IOWA DEPARTMENT OF NATURAL RESOURCES

2016 Iowa Statewide Greenhouse Gas Emissions Inventory Report

Required by Iowa Code 455B.104

December 5, 2017

Iowa Department of Natural Resources
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Des Moines, IA 50319

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Background

This report is required by Iowa Code 455B.104, which requires the Iowa DNR to estimate greenhouse gas (GHG) emissions during the previous year and forecast trends in emissions. The report must be submitted to the Governor and Iowa General Assembly by December 31 each year. This report focuses on calendar year 2016 GHG emissions and includes emissions of six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC), hydroflurocarbons (HFC) and sulfur hexafluoride (SF_6).

This inventory is based on statewide activity data from the following sectors:

- agriculture
- fossil fuel combustion
- industrial processes
- natural gas transmission and distribution
- transportation
- solid waste
- wastewater treatment
- land use, land use change, and forestry (LULUCF)

Emissions were calculated using the U.S. Environmental Protection Agency's (EPA) State Inventory Tool (SIT) and self-reported emissions data from landfills, industrial facilities and power plants. The calculation method and uncertainty for each sector are discussed in detail in the Iowa DNR's Technical Support document available on the DNR's Greenhouse Gas Emissions Inventory webpage. Benefits of preparing this report include the ability to evaluate emissions trends and develop a baseline to track progress in reducing emissions. A state-specific inventory also provides a more in-depth analysis and more accurate inventory of emissions compared to national emissions.

2016 Statewide GHG Emissions

In 2016, total gross Iowa greenhouse gas emissions were 128.28 million metric tons carbon dioxide equivalents ($MMtCO_2e$) as shown in Table 1. This is a decrease of 2.61 $MMtCO_2e$ (2.00%) from 2015. Most of this decrease comes from a 4.13 $MMtCO_2e$ reduction from power plants due to mild weather, decreased electric generation from coal (-14.12%) and increased generation from zero-emitting sources such as wind (12.18%) and solar.[1]

These decreases helped to offset increases in emissions from industrial processes (+4.28%), LULUCF (+4.69%), agriculture (+1.82%) and other sectors. Overall, total 2016 statewide GHG emissions were 9.29% lower than their peak in 2007 as shown in Figures 1 and 2.

[1] Solar generation in 2015 rounded to zero million megawatt hours. Solar generation in 2016 was 416 million megawatt hours.

Table 1: GHG Emissions 2005 – 2016 by Sector ((Million Metric Tons Carbon Dioxide Equivalents ($MMtCO_2e$))[2]

Emissions ($MMtCO_2e$)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Change from 2015		
													$MMtCO_2e$	%	
Agriculture	33.60	35.71	40.23	36.65	36.48	36.38	37.91	36.67	37.03	37.76	38.78	39.48	+0.71	+1.82%	↑
Power Plants	36.83	36.35	40.04	41.78	37.71	42.33	38.98	35.76	33.06	33.44	29.46	25.33	-4.13	-14.02%	↓
Residential, Commercial, and Industrial Fuel Use	27.03	27.26	28.55	31.34	30.73	31.23	31.44	29.96	32.82	32.82	31.54	31.90	+0.36	+1.16%	↑
Industrial Processes	4.57	4.71	4.78	4.92	4.22	4.79	4.49	5.17	5.34	5.28	5.28	5.50	+0.23	+4.28%	↑
Land Use, Land Use Change, and Forestry (LULUCF)[3]			3.40				0.67	0.48		3.27	2.99	3.13	+0.14	+4.69%	↑
Natural Gas Transmission and Distribution	1.37	1.37	1.39	1.40	1.40	1.39	1.40	1.40	1.40	1.40	1.40	1.41	+0.01	+0.62%	↑
Transportation	20.14	20.35	19.96	19.99	19.40	19.41	19.58	19.59	19.46	19.55	19.31	19.36	+0.05	+0.28%	↑
Waste	3.10	3.03	3.07	3.10	3.06	2.01	1.94	2.15	1.96	1.94	2.14	2.16	+0.02	+1.00%	↑
Total Gross Emissions	126.63	128.77	141.42	139.16	133.00	137.54	136.39	131.18	131.07	135.46	130.90	128.28	-2.61	-2.00%	↓
Carbon Stored in LULUCF[4]	-20.56	-5.81	0	-3.92	-5.00	-2.01	0	0	-0.71	0	0	0			
Total Net Emissions	106.07	122.96	141.42	135.25	128.00	135.54	136.39	131.18	130.36	135.46	130.90	128.28	-2.61	-2.00%	↓

