Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Quarterly Greenhouse Gas Emissions Indicator Report

2024 Quarter 1

October 2024

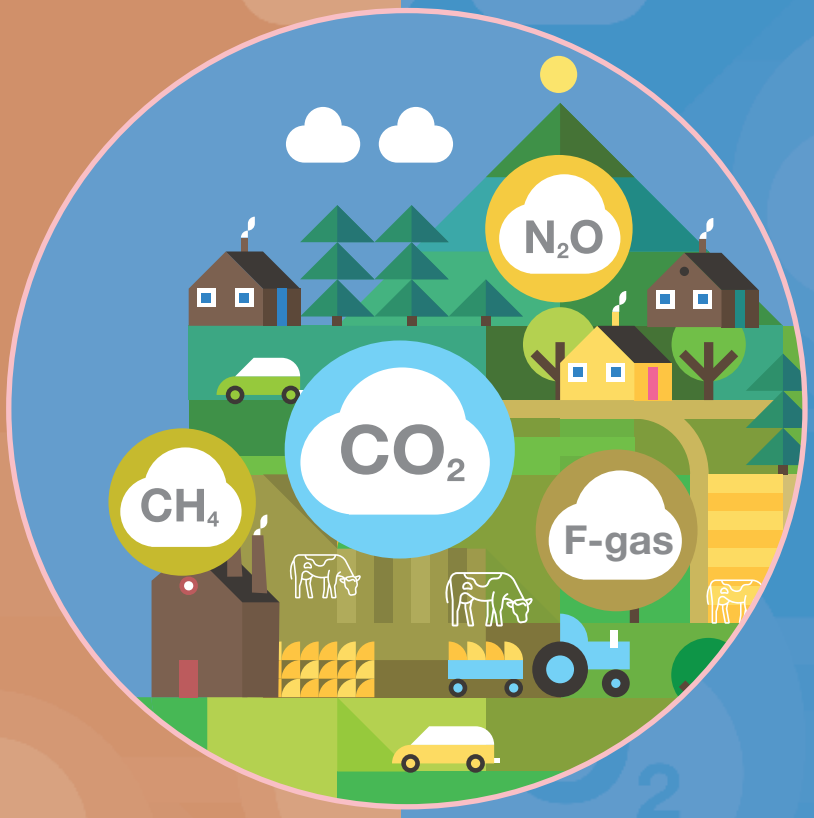


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Table of Contents

1: Key Findings

Please note that all quoted figures in Key Findings are comparing emissions at the end of Q1 2024 with emissions at the end of Q1 2023 unless otherwise indicated.

Quarterly figures are more susceptible to volatility and seasonality, particularly in the case of comparison to the previous quarter. In addition, these data have been seasonally adjusted to provide a clearer picture of underlying trends by eliminating the noise caused by seasonal fluctuations.

An increase or decrease in quarterly emissions does not indicate an overall yearly change in the same direction.

- In Quarter 1 2024 overall greenhouse gas emissions decreased by -2.2% (-305.8 kt CO_2 eq) compared to the same quarter last year (2023 Q1).
- The largest sectoral decrease in emissions in Quarter 1 2024 was observed in the electricity generation sector with a change of -16.7% (-311.9 kt CO_2 eq).
- Significant decreases were also observed in the Industry (-4.7%, -69.1 kt CO_2 eq) and Agriculture (-2.6%, -208.4 kt CO_2 eq) sectors.
- The largest increase in emissions this quarter was observed in the Buildings sector at +6.1% (+111.7 kt CO_2 eq) for residential and +4.1% (+14.3 kt CO_2 eq) for commercial and public buildings. Several factors have contributed to this. For example, Quarter 1 2024 had 3.7% more heating degree days (days below 15.5 degrees Celsius, where heating would be needed) than Quarter 1 2023. The cost of gas was 38% higher in Quarter 1 2023 which could have led to a further reduction of heating use in Quarter 1 2023 compared to Quarter 1 2024.
- Emissions across the transport sector are rebounding to pre-COVID levels and are presently at 98% of 2019 levels.

Table 1: Key Findings

Sector	Key Finding
GHG Emissions Q1 2023 to Q1 2024	Overall emissions decreased by -2.2% (-305.8 kt CO_2 eq), driven mainly by reductions in emissions from electricity generation (-16.7%), agriculture (-2.6%) and industrial processes (-4.7%).
Agriculture	Emissions reduced by -2.6% driven by reduced limestone sales for application to agricultural land (due to adverse weather conditions), and a decline in methane emissions associated with reduced milk output (-7.7% compared to 2023 Q1). Total cattle numbers increased by 4.5%, however dairy cattle decreased by 0.7%.
Transport	The key driver for the +2.7% increase in transport emissions was increased sales of petrol (+9.6%) and diesel (+1.3%) compared to the year-ago quarter, as the sector overall rebounds to pre-COVID levels (98% of 2019 levels).
Electricity	Electricity generation emissions decreased by -16.7% (-311.9 kt CO_2 eq) due to reductions in coal, oil and gas use and an increase in renewable energy for electricity generation. In addition, the amount of net imported electricity in Q1 2024 doubled vs Q1 2023

Sector	Key Finding
Buildings	**(Commercial and Public)** Emissions were up +4.1% (+14.3 kt CO_2 eq) due to increased energy demand for buildings. The number of heating degree days (days below 15.5 degrees Celsius, where heating would be needed) had increased by 3.7%.
	(Residential) Emissions were up +6.1%, (+111.7 kt CO_2 eq) due to increased energy demand for heating. The number of heating degree days (days below 15.5 degrees Celsius, where heating would be needed) had increased by 3.7%.
Industry	Industry emissions were down -4.7% (-69.1 kt CO_2 eq), driven mainly by reductions in both process and combustion emissions from cement production, and continuing the trend reported in the provisional inventory for 2023.
Other	Emissions from Other sectors were relatively flat (-0.1%) with increases from landfilled waste (+3.3%) and wastewater treatment (+0.6%) offset by decreases from gas and liquid fuel combustion in Petroleum Refining (-7.3%).
GHG Emissions Q4 2023 to Q1 2024	Overall emissions increased by 0.2% (23.3 kt CO_2 eq) on a seasonally adjusted basis, driven mainly by increases in emissions from Commercial and Public Buildings (6.7%) and Residential Buildings (4.2%)

Table 2 summarises the year on year changes for 2024 Quarter 1 compared to 2023 Quarter 1, and also the quarter-on-quarter changes for 2024 Quarter 1 compared to 2023 Quarter Q4.

Table 2: Key Findings

Sector	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (%)	Comparison with Q4 2023 (%)
Overall	**13,497**	**-2.2**	**0.2**
Agriculture	4,892	-2.6	-2.4
Buildings (Commercial and Public)	367	4.1	6.7
Buildings (Residential)	1,933	6.1	4.2
Electricity	1,561	-16.7	-0.3
Industry	1,398	-4.7	-2.5
Other	378	-0.1	1.8
Transport	2,968	2.7	2.6

2: 2024 Quarter 1 Summary

This section presents the key high-level emissions estimates for Quarter 1 2024, followed by further sectoral analysis.

Figure 1: Overall quarterly movement in greenhouse gas emissions for all sectors from Q1 2018 to Q1 2024.

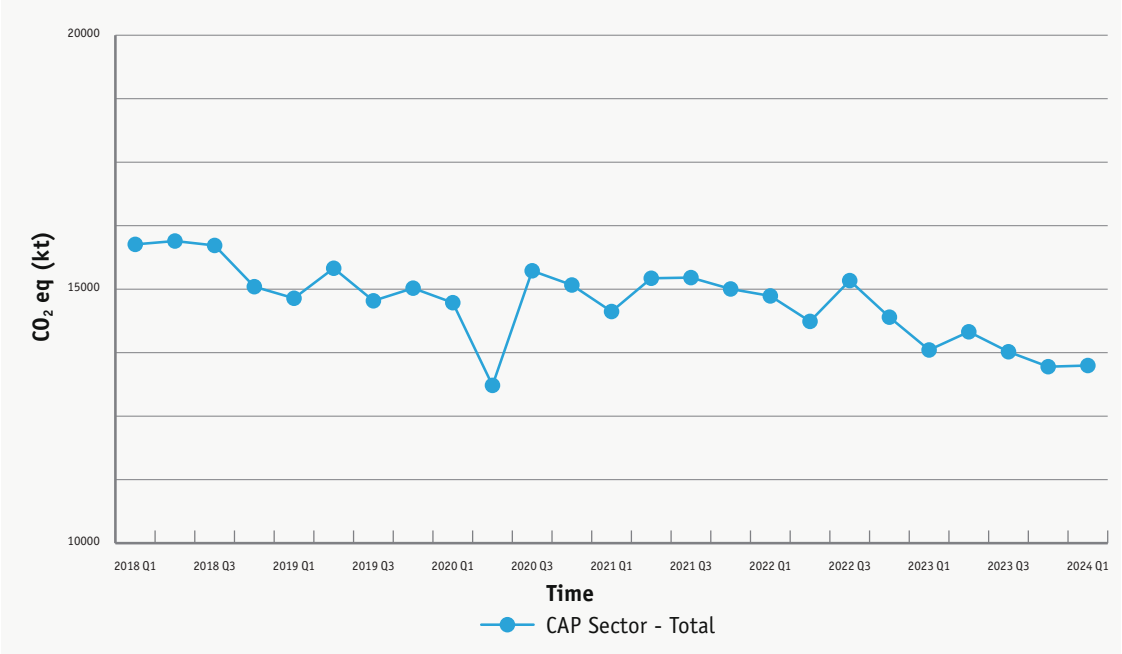
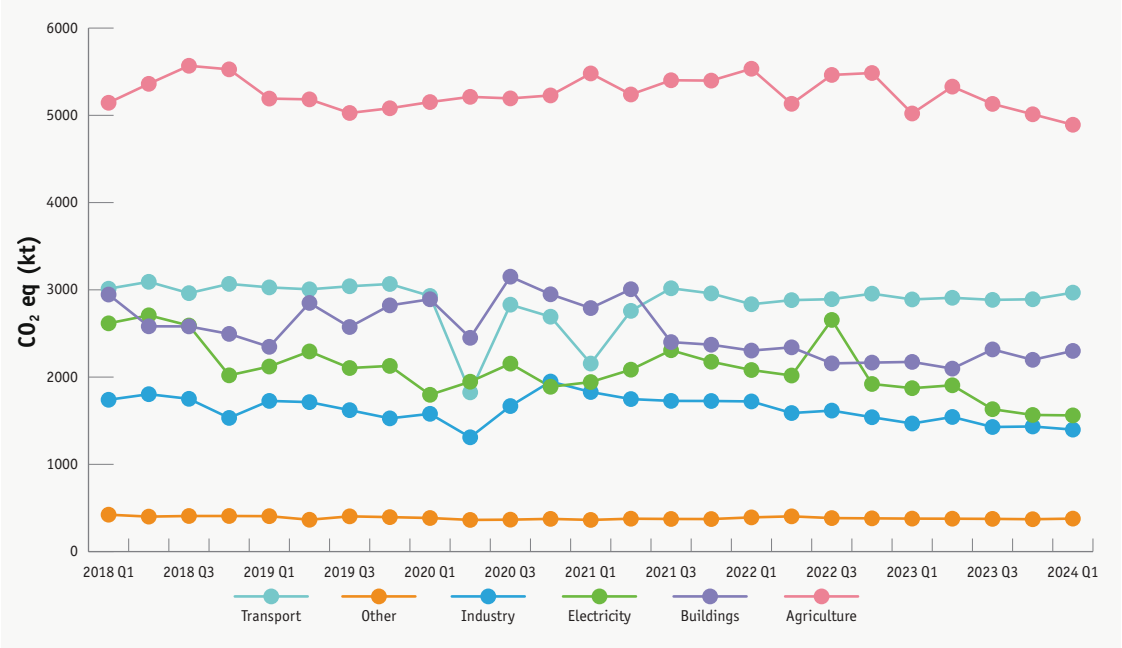


Figure 1 shows that from a high in Quarter 2 2018 overall emissions are on a downward trend with a marked drop in emissions during the Covid-19 pandemic lockdown in Quarter 2 2020.

