Department for Environment Food & Rural Affairs

STATISTICAL RELEASE: 15 FEBRUARY 2018

EMISSIONS OF AIR POLLUTANTS IN THE UK, 1970 TO 2016

- There has been a long term decrease in the emissions of all of the air pollutants covered by this statistical release (ammonia, nitrogen oxides, non-methane volatile organic compounds, particulate matter (PM_{10}, $PM_{2.5}$) and sulphur dioxide).

- Emissions of sulphur dioxide decreased by 29 per cent from 2015 to 2016, dropping to the lowest level in the time series.

- Emissions of nitrogen oxides decreased in 2016 compared to 2015 by 10 per cent, dropping to the lowest level in the time series.

- Emissions of non-methane volatile organic compounds are continuing to decline, by 2.0 per cent between 2015 and 2016. The rate of decline was most pronounced in the 1990s and early 2000s and has slowed in recent years.

- PM_{10} emissions have remained relatively static over the past five years but decreased by 1.9 per cent from 2015 to 2016.

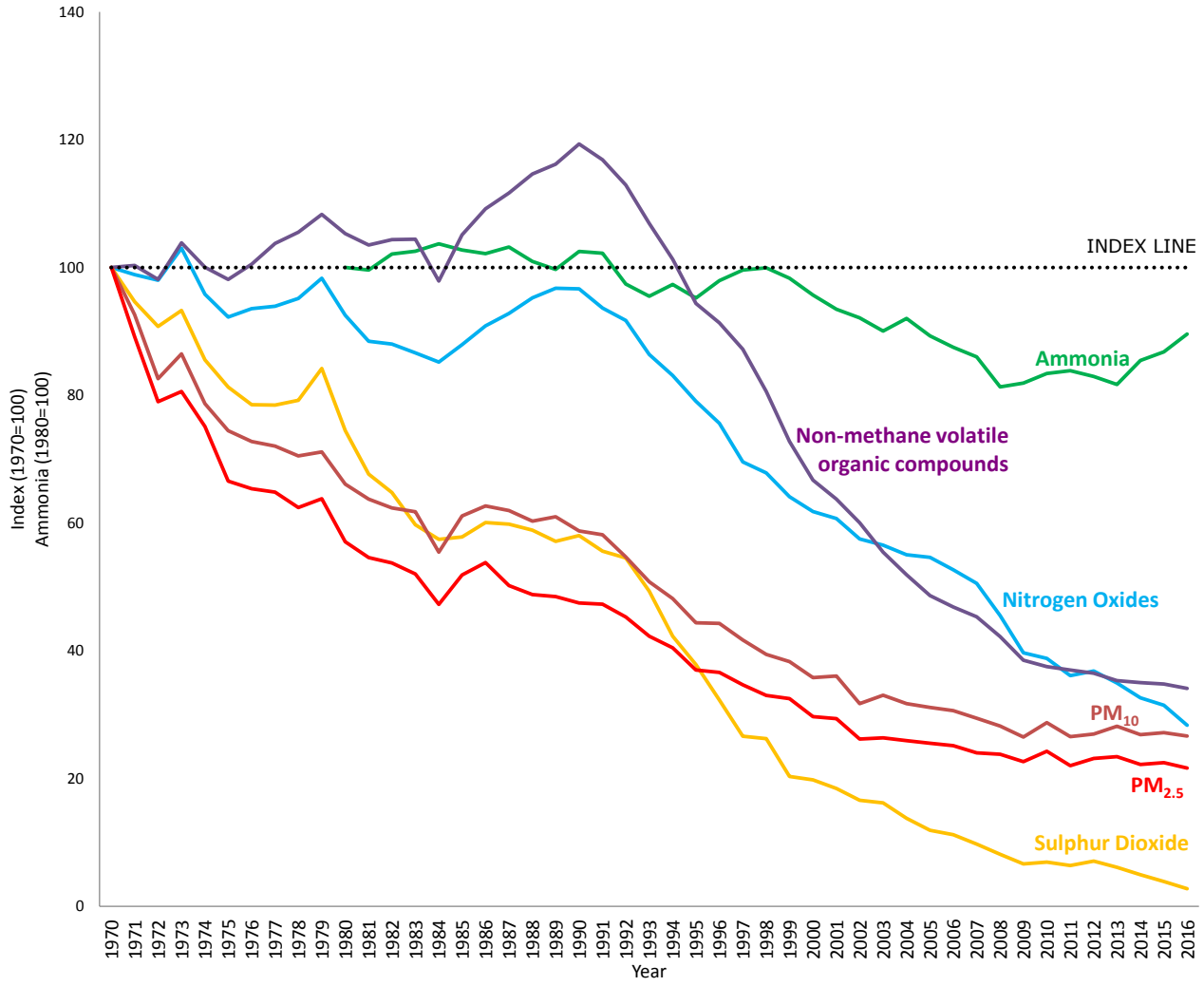
- $PM_{2.5}$ emissions decreased by 3.7 per cent between 2015 and 2016. 2016 emissions are the lowest level in the time series.

