IOWA DEPARTMENT OF NATURAL RESOURCES

2015 Iowa Statewide Greenhouse Gas Emissions Inventory Report

Required by Iowa Code 455B.104

December 14, 2016

Iowa Department of Natural Resources
502 E. 9th Street
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 31st each year. This report focuses on calendar year 2015 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 is a "top-down" inventory 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 electric generating facilities. 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.

2015 Statewide GHG Emissions

In 2015, total gross Iowa greenhouse gas emissions were 129.05 million metric tons carbon dioxide equivalents ($MMtCO_2e$) as shown in Table 1 on page 4. This is a decrease of 4.42 $MMtCO_2e$ (3.31%) from 2014. Most of this decrease comes from a 3.98 $MMtCO_2e$ reduction from electric generating facilities due to mild weather, decreased electric generation from coal and increased generation from zero-emitting sources such as wind, hydropower and solar. In 2015, 608 MW of new wind generation was installed, 355 MW of coal generating units were converted to natural gas and 131 MW of coal generation was retired.[1]

Emissions from residential, commercial and industrial fuel use decreased by 1.85 $MMtCO_2e$ (5.65%). This also helped to offset increases in emissions from agriculture (+2.68%), transportation (+1.72%), waste (+6.78%) and other sectors. Total 2015 statewide GHG emissions were 7.60% lower than their peak in 2007 as shown in Figures 1 and 2 on pages 5 and 6.

[1] Based on information provided to Iowa DNR by MidAmerican Energy Company and Alliant Energy.

Table 1: GHG Emissions 2005 – 2015 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	Change from 2014		
												$MMtCO_2e$	%	
Agriculture	32.14	34.25	38.73	34.81	34.63	34.07	36.61	34.90	**35.22**	**36.26**	37.23	+0.97	+2.68%	↑
Fuel Use by Electric Generating Facilities	36.84	36.35	40.04	41.78	37.71	42.33	38.98	35.76	33.06	33.44	29.46	-3.98	-11.89%	↓
Residential, Commercial, and Industrial Fuel Use	24.07	24.32	26.21	27.75	27.66	28.56	31.31	29.65	31.50	**32.81**	30.96	-1.85	-5.65%	↓
Industrial Processes	4.58	4.71	4.70	4.93	4.23	4.80	4.49	5.18	5.20	**4.91**	5.01	+0.10	+2.00%	↑
Land Use, Land Use Change, and Forestry (LULUCF)[3]			3.41				0.66	0.48		**3.29**	3.18	-0.11	-3.30%	↓
Natural Gas Transmission and Distribution	1.15	1.15	1.16	1.17	1.17	1.17	1.18	1.18	1.18	1.18	1.17	-0.004	-0.32%	↓
Transportation	21.88	22.38	22.81	21.97	21.42	22.07	**19.56**	**19.58**	**19.50**	**19.88**	20.22	+0.34	+1.72%	↑
Waste	2.62	2.56	2.60	2.62	2.58	**1.77**	**1.76**	**1.90**	**1.72**	**1.70**	1.82	+0.12	+6.78%	↑
Total Gross Emissions	123.27	125.73	139.67	135.04	129.41	**134.77**	**134.55**	**128.62**	**127.38**	**133.47**	129.05	-4.42	-3.31%	↓
Carbon Stored in LULUCF[4]	-20.54	-5.79		-3.91	-5.00	-2.00			-0.74					
Total Net Emissions	102.73	119.93	139.67	131.13	124.42	**132.77**	**134.55**	**128.62**	**126.64**	**133.47**	129.05	-4.42	-3.31%	↓

[2] Totals may not equal the exact sum of subtotals in this table due to independent rounding. Values that are bolded have been adjusted since the previous 2014 inventory published by the DNR in December 2015. 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 – 2015 ($MMtCO_2e$)