Similarly, Figure 2 summaries emissions per Climate Action Plan-aligned sector. Since 2018, the broadly consistent trend in emissions reductions can be seen in the Buildings and Electricity sectors. The only major change was in Quarter 2 2020 and Quarter 2 2021 during the Covid-19 pandemic lock downs, with marked reductions in transport emissions. Agriculture remains the largest source of emissions throughout this period and the 'Other' sector (waste, petroleum refining and fluorinated gases) the smallest source.

Figure 2: Sectoral quarterly movement in greenhouse gas emissions for all Sectors from Q1 2018 to Q1 2024.



2.1 Year-on-Year Change

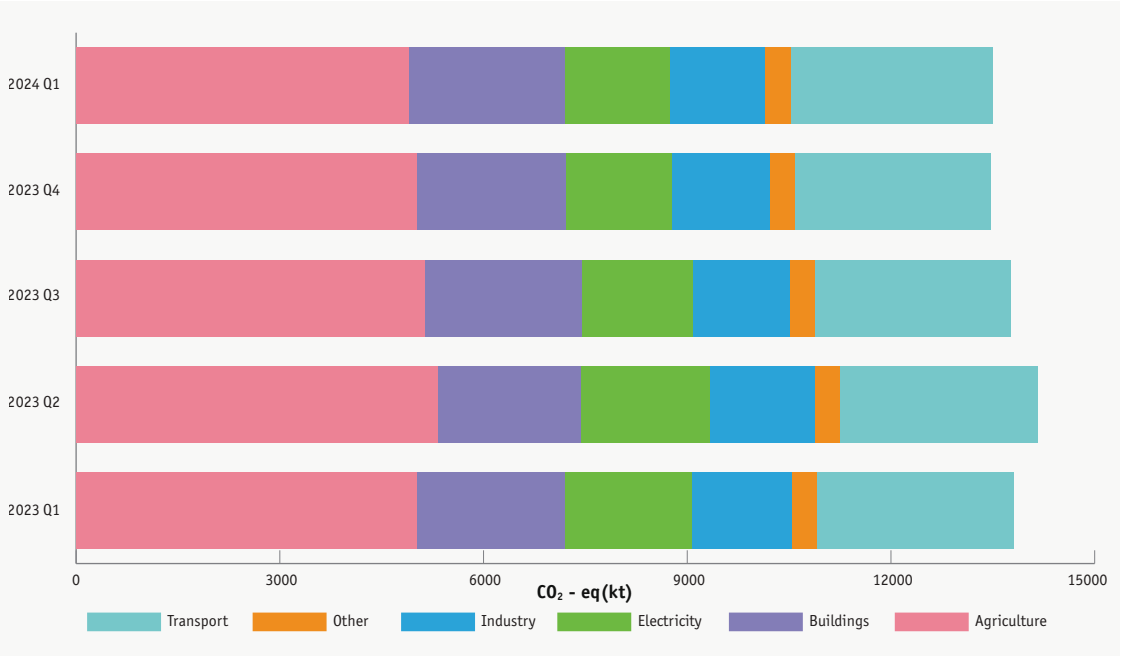
In this section we look at the emissions for Quarter 1 2024 and compare them to Quarter 1 2023

- Overall greenhouse gas emissions decreased by -2.2% (-305.8 kt CO_2 eq).
- The largest sectoral decrease in emissions was observed in the Electricity sector with a change of -16.7% (-311.9 kt CO_2 eq).
- Significant decreases were also observed in the Agriculture sector with emissions falling by -2.6% (-128.5 kt CO_2 eq).
- The largest increase in emissions this quarter was observed in the Buildings sector at +6.1% (+111.7 kt CO_2 eq) for residential and +4.1% (+14.3 kt CO_2 eq) for commercial and public buildings.

Table 3: Summary Q1 2024 compared to Q1 2023

Sector	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Overall	**13,497**	**-305.8**	**-2.2**
Agriculture	4,892	-128.5	-2.6
Buildings (Commercial and Public)	367	14.3	4.1
Buildings (Residential)	1,933	111.7	6.1
Electricity	1,561	-311.9	-16.7
Industry	1,398	-69.1	-4.7
Other	378	-0.4	-0.1
Transport	2,968	78.2	2.7

Figure 3: Overall quarterly movement in greenhouse gas emissions for all Sectors from Q1 2023 to Q1 2024.



2.2 Quarter-on-Quarter Change

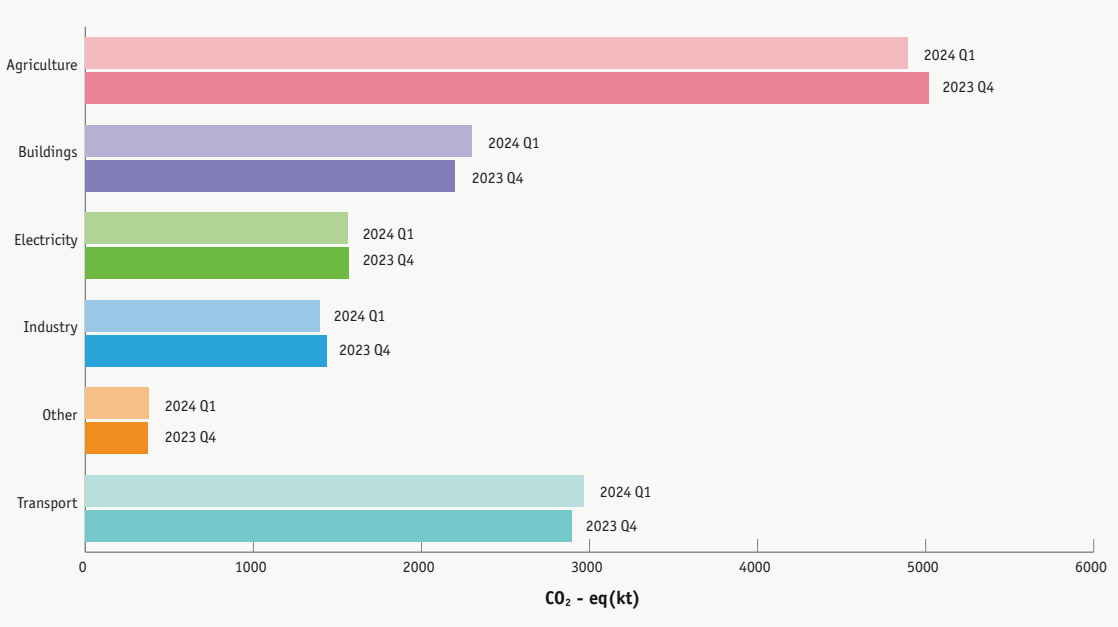
Looking at Quarter 1 2024 compared to Quarter 4 2023:

- The overall greenhouse gas emissions increased by 0.2% (23.3 kt CO_2 eq).
- The largest sectoral decreases in emissions were observed in the Agriculture (-2.4%, -119.4 kt CO_2 eq) and Industry sectors (-2.5%, -35.3 kt CO_2 eq). The largest increase in emissions was observed in the Buildings sector at +4.2% (+78.1 kt CO_2 eq) for residential fuel combustion and +6.7% (+23.0 kt CO_2 eq) for commercial and public buildings respectively.

Table 4: Summary Q1 2024 compared to Q4 2023

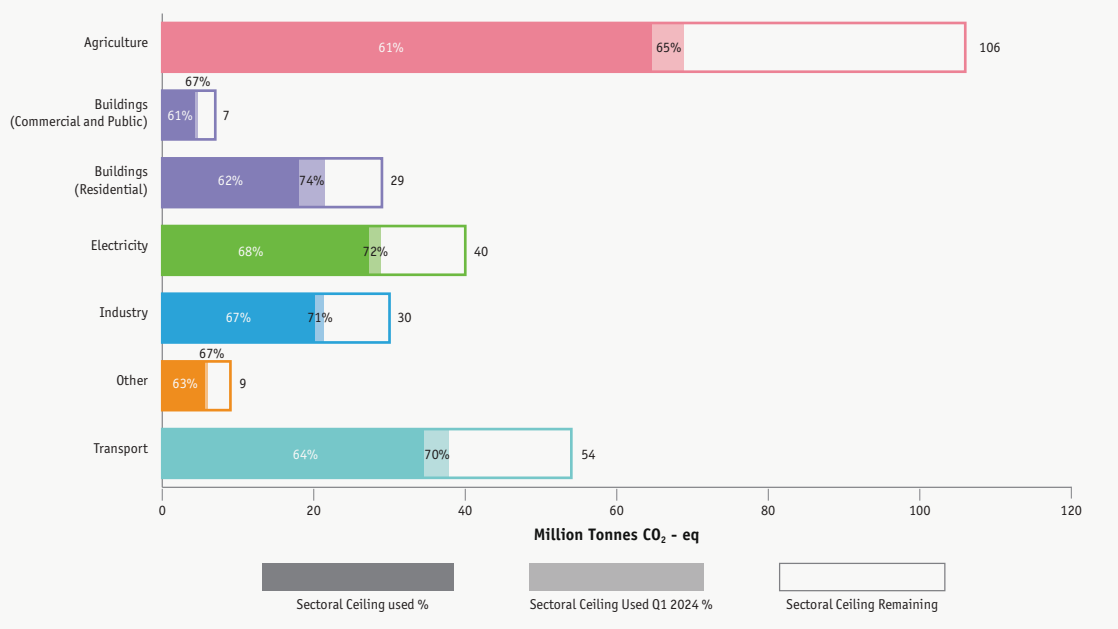
Sector	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q4 2023 (kt CO_2 eq)	Comparisons with Q4 2023 (%)
Overall	**13,497**	**23.3**	**0.2**
Agriculture	4,892	-119.4	-2.4
Buildings (Commercial and Public)	367	23.0	6.7
Buildings (Residential)	1,933	78.1	4.2
Electricity	1,561	-5.2	-0.3
Industry	1,398	-35.3	-2.5
Other	378	6.5	1.8
Transport	2,968	75.6	2.6

Figure 4: Comparison of Q1 2024 and Q4 2023 by sector



With regards to Sectoral Emissions Ceilings, looking specifically at the first Carbon Budget period of 2021-2025, Figure 5 shows the emissions used and the remaining CAP emissions until the ceiling is reached. The amount of sectoral budget used ranges from 65% in the Agriculture Sector to 74% in the buildings (residential) sector. The largest percentage increase of emissions of 12% was within Residential buildings; it should be noted that two of the three months in this quarter are meteorological winter.

