IOWA DEPARTMENT OF NATURAL RESOURCES

2022 Iowa Statewide Greenhouse Gas Emissions Inventory Report

Required by Iowa Code 455B.104

December 28, 2023

Iowa Department of Natural Resources
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Background

This report is required by 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 2022 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.

2022 Statewide GHG Emissions

In 2022, total gross Iowa greenhouse gas emissions were 124.22 million metric tons carbon dioxide equivalent (MMtCO_2e) as shown in Table 1 and Figure 1. This is a decrease of 4.11 MMtCO_2e (3.21%) from 2021 and a decrease of 4.07% from 2013. The 4.11 MMtCO_2e decrease in emissions is largely attributed to the following combination of reductions and partially offsetting increases:

- A 3.56 MMtCO_2e decrease in emissions from power plants, due to decreased generation of electricity from fossil fuels,
- A 1.04 MMtCO_2e decrease in emissions from mobile combustion,
- A 0.36 MMtCO_2e increase in emissions from industrial processes,
- A 0.23 MMtCO_2e increase in emissions from agriculture,
- A 0.15 MMtCO_2e decrease in emissions from industrial processes.

Emissions fluctuations from other sectors were smaller in magnitude, as shown in Figure 2, and differed by 0.06 MMtCO_2e or less per sector from 2021.

Table 1: GHG Emissions 2013 – 2022 by Sector (Million Metric Tons Carbon Dioxide Equivalents ($MMtCO_2e$))[1]

Emissions ($MMtCO_2e$)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Change from 2021		
											$MMtCO_2e$	%	Trend
Agriculture	35.77	37.39	39.00	39.49	41.71	38.60	37.85	36.00	38.84	39.07	0.23	0.60%	↑
Power Plants	33.06	33.44	29.46	25.33	26.62	30.87	24.57	17.07	24.27	20.71	-3.56	-14.68%	↓
Residential, Commercial, and Industrial Fuel Use	32.82	32.82	31.54	29.45	32.05	32.07	37.07	36.76	33.86	33.71	-0.15	-0.44%	↓
Industrial Processes	5.07	5.12	5.09	5.34	7.10	7.40	7.38	7.55	7.23	7.59	0.36	5.00%	↑
Natural Gas Transmission and Distribution	1.40	1.40	1.40	1.41	1.27	1.41	1.42	1.42	1.47	1.48	0.01	0.43%	↑
Transportation	19.46	19.55	20.02	20.12	20.42	19.92	20.20	18.81	20.73	19.70	-1.04	-5.01%	↓
Waste	1.91	1.88	2.08	2.11	2.10	2.10	2.11	1.97	1.93	1.96	0.04	1.82%	↑
Total Gross Emissions	**129.49**	**131.62**	**128.60**	**123.25**	**131.27**	**132.36**	**130.59**	**119.60**	**128.33**	**124.22**	**-4.11**	**-3.21%**	↓
Carbon Stored in LULUCF[2]	-8.37	-6.07	-6.85	-7.89	-7.99	-7.38	-7.53	-8.37	-8.08	-8.14	-0.06	0.74%	↑
Total Net Emissions	**121.12**	**125.55**	**121.75**	**115.36**	**123.28**	**124.98**	**123.06**	**111.22**	**120.25**	**116.08**	**-4.17**	**-3.47%**	↓

[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 2022. 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 2013 – 2022 ($MMtCO_2e$)