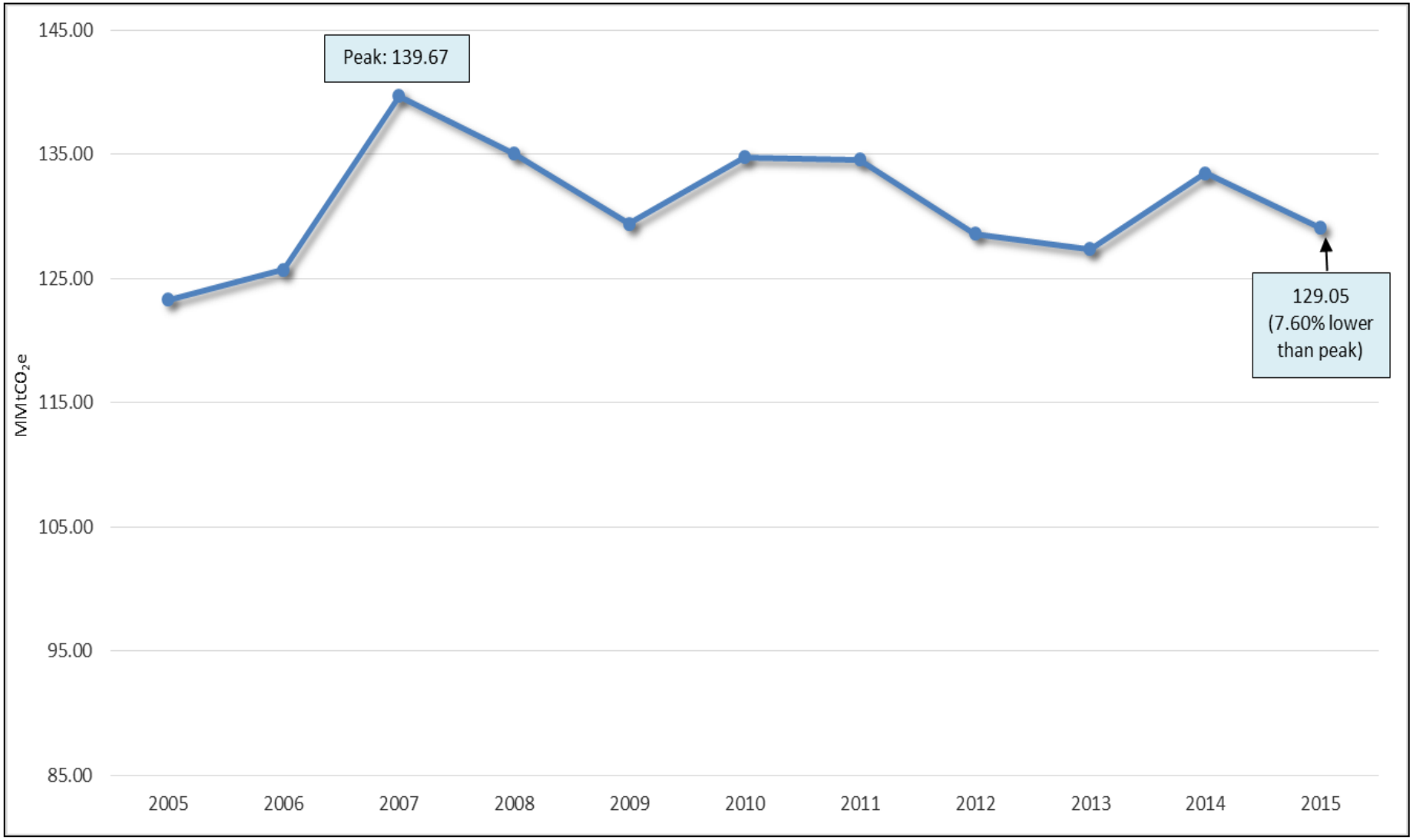
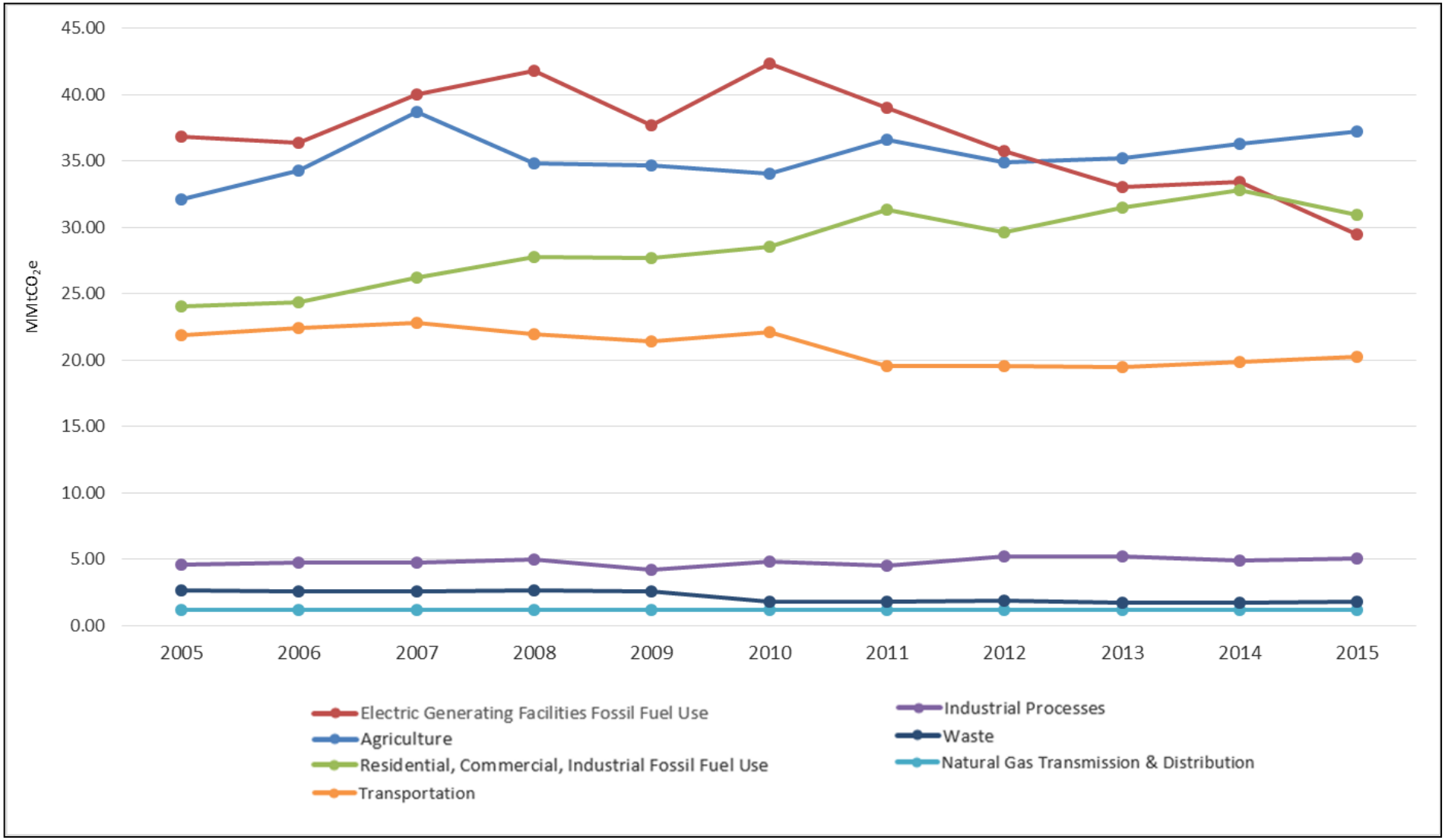


Figure 2: Iowa Gross[5] GHG Emissions 2005 – 2015 by Sector ($MMtCO_2e$)

