Ireland's Final Greenhouse Gas Emissions

1990-2017

April 2019

CONTENTS

IRELAND'S FINAL GREENHOUSE GAS EMISSIONS IN 2017

KEY HIGHLIGHTS

- The EPA has produced final estimates of greenhouse gas emissions for the period 1990 - 2017.
- For 2017, total national greenhouse gas emissions are estimated to be 60.74 million tonnes carbon dioxide equivalent (Mt CO_2eq). This is 0.9% lower (0.53 Mt CO_2eq) than emissions in 2016.
- In 2017, emissions in the European Union's Emissions Trading Sector[1] (ETS) sector decreased by 4.7% or 0.84 Mt CO_2eq and non-ETS emissions increased by 0.7% or 0.31 Mt CO_2eq.
- Emissions in the *Energy Industries* sector show a decrease of 6.9% or 0.86 Mt CO_2eq which is attributable to a 5.9% decrease in fossil fuel consumption (21.2% decrease in coal and 6.2% decrease in peat) in 2017 and an increase of 21.1% and 1.6% respectively for electricity generated from wind and hydro renewables in 2017.
- *Agriculture* emissions increased by 2.9% or 0.57 Mt CO_2eq in 2017. The most significant drivers for the increased emissions in 2017 are higher dairy cow numbers (+3.1%) with an increase in milk production of 9.2%. Nitrogen fertiliser use also increased by 8.8% in 2017.
- Greenhouse gas emissions from the *Transport* sector decreased by 2.4% or 0.29 Mt CO_2eq in 2017. This is the first year of decreased emissions after four successive years of increases in transport emissions. In road transport in 2017, petrol use continued to decrease by 9.8% while diesel use increased by 0.4% and biofuels use increased by 35.6%.
- *Agriculture* and *Transport* accounted for 73.5% of total ESD emissions in 2017.
- Emissions from the *Manufacturing Combustion*[2] sector increased by 0.14 Mt CO_2eq or 3.1% in 2017. There were minor increases in combustion emissions for all sub sectors including cement which increased by 1.2% in 2017.
- The *Industrial Processes* sector emissions increased by 4.1% or 0.09 Mt CO_2eq, mainly from increased cement production. Cement process emissions increased by 2.6% in 2017.
- Greenhouse gas emissions from the *Residential* sector decreased 5.0% or 0.30 Mt CO_2eq due to a milder winter.
- Both *Commercial* and *Public services* sectors increased by 6.7% in 2017.
- Emissions from the *Waste* sector decreased by 2.5% or 0.02 Mt CO_2eq in 2017.
- These figures indicate that Ireland will exceed its 2017 annual limit set under the EU's Effort Sharing Decision (ESD), 406/2009/EC[3] by 2.94 Mt CO_2eq.
- Ireland's National Policy position is to reduce CO_2 emissions in 2050 by 80% on 1990 levels across the Energy Generation, Built Environment and Transport sectors, with a goal of Climate

[1] The European Union's Emissions Trading Scheme
[2] Manufacturing Combustion; includes combustion of fuels in Industry and Construction, both in ETS and non-ETS
[3] EU Effort Sharing Decision 406/2009/EC

neutrality in the Agriculture and Land-Use sector. The 2017 emissions for Transport, Energy Industries and Residential sectors decreased, however, emission in the Agriculture, Commercial and Public Services sectors are heading in the wrong direction.

Introduction

The EPA is responsible for compiling the inventories of greenhouse gas emissions for Ireland and for reporting the data to the relevant European and international institutions. As such, Ireland's legal reporting obligations require that we submit data for the period 1990-2017 in January, March and April 2019 to the European Commission and the UNFCCC.

The final estimates of Ireland's greenhouse gas figures for the years 1990-2017, based on the SEAI's final energy balances released in October 2018 and are estimated using methodologies employed in the inventory in accordance with UNFCCC reporting guidelines and the latest available input data. In addition, verified emissions data from installations covered by the ETS are included. These estimates are final estimates of Ireland's greenhouse gas figures for the years 1990-2017 and have been officially submitted to the European Commission on March 15th 2019 and the UNFCCC on April 15th 2019.

The 2017 estimates are given below, followed by an account of how these differ from the 2016 estimates. The longer-term trends in greenhouse gas emissions and their significance in relation to Ireland's target under the EU's Effort Sharing Decision on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 are also assessed.

Ireland's Greenhouse Gas Emissions in 2017

For 2017, total national greenhouse gas emissions are estimated to be 60.74 million tonnes carbon dioxide equivalent (Mt CO_2 eq) which is 0.9 % lower (or 0.53 Mt CO_2 eq) than emissions in 2016 (61.27 Mt CO_2 eq) and follows the 3.5% increase in emissions reported for 2016. Emission reductions have been recorded in 7 of the last 10 years, however two of the last three years have seen large increases in emissions. In the last 3 years, national total emissions increased by 6.4% or 3.65 Mt CO_2eq. In the same period, emissions in the stationary ETS sector have increased by 5.9% or 0.94 Mt CO_2eq and emissions under the ESD by 6.6% or 2.70 Mt CO_2eq. Whilst there was a reduction in emissions in 2017, the decreases are mainly due to mild weather conditions which is evident in residential heating and increased renewables in electricity generation.