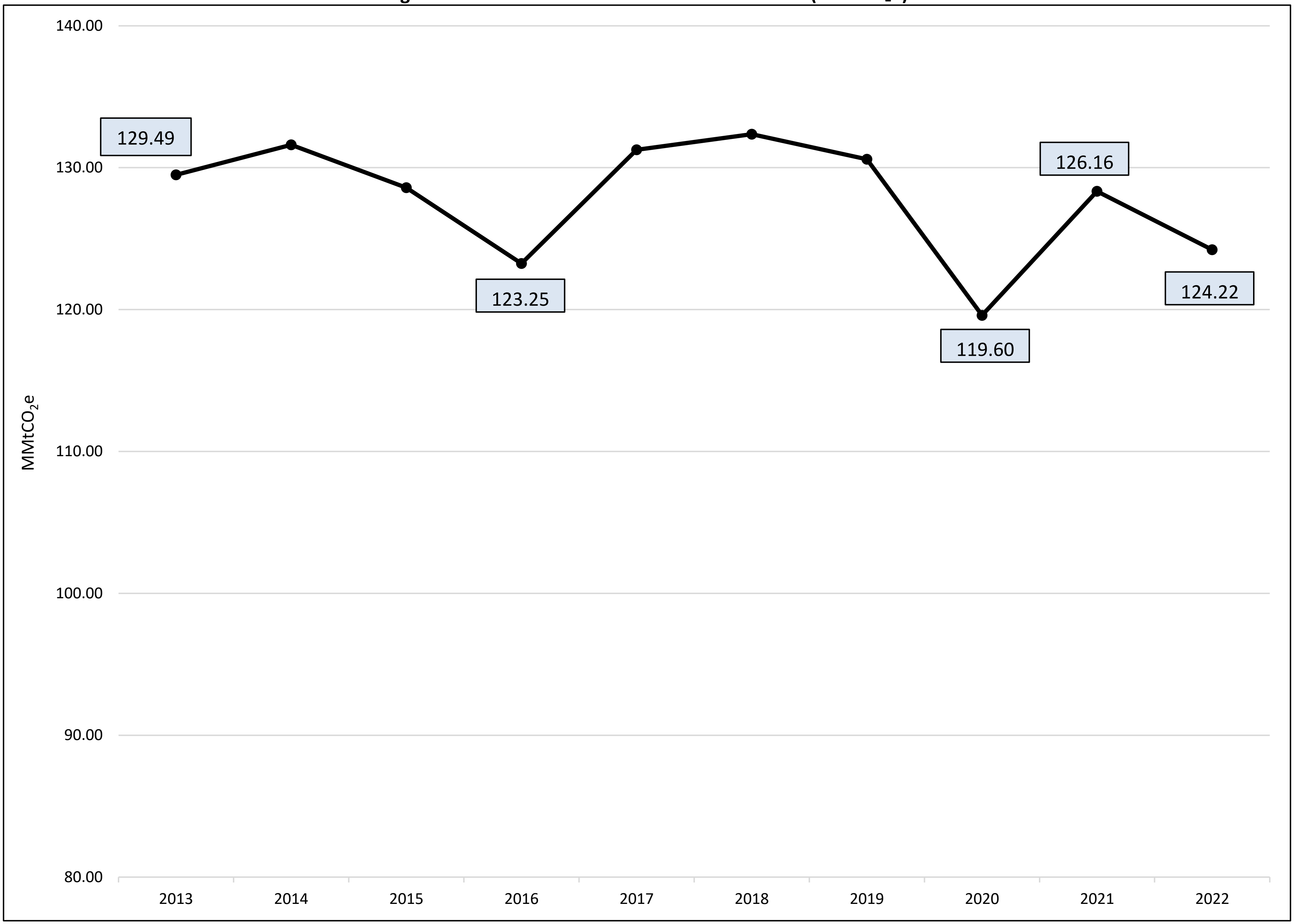
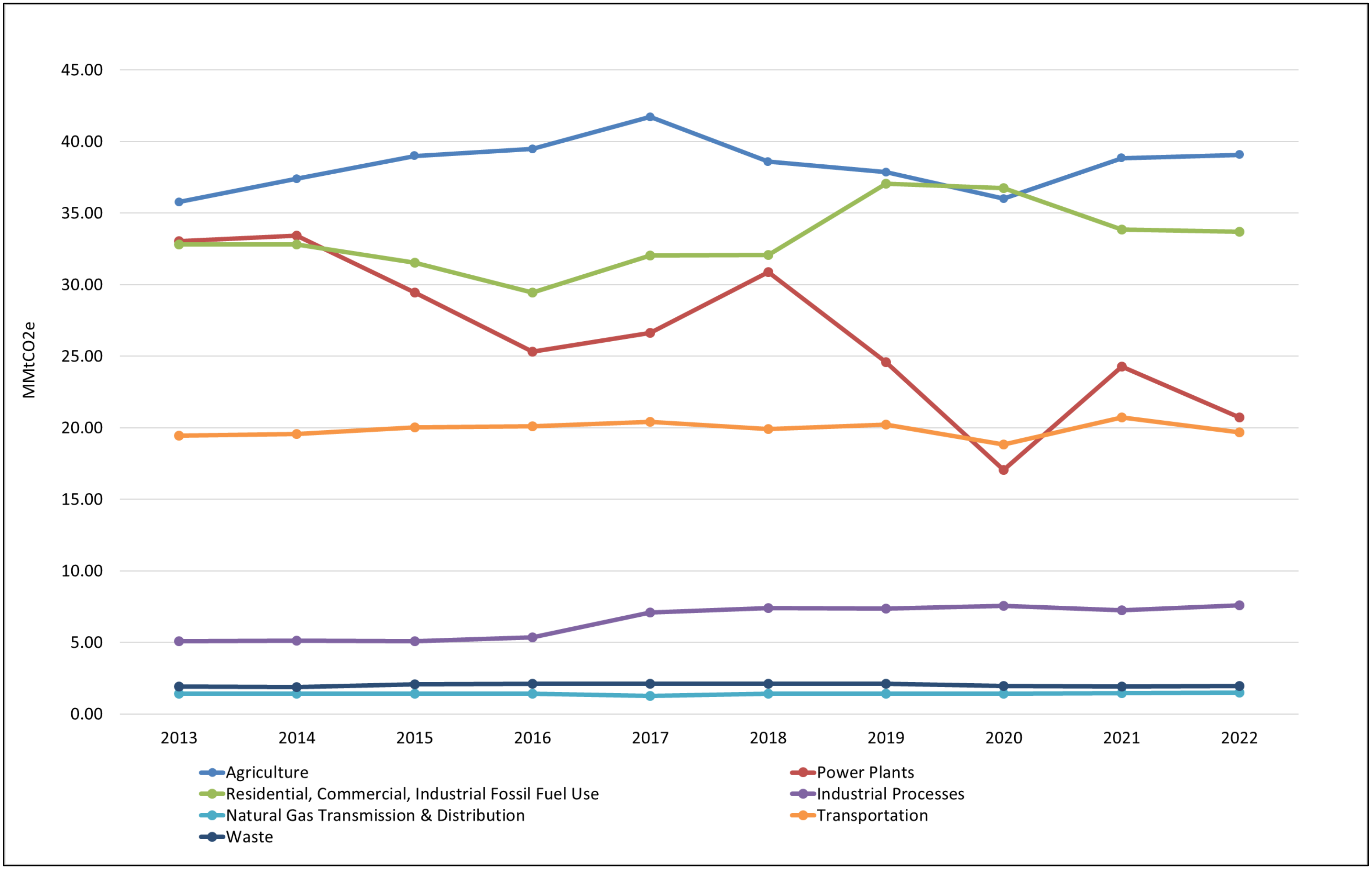


