas inventories have calculated emissions from MSW using default landfilling rates and LGTE data from EPA. However, for this inventory the Department was able to refine the MSW emissions estimations by using Iowa-specific data collected by the Department's solid waste and air quality programs as follows:

- MSW landfills report the amount of MSW they landfill to the Department, so the inventory was refined by using Iowa-specific landfilling rates for 1990 – 2010 (Jolly 2011 and DNR 2011a).

- The quantity of landfill gas flared and landfill gas collected in LFGTE projects is reported by individual facilities to the Department on their annual air emissions inventories. These inventories were used to tabulate the statewide annual tons of methane flared or combusted in LFGTE projects, and this data was entered in the SIT. The SIT does not include default data for the quantity of methane flared (DNR 2011b).

As shown in Table 20, the quantity of methane combusted in LFGTE projects reported to the Department is smaller than the default values in the SIT. The values in the SIT are derived from EPA's Landfill Methane Outreach Program (LMOP) and are not as accurate as the data reported to the Department. This is because the LMOP data is an estimate that does not account for when the projects or engines are not operating during to the year (Edwards and Ganguli 2011).

Table 20: Methane Values Used (tons)

Category	Year	SIT Value	Value Reported to Department and Used
CH_4 Recovered from LFGTE	2005	39,236	7,716
	2006	48,031	15,706
	2007	48,031	17,978
	2008	48,031	18,014
	2009	NA	13,385
	2010	NA	19,545[30]

The Department was unable to obtain Iowa-specific waste composition and oxidation rates, so the following SIT defaults were used to calculate emissions:

- CH_4 generation from industrial landfills in the U.S. is assumed to be 7% of generation from MSW landfills.
- 10% of landfill CH_4 that is not flared or recovered is oxidized in the top layer of the soil over the landfill.[31]
- The fraction oxidized for plastics, synthetic rubbers, and synthetic fibers is 98%.
- 2009 and 2010 data for the proportions of plastics, synthetic rubbers, and synthetic fibers discarded was not available, so the 2008 proportions were used for 2009 and 2010.

MSW Combusted

The Department is currently aware of only two facilities, City of Ames Steam Electric Plant and the Cherokee County Solid Waste Commission, that have combusted MSW from 2006 - 2010. The quantity of MSW combusted at these facilities and reported to the Department was used instead of the default values in the SIT which could not be verified. The values used by the Department are 30 – 50% lower than the SIT default values as shown in Table 21 below.

Table 21: Total Annual MSW Combusted in Iowa (tons)

Year	SIT Default Value	Value Reported to DNR and Used
2006	56,439	30,114
2007	53,533	34,124
2008	50,626	36,545
2009	NA	31,180
2010	NA	37,749

The inventory was also refined by using state-specific proportions of discards that are plastics, synthetic rubbers, and synthetic instead of SIT default values to calculate CO_2 emissions from MSW combustion. These state-specific proportion values are from two characterization studies done of Iowa MSW. The

[30] In 2010, seven MSW landfills operated flares and three facilities combusted landfill gas in engines, kilns, or dryers. Four of these projects are operating as part of EPA's Landfill Methane Outreach Program (LMOP).

[31] This assumption was not made in the 2005 Iowa GHG Inventory completed by CCS for the Iowa Climate Change Advisory Council (Strait 2008).

first, *Iowa Statewide Waste Characterization Study* (R.W. Beck 2006), was used to calculate emissions from 2005 – 2009. The second, *2011 Iowa Statewide Waste Characterization Study (*MSW 2011*)*, was used to calculate 2010 emissions. The state-specific proportions of discards used are shown in Table 22 below.

Table 22: Proportions of Discards used in the Solid Waste Module

Material	SIT Default Value[32]	2005 Iowa Study	2011 Iowa Study
Plastics	17.0 – 18.0%	14.9%	16.7%
Synthetic Rubber[33]	2.3 – 2.6%	0.5%	1.0%
Synthetic Fibers[34]	5.6 – 6.3%	4.9%	4.1%

Plastics and synthetic rubber materials may be further divided in the SIT into subcategories of plastics and rubber (e.g. polyethylene terephthalate (PET), polyvinyl chloride (PVC), polystyrene (PS), etc.), but the subcategories in the SIT do not match the subcategories in the waste characterization study. Therefore, the Department did subcategorize the proportion of MSW discards.

Results

Total GHG emissions from solid waste were 2.03 MMtCO_2e in 2010, accounting for 1.5% of 2010 statewide GHG emissions. 99.0% of GHG emissions from solid waste were CH_4 emitted by MSW landfills. The remaining 1.0% was CO_2, N_2O, and CH_4 from the combustion of MSW.

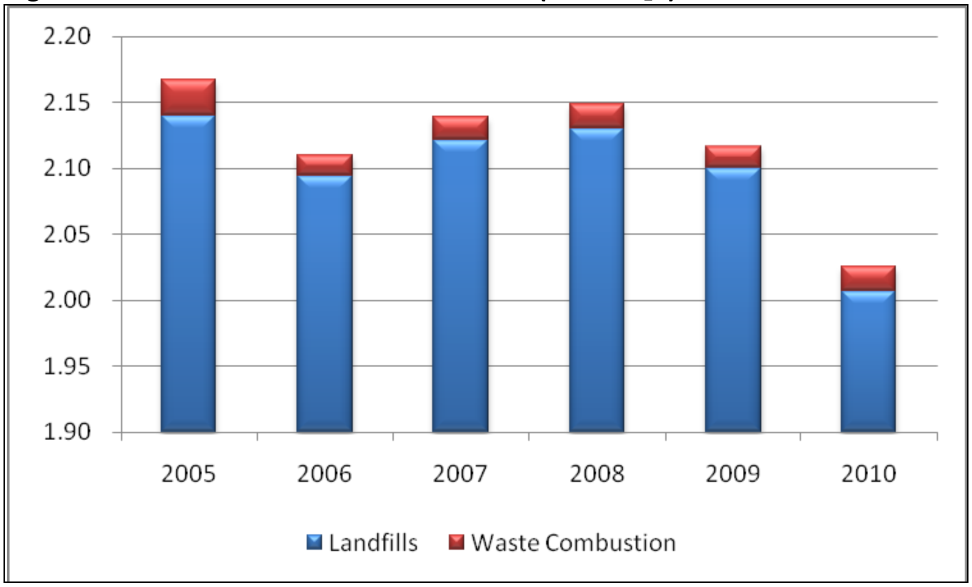
GHG emissions from solid waste decreased 6.5% from 2005 as shown in Table 23 and Figure 17. This decrease in emissions from 2005 can be attributed to a decrease in the amount of MSW disposed (-0.8%) and MSW combusted (-28.5%), as well as significant increases in the amount of methane emissions avoided by flaring (42.0%) and LFGTE projects (153.3%).