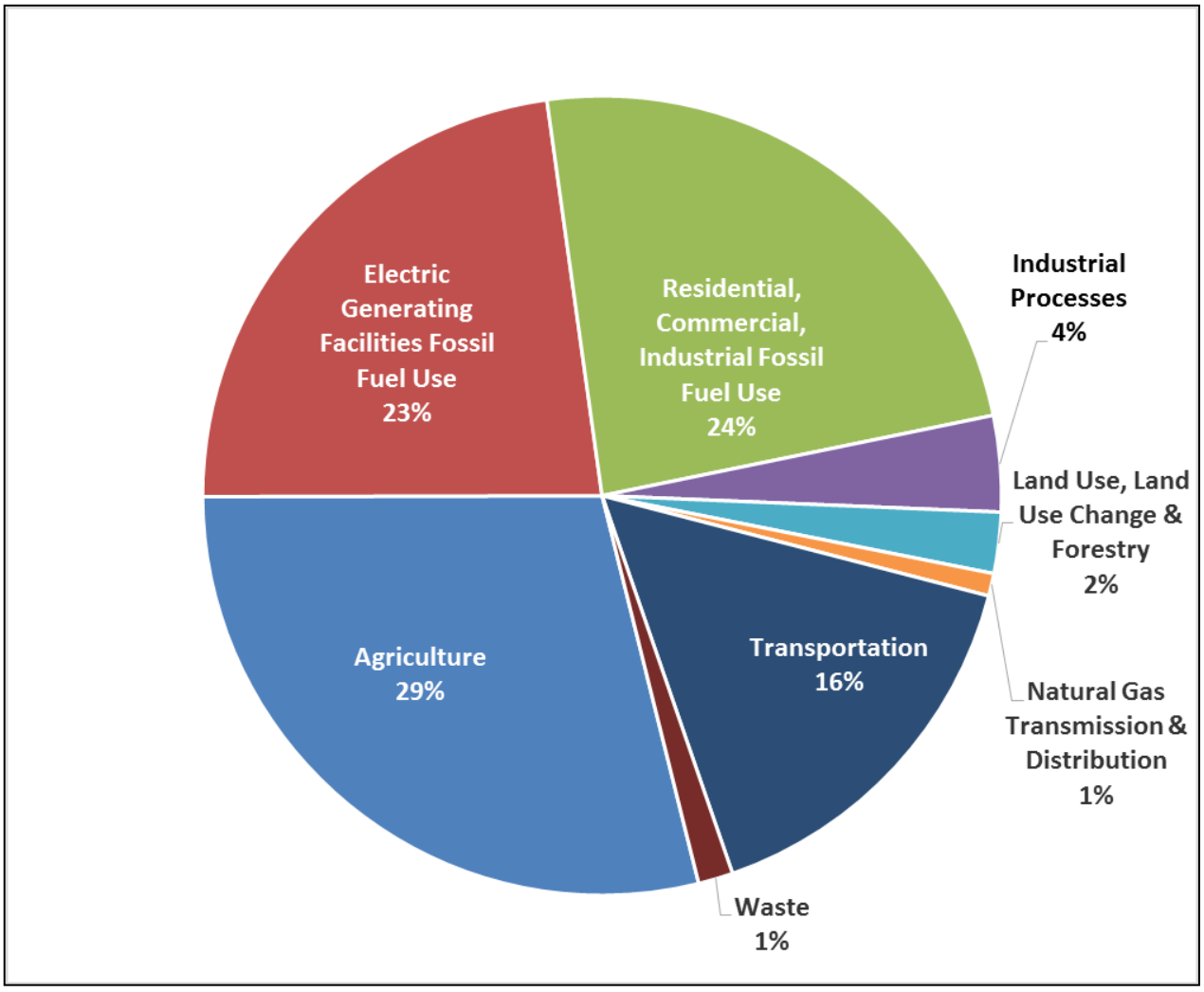


[5] Does not include carbon storage or emissions from land use, land use change, and forestry (LULUCF).

GHG Emissions by Sector

The majority of GHG emissions in Iowa in 2015 were from the agriculture sector and from fossil fuel use by electric generating facilities and the residential/commercial/ industrial (RCI) sectors. Together the emissions from electric generation and RCI fuel use account for nearly half (46.82%) of the state's GHG emissions as shown in Figure 3 below.

Figure 3: 2015 Iowa GHG Emissions by Sector[6]



Emissions from each sector are summarized below. For more information on a specific sector, such as sources of emissions, calculations and uncertainty, please refer to the Iowa DNR Technical Support Document.

[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.

Agriculture

This sector includes GHG emissions from livestock and crop production such as enteric fermentation, manure management, agricultural soils and burning of agricultural crop waste. Enteric fermentation includes emissions from the digestive systems of ruminant animals. Emissions from agricultural soils include emissions from animals and 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. In 2015, agriculture emissions increased 2.68% from the previous year as shown in Table 2 below due to increases in both livestock and crop production.

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

Category	2014	2015	% Change
Enteric Fermentation	6.85	7.02	+2.41%
Manure Management	8.47	8.75	+3.39%
Agricultural Soil Management	20.94	21.46	+2.48%
Total	**36.26**	**37.23**	**+2.68%**

Fossil Fuel Combustion

This sector includes GHG emissions from fossil fuels combusted in four categories: electric generating facilities, residential, industrial and commercial. The residential, industrial and commercial categories are often combined into one category called RCI. Together, these four categories account for 46.82% of Iowa's GHG total emissions. This is the first year that emissions from fossil fuel combustion did not account for 50% or more of Iowa's total GHG emissions, mostly due to the decrease in the amount of fossil fuels burned to generate electricity. Emissions from electric generating facilities decreased by 3.98 $MMtCO_2e$ (11.89%) from the previous year, and emissions from the other three fossil fuel combustion categories also decreased as shown in Table 3.

