2023 Iowa Statewide Greenhouse Gas Emissions Inventory Report

Required by Iowa Code 455B.104

December 30, 2024

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Background

This report is prepared per Iowa Code 455B.104, which requires the Iowa Department of Natural Resources (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 and is beneficial because it provides an opportunity to evaluate Iowa-specific GHG emissions trends, is more detailed and more accurate than national efforts, and can be used to establish a baseline for tracking emissions reductions progress in Iowa. This report focuses on calendar year 2023 GHG emissions and includes emissions of six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC), hydrofluorocarbons (HFC), and sulfur hexafluoride (SF_6).

The emissions are 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 depth in the DNR's Technical Support document (TSD), available on the DNR's Greenhouse Gas Emissions webpage.

The DNR previously used the global warming potentials (GWPs) from the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) to estimate emissions through emissions year 2022. Beginning with 2023 emissions, DNR used the GWPs from the IPCC's Fifth Assessment Report (AR5). All values in this report were updated to the AR5 GWPs and may not match values previously published. The GWP values used are shown in Table 1.

Table 1: Global Warming Potentials

Pollutant	GWPs used by DNR until 2022	GWPs used by DNR in this report
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	25	28
Nitrous Oxide (N_2O)	298	265
Sulfur Hexafluoride (SF_6)	22,600	23,500
Hydrofluorocarbons (HFC)	Varies by pollutant – For a complete list, refer to DNR's Greenhouse Gas Emissions Estimation Guidance.	Varies by pollutant – For a complete list, refer to DNR's Greenhouse Gas Emissions Estimation Guidance.
Perfluorocarbons (PFC)		

2023 Statewide GHG Emissions

In 2023, total gross Iowa greenhouse gas emissions were 125.95 million metric tons carbon dioxide equivalent ($MMtCO_2e$) as shown in Table 2 and Figure 1. This is a decrease of 1.02 $MMtCO_2e$ (-0.80%) from 2022 and a decrease of 5.40% from 2014. The 1.02 $MMtCO_2e$ decrease in emissions is largely attributed to the following combination of reductions and partially offsetting increases:

- A 0.94 $MMtCO_2e$ decrease in emissions from residential, commercial and industrial fossil fuel combustion,
- A 0.49 $MMtCO_2e$ decrease in emissions from power plants, due to decreased generation of electricity from coal,
- A 0.10 $MMtCO_2e$ decrease in emissions from industrial processes,
- And a 0.44 $MMtCO_2e$ increase in emissions from mobile combustion due to an increase in vehicle miles traveled.

Emissions fluctuations from other sectors were smaller in magnitude, as shown in Figure 2, and differed by 0.07 $MMtCO_2e$ or less per sector from 2022.

Table 2: GHG Emissions 2014 – 2023 by Sector (Million Metric Tons Carbon Dioxide Equivalents ($MMtCO_2e$))[1]

Emissions ($MMtCO_2e$)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Change from 2022		
											$MMtCO_2e$	%	Trend
Agriculture	38.18	38.89	39.31	40.32	36.59	36.05	35.70	36.60	36.20	36.20	-0.01	-0.02%	↓
Power Plants	33.43	29.45	25.32	26.61	30.86	24.56	17.07	24.26	20.70	20.21	-0.49	-2.38%	↓
Residential, Commercial, and Industrial Fuel Use	32.84	31.56	29.48	32.08	32.10	37.09	36.76	33.86	35.53	34.59	-0.94	-2.65%	↓
Industrial Processes	5.42	5.49	5.57	7.40	7.38	7.31	7.36	7.57	7.92	7.82	-0.10	-1.20%	↓
Natural Gas Transmission and Distribution	1.57	1.57	1.58	1.58	1.58	1.59	1.59	1.65	1.66	1.66	0.01	0.32%	↑
Transportation	19.61	20.09	20.20	20.42	19.99	20.35	18.80	20.71	22.70	23.13	0.44	1.93%	↑
Waste	2.09	2.31	2.34	2.33	2.33	2.33	2.23	2.16	2.27	2.34	0.07	3.11%	↑
Total Gross Emissions	**133.14**	**129.37**	**123.80**	**130.74**	**130.82**	**129.28**	**119.50**	**126.81**	**126.97**	**125.95**	**-1.02**	**-0.80%**	↓
Carbon Stored in LULUCF[2]	-6.68	-7.47	-8.53	-8.60	-8.05	-8.11	-8.74	-8.24	-8.29	-8.15	0.13	-1.62%	↓
Total Net Emissions	**126.47**	**121.90**	**115.27**	**122.14**	**122.77**	**121.17**	**110.77**	**118.57**	**118.68**	**117.79**	**-0.88**	**-0.75%**	↓

[1] Totals may not equal the exact sum of subtotals in this table due to independent rounding. Values may not match values in the previous inventory published by the DNR in December 2023. Any adjustments are described in detail in the Technical Support Document.

[2] Carbon stored by the LULUCF sector is shown as a negative number.