The inter-annual change in total greenhouse gas emissions is presented in Figure 1 and sectoral emissions in Figures 2 and 3. Detailed sectoral data are shown in Table 3.

Agriculture remains the single largest contributor to the overall emissions at 33.3% of the total. *Transport* and *Energy Industries* are the second and third largest contributors at 19.8% and 19.3% respectively. *Residential* and *Manufacturing Combustion* emissions account for 9.5% and 7.7 % respectively. These five sectors accounted for almost 90% of national total emissions in 2017. The remainder is made up by the *Industrial Processes* at 3.7%, *F*-Gases at 2.0%, *Waste* at 1.5%, *Commercial Services* at 1.8% and *Public Services* at 1.5%. Figure 2 shows the contributions from each of the sectors in 1990 and 2017.

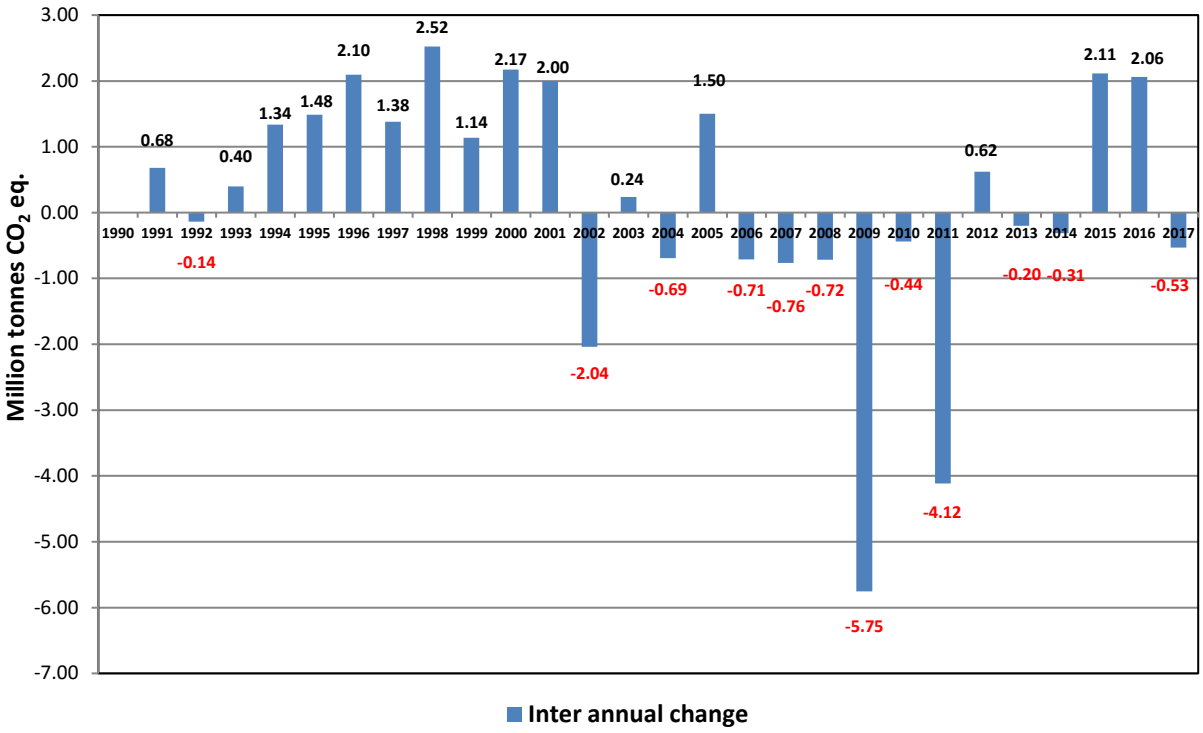

Figure 1. Inter annual changes in GHG emissions 1990-2017

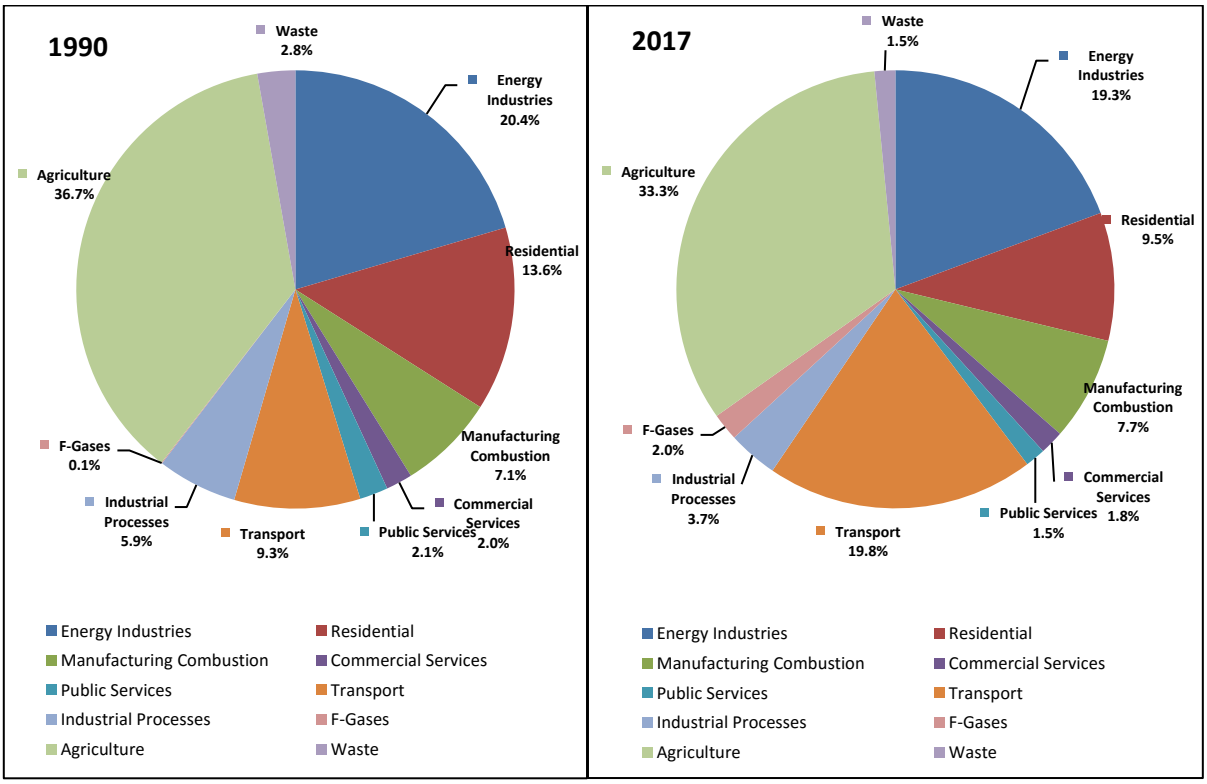

Figure 2. Greenhouse Gas Emissions in 1990 and 2017 by Sector

Changes in Emissions from Sectors between 2016 and 2017

An overview of changes in emissions since the previous year is presented in Table 1.

Table 1. Final greenhouse gas emissions for 2016 and 2017 for Ireland

Mt CO_2 eq	2016	2017	% Change
Agriculture	19.645	20.213	2.9%
Transport	12.295	12.003	-2.4%
Energy Industries	12.608	11.744	-6.9%
Residential	6.046	5.742	-5.0%
Manufacturing Combustion	4.526	4.665	3.1%
Industrial Processes	2.148	2.236	4.1%
F-Gases	1.191	1.231	3.4%
Commercial Services	1.005	1.072	6.7%
Waste	0.957	0.933	-2.5%
Public Services	0.849	0.906	6.7%
Total	**61.270**	**60.744**	**-0.9%**

Agriculture emissions increased by 2.9% or 0.57 Mt CO_2eq in 2017 following an increase in 2016 of 2.7%. The most significant drivers for the increased emissions in 2017 are higher dairy cow numbers (+3.1%) with an increase in milk production of 9.2%. In the last 5 years, dairy cow numbers have increased by 26.1% and corresponding milk production by 38.8%. This reflects national plans to expand milk production under Food Wise 2025 and the removal of the milk quota in 2015. In 2017, there were also increased CO_2eq emissions from synthetic fertiliser application on agricultural soils (+10.3%). Other cattle, pig and sheep numbers increased by 1.6%, 1.6% and 7.2% respectively. Total fossil fuel consumption in agriculture/forestry/fishing activities increased by 5.2% in 2017.