Figure 5: Summary of Sectoral Ceiling Emissions Used across 2021 to 2023 as reported in the Provisional Inventory (dark colour), Emissions Used in Q1 2024 (light colour) and the Sectoral Ceiling Emissions Remaining.



3 Sectoral Summaries

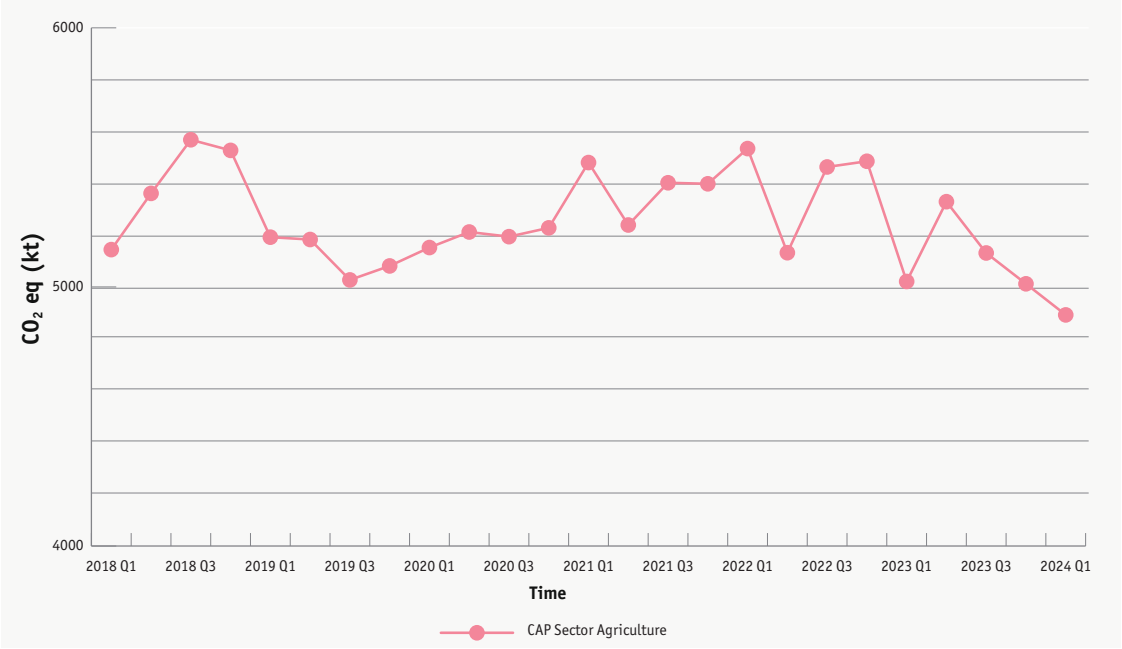
3.1 Agriculture

Subsectors: Agricultural soils, Agriculture/Forestry fuel combustion, Enteric fermentation, Fishing fuel combustion, Liming, Manure management, Urea application

Number of indicator categories: 18

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 97.0%

Figure 6: Changes in emissions in the Agriculture Sector from Q1 2018 to Q1 2024, based on seasonally adjusted data.



3.1.1 Agriculture Year-on-Year Change

Key finding:

- The most significant drivers for the -2.6% decrease in emissions this quarter were significantly reduced limestone application to agricultural land (due to adverse weather conditions), and a reduction in methane emissions associated with reduced milk output (-7.7% compared to 2023 Q1).

Looking at Quarter 1 2024 compared to Quarter 1 2023:

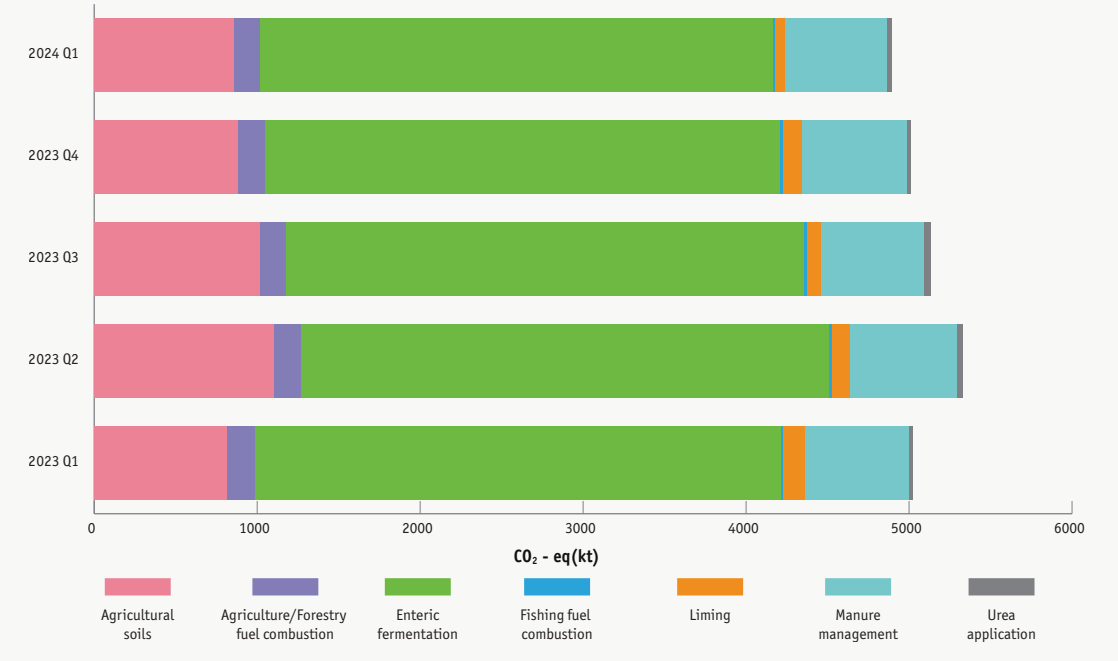
- Agriculture greenhouse gas emissions decreased by -2.6% (-128.5 kt CO_2 eq) compared to a year ago (2023 Q1).
- The largest sub-sectoral decreases in emissions were observed in Liming with a change of -56.6% (-75.7 kt CO_2 eq) and CH_4 production from enteric fermentation of ruminant livestock (-2.6%, -84.3 kt CO_2 eq) due to reduced milk output compared to Quarter 1 2023. Total cattle numbers increased by 4.5% however dairy cattle decreased by 0.7%.
- There were increases in emissions attributed to Agricultural Soils (+42.4 kt CO_2 eq) and Urea Application (+6.1 kt CO_2 eq) due to increased sales of fertilisers and urea-based products during the quarter. However,

due to the adverse weather and ground conditions some stockpiling may have occurred during this quarter.

Table 5: Summary Q1 2024 compared to Q1 2023 - Agriculture

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Agriculture	**CH_4, CO_2, N_2O**	**4,892**	**-128.5**	**-2.6**
Agricultural soils	N_2O	853	42.4	5.2
Agriculture/Forestry fuel combustion	CO_2	163	-9.9	-5.7
Enteric fermentation	CH_4	3,145	-84.3	-2.6
Fishing fuel combustion	CO_2	15	0.8	5.5
Liming	CO_2	58	-75.7	-56.6
Manure management	CH_4, N_2O	630	-7.8	-1.2
Urea application	CO_2	29	6.1	26.9

Figure 7: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.1.2 Agriculture Quarter-on-Quarter Change

Key finding:

- The most significant driver for the -2.4% decrease in emissions this quarter were significantly reduced (-52.2%) limestone application to agricultural land due to adverse weather conditions and overall reductions across all but two sub-sectors (Agriculture/Forestry fuel combustion and Urea application) of agricultural activity on a seasonally adjusted basis.

Looking at Quarter 1 2024 compared to Quarter 4 2023:

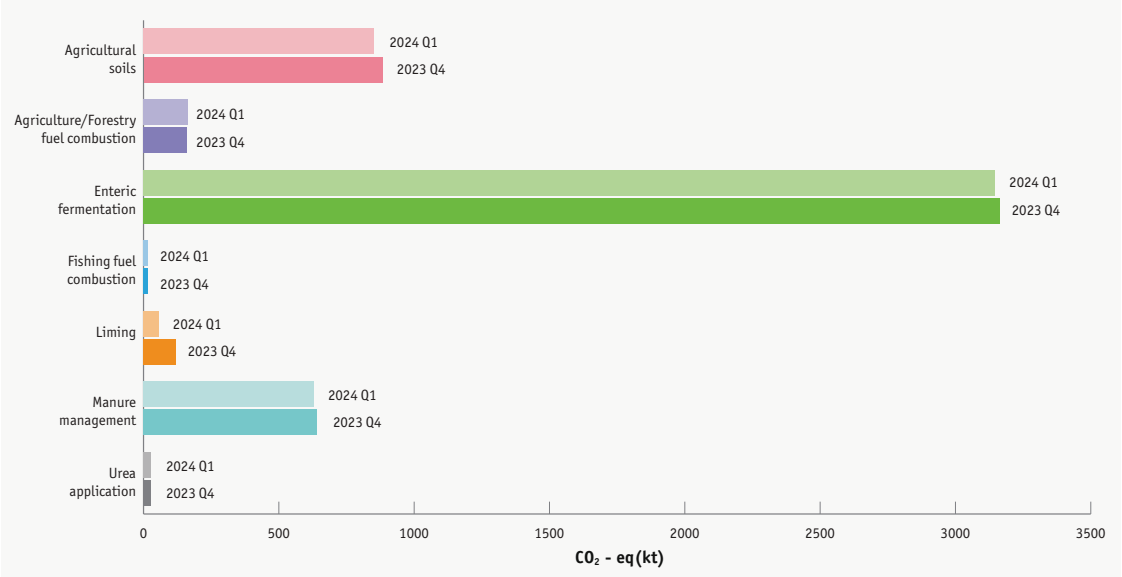
- Agriculture greenhouse gas emissions decreased by -2.4% (-119.4 kt CO_2 eq) compared to the previous quarter (2023 Q4) on a seasonally adjusted basis.

- There were decreases in emissions across five of the seven sub-sectors in agriculture. The largest sectoral decreases in emissions were observed in CO_2 emissions from Liming with a seasonally adjusted change of -52.2% (-63.1 kt CO_2 eq) and N_2O emissions from Agricultural soils (-3.4%, -30.3 kt CO_2 eq).