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

Category	2014	2015	% Change
Residential, Commercial, Industrial (RCI)	32.81	30.96	-5.65%
Residential	*5.37*	*4.28*	*-20.24%*
Commercial	*4.91*	*4.42*	*-10.01%*
Industrial	*22.53*	*22.25*	*-1.22%*
Electric Generating Facilities	33.44	29.46	-11.89%
Total	**66.25**	**60.42**	**-8.80%**

Residential, Commercial, Industrial (RCI)

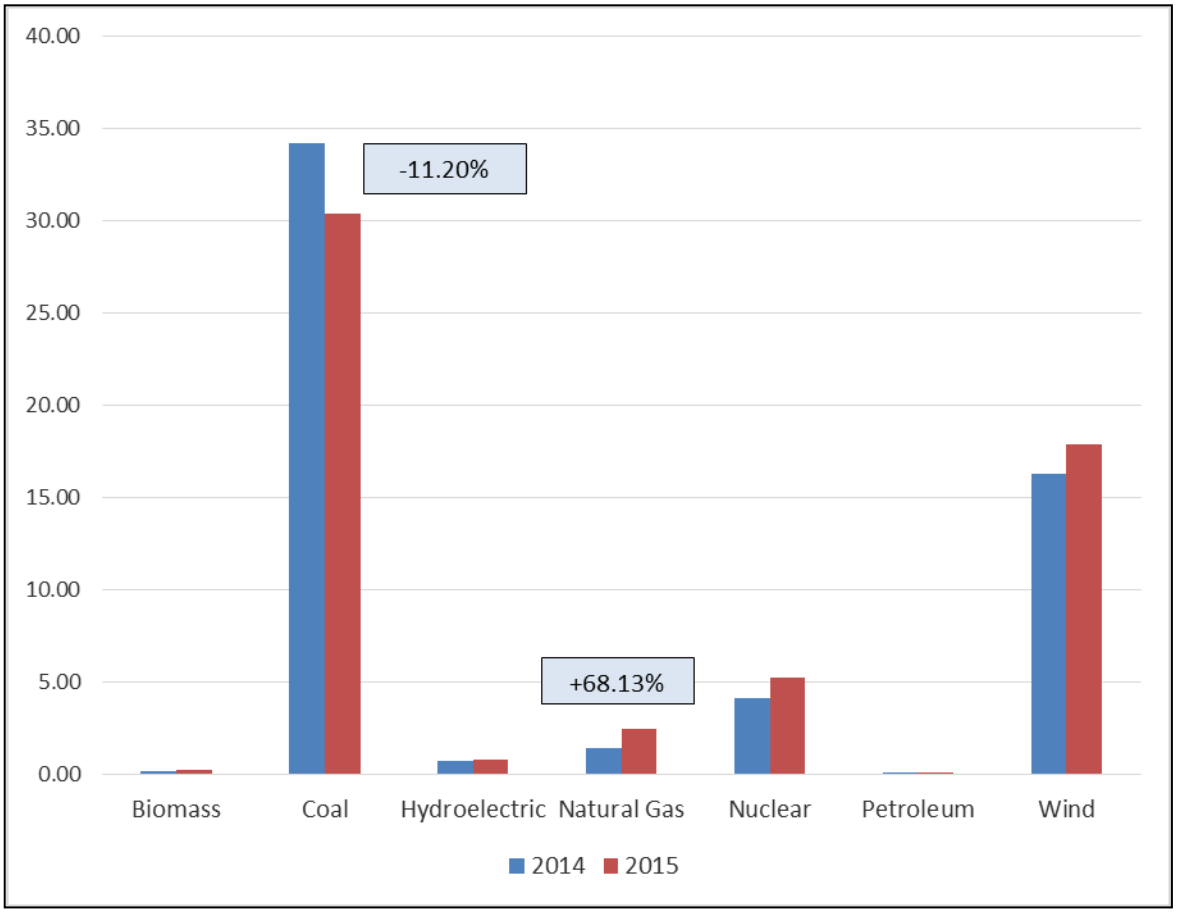
Actual fuel use data for 2015 for the RCI sector was not available from the U.S. Energy Information Administration (EIA), so emissions were calculated based on projected energy consumption values from the EIA's *Annual Energy Outlook 2016 with Projections to 2040.* Emissions predicted for 2014

from the RCI sector in last year's inventory (33.44 $MMtCO_2e$) were replaced with actual 2014 consumption values now available from EIA. The resulting recalculated 2014 emissions were 32.81 $MMtCO_2e$. Emissions from this sector decreased because the consumption of fossil fuels by users in each category decreased, as did consumption of electricity.

Electric Generating Facilities

For the electric generating facilities category, 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 below. 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 wind, hydroelectric or nuclear power and are often referred to as "zero-emitting carbon sources".

Figure 4: 2014 and 2015 Net Iowa Electric Generation by Energy Source (Million Megawatt Hours)[7]



[7] U.S. EIA: Net Generation by State by Type of Producer by Energy Source, September 26, 2016.

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 2.00% from 2014 - 2015 as shown in Table 4.

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 ($MMtCO_2e$)l

Category	2014	2015	% Change
Ammonia and Urea Production	0.86	0.81	-5.65%
Cement Manufacture	1.38	1.50	+8.80%
Electric Power Transmission & Distribution Systems	0.06	0.06	NA[8]
Iron and Steel Production	0.18	0.16	-10.59%
Lime Manufacture	0.17	0.13	-18.83%
Limestone and Dolomite Use	0.21	0.21	NA[4]
Nitric Acid Production	0.69	0.77	+11.63%
Ozone Depleting Substance Substitutes	1.33	1.34	-0.26%
Soda Ash Consumption	0.02	0.02	-4.51%
Total	**4.91**	**5.01**	**+2.00%**

Natural Gas Transmission and Distribution (T & D)

This sector includes emissions from natural gas transmission and distribution systems in the state. 2015 GHG emissions decreased 0.32% from 2014 as shown in Table 5, due to a decrease in the number of steel services (e.g. gas meters).