Transport emissions decreased by 2.4% in 2017 or 0.29 Mt CO_2eq. This year sees a decrease in transport emissions after four successive years of increases. Total energy consumption in road transport decreased by 1.1% in 2017; petrol, -9.8%, diesel +0.4% and biofuels +35.6%. However, when considering cross border fuel tourism, total energy consumption grew by 2.1% in 2017; petrol -8.5%, diesel +4.6% and biofuels +39.3%. Total diesel use (bio and fossil) increased in 2017 by 6.2%. Looking at the underlying drivers, the number of passenger diesel cars increased by 10.3% in 2017 while the number of passenger petrol cars decreased by 6.0%, commercial vehicle numbers increased by 2.3% and employment grew by 3.1% between Q4 2016 and Q4 2017.

Sectoral emissions in the *Energy Industries* sector show a decrease of 6.9% which is attributable to decreases in consumption of coal, peat and oil by 21.2%, 6.2% and 47.8% respectively whilst there were increases in natural gas, biomass and non-renewable wastes of 3.6%, 22.3% and 126.1% respectively for electricity generated from wind and hydro renewables. The increases in biomass and non-renewable waste are due to the new waste to energy facility at Dublin's Poolbeg peninsula coming on line in 2017. Also in 2017, electricity generated from wind and hydro increased by 21.1% and 1.6% respectively, reflected in a 9.1% decrease in the emissions intensity of power generation in 2017 (437 g CO_2/kWh) compared with 2016 (480 g CO_2/kWh). Renewables now account for 29.6% of electricity generated in 2017 (up from 25.5% in 2016). Ireland exported 2.3% of electricity generated in 2017, whereas total final consumption of electricity increased by 1.1%.

Emissions in the *Residential* sector decreased by 5.0% or 0.30 Mt of CO_2eq. in 2017. Within the different fuels used in household space and water heating, gasoil use increased by 3.6%, whereas kerosene use decreased by 5.2%, natural gas by 1.3% and coal and peat use continued to decline by

16.8% and 4.3% respectively in 2017. There were 5.9% fewer degree days in 2017, with all 25 weather stations showing fewer heating days especially during the winter months.