Table 23: GHG Emissions from Landfills and Waste Combustion (MMtCO_2e)

Pollutant	2005	2006	2007	2008	2009	2010
CH_4	2.14	2.09	2.12	2.13	2.10	2.01
CO_2	0.03	0.02	0.02	0.02	0.02	0.02
N_2O	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**2.17**	**2.11**	**2.14**	**2.15**	**2.12**	**2.03**

[32] Default values for 2005 – 2008.
[33] The 2005 and 2011 Iowa waste characterization studies identify this material as "rubber".
[34] The 2005 and 2011 Iowa waste characterization studies identify this material as "textiles and leather".

Figure 17: GHG Emissions from Solid Waste ($MMtCO_2e$)



Approximately 0.74 $MMtCO_2e$ of CH_4 emissions were avoided in 2010 by combusting CH_4 in flares as shown in Table 24. This is an 82.4% increase from 2005.

Table 24: CH_4 Emissions from Landfills ($MMtCO_2e$)[35,36]

Category	2005	2006	2007	2008	2009	2010
Potential CH_4	**2.78**	**2.81**	**2.86**	**2.90**	**2.94**	**2.97**
MSW Generation	2.60	2.63	2.67	2.71	2.74	2.77
Industrial Generation	0.18	0.18	0.19	0.19	0.19	0.19
CH_4 Avoided	**(0.40)**	**(0.49)**	**(0.50)**	**(0.53)**	**(0.60)**	**(0.74)**
Flare	(0.26)	(0.19)	(0.16)	(0.19)	(0.35)	(0.37)
Landfill Gas-to-Energy	(0.15)	(0.30)	(0.34)	(0.34)	(0.25)	(0.37)
Oxidation at MSW Landfills	**0.22**	**0.21**	**0.22**	**0.22**	**0.21**	**0.20**
Oxidation at Industrial Landfills	**0.18**	**0.18**	**0.19**	**0.19**	**0.19**	**0.02**
Total CH_4 Emissions	**2.14**	**2.09**	**2.12**	**2.13**	**2.10**	**2.01**

The greatest contributor to GHG emissions from MSW combustion were CO_2 emissions from plastics, accounting for 77.5% of CO_2 emissions and 75.4% of total combustion emissions as shown in Table 25 on the next page.

[35] Totals may not equal the sum of subtotals shown in this table due to independent rounding.
[36] Numbers in parentheses are negative numbers.

Table 25: Emissions from MSW Combustion ($MMtCO_2e$)[37]

Gas/Waste Product	2005	2006	2007	2008	2009	2010
CO_2	0.03	0.01	0.02	0.02	0.02	0.02
Plastics	0.02	0.01	0.01	0.01	0.01	0.02
Synthetic Rubber in MSW	7.3E-04	4.0E-04	4.6E-04	4.9E-04	4.2E-04	1.0E-03
Synthetic Fibers	5.9E-03	3.4E-03	3.8E-03	4.1E-03	3.5E-03	3.5E-03
N_2O	7.4E-04	4.2E-04	4.8E-04	5.1E-04	4.4E-04	5.3E-04
CH_4	2.0E-05	1.1E-05	1.3E-05	1.4E-05	1.2E-05	1.4E-05
Total Emissions	0.03	0.02	0.02	0.02	0.02	0.02

Uncertainty

Excerpted from SIT Solid Waste Module (ICF 2011a):

MSW Landfills

The methodology does not account for characteristics of individual landfills that impact CH_4 emissions such as temperature, rainfall, landfill design, and the time period that the landfill collects waste. The methodology also assumes that the waste composition of each landfill is the same. The SIT also assumes that 10% of CH_4 is oxidized during diffusion through the soil cover over landfills. This assumption is based on limited information. The methodology also does not account for the presence of landfill gas collection systems that may affect activity in the anaerobic zones of landfills since active pumping may draw more air into the fill (ICF 2011a).

MSW Combustion

There are several sources of uncertainty in this sector, including combustion and oxidation rates, average carbon contents, and biogenic content.

- The combustion rate is not exact and varies by the quantity and composition of the waste.
- The oxidation rate varies depending on the type of waste combusted, moisture content, etc.
- The SIT uses average carbon contents instead of specific carbon contents for other plastics, synthetic rubber, and synthetic fibers.
- Non-biogenic CO_2 emissions vary depending on the amount of non-biogenic carbon in the waste and the percentage of non-biogenic carbon that is oxidized.
- The SIT assumes that all carbon in textiles is non-biomass carbon and the category of rubber and leather is almost all rubber. This may result in CO_2 emissions being slightly over-estimated (ICF 2011a).

[37] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

Chapter 8 – Waste: Wastewater Treatment

This chapter includes GHG emissions from the treatment of municipal and industrial wastewater. The pollutants from this sector are methane (CH_4) and nitrous oxide (N_2O). CH_4 is emitted from the treatment of wastewater, both industrial and municipal. CH_4 is produced when organic material is treated in anaerobic environment (in the absence of oxygen) and when untreated wastewater degrades anaerobically. N_2O is produced through nitrification followed by incomplete denitrification of both municipal and industrial wastewater containing both organic and inorganic nitrogen species. Production and subsequent emission of N_2O is a complex function of biological, chemical, and physical factors, and emission rates depend on the specific conditions of the wastewater and the wastewater collection and treatment system. Human sewage makes up a signification portion of the raw material leading to N_2O emissions (ICF 2011b).

Method

Municipal Wastewater

GHG emissions from municipal wastewater are calculated in the SIT by multiplying a series of emission factors by the annual Iowa population, which was updated for 2009 and 2010 (U.S. Census Bureau 2011). For example, to calculate CH_4 emissions, the state population was multiplied by a the quantity of biochemical oxygen demands (BOD)per person emission factor, by the fraction that is treated anaerobically, and by the quantity of CH_4 produced per metric ton. It does not account for any digester methane that is collected and combusted instead of fossil fuels in equipment such as boilers, generators, or flares.

SIT default emission factors and assumptions were used to calculate both CH_4 and N_2O emissions, except that N_2O was calculated using the most recent protein (kg/person-year) value of 42.40 from Table 8-14 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009* (EPA 2011). Because the 2010 protein value was not available at the time of publication, the 2009 value was used as a surrogate for 2010.