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

Category	2014	2015	% Change
Transmission	0.6605	0.6609	+0.06%
Distribution	0.5181	0.5139	-0.81%
Total	**1.1786**	**1.1748**	**-0.32%**

[8] Due to a lack of current data, the DNR assumed 2014 emissions = 2015 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.

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 to be 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 2.40%, resulting in a 1.72% increase in GHG emissions as shown in Table 6.

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

Category	2014	2015	% Change
Transportation	19.88	20.22	+1.72%

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 6.78% from 2014 as shown in Table 7 due to more solid waste being placed in landfills and less landfill gas being collected, combusted and/or flared. DNR primarily used facility-specific emissions data directly reported by landfills and industrial wastewater facilities to U.S. EPA for these calculations. 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 ($MMtCO_2e$)[10]

Category	2014	2015	% Change
Solid Waste	1.2994	1.4189	+9.20%
Wastewater	0.4008	0.3965	-1.08%
Total	**1.7003**	**1.8155**	**+6.78%**

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. Carbon sequestration from forests and trees in 2014 was recalculated using more current Iowa-specific data, and the 2014 value was used as a surrogate for 2015. This recalculation is discussed in detail in the

[10] 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.

Technical Support Document. Overall, total 2015 emissions from LULUCF were 3.18 $MMtCO_2e$ as shown in Table 8. This is a 3.30% decrease in the amount of CO_2e being emitted. This can be attributed to decreases in emissions from liming agricultural soils and fertilizing settlement soils as well as an increase in the amount of CO_2e sequestered in yard trimmings and food scraps disposed of in landfills. Due to a lack of current data, carbon sequestration from forest carbon flux and urban trees was assumed to be unchanged from 2014, as were emissions from urea fertilization. Emissions from forest fires were not calculated due to a lack of data.

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

Category	2014	2015	% Change
Forest Carbon Flux	3.04	3.04	NA[11]
Liming of Agricultural Soils	0.41	0.34	-17.17%
Urea Fertilization	0.15	0.15	-3.58%
Urban Trees	-0.74	-0.74	NA[6]
Yard Trimmings & Food Scraps in Landfills	-0.1164[12]	-0.1118	+1.69%
Fertilization of Settlement Soils	0.55	0.51	-5.79%
Total	**3.29**	**3.18**	**+3.30%**

Carbon emissions or sequestration 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. Recent scientific studies and literature reviews do not agree on the relationship between soil 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 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 2015 by both pollutant and by category.

Carbon dioxide (CO_2) is the greenhouse gas emitted in the highest amounts in Iowa, accounting for 66.31% of all greenhouse gas emissions in 2015 as shown in Figure 5. Nearly all CO_2 emissions are from fossil fuel combustion and transportation as shown in Figure 6, with a small percentage 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.

[11] Due to a lack of current data, the DNR assumed 2014 values = 2013 values.

[12] 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.

Figure 5: 2015 GHG Emissions by Pollutant ($MMtCO_2e$)

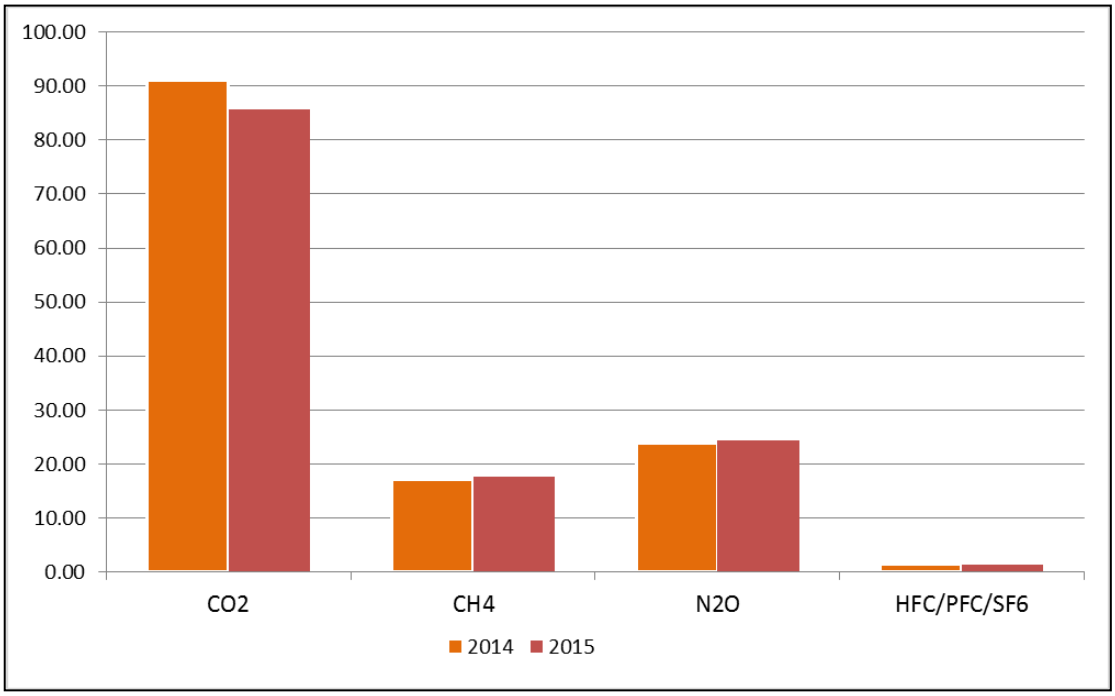
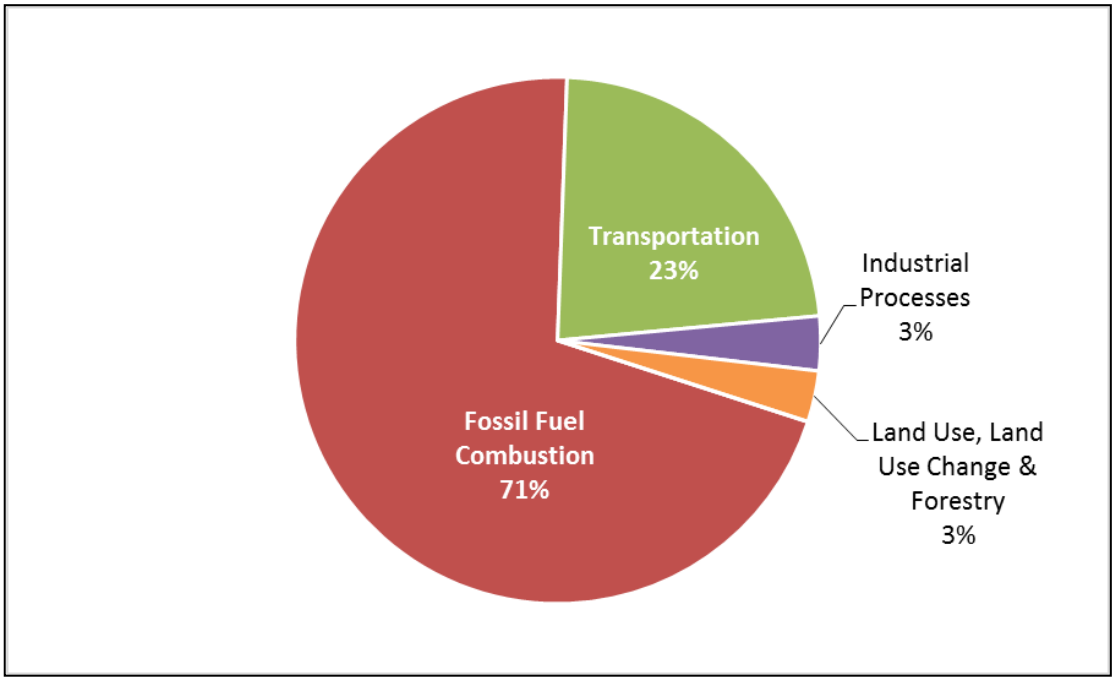