Emissions from the *Manufacturing Combustion* sector increased by 3.1% or 0.14 Mt CO_2eq in 2017. There were increases in combustion emissions for all sub sectors including cement which increased in 2017. Increased emissions from companies within the ETS were evident in the food and drink and cement sectors, with emissions increasing by 2.5% and 1.2% respectively.

Emissions from the *Industrial Processes* sector continue to increase by 4.1% (0.09 Mt CO_2eq) in 2017 following a 7.1% increase in 2016, mainly from increased cement production. Total process emissions from the mineral products subsector (including cement) increased by 3.6%.

In 2017, total emissions (combustion and process) from the cement sector increased by 2.1% and amount to 2.78 Mt CO_2eq, or 4.6% of national total emissions. Cement sector emissions have now increased by 83% since 2011.

Emissions from *Commercial Services* and *Public Services* both increased by 6.7% respectively, with increases of 6.4% in natural gas use in both sectors in 2017. There was a decrease in biomass/biogas use of 14.9% in commercial services and an increase of 9.3% in public services.

Emissions from the *Waste* sector decreased by 2.5% in 2017, with a decrease in sub category; landfills of 3.4%. Overall emissions decreased by 0.02 Mt CO_2eq.

Long-term Changes in Sectoral Emissions 1990 – 2017

The trend in emissions from 1990 to 2017 is shown in Figures 3 and 4 and Table 3. The share of CO_2 in total greenhouse gas emissions has increased to 63.8% of total greenhouse gas emissions in 2017 compared to 59.4% in 1990. In contrast, CH_4 and N_2O emissions, primarily from the agriculture sector, have fallen from 40.6% of total greenhouse gas emissions in 1990 to 34.2% in 2017. Emissions from F-gases account for 2.0% of the total in 2017.

Between 1990 and 2017, *Transport* shows the greatest overall increase at 133%, with road transport increasing by 140%. Emissions decreased by 2.4% in 2017, the first year of decrease after four years of increases in *Transport* emissions. *Transport* emissions have decreased by 16.7% below peak levels in 2007 primarily due to the economic downturn, improving vehicle standards due to the changes in vehicle registration tax, the increase use in biofuels and this year, a significant decrease in fuel tourism. The increase up to 2007 can be attributed to general economic prosperity, increasing population with a high reliance on private car travel as well as rapidly increasing road freight transport.

Energy Industries shows an increase in emissions of 3.7% over the period 1990 – 2017. Over the time series, emissions from electricity generation have increased by 2.3% whereas total electricity consumption has increased by 117.8%. Emissions from electricity generation increased from 1990 to 2001 by 54.5% and have decreased by 32.8% between 2001 and 2017. This decrease reflects the improvement in efficiency of modern gas fired power plants replacing older peat and oil fired plants and the increased share of renewables, primarily, wind power.

Emissions from *Agriculture* reached a peak in 1998 and have decreased to below their 1990 level since 2002, reflecting long-term decline in livestock populations and in fertiliser use due to the Common Agricultural Policy. Emissions from *Agriculture* in 2017 are now 0.7% below their 1990 levels but have increased for 5 out of the last 6 years. The changes in *Agriculture* emissions are underpinned by higher animal numbers; in the 5-year period 2012-2017, dairy cow numbers have increased by 26.1% and corresponding milk production by 38.8%. This reflects national plans to expand milk production under Food Wise 2025 and the removal of the milk quota in 2015.

Increased housing stock drove the gradual upward trend in the emissions from the *Residential* sector after 1998 following a sharp reduction in the early 1990s that resulted from fuel switching to reach a

peak in 2010. The 2017 emissions in this sector are 5.0% lower than 2016 levels and are 23.7% lower than their 1990 level whereas the housing stock has increased by 75.6% in the same period. Winter heating demand is the most important variable determining emissions from this sector with 5.9% fewer degree days in 2017.