Figure 2: Iowa Gross[3] GHG Emissions 2013 – 2022 by Sector ($MMtCO_2e$)

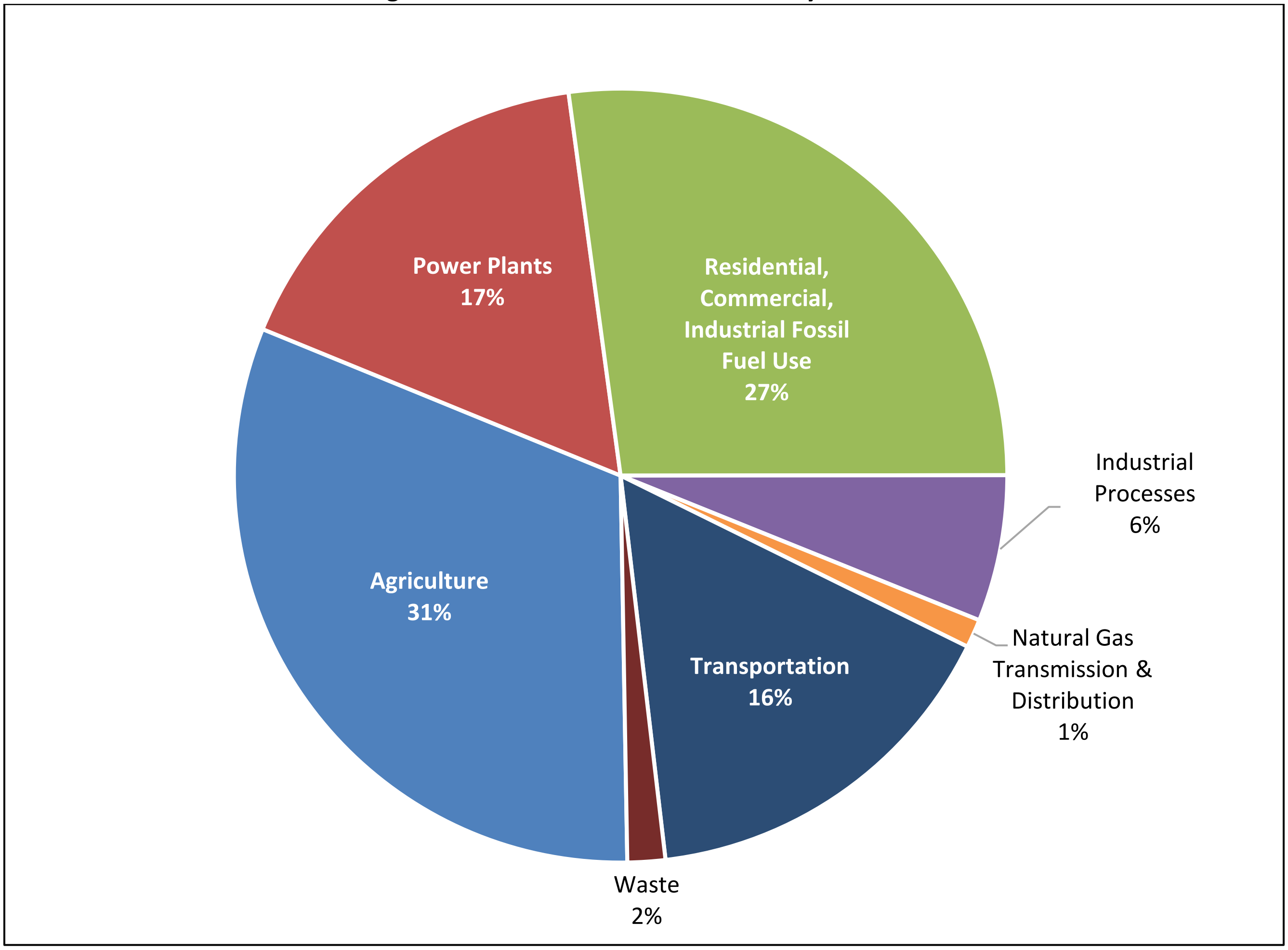


[3] Does not include carbon storage from land use, land use change, and forestry (LULUCF).