The Iowa fraction of population without septic systems, 76%, from EPA's *Onsite Wastewater Treatment Systems Manual* (EPA 2002), was also used to estimate N_2O emissions. This value taken from the *1990 Census of Housing* and is lower than the SIT default value of 79%. The *2000 Census of Housing* and *2010 Census of Housing* data published to date does not include the Iowa fraction of population without septic systems.

Industrial Wastewater

The SIT calculates GHG emissions from industrial wastewater treatment from four industries – fruits and vegetables, red meat, poultry, and pulp and paper. However, the SIT only contains default activity data for red meat production. The Department was not able to find Iowa–specific data for fruits and vegetables, poultry, or pulp and paper.

The default value in the SIT for 2008 Iowa red meat production was 2,426,579 metric tons. This value was replaced the most recent USDA published value for 2008, which is 3,205,883 metric tons (USDA 2010b). While the Department was not able to find annual production data for all poultry in the SIT-required units (metric tons per year), the Department did find and was available to use Iowa chicken production data (USDA 2010b) to calculate emissions.

Results

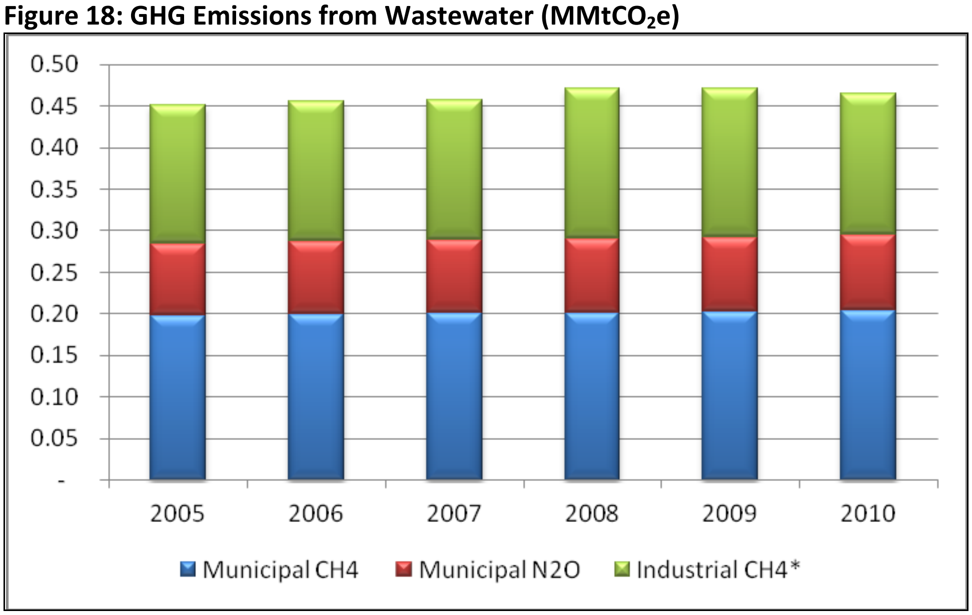
Total emissions from the wastewater treatment sector were 0.46 $MMtCO_2e$ in 2010, a 2.7% increase from 2005 and 0.3% of total statewide GHG emissions as shown in Table 26. This increase may be explained by the fact that the default emission factors used remained the same year while Iowa's population increased 3.1% during the same time period.

CH_4 and N_2O from municipal wastewater treatment accounted for 63.8% (0.30 $MMtCO_2e$) of total wastewater treatment GHG emissions as shown in Figure 18.

Table 26: GHG Emissions from Wastewater ($MMtCO_2e$)[38]

Sector	2005	2006	2007	2008	2009	2010
Municipal CH_4	0.20	0.20	0.20	0.20	0.20	0.21
Municipal N_2O	0.09	0.09	0.09	0.09	0.09	0.09
Industrial CH_4	0.17	0.17	0.17	0.17	0.18	0.17
TOTAL	**0.45**	**0.45**	**0.46**	**0.47**	**0.47**	**0.46**

Figure 18: GHG Emissions from Wastewater ($MMtCO_2e$)



*Does not include emissions from production of fruits and vegetables, pulp and paper, and turkeys.

[38] Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

Uncertainty

Excerpted from SIT Wastewater Module (ICF 2011a):

Municipal Wastewater

Uncertainty is associated with both the emission factors and activity data used to calculate GHG emissions. The quantity of CH_4 emissions from wastewater treatment is based on several factors with varying degrees of uncertainty. For human sewage, there is some degree of uncertainty associated with the emission factor used to estimate the occurrence of anaerobic conditions in treatment systems based on septic tank usage data. While the Iowa-specific percentage of the population without septic systems was used to calculate emissions, the value is from 1990. There can also be variation in the per-capita BOD production association with food consumption, food waste, and disposal characteristics for organic matter. Additionally, there is variation in these factors that can be attributed to differences in wastewater treatment facilities (*ICF 2011a*).

N_2O emissions are dependent on nitrogen (N) inputs into the wastewater and the characteristics of wastewater treatment methods. Estimates of U.S. population, per capita protein consumption data, and the fraction of nitrogen in protein are believed to be fairly accurate. However, the fraction that is used to represent the ratio of non-consumption nitrogen also contributes to the overall uncertainty of these calculations, as does the emission factor for effluent, which is the default emission factor from IPCC (1997). Different disposal methods of sewage sludge, such as incineration, landfilling, or land-application as fertilizer also add complexity to the GHG calculation method (*ICF 2011a*).

Industrial Wastewater

GHG emissions from industrial wastewater are underestimated because they do not include emissions from the treatment of wastewater from the production of fruits and vegetables, pulp and paper, or turkeys. While Iowa-specific red meat production data was used to calculate GHG emissions from the treatment of industrial wastewater from red meat, there can be large uncertainties associated with using default emission factors. For example, wastewater outflows and organics loadings can vary considerably for different plants and different sub-sectors, and there can also be variation in the per-capita BOD production associated with industrial processes, and disposal characteristics for organic matter. Furthermore, there is variation in these factors that can be attributed to characteristics of industrial pre-treatment systems as well as eventual treatment at municipal facilities (*ICF 2011a).*

Chapter 9 - Land Use, Land Use Change, and Forestry (LULUCF)

This chapter addresses carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from liming of agricultural soils and fertilization of settlement soils, as well as carbon sequestered by forests, urban trees, and yard waste and food scraps that are sent to the landfill. This balance between the emission of carbon and the uptake of carbon is known as carbon flux (SIT 2011).

Method

Forest Carbon Flux

CO_2 is taken in by plants and trees and converted to carbon in biomass during photosynthesis. "Growing forests store carbon naturally in both the wood and soil. Trees are about fifty percent carbon, and wood products from harvested trees continue to store carbon throughout their lives as well" (Flickinger 2011). CO_2 is emitted by live tree respiration, decay of dead material, fires, and biomass that is harvested and used for energy (Strait et al. 2008).