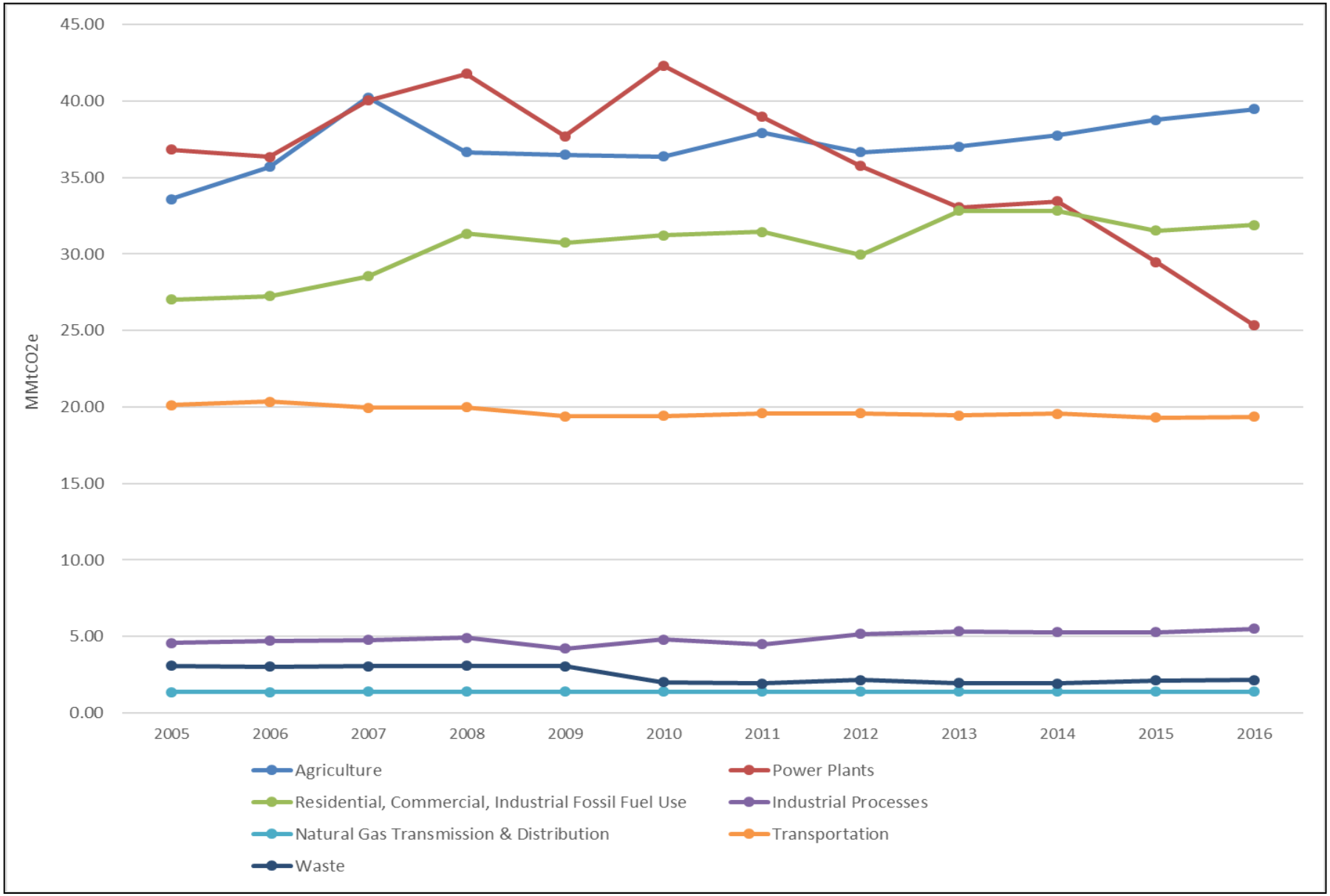
[2] Totals may not equal the exact sum of subtotals in this table due to independent rounding Values may not match values in the previous 2015 inventory published by the Department in December 2016 as they have been recalculated using the IPCC AR4 GWP. The adjustments are described in detail in the Technical Support Document.

[3] Carbon is emitted in some years from the LULUCF sector, but carbon is stored in the LULUCF sector in other years. Emissions from the LULUCF sector are shown in this row as positive numbers.

[4] Carbon stored in LULUCF is shown in this row as a negative number.

Figure 1: Iowa Gross GHG Emissions 2005 – 2016 ($MMtCO_2e$)

Figure 2: Iowa Gross[5] GHG Emissions 2005 – 2016 by Sector ($MMtCO_2e$)

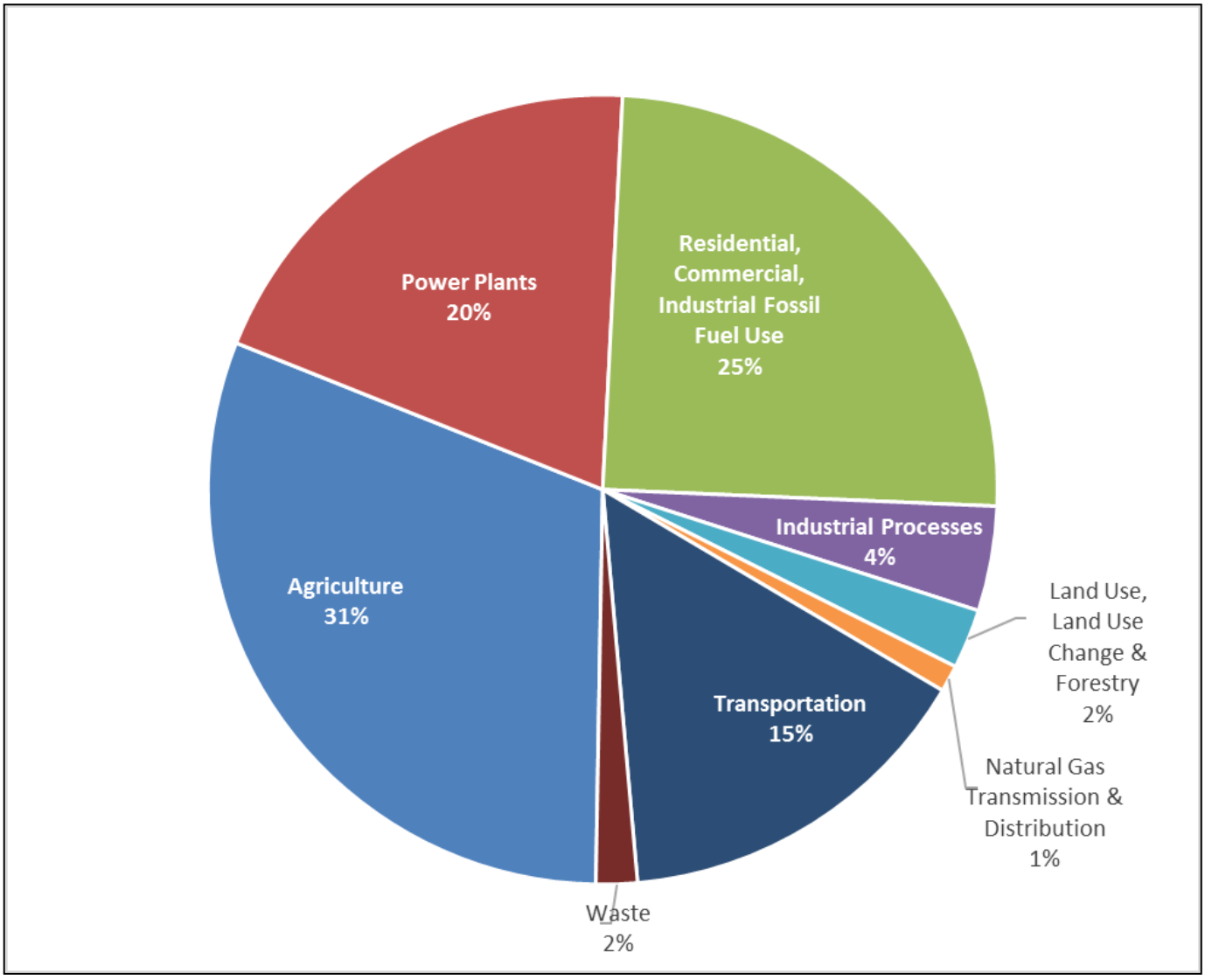


[5] Does not include carbon storage or emissions from land use, land use change, and forestry (LULUCF).