GHG Emissions by Sector

The majority of GHG emissions in Iowa in 2022 were from the agriculture sector (31%), followed by emissions from the residential/commercial/industrial (RCI) sector (27%), fossil fuel use by power plants (17%), and transportation (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 2022 GHG Inventory Technical Support Document for more information on a specific sector, such as sources of input data, calculations, and uncertainty.

Figure 3: 2022 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 (such as tractors) are included in the transportation sector. As shown in Table 2, total agriculture emissions

[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 2022.

increased 0.60% between 2021 and 2022. Emissions from enteric fermentation exhibited the largest percentage change. The number of cattle in Iowa have the largest influence on enteric fermentation emissions, and in 2022 the number of cattle increased 2.41%.

Emissions from ag soil management and manure management also increased, but in smaller amounts. Ag soil management emissions increased 0.47% because synthetic fertilizer usage increased 28.27% from 2021 to 2022. Emissions from manure management increased slightly at 0.06%.

Table 2: GHG Emissions from Agriculture (MMtCO$_2$e)

Category	2021	2022	% Change
Enteric Fermentation	8.09	8.22	1.56%
Manure Management	9.13	9.14	0.06%
Agricultural Soil Management	21.62	21.72	0.47%
Total	**38.84**	**39.07**	**0.60%**

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 45.29% of Iowa's total GHG emissions. Table 3 shows a decrease of 0.44% in emissions from RCI and a decrease of 14.68% in power plant emissions between 2021 and 2022.

Table 3: GHG Emissions from Fossil Fuel Combustion (MMtCO$_2$e)

Category	2021	2022	% Change
Residential, Commercial, Industrial (RCI)	33.86	33.71	-0.44%
Residential	5.07	4.92	-2.97%
Commercial	3.93	4.18	6.40%
Industrial	24.86	24.61	-1.00%
Power Plants	24.27	20.71	-14.68%
Total	**58.12**	**54.41**	**-6.39%**

Residential, Commercial, and Industrial (RCI)

Actual fuel use data for 2022 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 2021 from the RCI sector in last year's inventory (34.45 MMtCO$_2$e) were replaced with actual 2021 consumption values now available from EIA. The resulting recalculated 2021 emissions were 33.86 MMtCO$_2$e.