Figure 6: 2015 Carbon Dioxide Emissions by Sector



Methane (CH_4) and nitrous oxide (N_2O) were emitted in smaller amounts: 17.71 $MMtCO_2e$ of CH_4 and 24.37 $MMtCO_2e$ of N_2O. The majority of these two pollutants are from agriculture as shown in Figures 7 and 8. Emissions of Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6)

are emitted in the Industrial Processes sector. In 2015, emissions of these three pollutants totaled 1.39 $MMtCO_2e$ or 1.08% of total 2015 Iowa GHG emissions.

Figure 7: 2015 Methane Emissions by Sector

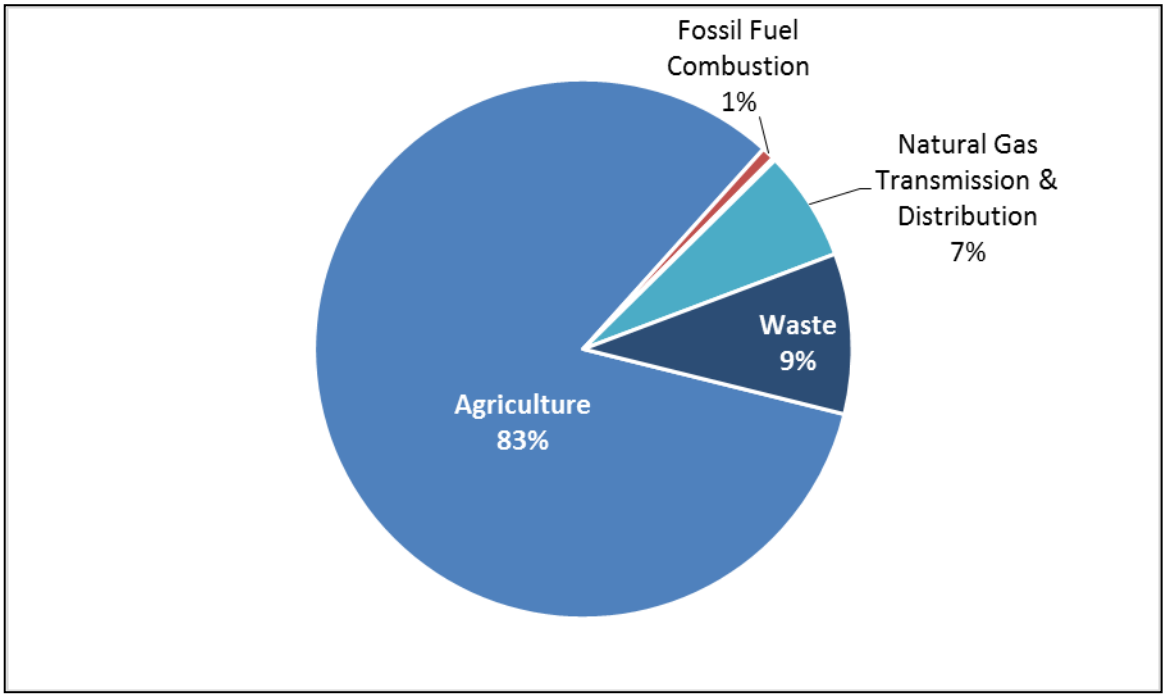
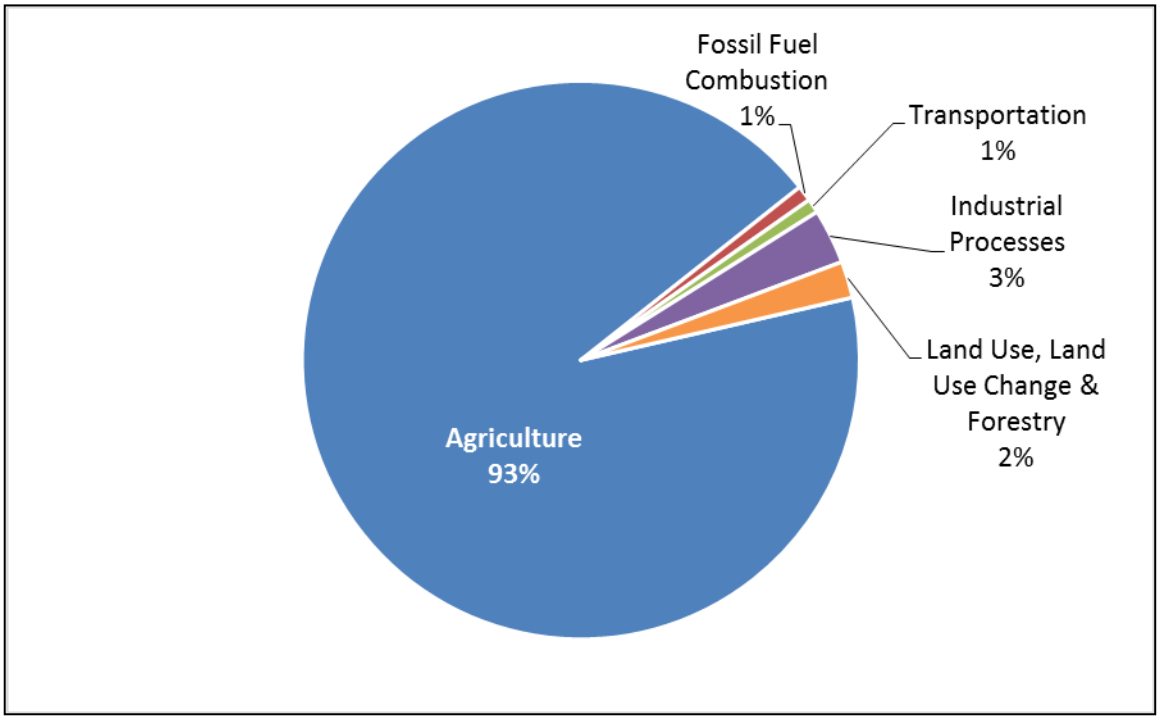