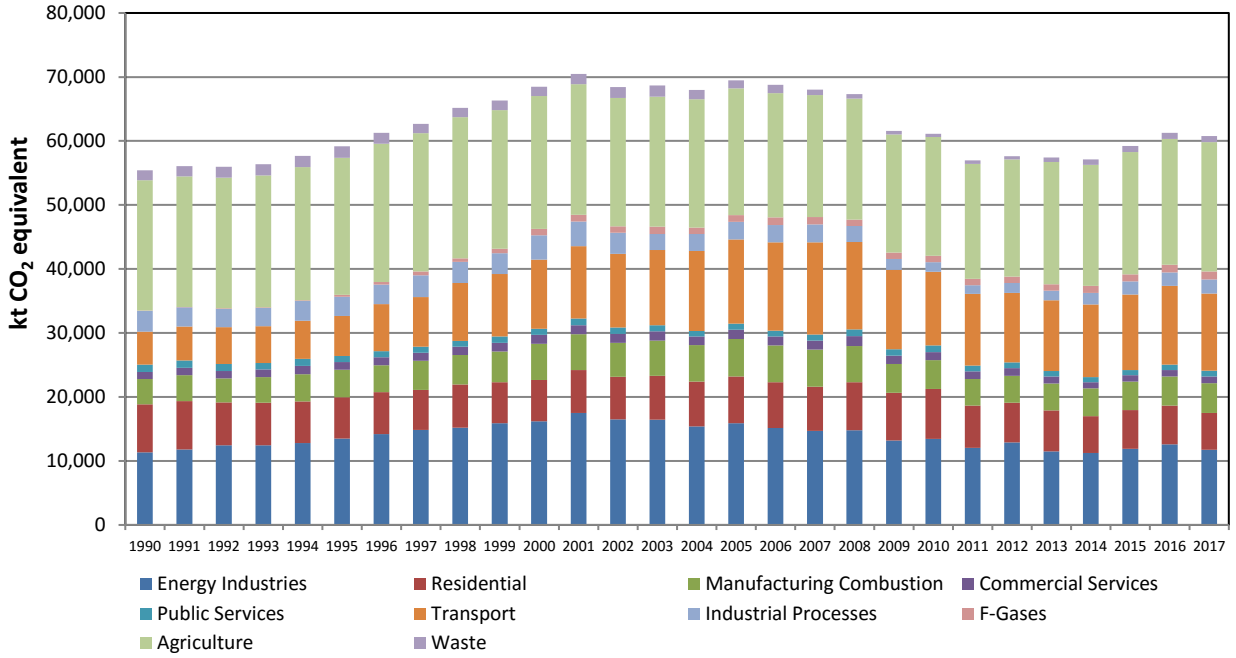

Figure 3. GHG emissions by sector 1990-2017

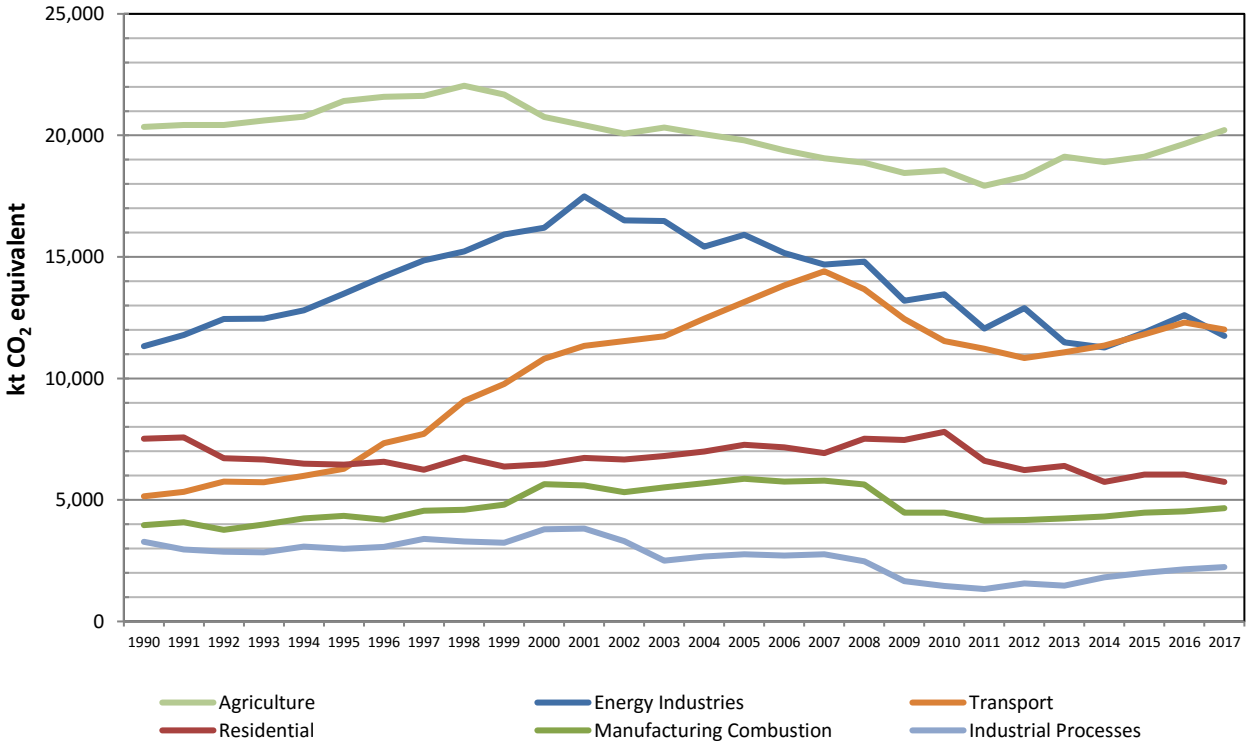

Figure 4. Trend in emissions for largest sectors 1990-2017

Compliance with EU and international commitments

The greenhouse gas emission inventory for 2017 is the fifth year that compliance under the European Union's Effort Sharing Decision (Decision 406/2009/EC) will be assessed. This Decision sets 2020 targets for sectors outside of the Emissions Trading Scheme (known as non-ETS sector emissions) and annual binding limits for the period 2013-2020. Ireland's target is to reduce non-ETS emissions by 20% by 2020 compared with 2005 levels.

The final inventory reviews for 2013 and 2014 data was completed in August 2016, 2015 data was completed in April 2017 and 2016 data was completed in April 2018, following submission of official data in March 2018 to the European Commission. Ireland has currently 10.08 Mt CO_2 eq additional annual emission allowances (AEAs) compared with greenhouse gas emissions for the period 2013 to 2016, see Table 2 and Figure 5.