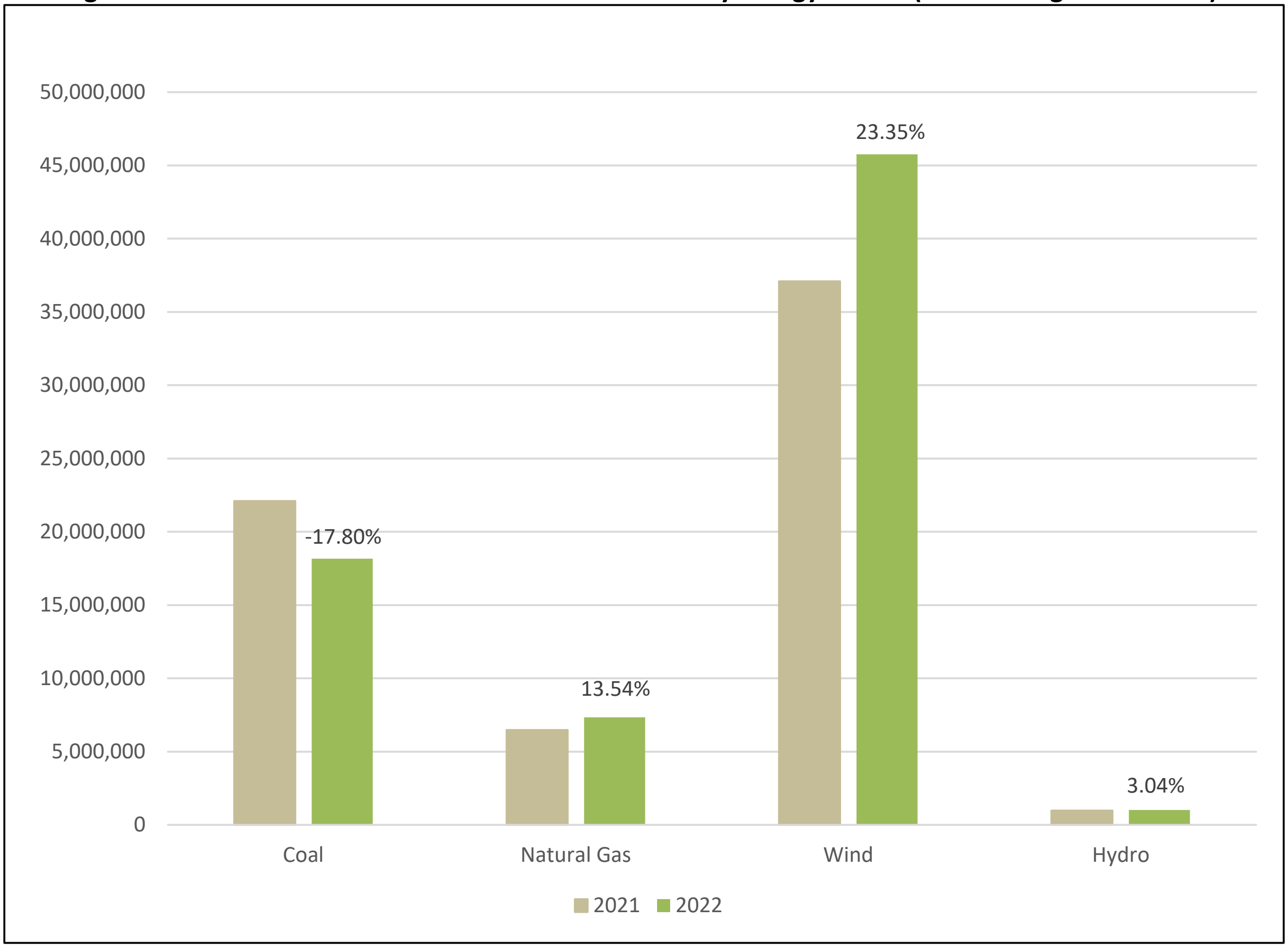
Power Plants

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 Part 98). Continuous emission monitoring systems (CEMS) measure the CO_2

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

emissions from these facilities. Emissions from power plants decreased 3.56 $MMtCO_2e$ (14.68%) from the previous year. As shown in Figure 4, from 2021 to 2022 electricity generation from wind increased by 23.35%; electricity generated by wind does not contribute to GHG emissions. Electricity generated from coal decreased by 17.80%% from 2020 to 2021, and electricity generated from natural gas increased by 13.54%.

Figure 4: 2021 and 2022 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 increased 5.00% from 2021 to 2022, 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 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, November 28, 2023.

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

Category	2021	2022	% Change
Ammonia and Urea Production	2.88	3.24	12.52%
Cement Manufacturing	1.31	1.28	-2.30%
Electric Power Transmission & Distribution Systems	0.05	0.05	NA[8]
Iron and Steel Production	0.14	0.11	-22.11%
Lime Manufacturing	0.16	0.12	-27.84%
Limestone and Dolomite Use	0.31	0.31	NA[8]
Nitric Acid Production	0.81	0.92	13.34%
Ozone Depleting Substances Substitutes	1.54	1.54	NA[8]
Soda Ash Consumption	0.02	0.02	NA[8]
Total	**7.23**	**7.59**	**5.00%**

Natural Gas Transmission and Distribution (T & D)

This sector includes emissions from natural gas transmission and distribution systems in the state. GHG emissions increased 0.43% from 2021 as shown in Table 5, mainly due to an increase in Iowa's number natural gas service connections.

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

Category	2021	2022	% Change
Transmission	0.8438	0.8440	0.02%
Distribution	0.6292	0.6353	-0.98%
Total	**1.4730**	**1.4793**	**0.43%**

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 2021 emissions from the transportation sector (published as 20.76 $MMTCO_2e$) gasoline fuel activity data from the FHWA. For the vehicles that operate using distillate fuel, DNR continued to use 2020 as a proxy for fuel usage in 2021 and 2022 because updated fuel usage was not available. The estimated emissions for 2021 decreased by 0.03 $MMTCO_2e$ to 20.73 $MMTCO_2e$. Additionally, EPA updated the SIT and vehicle classifications in 2022.

Total vehicle miles traveled by Iowans decreased 0.85% between 2021 and 2022, which contributed to the overall 5.01% decrease in transportation GHG emissions shown in Table 6.