- There was an increase of 3.2 per cent in emissions of ammonia between 2015 and 2016. Increases since 2013 go against the trend of steady overall reduction observed from 1997 to 2013.

- The UK continues to meet current international and EU ceilings for emissions of ammonia, non-methane volatile organic compounds and sulphur dioxide. The Gothenburg Protocol under the UNECE Convention on Long-range Trans-boundary Air Pollution was revised in 2012 to set new emission ceilings to apply from 2020. These ceilings are indicated in the charts of the results.

- This latest data suggests that the UK exceeded the current international and EU ceiling for nitrogen oxides for the year 2010 only, but came back into compliance from 2011 onwards. This is due to a revision to the time series of emissions, resulting primarily from improvements in understanding of emissions from shipping and agriculture sources, and emission factors applicable to road transport. This has led to an increase in historical estimates of emissions of nitrogen oxides. As permitted under the 2016 National Emission Ceilings Directive and the Gothenburg Protocol, the UK has applied for an adjustment to the national emissions inventory for NOx emissions. If this application is successful, the total NO_x emissions for compliance purposes in 2010 will reduce to below the emission ceiling.

Figure 1: Trends in UK sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, ammonia and particulate matter (PM_{10}, $PM_{2.5}$) emissions 1970 – 2016



The index line is a comparator that shows the level of emissions if they had remained constant from the beginning of the time series.

Why quantify UK emissions of air pollutants?

Air pollution is a local, regional and international problem caused by the emission of pollutants, which either directly or through chemical reactions in the atmosphere lead to negative impacts on human health and ecosystems.

There are many sources of air pollution, including, but not limited to, power stations, transport, household heating, agriculture and industrial processes. The National Atmospheric Emissions Inventory (NAEI)[1] provides estimates of the amount of different pollutants that are emitted to the air each year from human activity in the UK. Knowledge of the sources of pollution aids the development of strategies to reduce air pollution from human activities and thereby reduce the impact of pollution on the environment and our health.

This publication covers UK emissions of:

- sulphur dioxide (SO_2);
- nitrogen oxides (NO_x) [2];
- non-methane volatile organic compounds (NMVOCs);
- ammonia (NH_3); and
- particulate matter (PM_{10} and $PM_{2.5}$) [3].

This is consistent with the reporting under the EU National Emissions Ceiling Directive. Data on emissions of other air pollutants will be available in late Spring 2018 from the NAEI website[1].

The Effects of Air Pollution

Air pollution has negative impacts on human health and the environment. Long term exposure to particulate matter contributes to the risk of developing cardiovascular diseases and lung cancer[4]. Particles can be inhaled and penetrate into the lungs. The smaller the particles, the deeper they can penetrate into the lungs and therefore health impacts are more strongly associated with the smaller $PM_{2.5}$ fraction. As well as being emitted directly, particulate matter can be formed in the atmosphere from reactions between other pollutants, of which SO_2, NO_x, NMVOCs and NH_3 are the most important.