Net carbon sequestration in Iowa forests from 2005 – 2010 was calculated using the most recent data[39] available in the United States Department of Agriculture Forestry Service's *Carbon Calculation Tool (CCT) 4.0*. Sequestered carbon was divided into five categories – above ground biomass, below ground biomass, dead wood, litter, and soil carbon. The *Carbon Calculation Tool 4.0* is a computer program that uses publicly available forestry inventory data from the U.S. Forest Service's Forest Inventory and Analysis Program (FIA) to generate state-level annual estimates of carbon stocks on forest land (Smith 2011). Since the Forest Service does not conduct annual carbon stock surveys, carbon emissions and/or storage from forest carbon flux were calculated by using USDA Forest Service estimates of each state's harvested wood stocks in 1992 and 1997. The total change from 1992 – 1997 was divided by 5 (the number of intervening years) to determine the average annual change. This average annual change is then applied to each year, giving total annual change. For the years 1998-2010, the average annual change for 1992-1997 was used as a surrogate (ICF 2011a).

The Department used the default SIT value of 0.05 $MMtCO_2e$ for average annual change in carbon stored in wood productions and landfills.

Liming of Agricultural Soils

CO_2 is emitted when acidic agricultural soils are neutralized by adding limestone or dolomite. The SIT uses the quantity of limestone and dolomite produced annually in Iowa from the United States Geological Survey's annual *Minerals Yearbook* (USGS 2011). However, the yearbook does not provide the quantity of these minerals applied to agricultural soils, so the SIT applies the national ratio of

[39] Carbon Calculation Tool 4.0 – last modified 5/9/2011. Iowa summary data downloaded from the FIA Data Mart < http://www.fia.fs.fed.us/tools-data/> on 7/26/2011.

limestone and dolomite applied to agricultural soils in the data to the Iowa values. For 2009, the national ratio was 91% limestone and 9% dolomite (USGS 2011). Because the use of these minerals is not specified for all limestone and dolomite produced, the SIT also applies another formula to correct for unspecified data.

The Department obtained improved data from the Iowa Limestone Producers Association (ILPA). The IPLA provided the Department with the total annual amount of limestone produced for agricultural use as reported by their members (Hall 2011). However, producers do not report the percentage of limestone that is dolomitic. The Iowa Department of Transportation (DOT) tracks general information for active aggregate sources used for construction, including whether the material is limestone or dolomite. However, they do not track that information for limestone produced for agricultural purposes. The DOT indicated that some areas of the state have 100% dolomite, some have 100% limestone, and some areas are mixed (Reyes 2011). Therefore, the Department assumed that 50% of the material produced in Iowa for agricultural use is dolomite and 50% is limestone.

Urea Fertilization

The SIT default values for fertilizer application were used for 2005 – 2007. The quantity of urea fertilizer applied in growing year 2008 and 2009 was obtained from *Commercial Fertilizers 2009* (Slater 2011).

Urban Trees

Emissions were calculated 2005 – 2008 using the default SIT data for total urban area (km^2), percent of urban area with tree cover, and carbon sequestration emission factor. The SIT extrapolated the total urban area values for 2001 – 2008 from the 1990 – 2000 values using the least squares method in Excel. The Department used this same method to extrapolate the total urban area values for 2009 and 2010. The 2010 value will be updated when the final 2010 US Census is released.

The SIT assumes that 33% of urban areas have tree cover. A recent USDA Forest Service study found that average tree cover in Iowa urban areas was 13.7% (Nowak 2010). However, a recent canopy cover assessment in Des Moines, Iowa using light detection and ranging (LIDAR) data found that Des Moines had 27% tree coverage. The Department’s state urban forester estimated tree coverage to range from 10 - 35% (Bruemmer 2011). The Department used the SIT default value of 33% to calculate emissions.

Settlement Soils

Approximately 10% of the fertilizers applied to soils in the United States are applied to soils in settled areas such as landscaping, lawns, and golf courses (ICF 2011b). N_2O emissions from settlement soils were calculated using 10% of the total annual synthetic fertilizer value from the SIT Agriculture module. For more information on how the 2008 – 2010 values were derived, please see *Chapter 2- Agriculture* of this report.

Non-CO_2 Emissions from Forest Fires

CH_4 and N_2O emissions from forest fires in Iowa were not estimated because the default values in the SIT are not representative of the vegetation typically burned in Iowa. The SIT default combustion efficiencies and emission factors are provided for primary tropical forests, secondary tropical forests, tertiary tropical forests, boreal forest, eucalypt forest, other temperate forests, shrublands, and savanna woodlands. This is not reflective of Iowa's 8% forested land - 3.05 million acres -(Flickinger 2010) and the majority[40] of wildfires and prescribed burns in Iowa in 2010 were on grasslands (Kantak 2011). Annual fire data is also available from the National Interagency Fire Center (NIFC 2011), but it also does not divide the data into the vegetation types required by the SIT.

Landfilled Yard Trimmings and Food Scraps

GHG estimations from this sector were refined by using Iowa-specific data from the 2006 *Iowa Statewide Waste Characterization Study* (R.W. Beck 2006). The default values in the SIT overestimated the amount of yard waste landfilled and underestimated the amount of food scraps landfilled as shown in Table 27. This is because the SIT calculated the annual amount of yard waste and food scraps landfilled by applying the national per capita amount landfilled to the state population.

Table 27: Annual Yard Waste and Food Scraps Landfilled (1000 tons)

	Yard Waste		Food Scraps	
Year	Iowa-specific Value	SIT Default Value	Iowa-specific Value	SIT Default Value
2005	43	99	285	240
2006	43	100	286	246
2007	45	94	295	248
2008	45	92	301	247
2009	43	-	287	-
2010	43	-	282	-

Due to lack of state-specific data, GHG emissions were calculated using the SIT default values for content of yard trimmings (e.g. % grass, % leaves, % branches), carbon content, proportion of carbon stored permanently, and half-life of degradable carbon.

[40] Of those that specified the vegetation type burned on their fire report to the Department. The Department tracks the date, location, and total acres of wildfires and prescribed burns reported to the Department, but the type of vegetation burned is not required to be reported for each fire.

Results

According to the United States Department of Agriculture Forestry Service's, Iowa had more than 124 million metric tons of carbon (MMtC) stored in its forests and an additional 76 MMtC stored in soil carbon (Smith 2007), resulting in 17.35 MMtCO_2e of forest carbon flux. The two largest contributors to forest carbon flux in Iowa are above ground biomass and soil organic carbon as shown in Table 28.