Figure 8: 2015 Nitrous Oxide Emissions by Sector



Comparison with U.S. Emissions

Figures 9 and 10 below 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 2014 are used for this comparison as the 2015 national GHG inventory has not yet been published. Overall, Iowa emitted 1.94% of total 2014 U.S. GHG emissions. Nationally, there were no emissions from the LULUCF sector as carbon was stored, not emitted. Agriculture emissions account for a greater percentage of GHG emissions in Iowa than in the total U.S., which is logical given Iowa's robust agricultural economy.

Figure 9: 2014 U.S. GHG Emissions by Sector

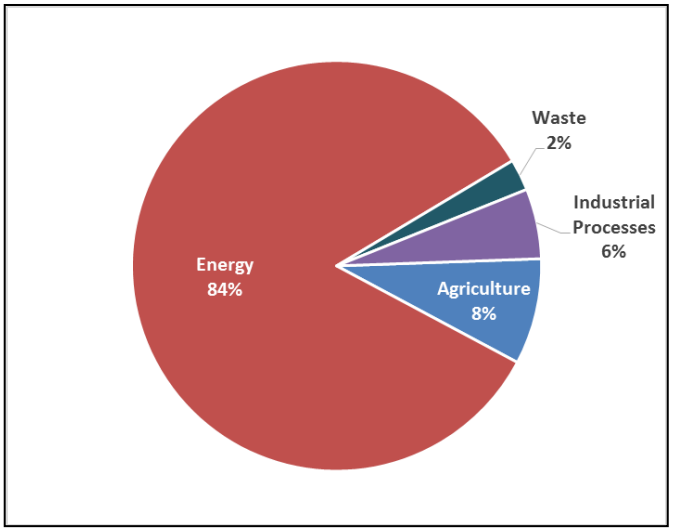
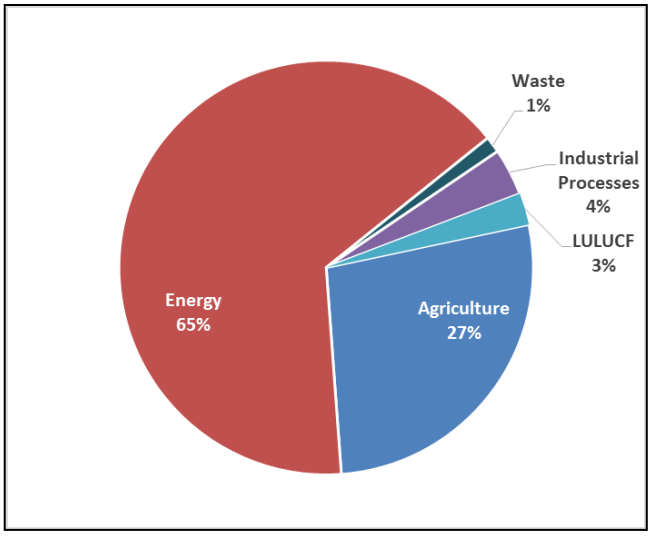


Figure 10: 2014 Iowa GHG Emissions by Sector



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, there are numerous factors that 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 – 2012, 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 on the next page.