GHG Emissions by Sector

The majority of GHG emissions in Iowa in 2016 were from the agriculture sector and from fossil fuel use by power plants and the residential/commercial/ industrial (RCI) sectors. Together the emissions from power plants and RCI fuel use account for nearly half (44.61%) of the state's GHG emissions as shown in Figure 3.

Figure 3: 2016 Iowa GHG Emissions by Sector[6]



[6] Industrial fossil fuel use refers to GHG emissions from fossil fuels combusted by industrial facilities. Industrial processes means GHGs emitted during the production of or use of specific products such as ammonia, urea, nitrogen, cement, iron, steel, lime, etc.

Emissions from each sector are summarized below. Please refer to the 2016 GHG Inventory Technical Support Document for more information on a specific sector, such as sources of emissions, calculations and uncertainty.

Agriculture

This sector includes GHG emissions from livestock and crop production such as enteric fermentation, manure management and agricultural soils. Enteric fermentation includes emissions from the digestive systems of ruminant animals. Emissions from agricultural soils include emissions from manure, runoff, plant fertilizers, plant residues and cultivation of highly organic soils. GHG emissions from fossil-fuel fired agricultural equipment (such as tractors) are included in the transportation sector. As shown in Table 2, agriculture emissions increased 1.82% from the previous year due to increases in both livestock and crop production.

Table 2: GHG Emissions from Agriculture ($MMtCO_2e$)

Category	2015	2016	% Change
Enteric Fermentation	8.31	8.38	+0.83%
Manure Management	10.04	9.86	-1.74%
Agricultural Soil Management	20.43	21.24	+3.97%
Total	**38.78**	**39.48**	**+1.82%**

Fossil Fuel Combustion

This sector includes GHG emissions from fossil fuels combusted in four categories: power plants, residential, industrial and commercial (The residential, industrial and commercial categories are often combined into one category called RCI). Together, these four categories account for 44.61% of Iowa's GHG total emissions. Emissions from power plants decreased by 4.13 $MMtCO_2e$ (14.02%) from the previous year due to decreased combustion of coal and increases in the amount of electricity generated from lower-emitting fuels, such as natural gas, and zero-emitting fuels, such as wind and solar. Emissions from the other three fossil fuel combustion categories increased as shown in Table 3.

Table 3: GHG Emissions from Fossil Fuel Combustion ($MMtCO_2e$)

Category	2015	2016	% Change
Power Plants	29.56	25.33	-14.02%
Residential, Commercial, Industrial (RCI)	31.54	31.90	+1.16%
Residential	*4.49*	*4.55*	*+1.27%*
Commercial	*4.60*	*4.76*	*+3.52%*
Industrial	*22.44*	*22.59*	*+0.65%*
Total	**61.00**	**57.23**	**-6.18%**

Residential, Commercial, Industrial (RCI)

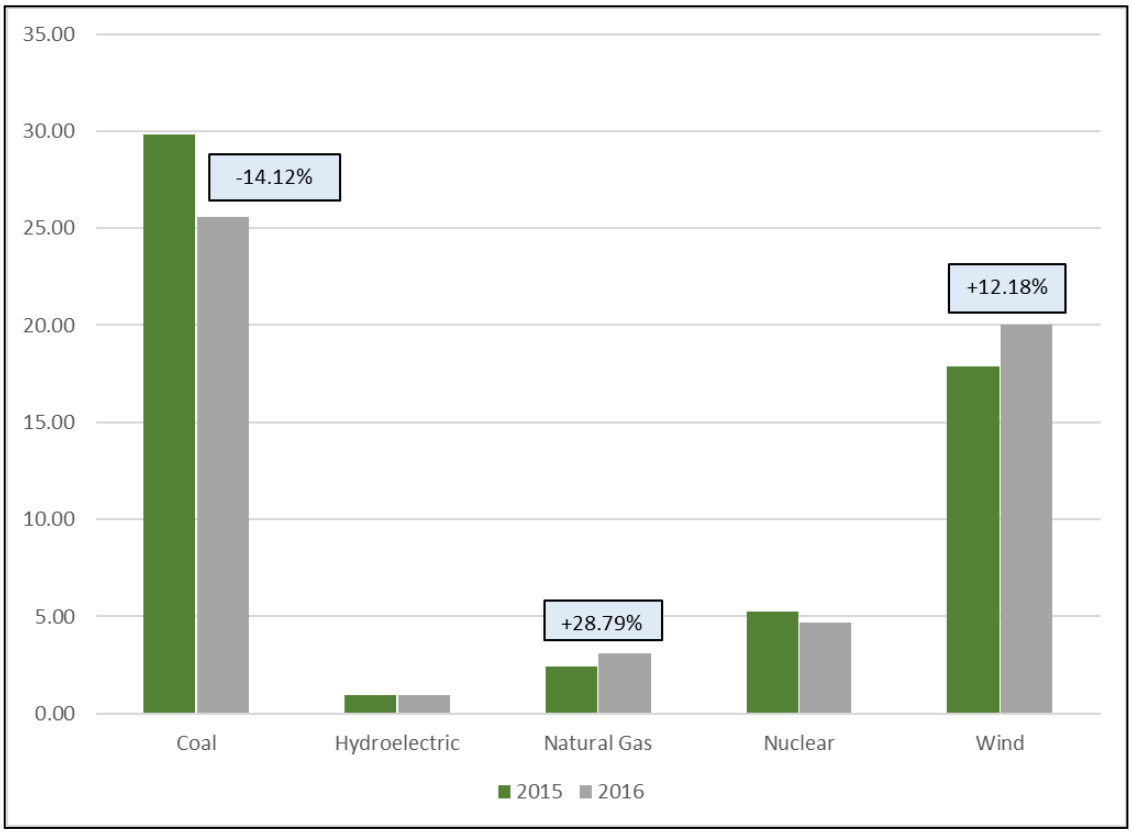
Actual fuel use data for 2016 for the RCI sector was not available from the U.S. Energy Information Administration (EIA), so emissions were calculated based on projected energy consumption values from the EIA's *Annual Energy Outlook 2017 with Projections to 2040.* Emissions predicted for 2015 from the RCI sector in last year's inventory (30.96 $MMtCO_2e$) were replaced with actual 2015

consumption values now available from EIA. The resulting recalculated 2015 emissions were 31.54 $MMtCO_2e$. Emissions from this sector increased because the consumption of fossil fuels by users in each category increased.