Table 28: 2010 GHG Emissions and Sinks from Forest Carbon Flux[41,42]

Category	Emissions (MMtCO_2e)
Forest Carbon Flux	**(17.35)**
Aboveground Biomass	(7.51)
Belowground Biomass	(1.41)
Dead Wood	(0.88)
Litter	(1.02)
Soil Organic Carbon	(6.35)
Total Wood Products and Landfills	(0.18)
Liming of Ag Soils	**0.47**
Limestone	0.22
Dolomite	0.24
Urea Fertilization	**0.14**
Urban Trees	**(0.63)**
Landfilled Yard Waste and Food Scraps	**(0.05)**
Grass	(0.00)
Leaves	(0.01)
Branches	(0.01)
Landfilled Food Scraps	(0.03)
N_2O from Settlement Soils	**0.46**
Total Sequestered	**(16.96)**

An additional 0.63 MMtCO_2e was sequestered in urban trees in 2010, and 0.05 MMtCO_2e was sequestered in landfilled yard waste and food scraps. 1.07 MMtCO_2e was emitted from liming of agricultural soils, urea fertilization, and settlement soils as shown below in Table 29 and Figure 19. Emissions from forest fires are not included, as earlier discussed under the "Method" heading.

Overall, sources in the LULUCF sector sequestered 16.96 MMtCO_2e, also referred to as a carbon sink of 16.96 MMtCO_2e. This is a decrease of 0.02% from 2005. Emissions of CO_2 are shown above the x-axis in Figure 19 and carbon sinks are shown below the x-axis.

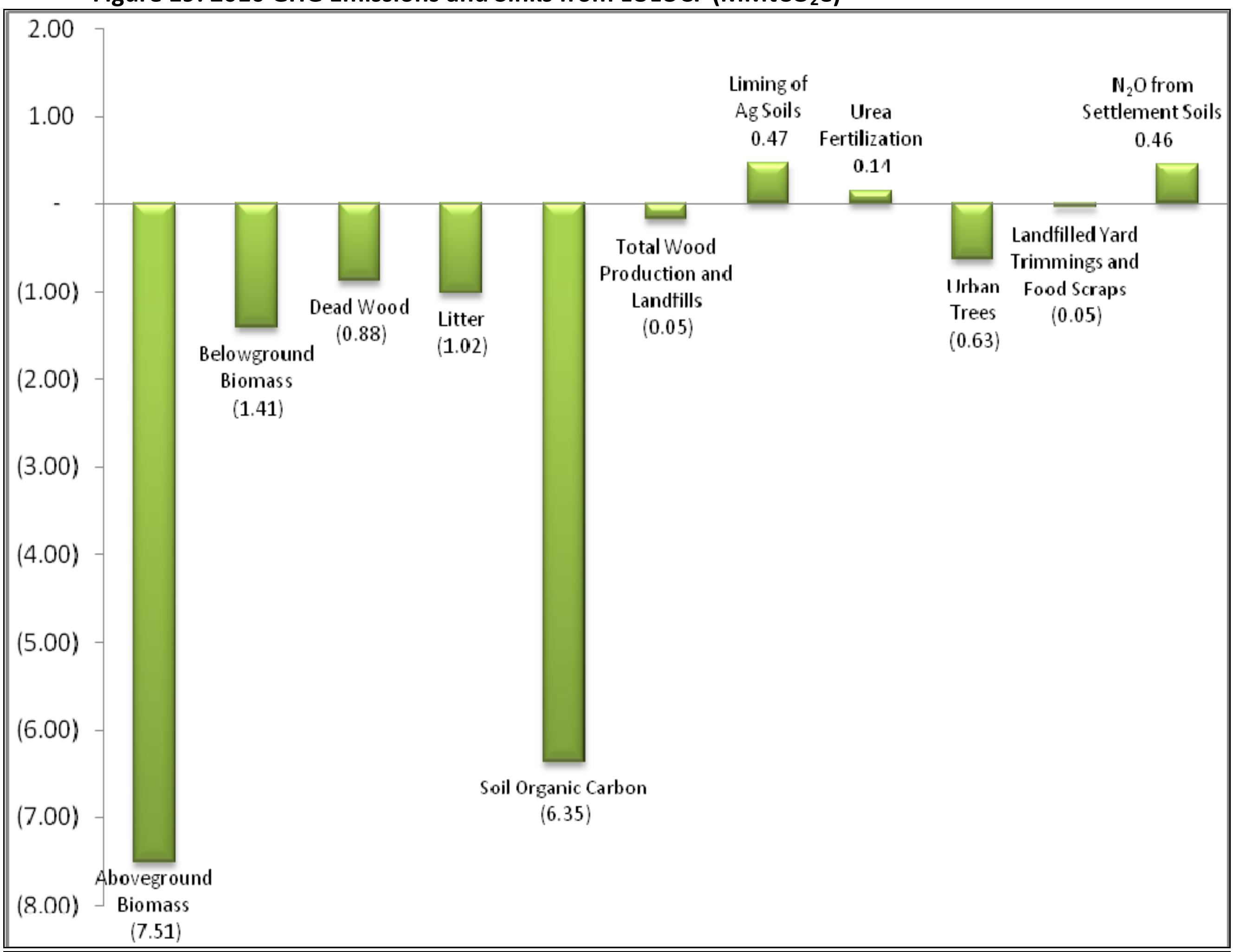
[41] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

[42] Numbers in parentheses are negative (carbon sinks).

Table 29: GHG Emissions and Sinks from LULUCF ($MMtCO_2e$)[43,44]

Sector	2005	2006	2007	2008	2009	2010
Forest Carbon Flux	(17.35)	(17.35)	(17.35)	(17.35)	(17.35)	(17.35)
Liming of Ag Soils	0.42	0.45	0.37	0.28	0.27	0.47
Urea Fertilization	0.15	0.15	0.15	0.15	0.14	0.14
Urban Trees	(0.60)	(0.61)	(0.62)	(0.62)	(0.63)	(0.63)
Landfilled Yard Trimmings & Food Scraps	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
N_2O from Settlement Soils	0.46	0.48	0.53	0.50	0.46	0.46
Total Sequestered	**(16.97)**	**(16.93)**	**(16.96)**	**(17.09)**	**(17.15)**	**(16.96)**

Figure 19: 2010 GHG Emissions and Sinks from LULUCF ($MMtCO_2e$)



[43] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

[44] Numbers in parentheses are negative numbers (carbon sinks).