Figure 1: Iowa Gross GHG Emissions 2014 – 2023 ($MMtCO_2e$)

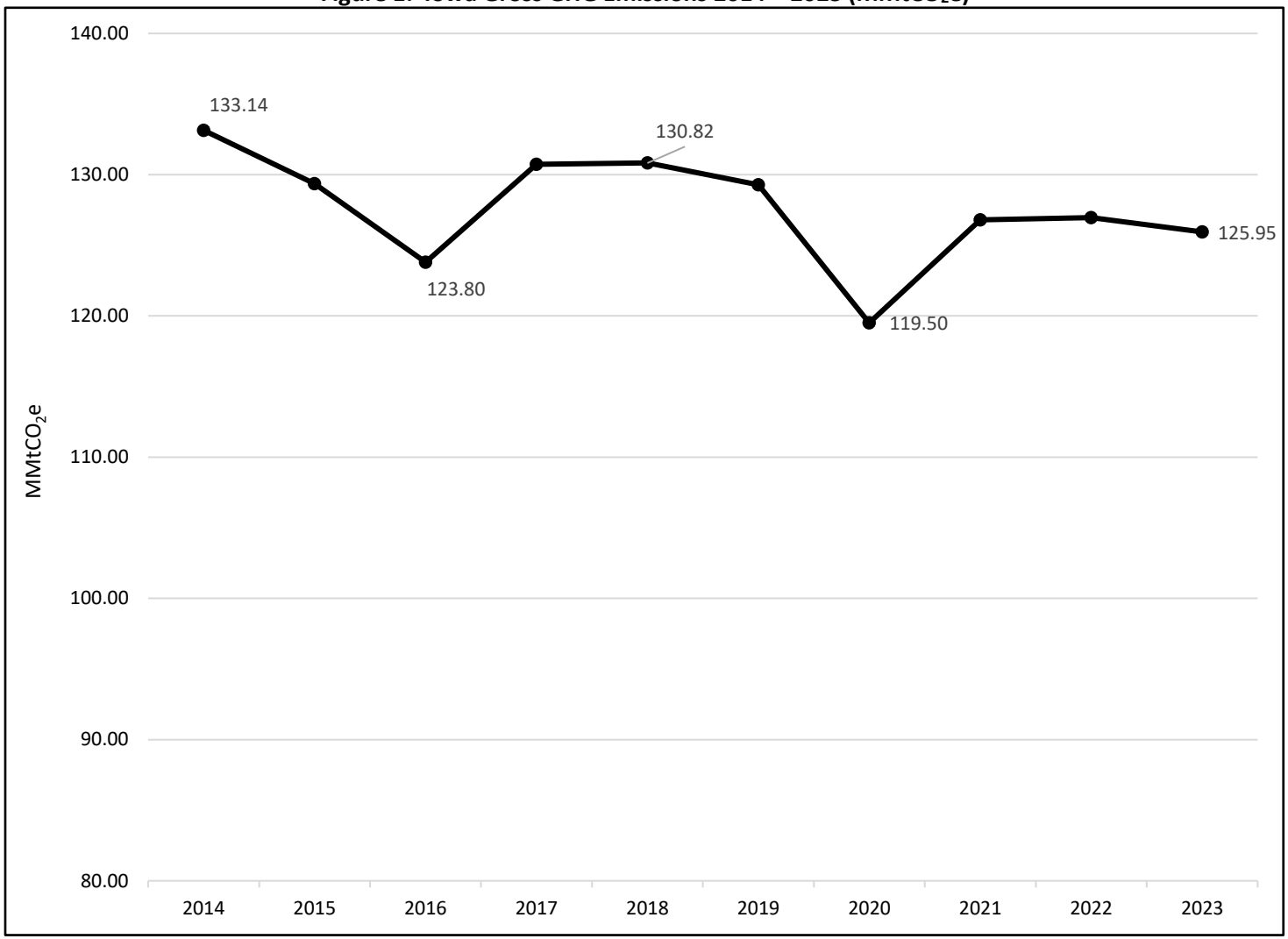
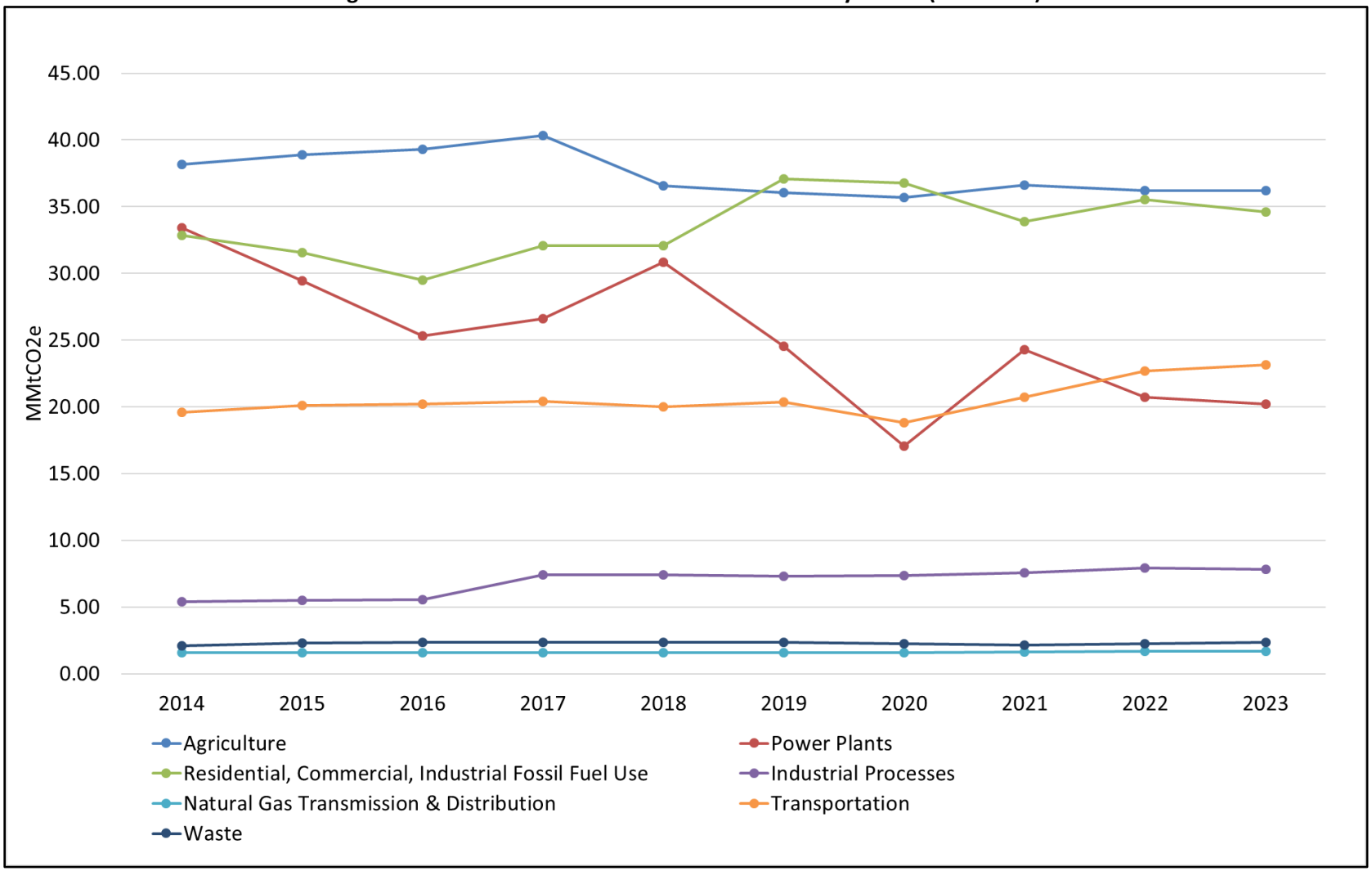