Power Plants

This category includes emissions from fossil fuels that are combusted at power plants to generate electricity. The DNR used emissions reported by power plants to EPA as required by the federal GHG reporting program (40 Code of Federal Regulations 98). The CO_2 emissions for these facilities are measured by continuous emission monitors (CEMS). Emissions from this sector decreased as electric generation from coal decreased and generation from renewables and natural gas increased as shown in Figure 4. Combustion of natural gas emits approximately half as much CO_2 as is emitted from the combustion of coal. CO_2 is not emitted when electricity is generated from "zero-emitting carbon sources" such as wind, hydroelectric or nuclear power.

Figure 4: 2015 and 2016 Net Iowa Electric Generation by Energy Source (Million Megawatt Hours)[7]



Industrial Processes

This sector 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 transmission and distribution. GHG emission trends in each process category vary, but overall total industrial process emissions increased 4.28% from 2015 - 2016 as shown in Table 4.

[7] U.S. EIA: Net Generation by State by Type of Producer by Energy Source, September 2017.

GHG emissions reported by industrial facilities to EPA as required by the federal GHG reporting program were used for these categories: ammonia and urea production, cement manufacture, iron and steel production, lime manufacture and nitric acid production. Emissions from the other categories were calculated using EPA's SIT.

Table 4: GHG Emissions from Industrial Processes ($MMtCO_2e$)

Category	2015	2016	% Change
Ammonia and Urea Production	0.81	0.92	+13.59%
Cement Manufacture	1.50	1.58	+4.88%
Electric Power Transmission & Distribution Systems	0.05	0.05	NA[8]
Iron and Steel Production	0.16	0.19	+14.80%
Lime Manufacture	0.13	0.15	+9.73%
Limestone and Dolomite Use	0.21	0.21	NA[8]
Nitric Acid Production	0.74	0.75	+1.07%
Ozone Depleting Substance Substitutes	1.64	1.63	-0.19%
Soda Ash Consumption	0.02	0.02	-2.48%
Total	**5.28**	**5.50**	**4.28%**

Natural Gas Transmission and Distribution (T & D)

This sector includes emissions from natural gas transmission and distribution systems in the state. GHG emissions increased 0.62% from 2015 as shown in Table 5, due to an increase in the number entities/customers connected to natural gas service in the state.

Table 5: GHG Emissions from Natural Gas Transmission and Distribution ($MMtCO_2e$)[9]

Category	2015	2016	% Change
Transmission	0.7868	0.7867	-0.01%
Distribution	0.6168	0.6205	+1.42%
Total	**1.4031**	**1.4073**	**+0.62%**

Transportation

The transportation sector includes GHG emissions from both highway and non-highway vehicles. Aviation, boats, locomotives, tractors, other utility vehicles and alternative fuel vehicles are considered non-highway vehicles. Emissions from highway vehicles are calculated based on vehicle miles traveled, while emissions from non-highway vehicles are calculated based on fuel consumption. Total vehicle miles traveled by Iowans increased 0.47%, resulting in a 0.28% increase in GHG emissions as shown in Table 6.

Table 6: GHG Emissions from Transportation ($MMtCO_2e$)

Category	2015	2016	% Change
Transportation	19.31	19.36	+0.28%

[8] Due to lack of current data, the DNR assumed 2015 emissions = 2016 emissions.

[9] DNR uses two decimal places throughout this report for consistency. However, in this sector four decimal places are needed to show the difference in emissions from year to year.

Waste

The waste sector includes GHG emissions from both solid waste landfills and the treatment of municipal and industrial wastewater. Overall, GHG emissions from waste increased 1.00% from 2015 as shown in Table 7 due to more solid waste being placed in landfills. DNR primarily used facility-specific emissions data directly reported by facilities to U.S. EPA. Emissions from smaller landfills that are not required to report to EPA were estimated using the LandGEM model. The SIT was used to estimate emissions from municipal wastewater treatment and combustion of municipal solid waste.

Table 7: GHG Emissions from Waste ($MMtCO_2e$)

Category	2015	2016	% Change
Solid Waste	1.69	1.71	+1.17%
Wastewater	0.45	0.45	+0.35%
Total	**2.14**	**2.16**	**+1.00%**

Land Use, Land Use Change, and Forestry (LULUCF)

The LULUCF sector includes emissions from liming agricultural soils and fertilizing lawns, golf courses and other landscaping (settlement soils). It also includes carbon sequestered by forests and urban trees, as well as carbon stored in yard waste and food scraps that are sent to the landfill. Data that is more current was used to recalculate carbon sequestration from forests and trees in 2015, and the 2015 value was used as a surrogate for 2016. This recalculation is discussed in detail in the Technical Support Document.

Overall, total 2016 emissions from LULUCF were 3.13 $MMtCO_2e$ as shown in Table 8. This is a 4.69% increase in the CO_2e being emitted. This can be attributed to increases in emissions from liming agricultural soils and fertilizing settlement soils (e.g. landscaping, lawns, golf courses). Due to a lack of current data, carbon sequestration from forest carbon flux and urban trees was assumed unchanged from 2015, as were emissions from urea fertilization and sequestration from yard trimmings and food scraps in landfills. Emissions from forest fires were not calculated due to a lack of data.