Ireland's annual limit for 2017 is 40.89 Mt CO_2 eq. Ireland's final 2017 greenhouse gas emissions for non-ETS sectors are 43.83 Mt CO_2 eq, 2.94 Mt CO_2 eq more than the annual limit for 2017. This value is the national total emissions less emissions covered by the EU's emissions trading scheme for stationary and aviation operators. Agriculture and Transport accounted for 73.5% of total ESD emissions in 2017. This indicates that Ireland will not be in compliance with its 2017 Effort Sharing Decision annual limit.

Table 2. Compliance with EU ESD Targets 2013-2020

		2013	2014	2015	2016	2017	2018	2019	2020	
A	Total greenhouse gas emissions without LULUCF[1]	57,903.4	57,626.0	59,878.2	61,545.8	60,743.7	0.0	0.0	0.0	kt CO_2eq
B	NF_3 emissions	0.9	1.0	1.0	1.0	1.3	0.0	0.0	0.0	kt CO_2eq
C	Total greenhouse gas emissions without LULUCF and without NF_3 emissions	57,902.5	57,625.1	59,877.3	61,544.9	60,742.5	0.0	0.0	0.0	kt CO_2eq
D	Total verified emissions from stationary installations under Directive 2003/87/EC[2]	15,685.7	15,952.7	16,829.7	17,737.0	16,896.4	0.0	0.0	0.0	kt CO_2eq
E	CO_2 emissions from 1.A.3.a. domestic aviation	10.0	9.4	10.4	9.7	17.3	0.0	0.0	0.0	kt CO_2eq
F	**Total ESD emissions (= C-D-E)**	42,206.8	41,663.0	43,037.2	43,798.2	43,828.7	0.0	0.0	0.0	kt CO_2eq
G	**EU ESD Targets**	46,891.9	45,760.9	44,629.9	43,498.9	40,885.1	39,807.1	38,729.2	37,651.3	kt CO_2eq
	Distance to target (= F-G)	-4,685.1	-4,097.9	-1,592.7	299.3	2,943.7				kt CO_2eq

Note: Shaded cells show data that has been reviewed, and compliance agreed, by the European Commission under Article 19 of the MMR No. 525/2013

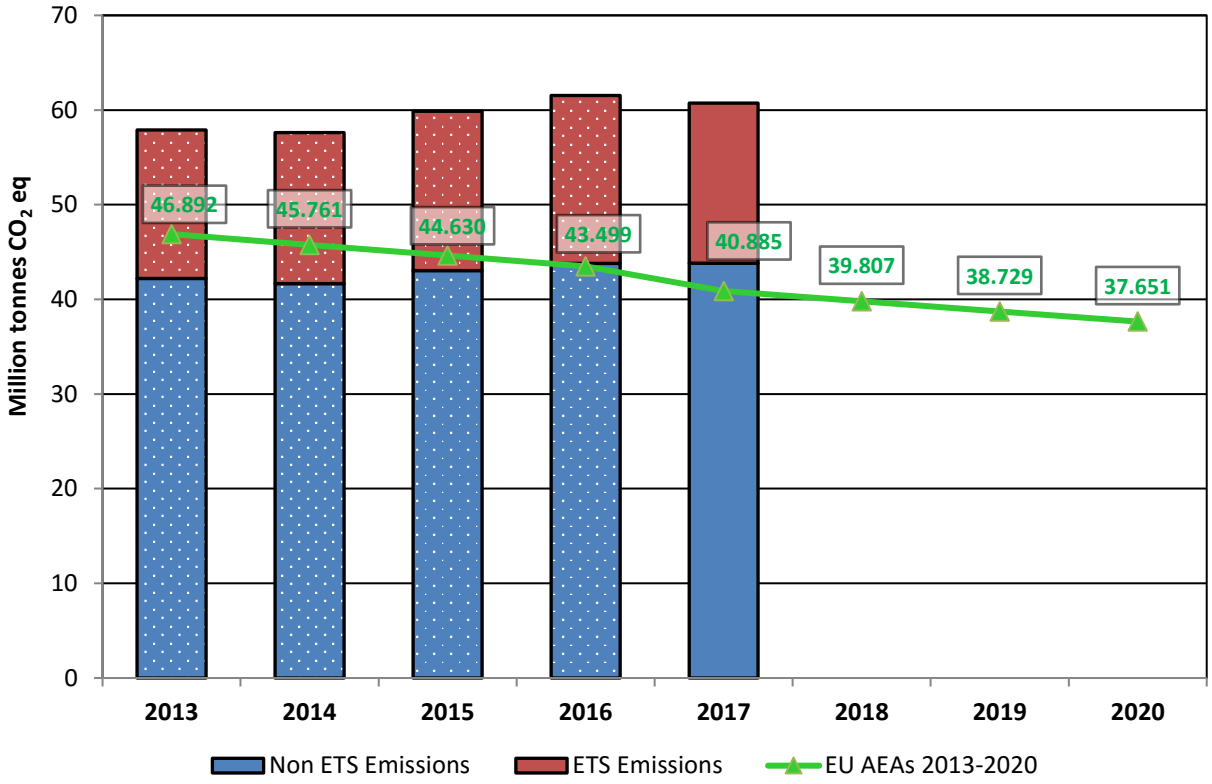

Figure 5. ESD Targets 2013-2020

Table 3. Ireland's GHG Emissions by Sector 1990-2017 (kilotonnes CO_2 equivalent)