Uncertainty

One of the largest sources of uncertainty in the LULUCF sector is the lack of Iowa-specific data and emission factors used to calculate emissions and/or sinks from forest carbon flux, urban trees, and settlement soils. A high level of uncertainty is also introduced due to the lack of emissions data from forest fires in Iowa, which was not estimated.

Emissions from categories such as urea fertilization, liming of agricultural soils, and landfilled yard waste and food scraps are more certain because Iowa-specific activity data was used, but uncertainty was also introduced by using surrogate data for 2010, assuming the ration of limestone to dolomite in Iowa is 50%, and using SIT default values for content of yard trimmings (e.g. % grass, % leaves, % branches), carbon content, proportion of carbon stored permanently, and half-life of degradable carbon.

Chapter 10 –Electricity Consumption

This chapter includes indirect emissions from electricity consumed at the point of use (e.g. residential electric hot water heaters, televisions, appliances, etc.) and does not include direct emissions generated at the electric power generating station (*see Chapter 3 – Fossil Fuel Combustion*). Electricity consumed by Iowans may not be generated in Iowa. It may have been imported from other states. Because of this, emissions from electricity consumption do not match emissions from electricity generation (ICF 2011b). Therefore, GHG emissions from electricity consumption are included in this inventory as an informational item only and are not included in the total statewide GHG emissions to avoid any possible double-counting. However, trends in electricity consumption are valuable because they are indicators of consumer behavior and trends in energy efficiency.

Method

2005 – 2009 Emissions

The total kWh of electricity consumed by the residential, commercial, and industrial sectors were calculated using bulk energy consumption data from the U.S. Energy Information Administration's – State Energy Data System (EIA 2011b).

The SIT tool uses emission factors from the Emissions & Generation Resource Integrated Database (eGRID), a comprehensive inventory of electric power systems. The SIT uses emission factors from eGRID 2007 Version 1.1 (2005 data) and uses calendar year 2005 data as surrogates for 2006, 2007, and 2008. However, since the SIT was last published, a newer version of eGRID, (2007 data) has been published, so the Department updated the 2007, 2008, and 2009 emission factors in the SIT with the factors from eGRID2010 Version 1.1. A grid loss factor of 6.471% in 2007 was used for 2008 and 2009 (EPA 2011). Due to a lack of state-specific data, the SIT default value for % of Iowa households in the region[45] was used.

The SIT has an error in the formula used to derive the state emission rate (pound per megawatt hour) on the "CO_2 eq.xls" worksheet of the Electricity Consumption module, so the Department corrected the formula. State data in the worksheet is listed alphabetically by state, but the calculation formula is off by one row. The result is that the CO_2e emissions from a state are calculated using the N_2O emissions from the state that appears before them alphabetically. For instance Iowa's emissions are calculated using Idaho's N_2O emissions.

[45] Iowa is in the Midwest Reliability Organization West (MROW) region.

2010 Emissions
State-specific 2010 electricity consumption data will not be published by EIA until 2012, so the Department projected 2010 emissions using the reference case in EIA's *Annual Energy Outlook 2011 with Projections to 2035* (EIA 2011a). To project 2010 emissions, the Department first calculated the state's percent electricity consumption for each sector in 2009, relative to the electricity consumption of the region. The Department then multiplied Iowa's proportion of consumption by the projected 2011 consumption for the West North Central region. A grid loss factor of 6.471% in 2007 was used as a surrogate for 2010.

Transportation
Electricity consumption from electric vehicles in Iowa was not calculated due to a lack of data. According to the Iowa Department of Transportation, only seven electric vehicles (five Volts and two Roadsters) are currently registered in Iowa. There are also many low speed, non-highway electric vehicles, such as golf carts, operating in Iowa. The Iowa DOT does not have electricity consumption data for these vehicles (Carroll 2011). In addition, the Federal Transit Administration's National Transit Database shows no data from electric propulsion or electric batteries (FTA 2009).

Results

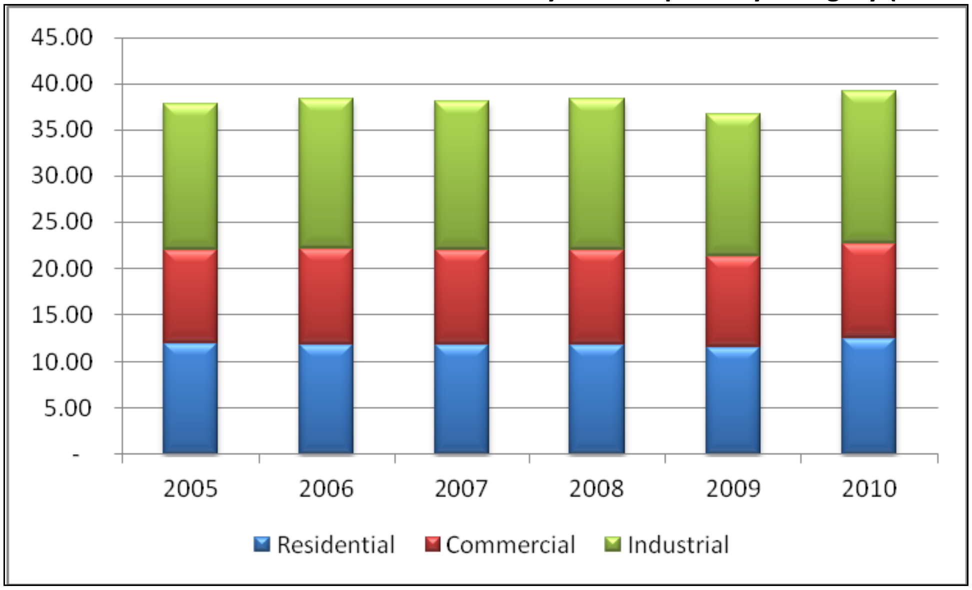
Indirect GHG emissions from electricity consumption were 39.13 MMtCO$_2$e in 2010, increasing 3.4% since 2005, as did Iowa's population during the same time period. Industrial users consumed 42.1% of electricity in the state, while residential users consumed 32.0% and commercial users 25.9% as shown in Table 30 and Figure 20.

Table 30: GHG Emissions from Electricity Consumption (MMtCO$_2$e)[46]

Sector/Fuel Type	2005	2006	2007	2008	2009	2010
Residential	12.02	11.82	11.81	11.83	11.53	12.52
Commercial	9.98	10.33	10.15	10.23	9.84	10.13
Industrial	15.86	16.23	16.07	16.33	15.30	16.48
Total	**37.86**	**38.38**	**38.04**	**38.39**	**36.67**	**39.13**

[46] Totals may not equal the sum of subtotals shown in this table due to independent rounding.