Table 6: Summary Q1 2024 compared to Q4 2023 - Agriculture

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Agriculture	**CH_4, CO_2, N_2O**	**4,892**	**-119.4**	**-2.4**
Agricultural soils	N_2O	853	-30.3	-3.4
Agriculture/Forestry fuel combustion	CO_2	163	3.1	2.0
Enteric fermentation	CH_4	3,145	-19.7	-0.6
Fishing fuel combustion	CO_2	15	-0.2	-1.3
Liming	CO_2	58	-63.1	-52.2
Manure management	CH_4, N_2O	630	-12.2	-1.9
Urea application	CO_2	29	3.0	11.8

Figure 8: Changes in emissions in the Agriculture Subsectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



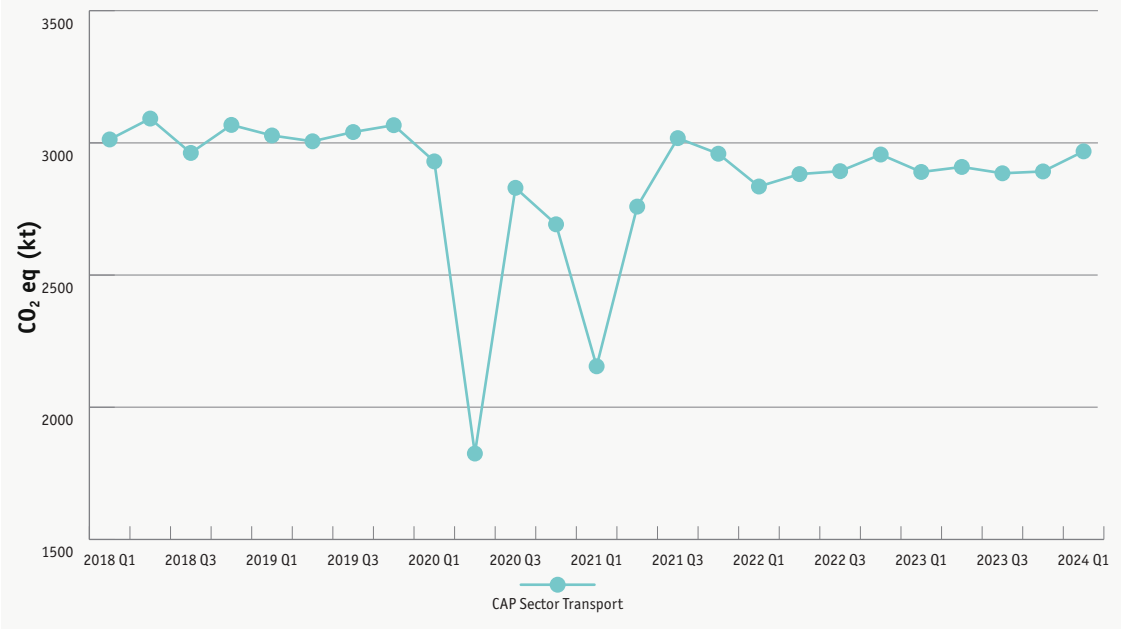
3.2 Transport

Subsectors: Domestic navigation, Other transportation, Railways,Road transportation

Number of indicator categories: 10

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 98.5%

Figure 9: Changes in emissions in the Transport Sector from Q1 2018 to Q1 2024, based on seasonally adjusted data.



3.2.1 Transport Year-on-Year Change

Key finding

- The key driver for the +2.7% increase in emissions in Quarter 1 2024 was increased sales of petrol (+9.6%) and diesel (+1.3%) compared to Quarter 1 2023, as the sector continues to rebound to pre-COVID emissions levels.

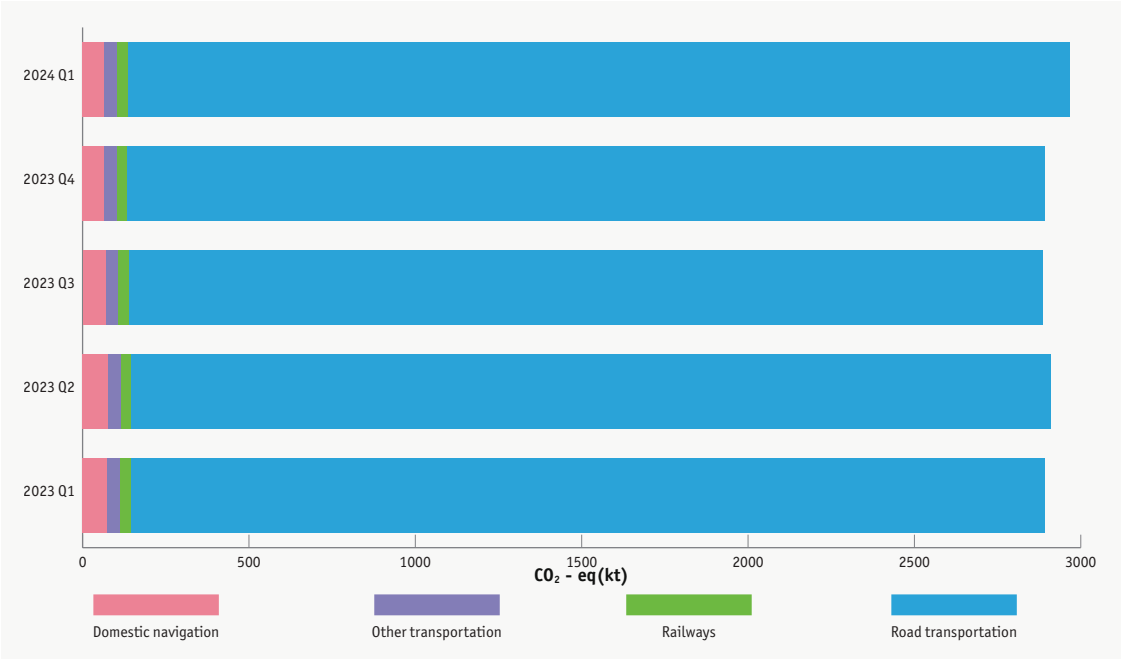
Looking at Quarter 1 2024 compared to Quarter 1 2023:

- Transport greenhouse gas emissions increased by +2.7% (+78.2 kt CO_2 eq) compared to Quarter 1 2023.
- The largest sectoral increase in emissions was observed in Road Transportation with a change of +0.6% (+87.0 kt CO_2 eq) associated with increased petrol (+9.6%) and diesel (+1.3%) sales. The blend of bio-ethanol in petrol (volume based) has increased from 5.1% to 8.7% but the blend of biodiesel in diesel (volume based) has remained the same at 7.2%; their overall contribution to curtailing emissions is modest compared to the increase in consumption.
- Decreased emissions were observed in Domestic Navigation, which includes all national water borne transport and excludes international bunkers/shipping, with emissions falling by -12.1% (-8.9 kt CO_2 eq).

Table 7: Summary Q1 2024 compared to Q1 2023 - Transport

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Transport	**CO_2**	**2,968**	**78.2**	**2.7**
Domestic navigation	CO_2	65	-8.9	-12.1
Other transportation	CO_2	38	-0.1	-0.1
Railways	CO_2	31	0.2	0.6
Road transportation	CO_2	2,834	87.0	3.2

Figure 10: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.2.2 Transport Quarter-on-Quarter Change

Key finding

- There was a +2.6% increase in emissions attributed to the transport sector quarter-over-quarter driven by an increase in emissions from road transportation on a seasonally-adjusted basis.

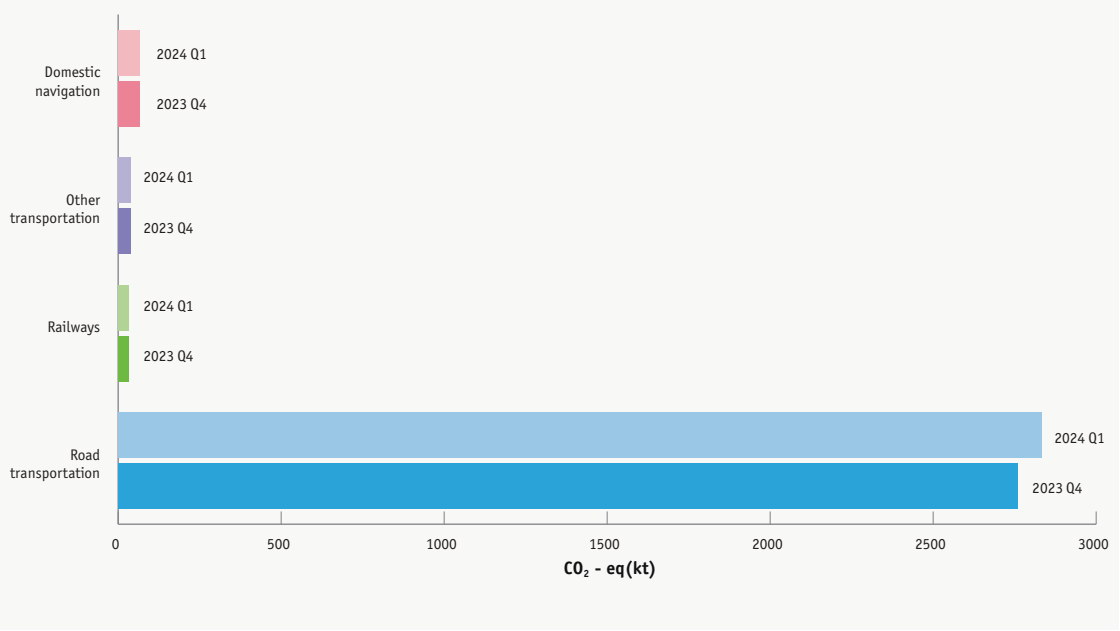
Looking at Quarter 1 2024 compared to Quarter 4 2023:

- Transport greenhouse gas emissions increased by +2.6% (+75.6 kt CO_2 eq) compared to the previous quarter (2023 Q4) on a seasonally adjusted basis.
- The largest sectoral increase in emissions was observed in Road Transportation with a change of +2.7% (+74.9 kt CO_2 eq).
- There was a small reduction in emissions from Railways with emissions falling by -1.1% (-0.3 kt CO_2 eq) driven by drop of 17.8% in passenger-kilometers over this time period.

Table 8: Summary Q1 2024 compared to Q4 2023 - Transport

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Transport	**CO_2**	**2,968**	**75.6**	**2.6**
Domestic navigation	CO_2	65	0.6	1.0
Other transportation	CO_2	38	0.4	1.1
Railways	CO_2	31	-0.3	-1.1
Road transportation	CO_2	2,834	74.9	2.7

Figure 11: Changes in emissions in the Transport sub-sectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



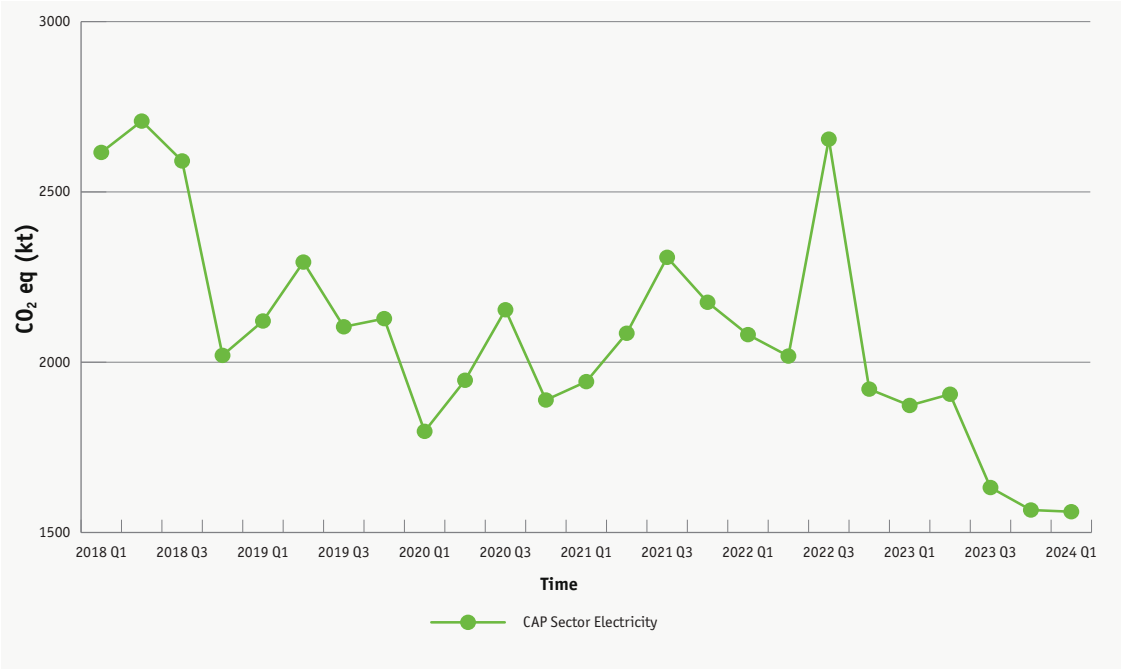
3.3 Electricity

Subsectors: Public electricity and heat production, Solid fuels and other energy industries

Number of indicator categories: 5

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 90.6%

Figure 12: Changes in emissions in the Electricity Subsectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



3.3.1 Electricity Year-on-Year Change

Key finding

- Greenhouse gas emissions decreased by -16.7% (-311.9 kt CO_2 eq) due to reductions in coal, oil and gas use and increases in the amounts of net imported electricity via interconnectors and renewable energy for electricity generation.