1990-2017_Submission 2019 Final	1990	1995	2000	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual change	kt CO2
Energy Industries	11328.06	13479.88	16204.68	15908.20	14678.32	14803.77	13194.08	13459.60	12054.73	12894.73	11487.42	11272.18	11891.44	12608.23	11743.99	**-6.9%**	**-864.24**
Public electricity and heat production	10953.92	13132.91	15754.35	15244.75	14055.76	14155.13	12610.63	12895.10	11556.54	12356.28	10952.93	10771.89	11328.27	12076.43	11206.21	**-7.2%**	**-870.22**
Petroleum refining	168.67	181.27	274.80	411.87	360.80	367.48	315.39	310.47	285.42	313.55	294.55	279.50	358.72	313.59	311.21	**-0.8%**	**-2.38**
Solid fuels and other energy industries	100.54	69.44	87.15	171.89	166.45	187.87	193.09	174.66	137.46	146.29	162.01	134.84	115.75	126.26	129.41	**2.5%**	**3.15**
Fugitive emissions	104.94	96.25	88.38	79.69	95.32	93.29	74.98	79.36	75.31	78.62	77.94	85.95	88.70	91.94	97.17	**5.7%**	**5.22**
Residential	7523.66	6452.05	6462.60	7271.61	6928.46	7521.49	7466.98	7800.88	6609.71	6232.29	6395.38	5745.58	6041.31	6046.48	5741.51	**-5.0%**	**-304.97**
Manufacturing Combustion	3961.75	4347.62	5642.37	5870.42	5788.73	5629.34	4480.28	4476.47	4142.36	4176.49	4236.52	4322.98	4482.62	4526.18	4665.07	**3.1%**	**138.89**
Commercial Services	1083.49	1165.57	1374.71	1475.61	1414.80	1547.87	1294.97	1293.65	1191.98	1181.39	1063.19	953.96	967.15	1004.67	1072.23	**6.7%**	**67.57**
Public Services	1160.65	936.34	989.43	952.44	958.73	1053.01	995.71	1014.35	902.85	917.02	855.85	798.26	832.22	849.35	905.83	**6.7%**	**56.48**
Transport	5150.94	6283.81	10801.16	13143.23	14405.80	13674.03	12451.48	11535.07	11222.75	10836.27	11067.61	11347.61	11812.73	12294.65	12002.56	**-2.4%**	**-292.08**
Domestic aviation	52.80	50.66	74.70	80.21	85.02	80.53	65.62	49.51	24.65	14.99	15.37	14.69	15.55	16.78	17.46	**4.0%**	**0.68**
Road transportation	4789.38	5890.73	10373.50	12561.65	13844.32	13086.66	11898.62	10985.73	10735.97	10366.24	10595.66	10841.78	11315.48	11751.17	11493.91	**-2.2%**	**-257.26**
Railways	148.87	124.51	137.65	136.58	147.71	156.54	137.36	136.31	136.52	131.93	131.38	120.53	122.83	125.10	129.14	**3.2%**	**4.04**
Domestic navigation	85.77	92.10	152.65	211.19	197.53	204.73	199.52	200.12	173.73	183.60	179.59	224.81	221.73	266.46	235.28	**-11.7%**	**-31.18**
Other transportation	74.12	125.80	62.65	153.60	131.22	145.56	150.36	163.40	151.88	139.52	145.61	145.79	137.13	135.13	126.77	**-6.2%**	**-8.37**
Industrial Processes	3274.18	2990.54	3788.48	2763.47	2769.06	2470.65	1657.33	1463.40	1333.68	1560.10	1475.85	1818.74	2005.65	2147.85	2235.59	**4.1%**	**87.74**
Mineral industry	1116.73	1084.18	1908.78	2552.80	2582.80	2301.58	1486.14	1300.01	1168.75	1393.44	1301.70	1650.45	1830.36	1968.40	2039.86	3.6%	71.45
Chemical industry	1985.55	1754.44	1663.30	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		
Metal industry	26.08	24.80	28.80	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		
Non-energy products from fuels and solvent use	114.48	94.93	153.72	173.72	147.14	128.97	130.66	122.67	124.03	125.66	133.09	127.07	133.84	136.88	152.95	**11.7%**	**16.08**
Other product manufacture and use	31.34	32.20	33.88	36.96	39.12	40.10	40.53	40.72	40.90	40.99	41.06	41.21	41.44	42.57	42.77	**0.5%**	**0.20**
F-Gases	35.23	285.45	968.41	1021.47	1174.95	1036.07	1036.87	1008.09	1014.58	994.75	1028.38	1086.08	1101.83	1190.69	1230.98	**3.4%**	**40.29**
Agriculture	20352.29	21413.19	20757.48	19797.90	19051.13	18878.21	18454.30	18553.62	17925.79	18303.40	19128.98	18900.68	19128.12	19644.93	20212.57	**2.9%**	**567.64**
Enteric fermentation	11356.97	11480.10	11260.82	10843.14	10586.99	10539.09	10370.00	10162.10	10045.18	10379.27	10532.74	10655.91	10880.29	11212.11	11542.43	**2.9%**	**330.31**
Manure management	1904.53	1937.12	1916.22	1881.76	1809.51	1797.39	1775.00	1739.75	1736.19	1812.79	1832.21	1840.20	1872.41	1936.82	1971.29	**1.8%**	**34.47**
Agricultural soils	5872.82	6295.02	6148.80	5679.79	5265.76	5205.92	5067.50	5349.00	4966.39	5102.86	5552.41	5379.83	5365.92	5426.11	5699.89	**5.0%**	**273.78**
Liming	355.04	494.60	366.38	266.73	376.77	262.21	307.32	427.93	360.68	229.40	515.69	391.07	401.15	433.60	332.75	**-23.3%**	**-100.85**
Urea application	44.47	39.68	42.25	27.90	23.36	30.76	40.93	45.16	32.32	21.32	21.66	25.09	28.31	35.80	35.04	**-2.1%**	**-0.76**
Agriculture/Forestry fuel combustion	730.62	1008.11	909.76	953.63	868.02	939.19	796.63	753.49	721.93	687.92	596.55	534.52	514.94	540.70	560.37	**3.6%**	**19.66**
Fishing	87.85	158.55	113.24	144.94	120.74	103.65	96.92	76.18	63.10	69.85	77.73	74.06	65.11	59.79	70.80	**18.4%**	**11.01**
Waste	1546.80	1823.02	1489.09	1290.68	848.51	687.39	515.21	499.72	590.77	515.09	671.03	852.47	948.75	957.18	933.40	**-2.5%**	**-23.78**
Landfills	1318.08	1592.76	1268.16	1007.00	615.99	463.84	284.80	278.65	381.56	302.79	460.97	648.10	742.15	767.78	741.81	**-3.4%**	**-25.98**
Biological treatment of solid waste	0.00	0.00	0.00	13.77	12.48	16.44	21.07	20.99	22.91	22.41	22.73	19.30	20.66	19.89	18.83	**-5.3%**	**-1.06**
Incineration and open burning of waste	92.48	94.43	75.83	131.19	83.69	62.64	64.11	55.63	43.34	46.11	43.57	39.14	39.65	22.39	24.62	**10.0%**	**2.23**
Wastewater treatment and discharge	136.24	135.83	145.10	138.72	136.34	144.46	145.22	144.46	142.96	143.77	143.76	145.93	146.29	147.12	148.15	**0.7%**	**1.03**
National Total	**55417.06**	**59177.47**	**68478.41**	**69495.03**	**68018.50**	**67301.83**	**61547.23**	**61104.84**	**56989.19**	**57611.53**	**57410.21**	**57098.54**	**59211.81**	**61270.20**	**60743.73**	**-0.9%**	**-526.48**