Figure 2: Iowa Gross[3] GHG Emissions 2014 – 2023 by Sector ($MMtCO_2e$)

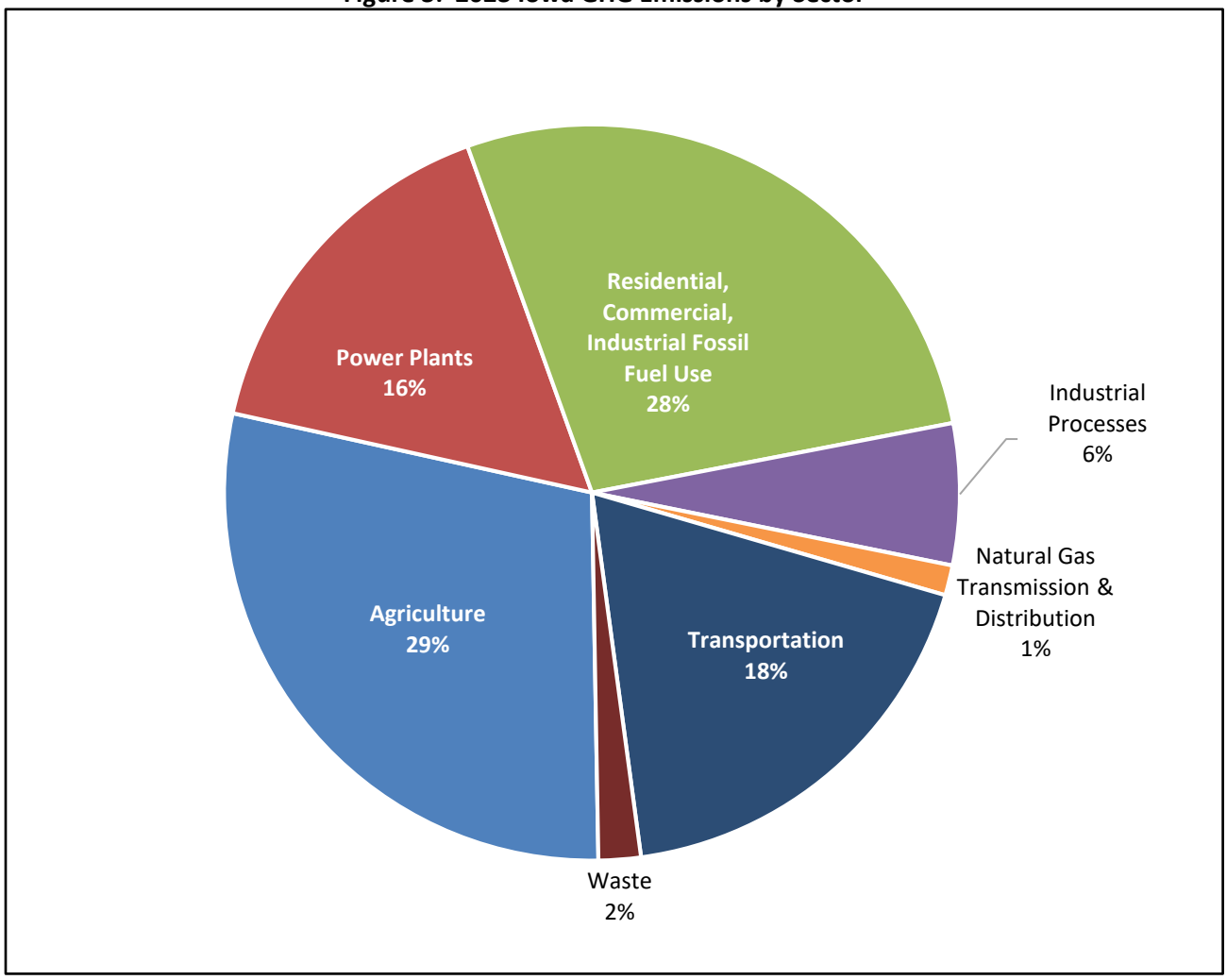


[3] Does not include carbon storage from land use, land use change, and forestry (LULUCF).

GHG Emissions by Sector

The majority of GHG emissions in Iowa in 2023 were from the agriculture sector (29%), followed by emissions from the residential/commercial/industrial (RCI) sector (28%), transportation (18%), and fossil fuel use by power plants (16%) as shown in Figure 3. The emissions from these, and other sectors, are summarized below and are ordered as presented in the TSD. Please refer to the 2023 GHG Inventory Technical Support Document for more information on a specific sector, such as sources of input data, calculations, and uncertainty.

Figure 3: 2023 Iowa GHG Emissions by Sector[4,5]



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

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

[5] Does not include Land Use, Land Use Change, and Forestry (LULUCF). LULUCF sequestered carbon in 2023.

(such as tractors) are included in the transportation sector. As shown in Table 3, total agriculture emissions decreased by 0.005 $MMtCO_2e$ between 2022 and 2023.

Emissions from enteric fermentation and manure management exhibited the largest percentage change. The number of cattle in Iowa have the largest influence on enteric fermentation emissions, and in 2023 the number of cattle decreased 7.07%. The number of hogs in Iowa have the largest influence on manure management emissions, and in 2023 the number of hogs increased 3.73%. Emissions from ag soil management remained steady.

Table 3: GHG Emissions from Agriculture ($MMtCO_2e$)

Category	2022	2023	% Change
Enteric Fermentation	9.00	8.69	-3.51%
Manure Management	9.02	9.33	3.32%
Agricultural Soil Management	18.17	18.18	0.05%
Total	**36.20**	**36.20**	**-0.05%**

Fossil Fuel Combustion

This sector includes GHG emissions from fossil fuels combusted in four categories: power plants, residential, commercial, and industrial (the residential, commercial, and industrial categories combine into one category called RCI). Together, these four categories account for 43.51% of Iowa's total GHG emissions. Table 4 shows a decrease of 2.55% in emissions from RCI and a decrease of 2.38% in power plant emissions between 2022 and 2023.

Table 4: GHG Emissions from Fossil Fuel Combustion ($MMtCO_2e$)

Category	2022	2023	% Change
Residential, Commercial, Industrial (RCI)	35.53	34.59	-2.65%
Residential	5.37	5.08	-5.54%
Commercial	4.35	4.15	-4.66%
Industrial	25.80	25.36	-1.71%
Power Plants	20.70	20.21	-2.38%
Total	**56.23**	**54.80**	**-2.55%**

Residential, Commercial, and Industrial (RCI)

Actual fuel use data for 2023 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 2023 with Projections to 2050.*[6] Emissions predicted for 2022 from the RCI sector in last year's inventory (33.72 $MMtCO_2e$) were replaced with actual 2022 consumption values now available from EIA. The resulting recalculated 2022 emissions were 35.53 $MMtCO_2e$.