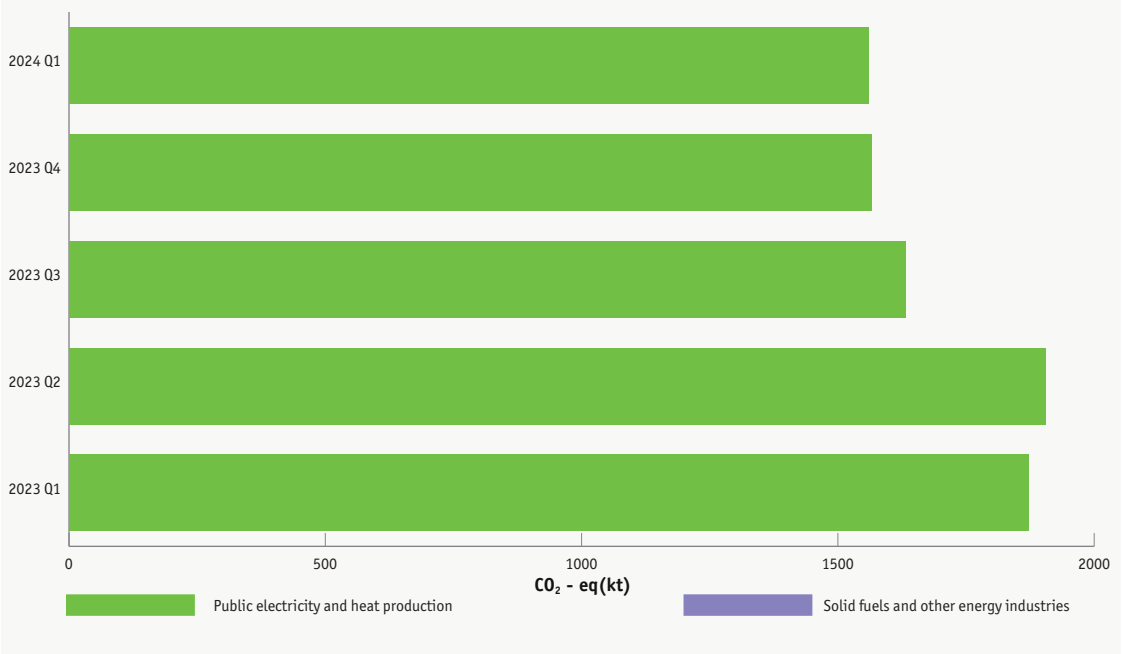
Looking at Quarter 1 2024 compared to Quarter 1 2023:

- The Electricity Sector greenhouse gas emissions decreased by -16.7% (-311.9 kt CO_2 eq). This was driven by a significant decrease in the Public electricity and heat production sub-sector with emissions falling by -16.7% (-311.8 kt CO_2 eq). The amount of net imported electricity via interconnectors in Quarter 1 2024 (1.02 TWh) was over double the amount recorded in Quarter 1 2023 (0.49 TWh). This represented 11% of electricity supplied in the quarter. It is estimated that imports contributed approximately 65% of the indicated reduction in emissions.

Table 9: Summary Q1 2024 compared to Q1 2023 - Electricity

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Electricity	**CO_2**	**1,561**	**-311.9**	**-16.7**
Public electricity and heat production	CO_2	1,560	-311.8	-16.7
Solid fuels and other energy industries	CO_2	1	-0.1	-5.7

Figure 13: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.3.2 Electricity Quarter-on-Quarter Change

Key finding

- Greenhouse gas emissions decreased by -0.3% (-5.2 kt CO_2 eq) due to reductions in coal use and an increase in renewable energy for electricity generation.

Looking at Quarter 1 2024 compared to Q4 2023

- The -0.3% decrease (-5.2 kt CO_2 eq) in this quarter was driven by reductions in emissions in the Public electricity and heat production sub-sector on a seasonally-adjusted basis.

Figure 14: Changes in emissions in the Electricity Sector from Q4 2023 to Q1 2024, based on seasonally adjusted data.

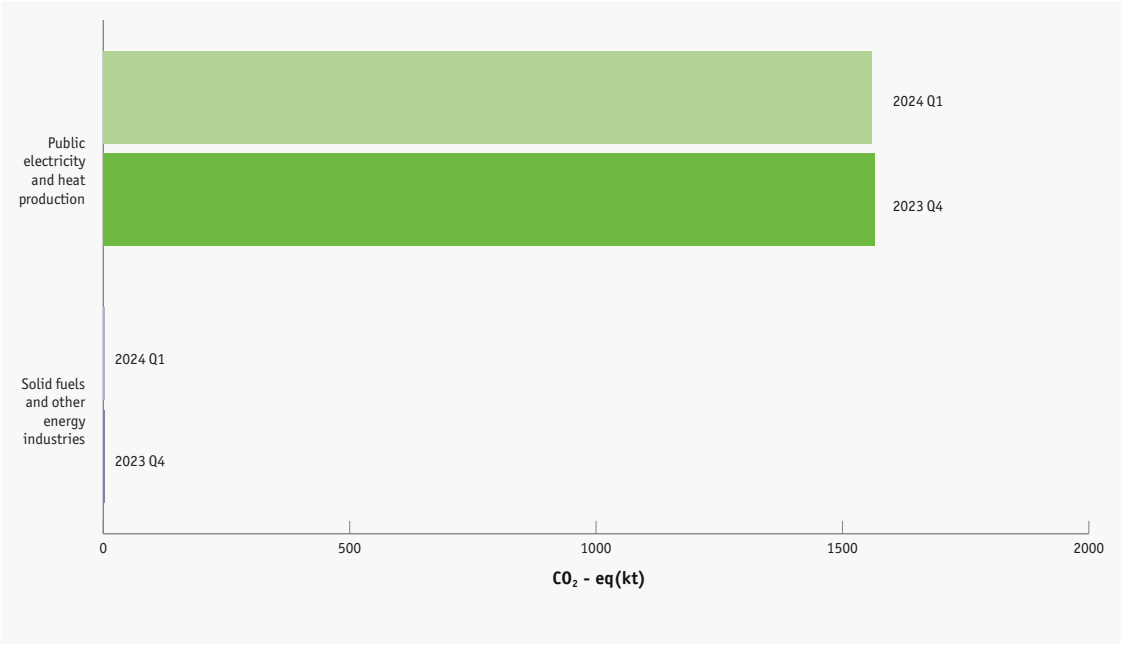


Table 10: Summary Q1 2024 compared to Q4 2023 - Electricity

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Electricity	**CO_2**	**1,561**	**-5.2**	**-0.3**
Public electricity and heat production	CO_2	1,560	-5.3	-0.3
Solid fuels and other energy industries	CO_2	1	0.02	1.5

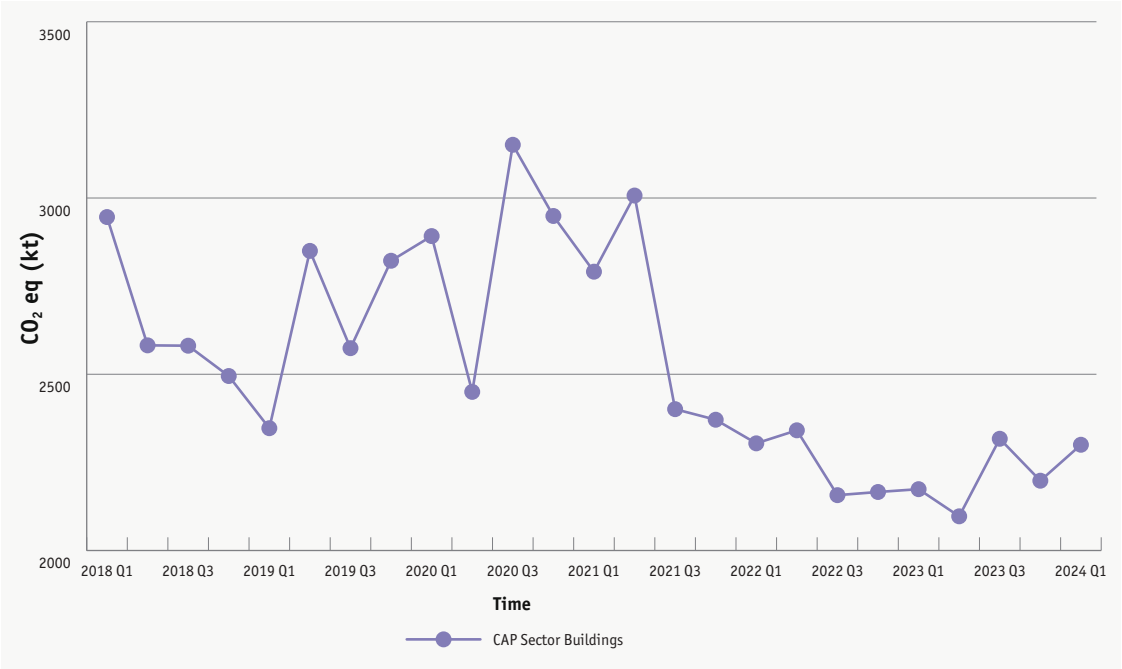
3.4 Buildings

Subsectors: Residential, Commercial & Public Services

Number of indicator categories: 8

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 93.4%

Figure 15: Changes in emissions in the Buildings (Residential) Sector from Q1 2018 to Q1 2024, based on seasonally adjusted data.



3.4.1 Buildings Year-on-Year Change

Key finding

- Overall GHG emissions from Buildings were up +5.8% (+126 kt CO_2 eq) due to increased energy demand for heating with the largest increase in the Residential sector (+6.1%, +111.7 kt CO_2 eq). In addition, the cost of gas was lower in Quarter 1 2024 which could have contributed to increased heating use compared to Quarter 1 2023.