Figure 20: Indirect GHG Emissions from Electricity Consumption by Category ($MMtCO_2e$)



Chapter 11 – Historical, Future, and National Emissions

This is the fifth top-down inventory of Iowa GHG emissions conducted from 1996 – 2011 as shown in Table 32 below.

Table 31: Historical Iowa GHG Emissions

Emissions Year	Gross $MMtCO_2e$ (excludes sinks)	Source
1990	78.7	Ney et al. 1996
2000	120.3	Wollin and Stigliani 2005
2003	108	WRI 2007
2005	119.5	Strait et al. 2008
2010	136.80	DNR 2011

For the past three years, the Department has developed "bottom-up" (GHG) inventories based on emission data reported directly to the Department by ethanol production plants and major sources with federally-enforceable operating permits (also known as Title V operating permits). These inventories were narrow in scope and called "bottom-up" inventories because facility-specific activity data was used to calculate emissions. Because these inventories included emissions from only approximately 300 facilities in Iowa, their results are not directly comparable to the results of this 2010 inventory. The majority of these facilities are now required to report their annual GHG emissions to EPA's federal mandatory GHG reporting program (40 CFR 98) instead of the Department. Their first reports were due to EPA on September 30, 2011.

Iowa GHG Emissions and Forecast

Strait et al. (2008) projected that Iowa GHG emissions would increase 4% from 2005 – 2010. However, the Department finds that GHG emissions increased 10.7% from 2005 – 2010, despite the economic downturn that began in 2008.

The Department used the SIT Projection Tool to project emissions to 2030. The SIT Projection Tool is currently is designed to project emissions using historical emissions from 1990 – 2008. However, EPA and their contractor, ICF International, updated to tool for the Department (Pederson 2011) using more current energy consumption projections from EIA's *Annual Energy Outlook 2011* (EIA 2011a). The SIT forecasts that Iowa GHG emissions will increase 3.4% from 2010 levels by 2020 and 8.3% from 2010 levels by 2030.

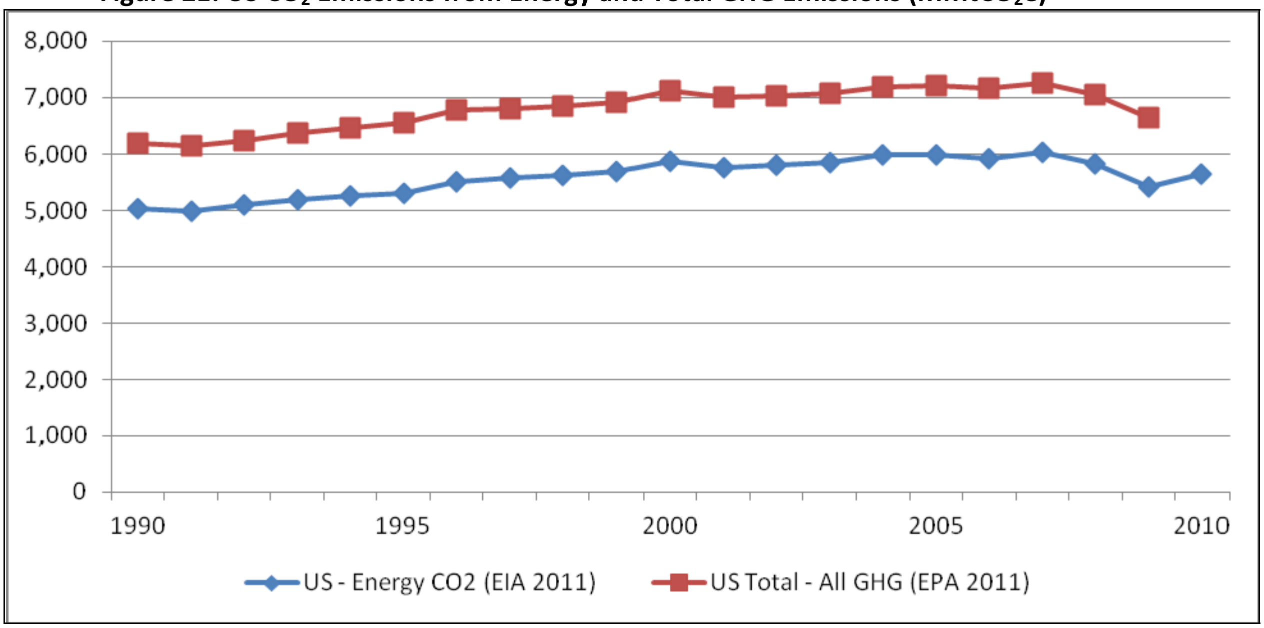
National GHG Emissions and Forecast

Each year the EPA develops a national top-down GHG inventory that is submitted to the United Nations in accordance with the Framework Convention on Climate Change. The latest version, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2009,* was released in April 2011 and found total nationwide GHG emissions were 6,633 $MMtCO_2e$ in 2009. This was a 6% decrease from the previous year. However, national GHG emissions have increased 7% from 1990 – 2008 at an annual average rate of 0.4% (EPA 2011) as shown in Figure 21 on the next page. EPA attributes the decrease from 2008 –

2009 to both a decrease in energy consumption due to the economic downturn and a decrease in fuel carbon intensity as electric generators switched from coal to natural gas. This switching occurred because the price of natural gas decreased "significantly" at the same time that the cost of coal increased (EPA 2011).

EPA's annual national inventory does not include a forecast of future GHG emissions, but on August 18, 2011 the United States Energy Information Administration (EIA) released new estimates for 2010 national energy-related CO_2 emissions. EIA estimated 2010 energy-related CO_2 emissions to be 5,638 $MMtCO_2e$, a 4% increase from 2008 but still 6% below the 2005 level (EIA 2011b). As energy emissions are the greatest contributor to national GHG emissions, it is reasonable to predict that total 2010 U.S. GHG emissions will increase from 2009 to 2010 as well.

Figure 21: US CO_2 Emissions from Energy and Total GHG Emissions ($MMtCO_2e$)



The State Department's last climate action report, U.S. Climate Action Report 2010, included GHG projections from 2005 – 2020. In that report, national GHG emissions were predicted to be 7,074 $MMtCO_2e$ in 2010 and 7,416 $MMtCO_2e$ by 2020 (DoS 2010). However, these projections are based on emissions prior to the economic downturn beginning in 2008 and do not account for the 6% decrease in national GHG emissions from 2008 – 2009.

Chapter 12 - Future Inventory Improvements

Future inventory improvements can be made by including more Iowa-specific activity data and emission factors where available. Table 32 below summarizes these opportunities for future improvements.