Table 8: GHG Emissions by LULUCF ($MMtCO_2e$)

Category	2015	2016	% Change
Forest Carbon Flux	2.87	2.87	NA[10]
Liming of Agricultural Soils	0.34	0.46	+37.22%
Urea Fertilization	0.15	0.15	NA[10]
Urban Trees	-0.74	-0.74	NA[10]
Yard Trimmings & Food Scraps in Landfills	-0.12	-0.12	NA[10]
Fertilization of Settlement Soils	0.49	0.51	+3.12%
Total	**2.99**	**3.13**	**+4.69%**

Carbon emitted or sequestered from agricultural soil carbon flux are not included in the inventory. This is because the SIT does not have a calculation function for this category and because of the uncertainty in this category. Scientific studies and literature reviews do not agree on the relationship between soil

[10] Due to a lack of current data, the DNR assumed 2015 values = 2016 values.

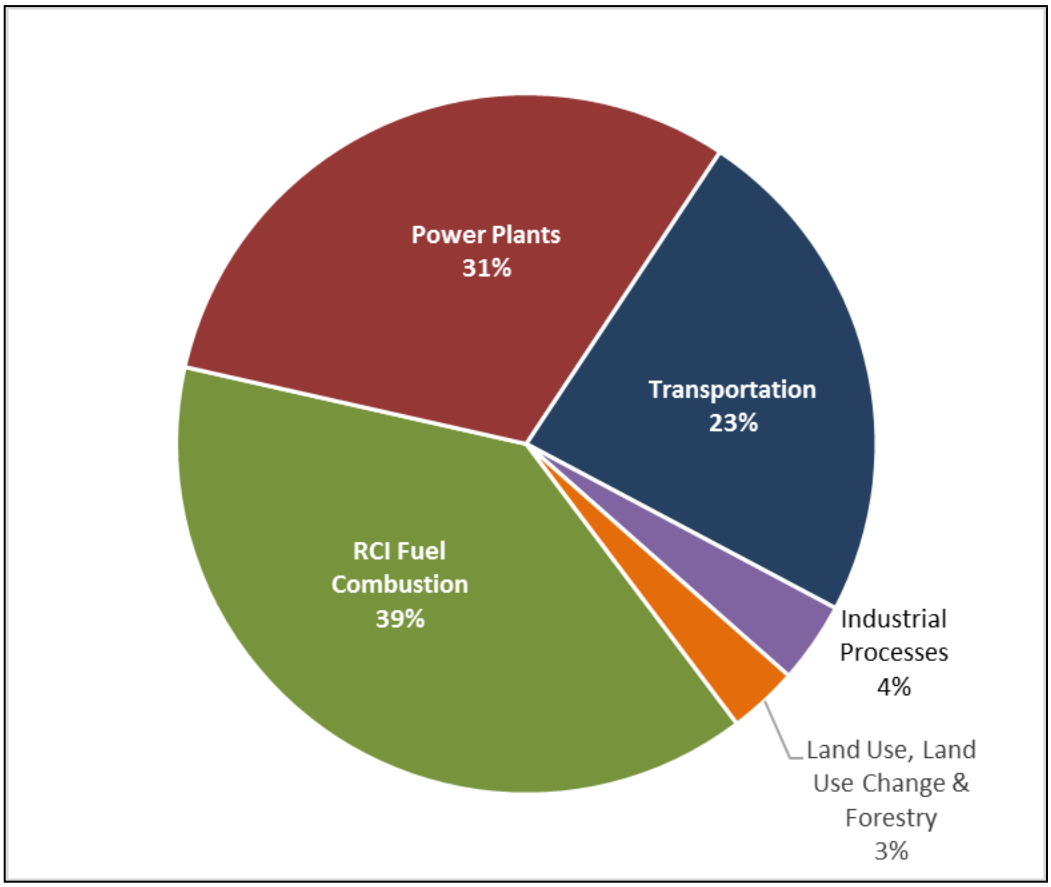
tillage and soil carbon. Therefore, the DNR did not include this category. More details on the uncertainty in soil carbon flux are included in the 2016 GHG Inventory Technical Support Document.

GHG Emissions by Pollutant

GHGs 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). Figures 5-8 show the distribution of GHG pollutants in 2016 by both pollutant and by category.

Carbon dioxide (CO_2) is the greenhouse gas emitted in the highest amounts in Iowa, accounting for 66.37% of all greenhouse gas emissions in 2016. Nearly all CO_2 emissions are from fossil fuel combustion and transportation as shown in Figure 5, with a small percentages coming from industrial processes such as the production of cement, lime, ammonia, urea, iron and steel; as well as the use of limestone, dolomite and soda ash in manufacturing.

Figure 5: 2016 Carbon Dioxide Emissions by Sector



Methane (CH_4) and nitrous oxide (N_2O) were emitted in smaller amounts, and the majority of these two pollutants are from agriculture as shown in Figures 6 and 7. CH_4 emissions were 20.86 $MMtCO_2e$ or 16.26% of total 2016 GHG emissions. N_2O emissions in 2016 were 24.94 $MMtCO_2e$ or 18.66% of total GHG emissions.