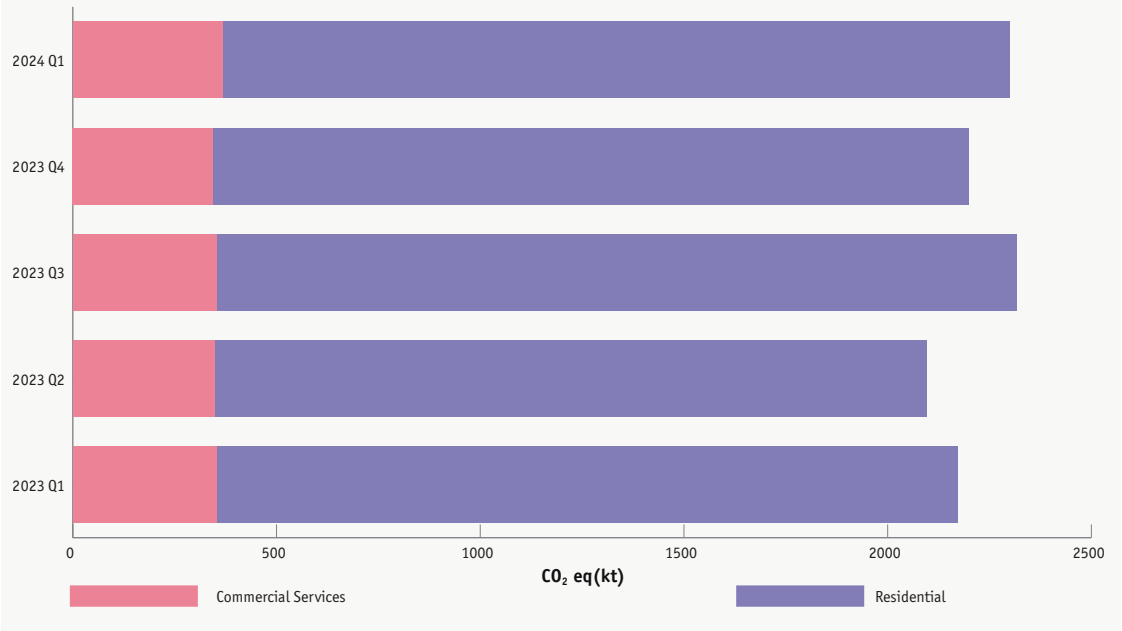
Looking at Quarter 1 2024 compared to Quarter 1 2023:

- Buildings greenhouse gas emissions increased by +5.8% (+126 kt CO_2 eq) driven by an increase in both Commercial & Public Services and Residential building sub-sectors. Factors influencing this increase include a 3.7% increase in heating degree days (days below 15.5 degrees Celsius) and a decrease in the price of gas.
- The largest increase in buildings emissions was observed in the residential sector at +6.1% (+111.7 kt CO_2 eq).
- Significant increases were also observed in the Commercial & Public Services sub-sector with emissions growing by +4.1% (+14.3 kt CO_2 eq).

Table 11: Summary Q1 2024 compared to Q1 2023

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Commercial and Public Services	CO_2	367	14.3	4.1
Residential	CH_4, CO_2	1,933	11.7	6.1

Figure 16: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.4.2 Buildings Quarter-on-Quarter Change

Key finding

- GHG emissions from Buildings were up +4.6% (+101.1 kt CO_2 eq) on a seasonally adjusted basis with the largest increase in Commercial & Public Services buildings (+6.7%, +23.0 kt CO_2 eq).

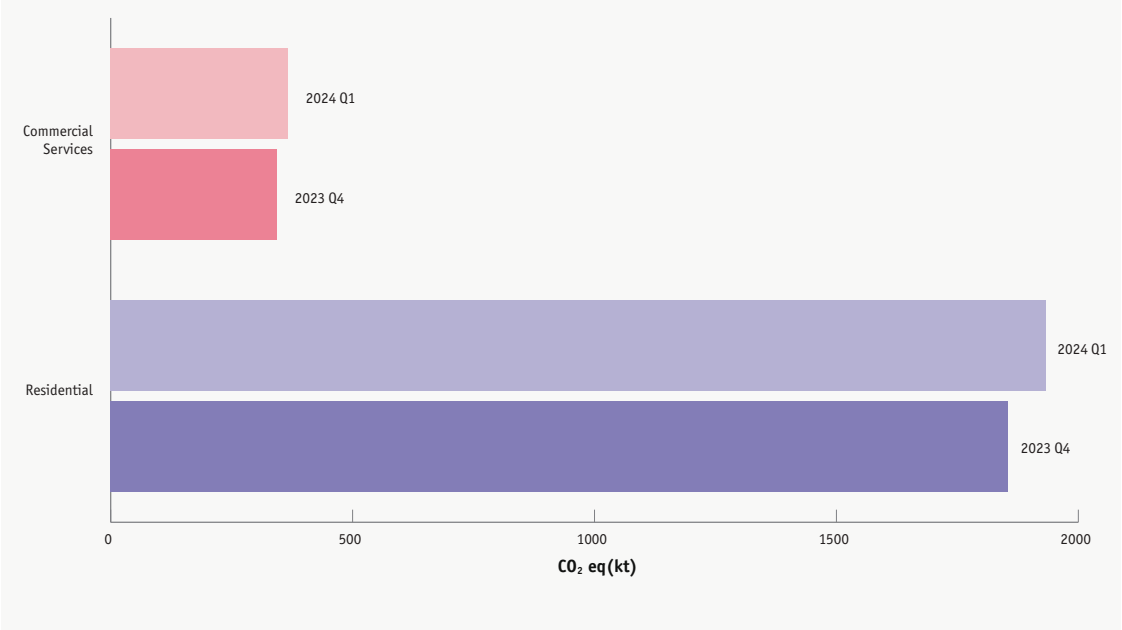
Looking at Quarter 1 2024 compared to Quarter 4 2023:

- The overall buildings greenhouse gas emissions increased by +4.6% (101.1 kt CO_2 eq)
- Both sub sectors of Commercial & Public Services and Residential had significant increases
- Significant increases were observed in the Commercial & Public Services sub-sector with emissions growing by +6.7% (+23.0 kt CO_2 eq).
- The largest increase in emissions was observed in the Residential sector at +4.2% (+78.1 kt CO_2 eq).

Table 12: Summary Q1 2024 compared to Q4 2023 - Bulidings

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Commercial and Public Services	CO_2	367	23.0	6.7
Residential	CH_4, CO_2	1,933	78.1	4.2

Figure 17: Changes in emissions in the Building Subsectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



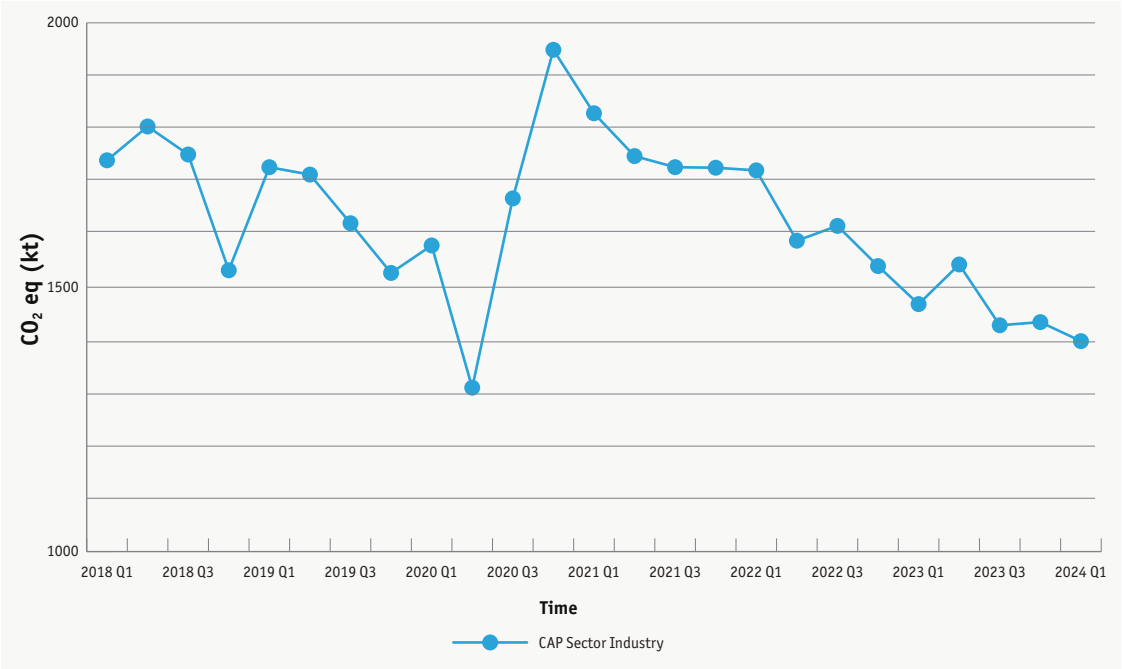
3.5 Industry

Subsectors: Manufacturing Combustion, Mineral Industry

Number of indicator categories: 10

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 93.9%

Figure 18: Changes in emissions in the Industry Sector from Q1 2018 to Q1 2024, based on seasonally adjusted data.



3.5.1 Industry Year-on-Year Change

Key finding

- Industry emissions were down -4.7% (-69.1 kt CO_2 eq), driven mainly by reductions in both process and combustion emissions from the Mineral Industry (largely represented by the cement production sector and includes lime, brick and ceramic sectors).

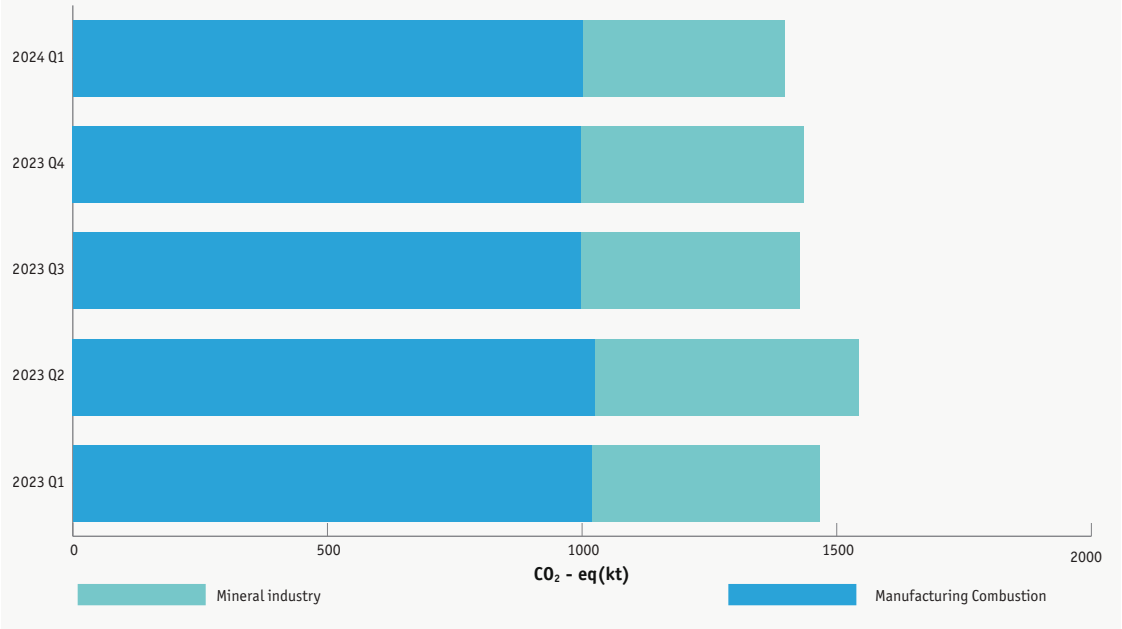
Looking at Quarter 1 2024 compared to Q1 2023

- The overall Industry greenhouse gas emissions decreased by -4.7% (-69.1 kt CO_2 eq) driven by the decrease in emissions in the Mineral industry sub sector, with emissions falling by -11.6% (-52.0 kt CO_2 eq).
- There was also a decrease in emissions observed in the Manufacturing Combustion sub-sector, which represents gas and liquid fuel use in beverage, food processing, chemical and mineral industries, at -1.7% (-17.1 kt CO_2 eq).