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[8] Due to lack of current data, the DNR assumed 2022 emissions are equal to 2021 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 6: GHG Emissions from Transportation ($MMtCO_2e$)

Category	2021	2022	% Change[8]
Gasoline Highway	11.22	10.62	-5.28%
Diesel Highway	4.66	4.22	-9.56%
Non-Highway	4.84	4.84	NA[10]
Alternative Fuel Vehicles	0.01	0.01	NA[10]
Total	**20.73**	**19.70**	**-5.01**

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 1.82% from 2021 as shown in Table 7. 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 CH_4 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 7: GHG Emissions from Waste ($MMtCO_2e$)

Category	2021	2022	% Change
Solid Waste	1.561	1.591	1.96%
Wastewater	0.365	0.369	1.25%
Total	**1.925**	**1.960**	**1.82%**

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, 8.14 $MMtCO_2e$ of carbon was stored in the LULUCF sector in 2022, as shown in Table 8. This is a 0.74% increase in the amount of CO_2e being stored compared to 2021. This is attributed to a decrease in emissions from liming of agricultural soils, urea fertilization, and fertilization of settlement soils.

[10] Due to lack of current data, the DNR assumed 2022 emissions are equal to 2021 emissions.

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

Category	2021	2022	% Change
Forest Carbon Flux	-3.24	-3.24	NA[11]
Liming of Agricultural Soils	0.56	0.53	-4.71%
Urea Fertilization	0.15	0.14	-7.35%
Urban Trees	-0.43	-0.43	N/A[12]
Yard Trimmings & Food Scraps in Landfills	-0.10	-0.10	0.13%
Fertilization of Settlement Soils	0.49	0.47	-4.57%
Agricultural Soil Carbon Flux	-5.50	-5.50	NA[13]
Total	**-8.08**	**-8.14**	**0.74%**

The estimated sequestration by urban trees in 2021 and 2022 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 included in the 2022 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 9 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 63.06% of all greenhouse gas emissions in 2022. Nearly all CO_2 emissions are from 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 18.80 $MMtCO_2e$ or 15.08% of total 2022 GHG emissions. Nitrous oxide emissions in 2022 were 25.66 $MMtCO_2e$ or 20.58% 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 2022, emissions of these three pollutants totaled 1.59 $MMtCO_2e$, or 1.28% of Iowa's 2022 total GHG emissions.

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

Table 9: 2022 Gross GHG Emissions by Pollutant ($MMtCO_2e$)

Pollutant	2022
CO_2	78.63
CH_4	18.80
N_2O	25.66
$HFC/PFC/SF_6$	1.59
Total	**124.68**[14]