Figure 6: 2016 Methane Emissions by Sector

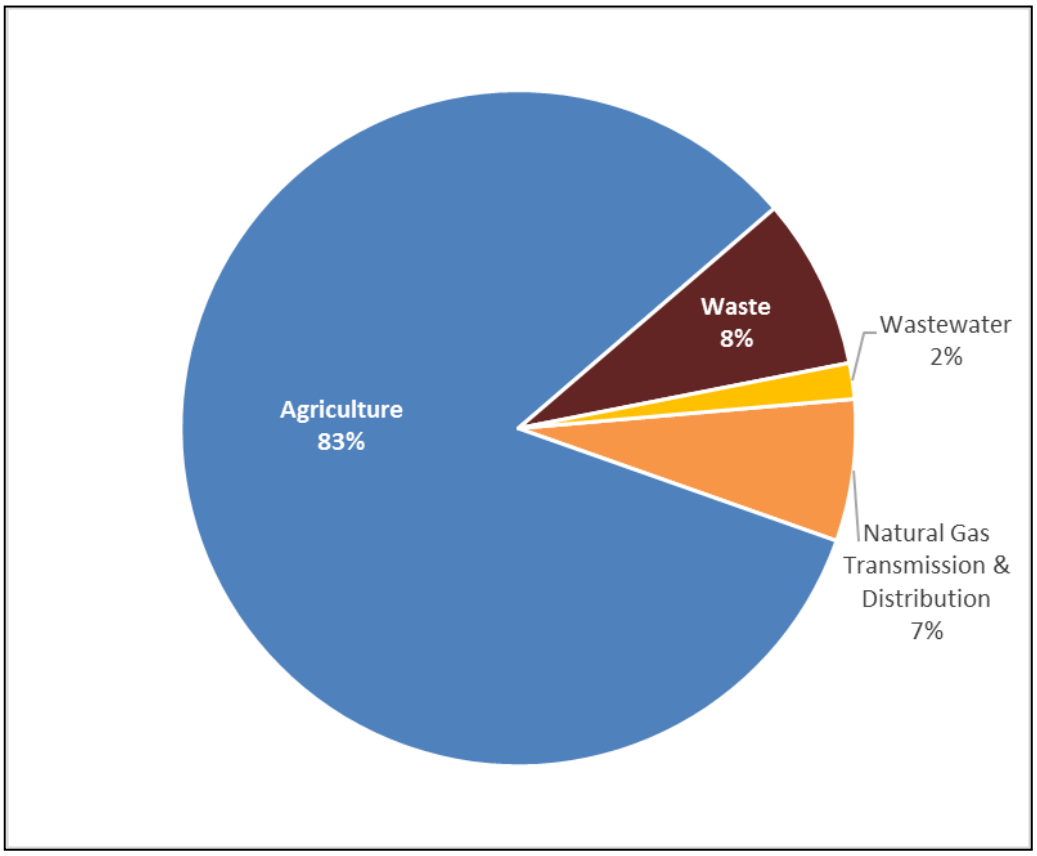
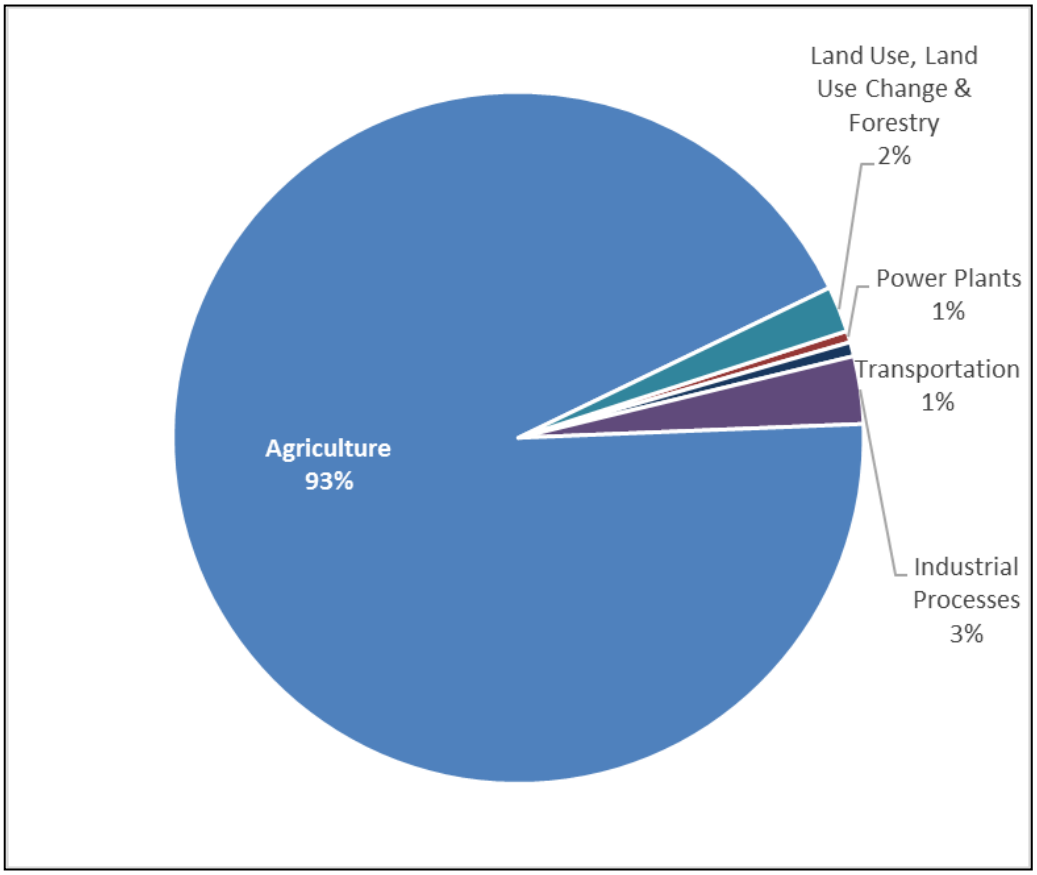
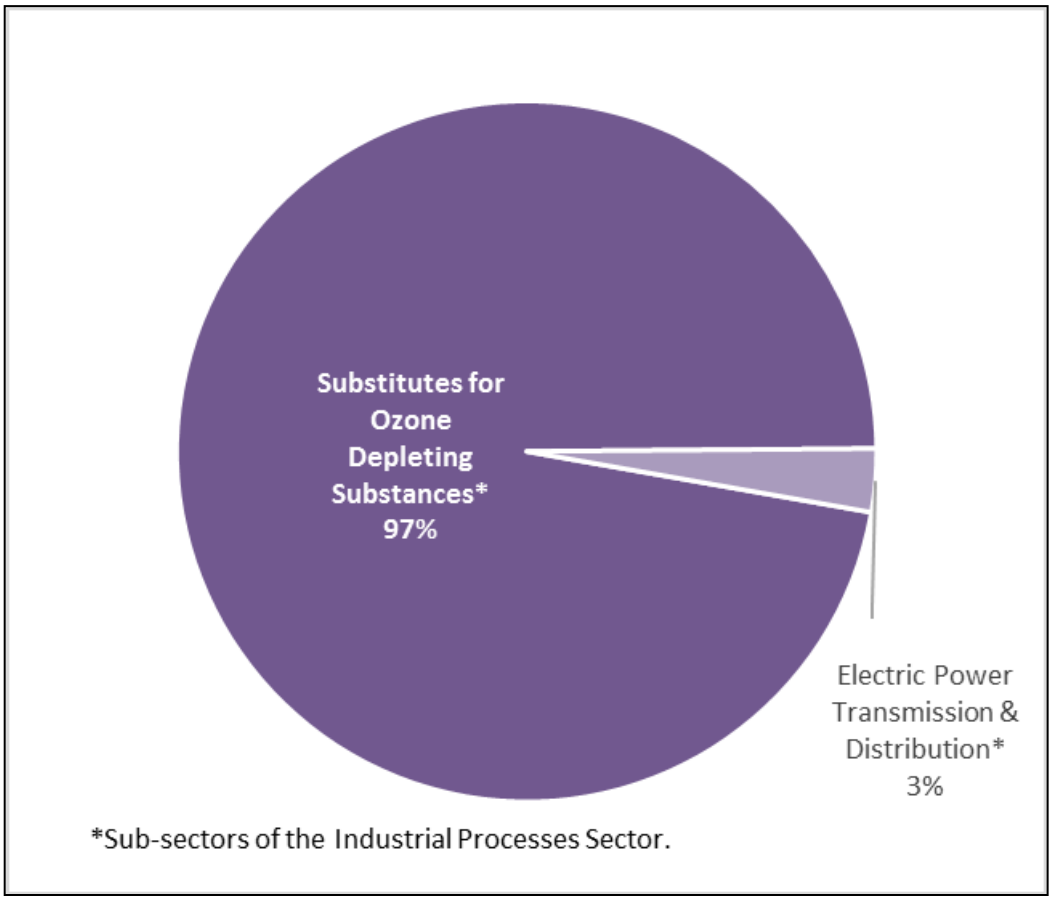