Table 13: Summary Q1 2024 compared to Q1 2023 - Industry

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Industry	**CO_2**	**1,398**	**-69.1**	**-4.7**
Manufacturing Combustion	CO_2	1,001	-17.1	-1.7
Mineral industry	CO_2	397	-52.0	-11.6

Figure 19: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.5.2 Industry Quarter-on-Quarter Change

Key finding

- Industry emissions were down -2.5% (-35.3 kt CO_2 eq), driven mainly by reductions in both process and combustion emissions from the Mineral Industry on a seasonally adjusted basis.

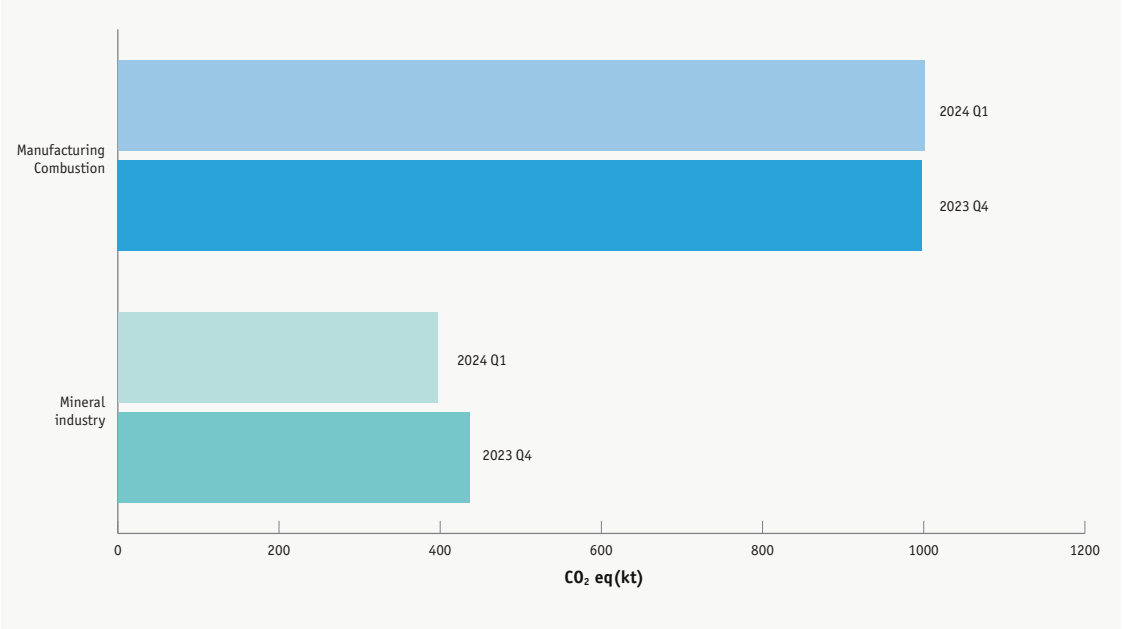
Looking at Quarter 1 2024 compared to Quarter 4 2023:

- The overall Industry greenhouse gas emissions decreased by -2.5% (-35.3 kt CO_2 eq)
- This was driven by a decrease in emissions in the Mineral industry sub sector, with emissions falling by -8.8% (-39.0 kt CO_2 eq) on a seasonally adjusted basis.
- There was a small increase in the Manufacturing Combustion sub-sector, which represents gas and liquid fuel use in beverage, food processing, chemical and mineral industries, at +0.3% (+3.2 kt CO_2 eq).

Table 14: Summary Q1 2024 compared to Q4 2023 - Industry

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Industry	**CO_2**	**1,398**	**-35.3**	**-2.5**
Manufacturing Combustion	CO_2	1,001	3.2	0.3
Mineral industry	CO_2	397	-38.5	-8.8

Figure 20: Changes in emissions in the Industry Subsectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



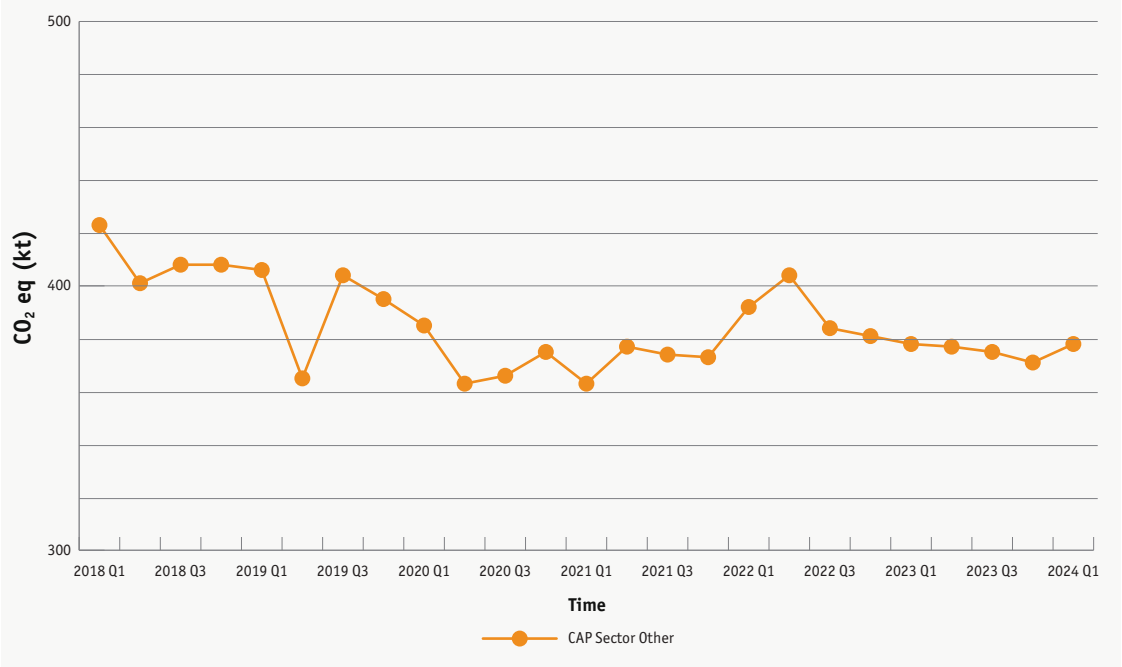
3.6 Other

Subsectors: F-Gases, Petroleum refining, Waste: Landfills, Waste: Wastewater treatment and discharge

Number of indicator categories: 6

Estimated total coverage of quarterly indicator categories compared to original annual National Inventory Report: 90.3%

Figure 21: Changes in emissions in the Other Sector from Q1 2018 to Q1 2024, based on seasonally adjusted data.



3.6.1 Other Year-on-Year Change

Key finding

- Emissions from Other sectors were relatively flat (-0.1%) with increases from landfilled waste (+3.3%) offset by decreases from gas and liquid fuel combustion in Petroleum Refining (-7.3%).

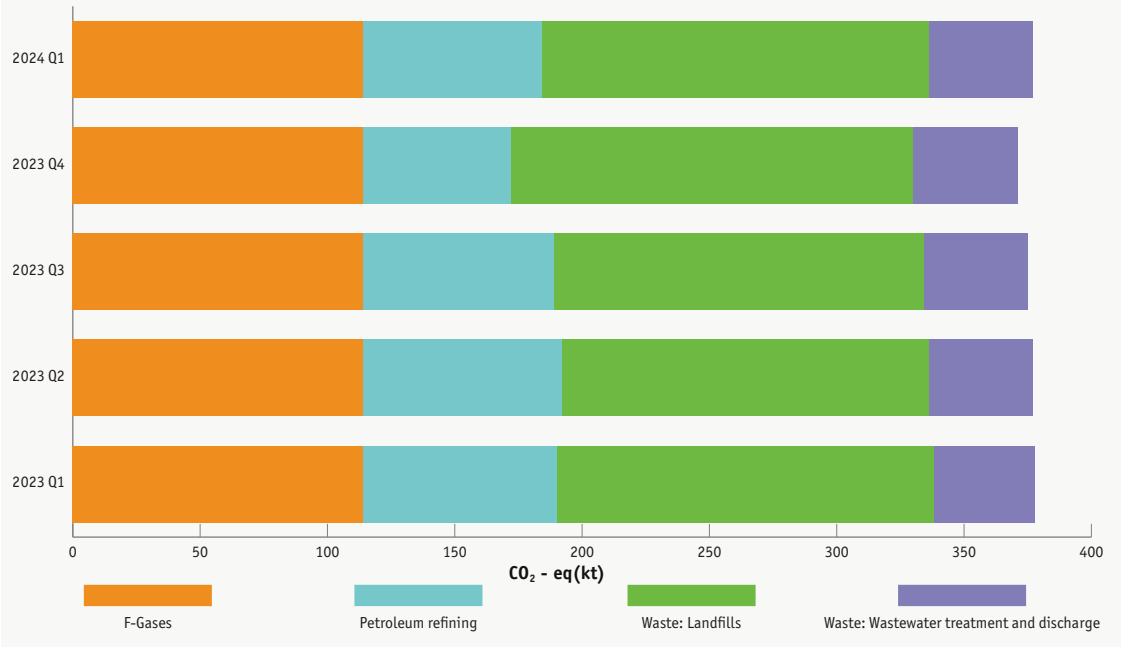
Looking at Quarter 1 2024 compared to Quarter 1 2023:

- Greenhouse gas emissions from Other sectors decreased by -0.1% (-0.4 kt CO_2 eq) compared to a year ago (2023 Q1).
- The largest sectoral decrease in emissions was from gas and liquid fuel combustion in Petroleum Refining with a change of -7.3% (-5.5 kt CO_2 eq). This is in line with reduced intake of these fuels to the remaining refinery facility in the state.
- Emissions from landfilled waste increased by +3.3% (+4.9 kt CO_2 eq) reflecting increases in kerbside collected waste being landfilled over this time period.