Figure 5: 2022 Carbon Dioxide Emissions by Sector

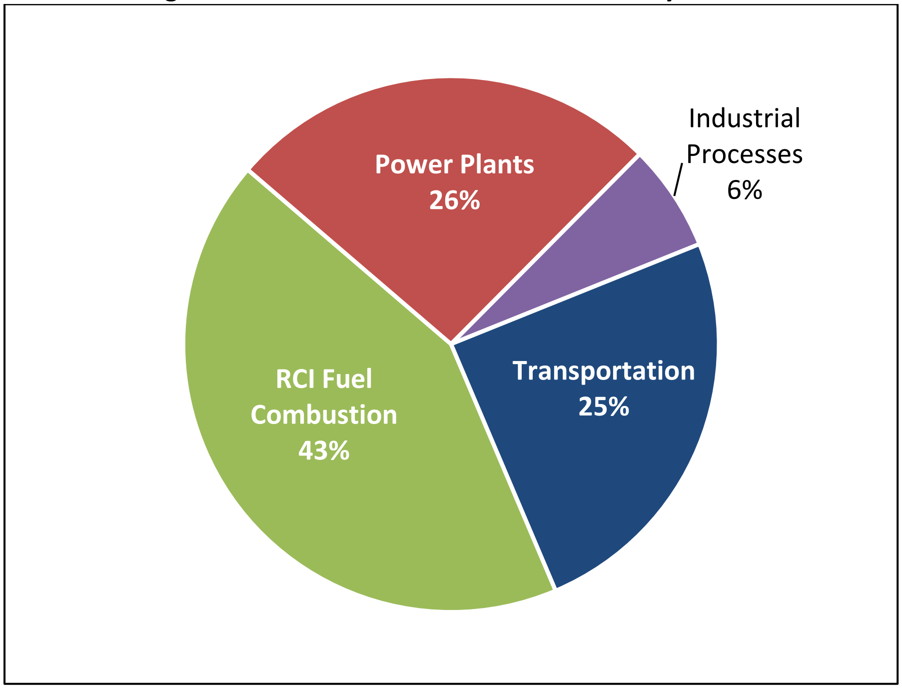


Figure 6: 2022 Methane Emissions by Sector

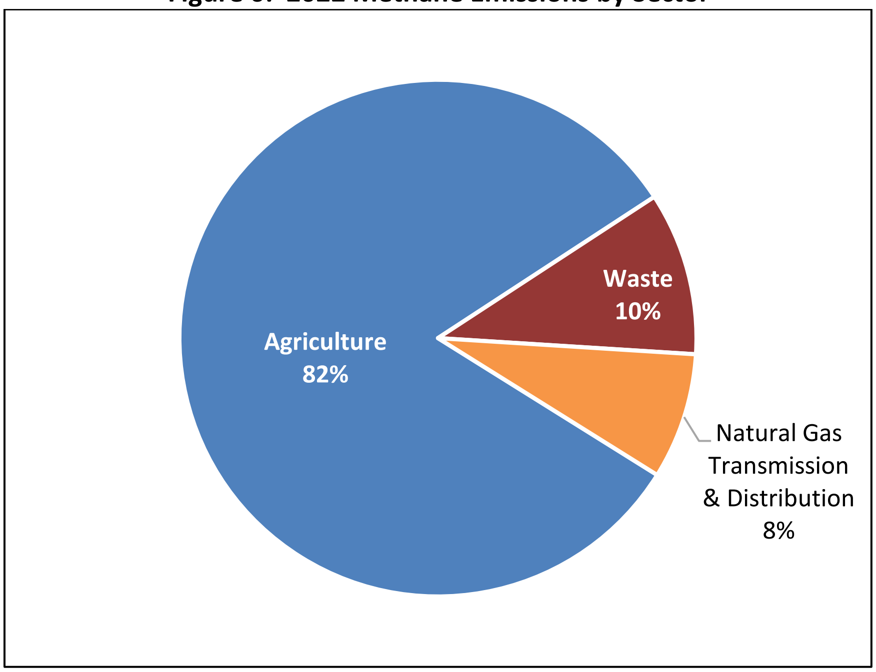


Figure 7: 2022 Nitrous Oxide Emissions by Sector

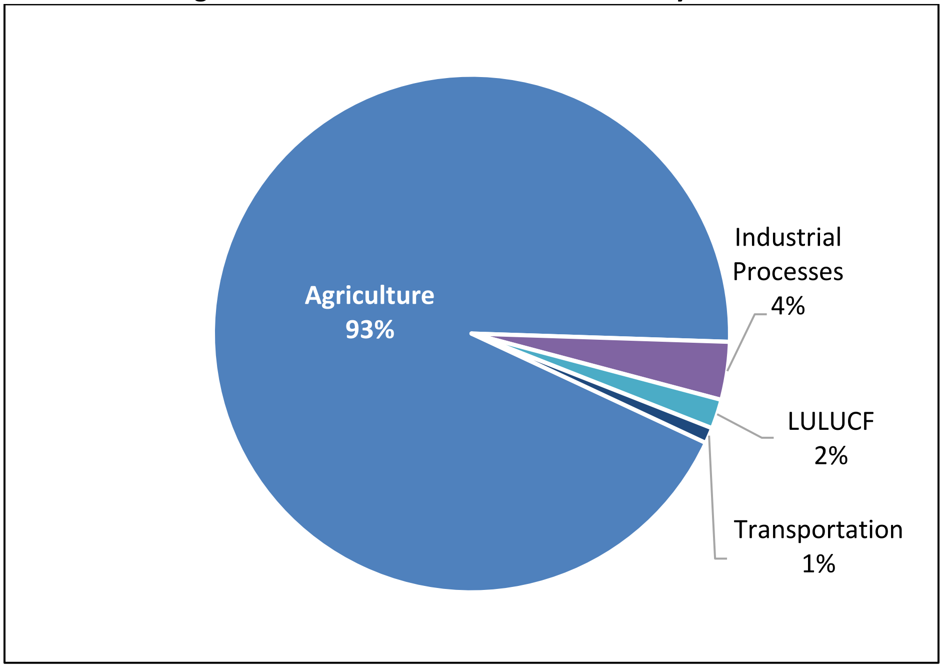
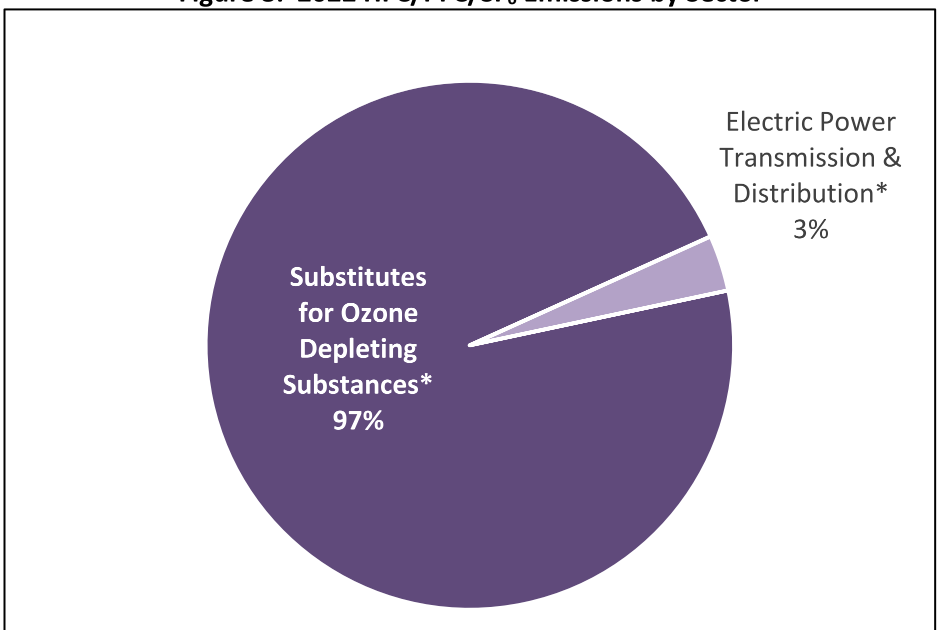