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

Sector	% Ave. Annual Change
Agriculture	+0.49%
Electric Power Generation Fossil Fuel Use	-1.64%
RCI Fuel Use	+0.08%
Industrial Processes	+3.04%
Natural Gas Transmission & Distribution	+0.71%
Transportation	-0.77%
Waste	+0.94%
Total Emissions	**-0.25%**

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

1. In sectors where the Projection Tool predicts future emissions based on historical emissions, it only uses emissions from 1990 – 2012 and does not consider 2013 - 2015 emissions.
2. Agricultural emissions are highly dependent on the weather and crop and livestock prices, which are not addressed by the Projection Tool.
3. The Projection Tool forecasts emissions from fossil fuel use based on the reference case from the EIA's *Annual Energy Outlook 2016 with Projections to 2040*, which projects emissions at the regional level and not the state level.
4. 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 time 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.
    - Approximately 4,000 MW of additional wind generation is planned to come online from 2016 – 2018, and at least an additional 9.5 MW of solar generation is planned to come online from 2016 – 2017.

- The Projection Tool does not address any future changes in emissions due to the EPA's Clean Power Plan (CPP) rule. The rule requires Iowa to reduce CO_2 emissions from affected energy generating units on the step-down schedule shown in Table 10. Iowa may choose to comply with a rate based-goal or one of two mass based-goals: one including existing sources only or one including both existing and new sources. EPA's implementation of the CPP was stayed by the U.S. Supreme Court on February 9, 2016 and is currently being litigated.

Table 10: EPA Clean Power Plan Interim (2022-2029) and Final Goals (2030) for Iowa

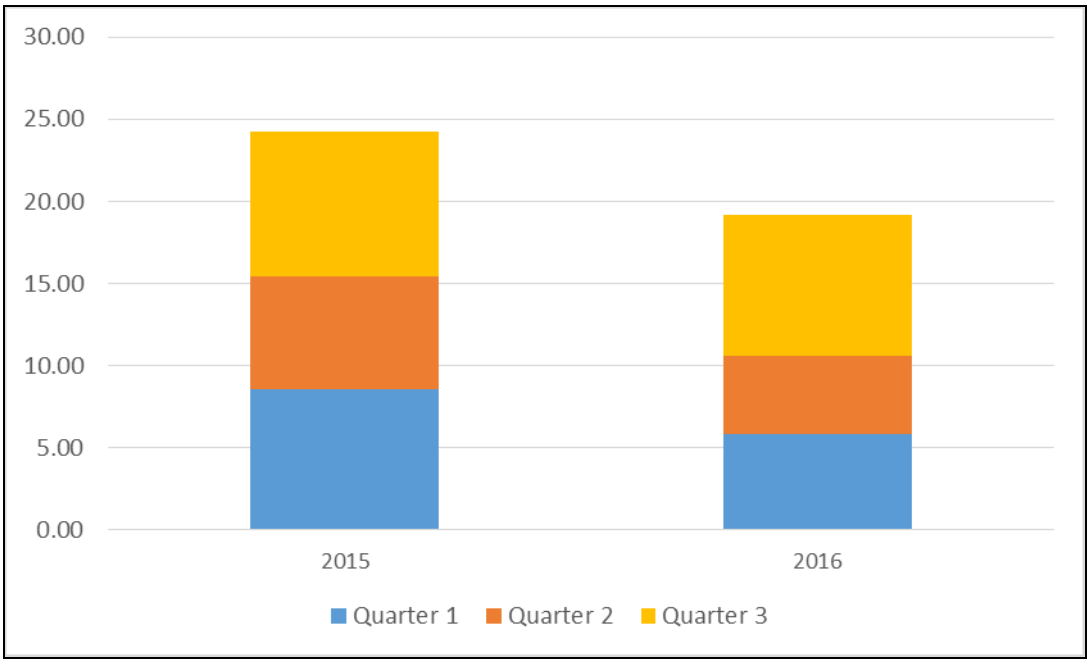
Time Period	CO_2 Rate (lbs./net MWh)	CO_2 Emissions ($MMtCO_2$)[13]	
2012 Historic	2,195	34.60	
		Mass-Based Goal	
	Rate-Based Goal	Existing Sources	Existing & New Sources
Interim Step 1	1,638	27.59	27.70
Interim Step 2	1,472	25.05	25.43
Interim Step 3	1,355	23.57	23.93
Final Goal 2030+	1,283	22.70	22.94

In October 2016, the EIA announced[14] that CO_2 emissions in the national energy sector during the first six months of 2016 decreased to their lowest levels since 1991. EIA attributes this to mild weather, decreasing coal use and increased electric generation from zero-emitting sources such as wind, solar and hydropower.

The most recent emissions data available for Iowa power plants follows similar trends. Data from EPA's Clean Air Markets Division (CAMD)[15] shows that CO_2 emissions from the electric power generation sector during the first nine months of 2016 are 20.92% lower than CO_2 emissions from the first nine months of 2015 as shown in Figure 11 on the next page. Decreased emissions are also related to the decreasing price of renewables and the low price of natural gas, which is in turn related to the amount of natural gas from fracking and other market forces. CO_2 emissions from the electric generating facilities may increase if the natural gas price increases.

[13] The emissions goals in the Clean Power Plan are in units of tons of CO_2 per year. The mass goals in Table 10 have been converted to million metric tons CO_2 ($MMtCO_2$) per year so that they are comparable to the results of 2015 Iowa Statewide GHG Inventory.
[14] U.S. EIA: Today in Energy, October 12, 2016.
[15] U.S. EPA, Clean Air Markets Program Data, November 3, 2016.

Figure 11: Quarterly CO_2 Emissions from Electric Power Generation ($MMtCO_2$)



Future Improvements

The DNR continually strives to make the annual statewide GHG inventory as accurate and timely as possible. DNR intends to update historical emissions in the 2017 Inventory report with the global warming potentials from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4). Rules requiring the use of the IPCC AR4 global warming potentials are currently going through the rulemaking process and will likely be effective in March 2017. Other areas for enhancement include improved forecasting and a more extensive literature review of research regarding soil carbon flux emissions or sinks. Furthermore, 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.