Table 15: Summary Q1 2024 compared to Q1 2023 - Other

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparisons with Q1 2023 (kt CO_2 eq)	Comparisons with Q1 2023 (%)
Other	**CH_4, N_2O, HFC, PFC, SF_6, NF_3**	**378**	**-0.4**	**-0.1**
F-Gases	HFC, PFC, SF_6, NF_3	114	-0.1	0.0
Petroleum refining	CO_2	70	-5.5	-7.3
Waste: Landfills	CH_4	152	4.9	3.3
Waste: Wastewater treatment and discharge	CH_4, N_2O	41	0.3	0.6

Figure 22: Comparison of sub-sectoral breakdown in emission for this quarter vs last four quarters, based on seasonally adjusted data.



3.6.2 Other Quarter-on-Quarter Change

Key finding

- Emissions from Other sectors increased +1.8% driven mainly by a quarter-over-quarter increase in gas and liquid fuel combustion in Petroleum Refining. However, emissions are still lower on a year-on-year basis for this sub-sector.

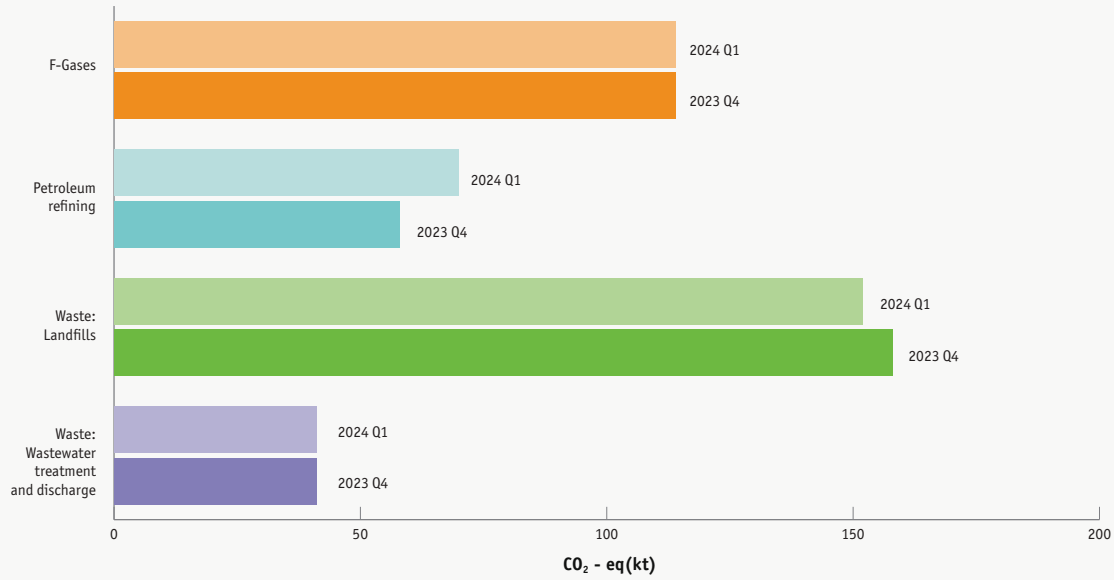
Looking at Quarter 1 2024 compared to Quarter 4 2023

- Greenhouse gas emissions from Other sectors increased by +1.8% (+6.5 kt CO_2 eq) compared to the previous quarter (2023 Q4) on a seasonally adjusted basis.
- The largest sectoral increase in emissions was from gas and liquid fuel combustion in Petroleum Refining with a change of +20.1% (+11.7 kt CO_2 eq).
- Emissions from landfilled waste decreased by -3.3% (-5.1 kt CO_2 eq) from reduced kerbside collected waste being landfilled compared to the previous quarter.

Table 16: Summary Q1 2024 compared to Q4 2023 - Other

Sector	Greenhouse Gas	Emissions Q1 2024 (kt CO_2 eq)	Comparison with Q4 2023 (kt CO_2 eq)	Comparison with Q4 2023 (%)
Other	**CH_4, N_2O, HFC, PFC, SF_6, NF_3**	**378**	**6.5**	**1.8**
F-Gases	HFC, PFC, SF_6, NF_3	114	0.0	0.0
Petroleum refining	CO_2	70	11.7	20.1
Waste: Landfills	CH_4	152	-5.1	-3.3
Waste: Wastewater treatment and discharge	CH_4, N_2O	41	-0.1	-0.2

Figure 23: Changes in emissions in the Other Subsectors from Q4 2023 to Q1 2024, based on seasonally adjusted data.



4 Data

All source data for this report is provided as a separate downloadable MS Excel file via the EPA website. For access to non-open licensed data, please contact the data provider directly.

5 Methodological Notes

This section provides an overview of the two key methodologies used to produce quarterly greenhouse gas emissions estimates:

- Temporal disaggregation and benchmarking of the existing EPA National Inventory Report emissions into quarterly values. The method allows for the estimation of quarterly emission while adhere to the constraint that the sum of all four quarters will equal the reported total annual emission tonnage. In addition, quarters can be extrapolated beyond current annual data.
- Once quarterly data are available, either primary data or data estimated from temporal disaggregation and benchmarking, the degree of seasonality in the data is assessed and, when present, a robust method of seasonal adjustment is applied.

5.1 Summary Methodology

5.1.1 Temporal Disaggregation with Benchmarking

Temporal disaggregation divides the annual inventory time series into four quarterly values. The benchmarking process ensures that the sum of the four quarters equals the annual reported value for the years. Importantly, the method also extrapolates estimates forward in time to predict quarterly values for which the annual totals are not yet available.

Temporal disaggregation and extrapolation can be employed naively or with information from high frequency time series known as proxy indicators. As a first step, domain experts from each sector produce a list of potential proxy indicators. The indicators should approximate the quarterly behaviour or movement of the greenhouse gases emissions in each IPCC category. Examples of proxy indicator variables include monthly energy statistics, monthly trade data, daily gas meter usage data, quarterly census of animal population.

The appropriate method of temporal disaggregation depends on the length of the high frequency proxy time series available. In the ideal case of ten plus years of high frequency data, the first step is to aggregate the high frequency data into annual data and test for correlation with the annual inventory time series using Kendall's tau. It is important to detrend both series by obtaining the first differences before testing for correlation.

There are two recommended static regression methods for the case of ten plus years of high frequency data. The Chow-Lin method is suited for stationary or cointegrated series, and for series with stable growth rates. The alternative Fernandez method is recommended for unstable growth rates or for non-co-integrated data. The appropriate method is selected by comparing the model goodness of fit between Chow-Lin and Fernandez.

The next steps involve checking the quality of the disaggregated quarterly series. The ratio of the quarterly benchmark (the annual values divided by four) to the quarterly indicator over time should be stable. Both the disaggregated quarterly time series and quarterly indicator values are detrended by getting the first difference, and the correlation between the two is calculated using Kendall's tau on the detrended values.

To evaluate the forecast accuracy of the model, out of sample predictive performance for the disaggregated quarterly estimates are calculated. For each full year of available annual inventory data, a comparable annual value is predicted using only the preceding years disaggregated quarterly estimates data. The RMSE, MAE and BIAS between the two estimates as well as the average across years gives a measure of the performance of the disaggregated quarterly series in predicting the annual totals.

Finally, to gauge the volatility in disaggregated quarterly estimates over time, a number of different ratios are

calculated between the quarterly estimates and annual totals. The calculated ratios also summarise which quarters, on average, contain the most emissions.

It is necessary to apply a slightly altered methodology for high frequency time series covering a period of five to ten years. As before, both Chow-Lin and Fernandez are applied, and the best fitting model chosen. However here we also implement the Denton-Chelotte method, which unlike the regression approaches, retains the movement of the high frequency series regardless of correlation with the annual series. The final model is selected based upon the quality of the disaggregated quarterly series produced from each approach. The Denton-Chelotte method can only accommodate one proxy indicator, and if a more complex model involving multiple indicators is required, a static regression method is used.

If only two to four years of high frequency are available, the implementation of a statistic regression method is not recommended. Here the Denton-Chelotte method is applied to produce disaggregated quarterly estimates. As before, the disaggregated quarterly time series is quality checked, and the predictive performance calculated.

5.1.2 Seasonal Adjustment

The first consideration is the length of the time series, and nine quarters of data is an absolute minimum for seasonal adjustment. If the disaggregated quarterly time series is less than nine quarters, then seasonal adjustment cannot be applied. Preferably, the time series will contain at least twenty quarters. If the time series contains more than nine but less than twenty quarters, a domain expert should be consulted to confirm if seasonal adjustment is necessary.

An important first step is to check for the presence of seasonality in the data. A number of different plots (ACF, PACF, Quarterly subseries, Lag correlation) are produced to visually inspect for seasonality. In combination with the visual inspection, three formal statistical tests are employed. The first known as the QS-test tests the null hypothesis that the first two seasonal lags for quarterly data (4 and 8) are zero. The second Kruskall Wallis test is non-parametric and tests if the means of each quarter are drawn from different distributions. The final Friedman test is also non-parametric and tests if the medians differ across quarters.12 If at least two out of the three tests identify seasonality, seasonal adjustment is implemented. If both the visual inspection, Kruskall Wallis and Friedman test fail to find any signal of seasonality (no seasonality or highly unstable seasonality), then the series is not adjusted.

All seasonal adjustment is implemented using the RJdemetra interface. As per CSO Methodology, X-13ARIMA-SEATS pre-treatment and the 'airline' model ARIMA(0, 1, 1, 0, 1, 1) are selected as an initial starting point. The software will test whether a log transformation is necessary and will automatically detect clear additive outliers, level shift outliers and temporary change outliers. It is important to check the quality of the model automatically selected by the RJdemetra interface. The normality, independence and linearity of the model residuals are tested, and the distribution of model residuals visually inspected. If the model is not a good fit, the fully automated model selection specification is used to find an appropriate model. If this also fails to produce a viable model and both Kruskall Wallis and Friedman tests also fail, then seasonal adjustment is not applied.

Given the conservative threshold of detection in automatic identification of outliers, the irregular component of the initial model is examined and points in the time series where the value is greater than 1.5 times the inter-quartile range are identified. The irregular component is visually inspected, and additional outliers are manually included into the model specification. After applying the new model, if the t-value of the additional outliers is greater than 2.0, then the outliers are included in the final model.

The quality of the seasonal adjustment is examined using a number of different outputs from RJdemetra. The idempotency test checks for residual seasonality in the adjusted series. The model decomposition is checked and a number of visual inspections on the diagnostic plots completed. An important output from RJdemetra is the Statistics Canada's Seasonal Adjustment Dashboard. The dashboard report includes graphs of the series, as well as summaries of individual seasonal effects and patterns. Additionally, key seasonal adjustment diagnostics are presented in a traffic light display, and the net effect of seasonal adjustment is decomposed into its various components. Red warnings on the Statistics Canada's Seasonal Adjustment Dashboard indicate poor seasonal adjustment.

If both the model and seasonal adjustment are deemed to be of good quality, then the model is implemented, and the resulting seasonally adjusted estimates used for reporting. However, if both the model and seasonal adjustment are considered poor quality, seasonal adjustment is not implemented, and the unadjusted estimates are used for reporting. In cases where either the model or seasonal adjustment are poor, CSO methodology are consulted to identify improvement actions.

5.2 Revisions and Methodological Changes of Note

For future reports, any revisions to past reported data or methodological changes implemented in latest data will be reported in this section.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