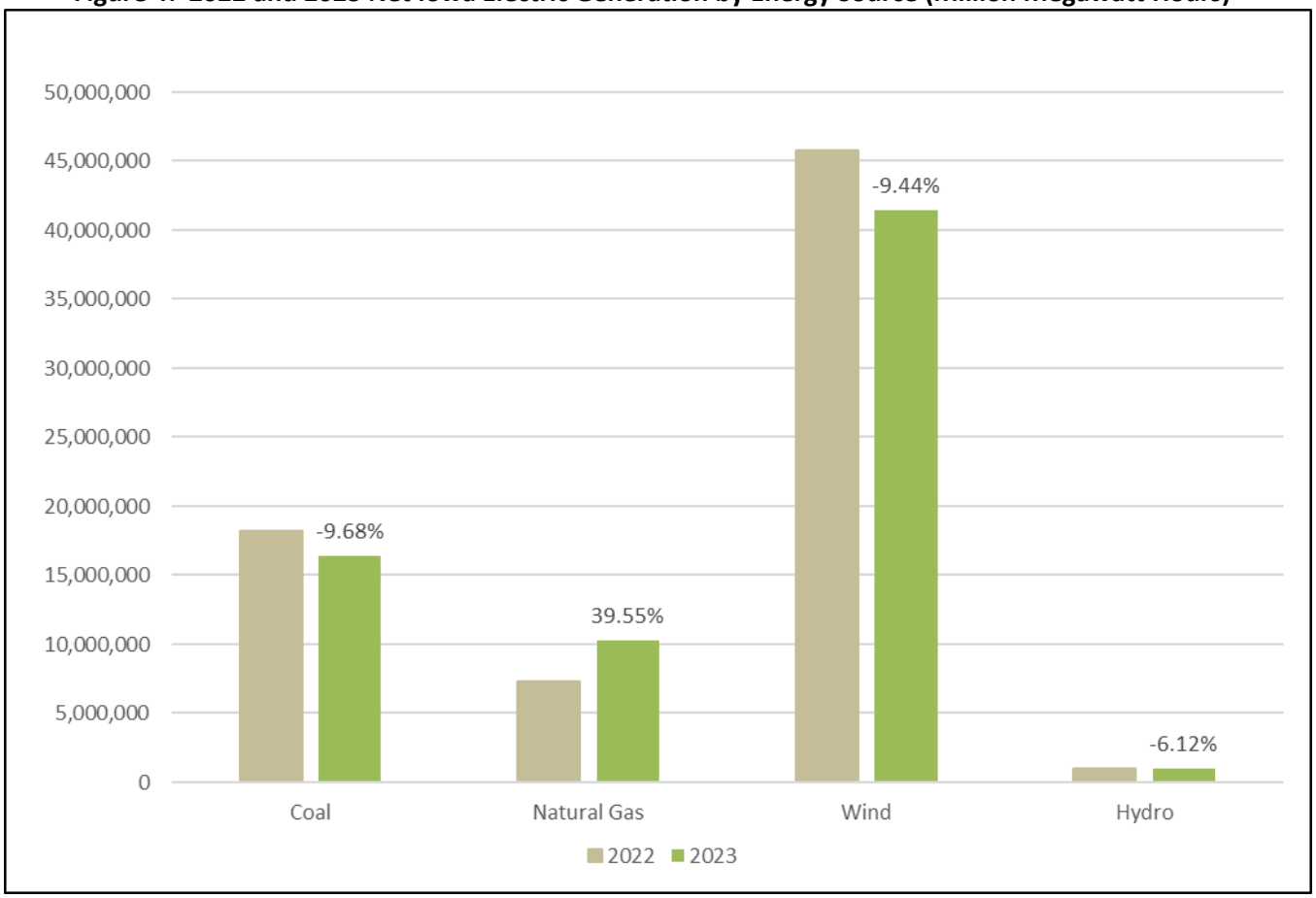
Power Plants

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

[6] U.S. EIA, Annual Energy Outlook 2023 with Projections to 2050, March 16, 2023.

Code of Federal Regulations Part 98). Continuous emission monitoring systems (CEMS) measure the CO_2 emissions from these facilities. Emissions from power plants decreased 0.49 $MMtCO_2e$ (-2.38%) from the previous year. As shown in Figure 4, from 2022 to 2023 electricity generation from wind decreased by 9.44% and hydroelectricity decreased 6.12%; electricity generated by wind and hydroelectricity does not contribute to GHG emissions. Electricity generated from coal decreased by 9.68% from 2022 to 2023, and electricity generated from natural gas increased by 39.55%.

Figure 4: 2022 and 2023 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 manufacturing, 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 decreased 1.20% from 2022 to 2023, as shown in Table 5. 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 manufacturing, iron and steel production, lime manufacturing, and nitric acid production. Emissions from the other categories were calculated using EPA's SIT.

[7] U.S. EIA, Net Generation by State by Type of Producer by Energy Source, December 9, 2024.

Table 5: GHG Emissions from Industrial Processes ($MMtCO_2e$)

Category	2022	2023	% Change
Ammonia and Urea Production	3.24	3.20	-1.22%
Cement Manufacturing	1.28	1.28	-0.10%
Electric Power Transmission & Distribution Systems	0.08	0.08	NA[8]
Iron and Steel Production	0.11	0.12	8.74%
Lime Manufacturing	0.12	0.11	-8.61%
Limestone and Dolomite Use	0.81	0.81	NA[8]
Nitric Acid Production	0.82	0.76	-6.57%
Ozone Depleting Substances Substitutes	1.43	1.43	NA[8]
Soda Ash Consumption	0.02	0.02	NA[8]
Total	**7.92**	**7.82**	**-1.20%**

Natural Gas Transmission and Distribution (T & D)

This sector includes emissions from natural gas transmission and distribution systems in the state. GHG emissions increased 0.32% from 2022 as shown in Table 6, mainly due to an increase in Iowa's number natural gas service connections.

Table 6: GHG Emissions from Natural Gas Transmission and Distribution ($MMtCO_2e$)[9]

Category	2022	2023	% Change
Transmission	0.9453	0.9437	-0.16%
Distribution	0.7115	0.7184	0.97%
Total	**1.6568**	**1.6622**	**0.32%**

Transportation

The transportation sector includes GHG emissions from both highway and non-highway vehicles. Non-highway vehicles include aviation, boats, locomotives, tractors, other utility vehicles, and alternative fuel vehicles. Emissions from highway vehicles are calculated based on vehicle miles traveled, while emissions from non-highway vehicles are calculated based on fuel consumption.