Figure 7: 2016 Nitrous Oxide Emissions by Sector



Emissions of Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) are accounted for in the Industrial Processes sector. They are emitted either from substitutes for ODS or as insulation in electric power transmission and distribution lines as shown in Figure 8. In 2016, emissions of these three pollutants totaled 1.68 $MMtCO_2e$ or 1.31% 2016 Iowa GHG emissions.

Figure 8: 2016 HFC/PFC/SF6 Emissions by Sector



Comparison with U.S. Emissions

Figures 9 and 10 compare Iowa and national GHG emissions by sector. Overall, Iowa emitted 1.95% of total 2015 U.S. GHG emissions. Agricultural emissions account for a greater percentage of GHG emissions in Iowa than in the total U.S., which is logical given Iowa's substantial agricultural economy.

The fossil fuel combustion, natural gas distribution and transmission, and transportation sectors have been combined into one sector called "Energy" to be consistent with the national GHG inventory. Emissions from 2015 are used for this comparison, as the 2016 national GHG inventory has not yet been published.

Figure 9: 2015 U.S. GHG Emissions by Sector

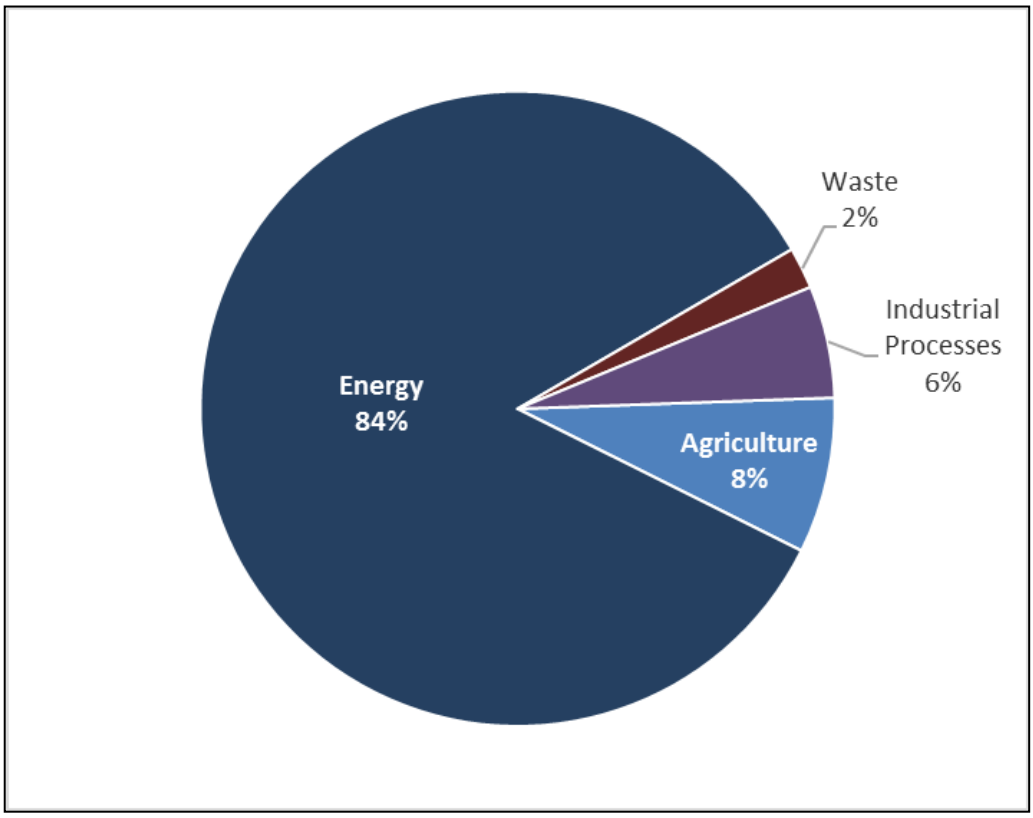
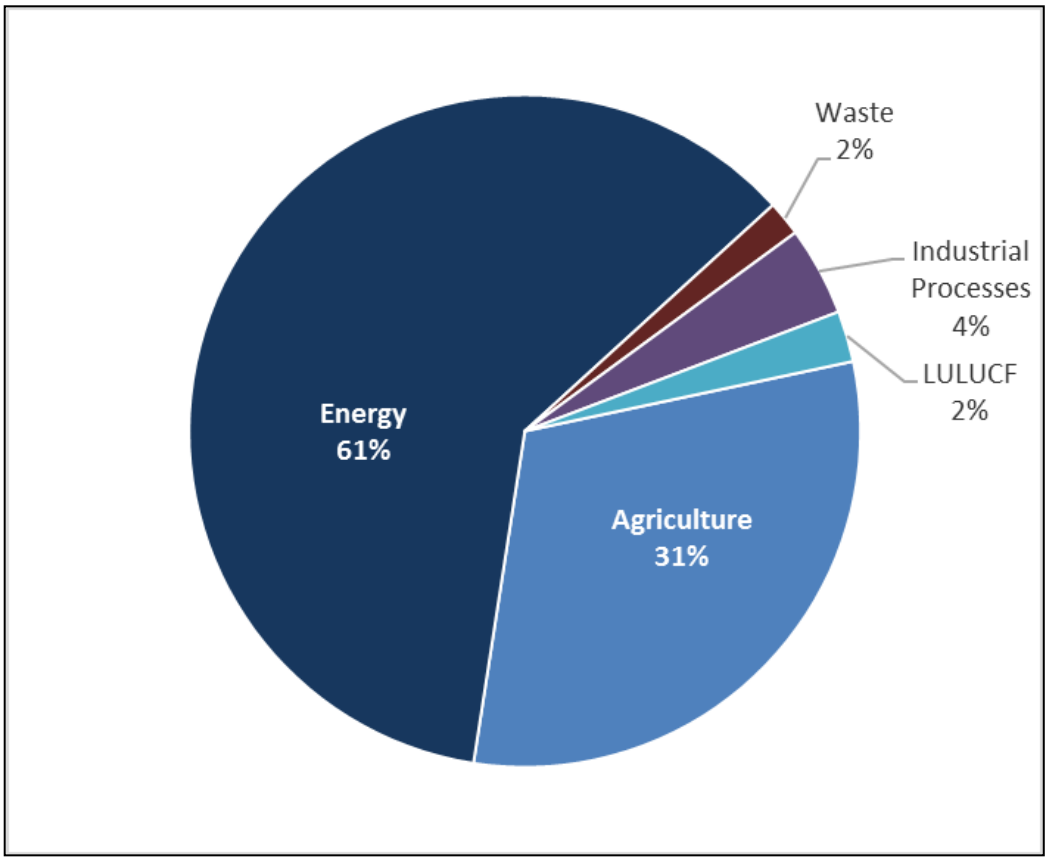