Notes

Units: 1 Mt = 1,000 kilotonnes

CO_2 Equivalent: greenhouse gases other than CO_2 (i.e. methane, nitrous oxide and F-gases) may be converted to CO_2 equivalent using their global warming potentials (GWPs).

F-gases: These gases comprise HFCs (Hydroflurocarbons), PFCs (Perfluorcarbons), SF_6 (Sulphur Hexafluoride) and NF_3 (Nitrogen Trifluoride). They are much more potent than the naturally occurring greenhouse gas emissions (carbon dioxide, methane and nitrous oxide).

GWPs:

Industrial designation or common name	Chemical formula	GWP for 100-year time horizon IPCC 4th assessment report (AR4)
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Hydrofluorocarbons	HFCs	12 to 14,800
Perfluorinated compounds	PFCs	7,390 to >17,340
Sulphur hexafluoride	SF_6	22,800
Nitrogen trifluoride	NF_3	17,200

Ireland's GHG Sectors: include the following ten sectors for analysis;

1. Energy Industries (electricity generation, waste to energy incineration, oil refining, briquetting manufacture and fugitive emissions)
2. Residential (combustion for domestic space and hot water heating)
3. Manufacturing Combustion (combustion for Manufacturing industries in ETS and non-ETS)
4. Commercial Services (combustion for Commercial Services space and hot water heating)
5. Public Services (combustion for Public services space and hot water heating)
6. Transport (combustion of fuel used in road, rail, navigation, domestic aviation and pipeline gas transport)
7. Industrial Processes (process emissions from mineral, chemical, metal industries, non-energy products and solvents)
8. F-Gases (gases used in refrigeration, air conditioning and semiconductor manufacture)
9. Agriculture (emissions from fertiliser application, ruminant digestion, manure management, agricultural soils and fuel used in agriculture/forestry/fishing)
10. Waste (emissions from solid waste disposal on land, solid waste treatment (composting), wastewater treatment, waste incineration and open burning of waste).

Uncertainty Analysis:

The EPA uses a method described by the 2006 IPCC guidelines to assess uncertainty in the emissions inventory data. This method estimates uncertainties for the entire inventory in a particular year and the uncertainty in the trend over time by combining the uncertainties in activity data and emission factors for each source category. The estimated uncertainty on the level of emissions in 2017 is 3.7% and the trend uncertainty over the period 1990-2017 is 2.1%. The most significant contributors to the level of uncertainty are methane emissions from livestock and nitrous oxide emissions from agricultural soils.