Figure 8: 2022 HFC/PFC/SF_6 Emissions by Sector



*Sub-sectors of the Industrial Processes 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, 2030, 2035, and 2040 as shown in Table 10. The Projection Tool forecasts emissions from industrial processes, agriculture, and waste based on historical emissions from 1990 – 2019,

[14] Includes 0.47 $MMtCO_2e$ N_2O from settlement soils that is accounted for in the LULUCF category.

using a combination of data sources and national projections for activity data. It would be preferable to forecast emissions using the DNR's 2022 calculated GHG inventory as the baseline, but the SIT Projection tool only allows input of emissions up to 2019, and it is not reasonable to fully update the data in the SIT Projection Tool to eliminate all such inconsistencies. EPA also produced a new SIT Projection tool that accepts input data until 2020, but the tool uses global warming potential (GWP) estimates from IPCC5 rather than IPCC4 as in this forecast and inventory. DNR elected to use the older tool to project emissions.[15] A 2022 "forecast" was also produced to help gauge the reasonableness of the projections.

Table 10: Projected Gross GHG Emissions 2022 – 2040 ($MMtCO_2e$)

	Calculated	Projected				
Sector	**2022**	**2022**	**2025**	**2030**	**2035**	**2040**
Agriculture	39.07	38.54	49.09	54.63	60.18	65.74
Power Plants	20.71	22.59	18.10	18.63	18.13	18.37
RCI Fossil Fuel Use	33.71	29.58	31.12	31.56	31.85	32.64
Industrial Processes	7.59	8.52	8.30	9.56	10.49	11.42
Natural Gas T & D	1.48	1.53	1.59	1.59	1.59	1.59
Transportation	19.70	20.55	20.05	19.32	18.93	18.88
Waste	1.96	2.74	3.30	3.45	3.60	3.71
Total	**124.22**	**124.06**	**131.55**	**138.74**	**144.77**	**152.63**

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. While emissions may continue to decrease as Iowa utilities shift away from burning coal to burning natural gas and installing renewable generation, 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,
   - how electricity generation is dispatched by the grid operator, and
   - other market forces.

   Emissions from power plants have increased or decreased by up to 40% from year to year in the last decade but have shown an overall downward trend, with the most recent three years being the lowest emissions recorded. The most recent data from EPA's Clean Air Markets Division shows that CO_2 emission from electric power generation during the first nine months of 2023 are 3% higher than CO_2 emissions from the first nine months of 2022. It is reasonable to expect 2023 emissions from electric power generation to be approximately equal to 2022 emissions.

[15] For further details on GWP, see EPA's document Understanding Global Warming Potentials.

2. Economic Uncertainty

   Greenhouse gas emissions are affected by economic conditions. The U.S. Energy Information Administration (EIA) released its *Short-Term Energy Outlook* (STEO) on December 12, 2023, stating that "Our labor market outlook affects our forecast of liquid fuels consumption. More employed workers generally leads to more vehicle miles traveled and, therefore, more gasoline consumption. In addition, the impact of tighter monetary policy and its eventual effect on the labor market is a source of uncertainty in our outlook. Further downward revisions to non-farm employment could lead us to revise our forecast of U.S. liquid fuels consumption lower."[16] It should be noted that the STEO addresses national emissions, not Iowa-specific emissions.

Uncertainty

As with many forecasts, numerous factors affect the certainty of the predictions. In addition to the factors affecting power plant emissions, GHG emission from other categories may be influenced by energy efficiency and conservation practices, driving practices, use of renewable fuels, and other variables. Discrepancies between the data used to calculate the 2022 GHG inventory and the assumptions within the SIT Projection Tool reduce confidence in the projections as the Tool is not configured to include activity data more recent than 2019. For example, the Tool projects that agriculture emissions will continue to increase at the rate they did from 1990 – 2019, when emissions from agriculture were highest in 2017 and in 2022 remained 6.3% below that peak. While we can't know with certainty how agricultural emissions will change in the future, it seems unlikely that they will increase 68% by 2040. The TSD provides a more detailed discussion of forecast uncertainty.

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 characterizing the injection of methane from wastewater digesters into natural gas pipelines. Additionally, DNR is considering using the GWP factors from IPCC5 rather than the GWP factors from IPCC4. This may lead to further improvements in Iowa's inventory.

[16] U.S. EIA, Short-Term Energy Outlook, December 2023.