DNR recalculated 2022 emissions from the transportation sector with updated gasoline fuel activity data from the FHWA. For the vehicles that operate using distillate fuel, DNR continued to use 2020 or 2021 as a proxy for fuel usage in 2022 and 2023 because updated fuel usage was not available. The estimated emissions for 2022 increased by 2.32 $MMTCO_2e$ to 22.70 $MMTCO_2e$.

Total vehicle miles traveled by Iowans increased 2.09% between 2022 and 2023, which contributed to the overall 1.93% increase in transportation GHG emissions shown in Table 7.

[8] Due to lack of current data, the DNR assumed 2023 emissions are equal to 2022 emissions.

[9] DNR generally 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.

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

Category	2022	2023	% Change
Gasoline Highway	12.81	13.02	1.69%
Diesel Highway	4.92	5.15	4.52%
Non-Highway	4.96	4.96	-0.02%
Alternative Fuel Vehicles	0.01	0.01	0.00%
Total	**22.70**	**23.13**	**1.93%**

Waste

The waste sector includes GHG emissions from both solid waste landfills and the treatment of municipal and industrial wastewater. DNR used facility-specific emissions data directly reported to EPA by both solid waste landfills and industrial wastewater facilities. EPA's LandGEM model was used to estimate emissions from smaller landfills that are not required to report to EPA.

Overall, GHG emissions from waste increased 3.11% from 2022 as shown in Table 8. Regarding solid waste emissions, it is important to note that the relationship between emissions and the cumulative amount of waste stored in landfills in not linear. Emissions vary as the decomposition rate of the waste fluctuates according to the amount of waste in the landfill and the length of time the waste is in the landfill. Additionally, the quantity of methane that is recovered and used as renewable natural gas or flared changes from year to year. Emissions from wastewater increased because more facilities were required to report facility-specific emissions data directly to EPA. Facilities are only required to report if they emit more than 25,000 metric tons CO_2e (0.025 $MMTCO_2e$) in the year.

Table 8: GHG Emissions from Waste ($MMtCO_2e$)

Category	2022	2023	% Change
Solid Waste	1.87	1.94	3.56%
Wastewater	0.39	0.40	0.98%
Total	**2.27**	**2.34**	**3.11%**

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, carbon stored in yard trimmings and food scraps sent to landfills, and agricultural soil carbon flux.

Overall, 8.15 $MMtCO_2e$ of carbon was stored in the LULUCF sector in 2023, as shown in Table 9. This is a 1.62% decrease in the amount of CO_2e being stored compared to 2022. This is attributed to an increase in emissions from liming of agricultural soils and urea fertilization.

Table 9: GHG Emissions by LULUCF ($MMtCO_2e$)

Category	2022	2023	% Change
Forest Carbon Flux	-3.57	-3.57	NA[10]
Liming of Agricultural Soils	0.53	0.65	22.89%
Urea Fertilization	0.07	0.08	9.91%
Urban Trees	-0.42	-0.42	NA[11]
Yard Trimmings & Food Scraps in Landfills	-0.11	-0.11	0.13%
Fertilization of Settlement Soils	0.42	0.42	1.46%
Agricultural Soil Carbon Flux	-5.20	-5.20	NA[12]
Total	**-8.29**	**-8.15**	**-1.62%**

The estimated sequestration by urban trees in 2021-2023 reflects the loss of urban tree cover from the August 10, 2020 derecho and emerald ash borer. DNR has conservatively estimated that state-wide tree cover of urban areas was reduced from 19% to 15.5% due to these two disruptions. The loss due to emerald ash borer has occurred over the last 10 years and the loss from the 2020 derecho occurred in 2020, but both are only reflected in the sequestration estimate of the 2021 inventory year. More details are included in the 2023 GHG Inventory Technical Support Document.

GHG Emissions by Pollutant

The 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). Table 10 shows the distribution of GHGs by pollutant in Iowa while Figures 5-8 show the distribution by both pollutant and by category.

Carbon dioxide is the greenhouse gas emitted in the highest amounts in Iowa, accounting for 65.92% of all greenhouse gas emissions in 2023. Nearly all CO_2 emissions are from stationary fossil fuel combustion (at power plants and in the RCI sector) and transportation as shown in Figure 5, 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.

Methane and nitrous oxide were emitted in smaller amounts, and the majority of these two pollutants are from agriculture as shown in Figures 6 and 7. Methane emissions were 21.10 $MMtCO_2e$ or 16.70% of total 2023 GHG emissions. Nitrous oxide emissions in 2023 were 20.81 $MMtCO_2e$ or 16.46% of total GHG emissions.

Emissions of HFCs, PFCs and SF_6 are accounted for in sub-sectors of the Industrial Processes sector as shown in Figure 8. They are emitted either from substitutes for ODS or from insulation (SF_6) in electric power transmission and distribution systems. In 2023, emissions of these three pollutants totaled 1.51 $MMtCO_2e$, or 1.20% of Iowa's 2023 total GHG emissions.

[10] For forest carbon flux, the DNR assumed 2020-2023 values equal 2019 values due to a lack of more current data.
[11] For urban trees, DNR assumes 2022 and 2023 are equal to 2021 due to a lack of more current data.
[12] For agricultural soil carbon flux, DNR assumes 2023 is equal to 2022 due to a lack of more current data.