Figure 10: 2015 Iowa GHG Emissions by Sector



Future Emissions

Iowa Code 455B.104 requires that the DNR forecast trends in GHG emissions. The DNR projected emissions from 2016 to 2030 using the SIT Projection Tool. As with many forecasts, numerous factors affect the level of uncertainty with future emissions. These factors may include among other things – the economy, weather, current and future environmental regulations, energy efficiency and conservation practices, driving practices, use of renewable fuels, etc.

The SIT Projection Tool forecasts emissions from industrial processes, agriculture and waste based on historical emissions from 1990 – 2014, using a combination of data sources and national projections for activity data. The average annual change in emissions that the SIT projects are shown in Table 9.

Table 9: Average Annual Projected Change in Emissions 2017 - 2030

Sector	% Ave. Annual Change
Agriculture	+0.17%
Electric Power Generation Fossil Fuel Use	-2.05%
RCI Fuel Use	+0.27%
Industrial Processes	+3.48%
Natural Gas Transmission & Distribution	+0.71%
Transportation	-0.90%
Waste	+0.98%
Total Emissions	**-0.24%**

Short-term Projections for the Electric Power Sector

In April 2017, the U.S. Energy Information Administration of the Department of Energy announced that CO_2 emissions in the national energy sector fell 1.7% from 2015 – 2016 due to a reduction in electricity generated from coal and an increase in generation from natural gas and renewable energy. Weather also played a role, as warmer years may result in reduced energy consumption because it typically costs less to cool a home than heat it. Heating days in the U.S. in 2016 were the second lowest of any year in the past 67 years.[11]

However, the most recent emissions data available for Iowa power plants does not follow the same trend as national emissions. Data from EPA's Clean Air Markets Division shows that CO_2 emissions from the electric power generation during the first six months of 2017 are 15.05% higher than CO_2 emissions from the first six months of 2016. It is unclear what caused this trend, but some factors may be a change in the number of heating and/or cooling days, changes in the prices of different fuels or other market forces.

Although the SIT Projection Tool provides a good first look at projected future emissions, it has several areas of uncertainty:

1. Agricultural emissions are highly dependent on the weather and crop and livestock prices, which are not addressed by the Projection Tool.

[11] U.S. EIA: Today in Energy - April 10, 2017.

2. In sectors where the Projection Tool predicts future emissions based on historical emissions, it only uses emissions from 1990 – 2014 and does not consider 2015 - 2016 emissions.
3. The Projection Tool forecasts emissions from fossil fuel use based on the reference case from the EIA's *Annual Energy Outlook (AEO) 2016 with Projections to 2040*, which projects emissions at the regional level and not the state level. A more current reference case, *AEO 2017,* has been published but is not used by the tool.
4. The *AEO 2016* used includes implementation of the CPP, which is currently stayed and EPA proposes to repeal.
5. The Projection Tool does not address publicly announced changes to Iowa's fossil fuel generation mix:
    - Iowa utilities have announced that from 2016 - 2025, approximately 1,000 MW of coal-fired electric generation units will retire or convert to natural gas. During that same period, approximately 185 MW of older natural gas-fired electric generation units will retire, and approximately 650 MW of newer, more efficient natural gas-fired electric generating units will come online. This will significantly reduce emissions from the electric power sector as natural gas emits approximately 50% less CO_2 per heating unit than coal emits.
    - At least 3,200 MW of additional renewables are planned for 2017 - 2020.

Future Improvements

The DNR continually strives to make the annual statewide GHG inventory as accurate and timely as possible. Possible areas for enhancement include improved forecasting and a more extensive literature review of research regarding soil carbon. Additionally, the DNR plans to work with U.S. EPA GHG inventory staff to investigate whether emissions from the application of synthetic fertilizer are double-counted in the agriculture and LULUCF sectors.