Table 32: Data Elements Required for Improving in Future Inventories

Sector	Year	Data Element	Activity Data Used
Agriculture	2010	Hen, pullet, and chicken population	2009 used as a surrogate for 2010.
	2009, 2010	Horse population	2008 used as a surrogate for 2009, 2010.
	2009, 2010	Feedlot heifer population	2008 used as a surrogate for 2009, 2010.
	2009, 2010	Feedlot steer population	2008 used as a surrogate for 2009, 2010.
	2009, 2010	Sheep (on feed/not on feed) population	2008 used as a surrogate for 2009, 2010.
	2009, 2010	Turkey population	2008 used as a surrogate for 2009, 2010.
	July – December 2010	Fertilizer usage	July – December 2009 used as a surrogate.
	2005 – 2010	Additional carbon sinks from agricultural practices	Not calculated.
Fossil Fuel Combustion	2010	Annual fossil fuel consumption	2010 values were projected from 2009 value using EIA's AEO 2011.
Indirect Emissions from Electricity Consumption	2010	Annual electricity consumption	2010 values were projected from 2009 value using EIA's AEO 2011.
Industrial Processes	2010	Industrial limestone and dolomite consumption	2009 used as a surrogate for 2010.
	2010	Soda ash consumption[47]	2009 used as a surrogate for 2010.
	2010	ODS substitutes consumption	2009 used as a surrogate for 2010.
	2010	Electricity sales for electric power and transmission	2009 used as a surrogate for 2010.
	2010	GHG emissions reported to the federal mandatory reporting program – cement, lime, ammonia, and nitric acid production	Emissions were calculated using throughput data from 2010 criteria and hazardous air pollutant inventories.

[47] Emissions were calculated using an estimated 2010 value from USGS.

Table 32 (Continued)

Sector	Year	Data Element	Activity Data Used
LULUCF	2009, 2010	Total urban area	Extrapolated from 1990 – 2000 values.
Natural Gas Transmission & Distribution	2010	Miles of natural gas transmission pipeline	2009 used as a surrogate for 2010.
Transportation	2010	Total VMT[48]	See footnote.
	2010	Aviation gasoline consumption	2010 value was projected from 2009 value using EIA's AEO 2011.
	2010	Jet fuel kerosene consumption	2010 value was projected from 2009 value using EIA's AEO 2011.
	2010	Boat gasoline consumption	2009 used as a surrogate for 2010.
	2010	Locomotive diesel consumption	2009 used as a surrogate for 2010.
	2010	Farm equipment fuel consumption	2009 used as a surrogate for 2010.
	2005 – 2010	Snowmobile gasoline consumption	Emissions from this category were not calculated due to lack of data.
	2010	Heavy duty utility vehicle gasoline consumption	2009 used as a surrogate for 2010.
	2010	Small utility vehicle gasoline consumption	2009 used as a surrogate for 2010.
	2010	Heavy duty utility diesel consumption	2009 used as a surrogate for 2010.
	2010	Alternative fuel vehicles VMT	2009 used as a surrogate for 2010.
	2005 – 2010	Fruit and vegetable production	Emissions from this category were not calculated due to lack of data.
	2005 – 2010	Poultry production (other than chickens)	Emissions from this category were not calculated due to lack of data.
	2005 – 2010	Pulp and paper production	Emissions from this category were not calculated due to lack of data.

[48] The total 2010 VMT calculated by the Iowa DOT was used in emissions calculations. The federal government has not yet released its calculation of Iowa 2010 VMT.

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Appendix A – Iowa GHG Emissions 2005 - 2010, by Pollutant[49,50]

Emissions (MMtCO_2e)	2005	2006	2007	2008	2009	2010
Gross CO_2	*84.68*	*85.04*	*91.04*	*93.52*	*88.10*	*95.98*
Net CO_2	*67.26*	*67.63*	*73.55*	*75.92*	*70.49*	*78.56*
Fossil Fuel Combustion	60.60	60.37	65.93	69.19	65.06	72.32
Transportation	21.25	21.82	22.31	21.54	21.03	21.34
Industrial Processes	2.80	2.83	2.78	2.76	1.99	2.30
Waste	0.03	0.01	0.02	0.02	0.02	0.02
Land Use, Land Use Change, and Forestry	(17.42)	(17.41)	(17.49)	(17.60)	(17.61)	(17.42)
CH_4	*15.61*	*15.93*	*16.89*	*17.65*	*17.74*	*17.08*
Fossil Fuel Combustion	0.08	0.08	0.08	0.08	0.08	0.09
Transportation	0.04	0.04	0.04	0.03	0.03	0.03
Natural Gas and Oil Transmission and Distribution	1.15	1.15	1.16	1.07	1.17	1.17
Enteric Fermentation	5.95	6.35	6.62	6.77	6.74	6.50
Manure Management	5.89	5.86	6.50	7.18	7.23	6.91
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00
Municipal Solid Waste (MSW)	2.14	2.09	2.12	2.13	2.10	2.01
Wastewater	0.36	0.37	0.37	0.38	0.38	0.37
N_2O	*22.33*	*24.11*	*27.73*	*22.99*	*22.70*	*22.58*
Fossil Fuel Combustion	0.23	0.23	0.25	0.26	0.24	0.27
Transportation	0.59	0.52	0.46	0.40	0.36	0.32
Industrial Processes	0.68	0.75	0.81	0.90	0.90	0.99
Manure Management	0.88	0.94	0.97	1.01	1.02	1.02
Agricultural Soil Management	19.41	21.09	24.63	19.84	19.63	19.44
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00
N_2O from Settlement Soils	0.46	0.48	0.53	0.50	0.46	0.46
Municipal Solid Waste (MSW)	0.00	0.00	0.00	0.00	0.00	0.00
Wastewater	0.09	0.09	0.09	0.09	0.09	0.09
HFC, PFC, and SF_6	*1.19*	*1.23*	*1.24*	*1.27*	*1.33*	*1.34*
Industrial Processes	1.19	1.23	1.24	1.27	1.33	1.34
Gross Emissions	**123.82**	**126.31**	**136.91**	**135.43**	**129.86**	**136.98**
Sinks	**(17.42)**	**(17.41)**	**(17.49)**	**(17.60)**	**(17.61)**	**(17.42)**
Net Emissions (Sources and Sinks)	**106.39**	**108.90**	**119.42**	**117.84**	**112.25**	**119.56**

[49] Totals may not equal the exact sum of subtotals in this table due to independent rounding.
[50] If the LULUCF sector is responsible for net sequestration, those totals will be registered in "Sinks".