Table 10: 2023 Gross GHG Emissions by Pollutant ($MMtCO_2e$)

Pollutant	2023
CO_2	82.95
CH_4	21.10
N_2O	20.81
$HFC/PFC/SF_6$	1.51
Total	**126.37**[13]

Figure 5: 2023 Carbon Dioxide Emissions by Sector

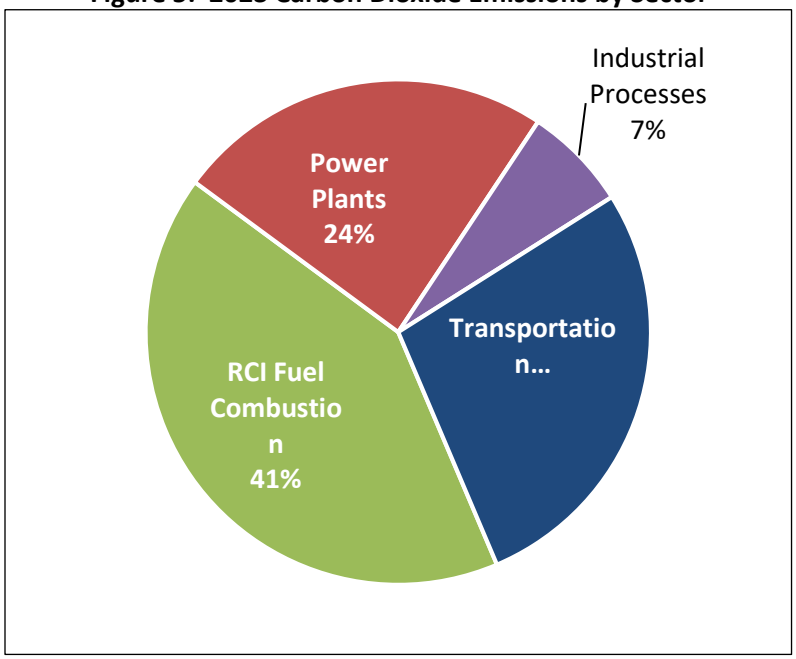
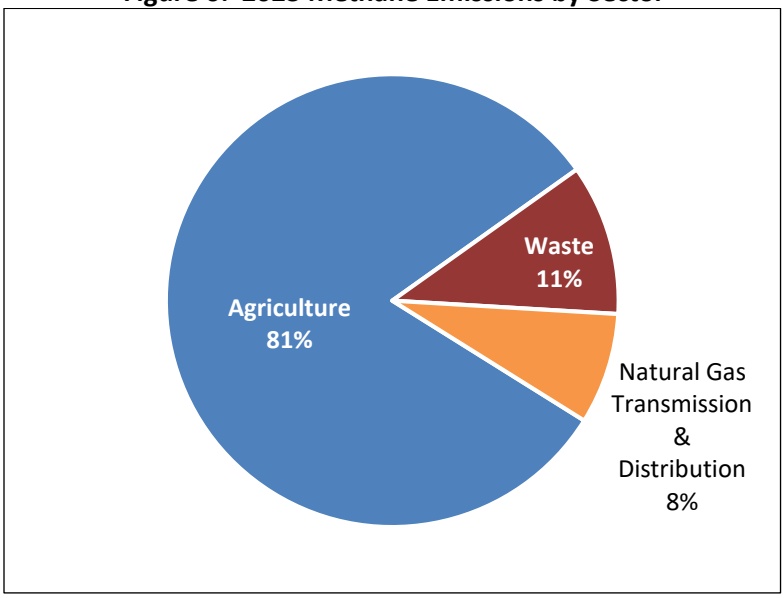


Figure 6: 2023 Methane Emissions by Sector



[13] Includes 0.42 $MMtCO_2e$ N_2O from settlement soils that is accounted for in the LULUCF category.

Figure 7: 2023 Nitrous Oxide Emissions by Sector

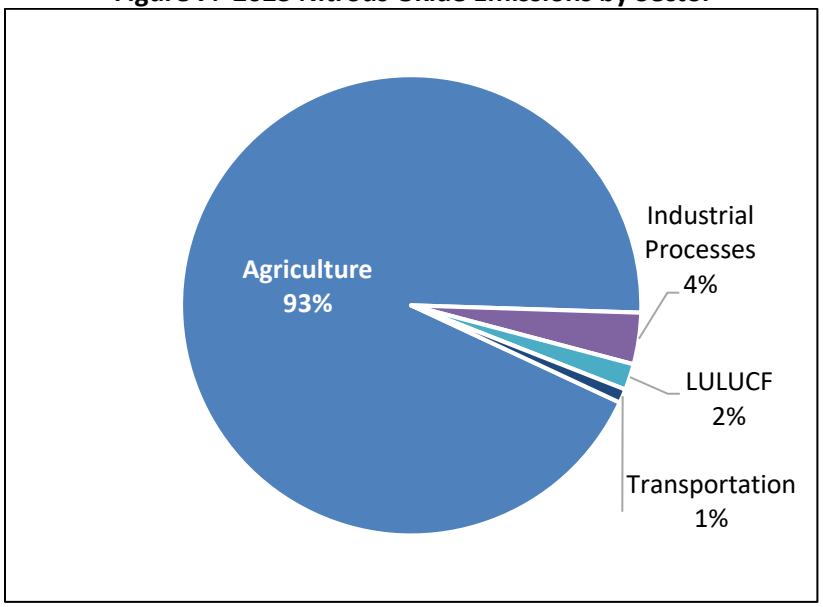
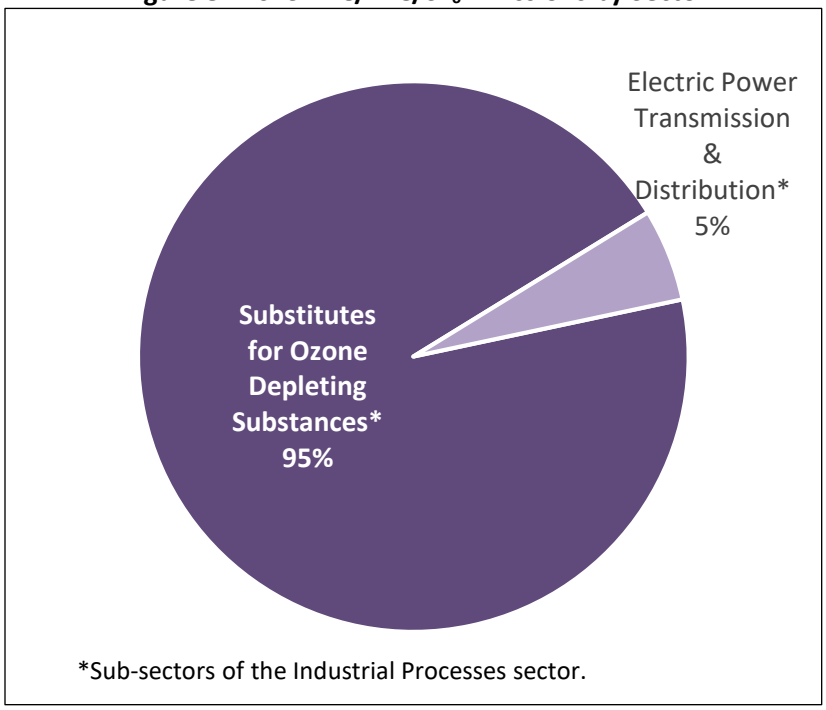


Figure 8: 2023 HFC/PFC/SF_6 Emissions by Sector



Future Emissions

Iowa Code 455B.104 requires that the DNR forecast trends in GHG emissions. Using the SIT Projection Tool, the DNR projected emissions to 2025 and 2030 as shown in Table 11. The Projection Tool forecasts emissions from industrial processes, agriculture, and waste based on historical emissions from 1990 – 2022, using a combination of data sources and national projections for activity data. A 2023 "forecast" was produced to help gauge the reasonableness of the projections.

Table 11: Projected Gross GHG Emissions 2023– 2030 ($MMtCO_2e$)

	Calculated	Projected		
Sector	**2023**	**2023**	**2025**	**2030**
Agriculture	36.20	36.37	37.18	38.85
Power Plants	20.21	13.97	11.77	5.37
RCI Fossil Fuel Use	34.59	30.89	28.48	28.95
Industrial Processes	7.82	8.05	9.22	10.66
Natural Gas T & D	1.66	1.39	1.41	1.41
Transportation	23.13	21.48	20.90	19.90
Waste	2.34	3.03	3.08	3.20
Total	**125.95**	**115.19**	**112.04**	**108.35**

While the DNR cannot predict with certainty what the effects on future emissions will be, the DNR has identified two factors that may affect future GHG emissions:

1. Emissions from Power Plants
   Emissions from power plants are difficult to forecast as the amount and fuel source of electricity generated is influenced by many factors such as:
   - the economy,
   - weather,
   - future environmental regulations,
   - electricity demand by customers (see #2 below),
   - how electricity generation is dispatched by the grid operator, and
   - other market forces.

2. Energy Consumption
   Greenhouse gas emissions are also affected by energy consumption. The U.S. Energy Information Administration (EIA) released its *Short-Term Energy Outlook* (STEO) on December 10, 2024, stating that "…our forecast for 2025 emissions is 2% (or around 100 million metric tons) higher than it was forecast in our January 2024 outlook. The outlook for more emissions in 2025 is mostly associated with an upward revision in coal-fired electricity generation. Compared with our January forecast, we expect more coal generation in 2025 due to an upward revision in overall electricity demand associated with rising electricity consumption from data centers. Increased petroleum product consumption, mostly motor gasoline, also increased our 2025 emissions estimates. We attribute this upward revision in consumption partially to an upward revision in disposable income, amid other factors influencing supply

and demand for gasoline."[14] It should be noted that the STEO addresses national emissions, not Iowa-specific emissions, and that the SIT Projection Tool contradicts the STEO by projecting that Iowa GHG emissions from power plants will decrease 15.74% from 2023 – 2025.

Uncertainty

As with many forecasts, numerous factors affect the certainty of the predictions. In addition to the factors affecting power plant emissions and energy consumption, GHG emission from other categories may be influenced by energy efficiency and conservation practices, driving practices, use of renewable fuels, and other variables.

Future Improvements

The DNR continually strives to make the annual statewide GHG inventory as accurate and timely as possible. Possible areas of enhancement are improved forecasting and more accurately calculating the injection of methane from wastewater digesters into natural gas pipelines.

[14] U.S. EIA, Short-Term Energy Outlook, December 2024.