Low level ozone also has an impact on health. This is formed when emissions of NO_x and NMVOCs react together in the atmosphere and, at higher concentrations, can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases[5].

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[1] http://naei.beis.gov.uk

[2] NO_x are emitted during fuel combustion, such as from road transport and industrial facility activities.

[3] PM_{10} refers to particles with a diameter smaller than 10µm and $PM_{2.5}$ to particles with a diameter smaller than 2.5µm. They may be produced directly from a source such as an engine (primary PM) or formed from reactions between other pollutants (e.g. NO_2, SO_2, NH_3) in the air (secondary PM). The NAEI only considers the emissions of primary PM.

[4] http://www.eea.europa.eu/publications/air-quality-in-europe-2017

[5] WHO, 2008, Air quality and health, Fact sheet no 313 (http://www.who.int/mediacentre/factsheets/fs313/en/).

Air pollution also damages ecosystems through:

- **acidification** (SO_2, NO_x and NH_3) - where chemical reactions involving air pollutants create acidic compounds which when deposited on land and aquatic systems can cause harm to soils, vegetation and buildings.
- **eutrophication** (NO_x and NH_3) - where nitrogen can be deposited in soils or in rivers and lakes through rain, affecting the nutrient levels and diversity of species in sensitive environments, for example encouraging algae growth in lakes and water courses.
- **ground-level ozone** (NO_x and NMVOCs) – where chemical reactions involving NO_x and NMVOCs produce the toxic gas ozone (O_3) which can damage wild plants, crops, forests and some materials, and is a greenhouse gas contributing to global warming.

Air pollutants released in one country may be transported in the atmosphere, contributing to harmful impacts elsewhere.

Reducing air pollutant emissions

Reductions in air pollutant emissions are being achieved through regulatory controls and other means across industry, domestic and transport sectors. Examples include changes in fuel use (such as switching from coal to gas power stations), reducing fuel use, changes to industrial processes, pollutant capture or conversion (for example catalytic convertors on vehicles, flue gas desulphurisation on coal power stations). Changes in behaviour such as individuals making more sustainable transport choices as well as wider economic conditions also impact on pollutant emissions.

Transboundary air pollution

While reducing UK emissions of air pollutants helps reduce atmospheric concentrations in the UK, the level of reduction in atmospheric concentrations is not always proportionate to the reduction in emissions. This is in part because of the trans-boundary nature of air pollution. For example emissions of the pollutants that lead to ozone formation have reduced substantially, but this is not reflected in the long-term trend in ozone concentrations. This may be partly explained by a proportion of the ozone experienced in the UK originating from releases of precursor pollutants that are transported across from mainland Europe and trends in hemispheric background concentrations.

There are two main sources of controls on trans-boundary air pollution:

- the **Gothenburg Protocol to the UNECE Convention on Long Range Trans-boundary Air Pollution (CLRTAP)** - sets 2010 emissions ceilings for the same pollutants and includes countries outside the EU. This Protocol was revised in May 2012 to set stricter emission reduction commitments from 2020. The Protocol has also been extended to set emission reduction commitments for $PM_{2.5}$.

- the EU **National Emission Ceilings Directive (NECD)** – sets annual ceilings for emissions of sulphur dioxide, nitrogen oxides, non-methane

volatile organic compounds, and ammonia from each Member State. A revised Directive which sets emission reduction commitments (ERCs) for 2020 (in line with the 2012 amendment to the Gothenburg Protocol) and 2030 for these four air pollutants as well as $PM_{2.5}$ entered into force on 31 December 2016. The revised NECD has implemented in the EU the 2020 ERCs as set by the 2012 amendment to the Gothenburg Protocol.

The NAEI is used to monitor emissions against these commitments and the UK figures are reported annually to the European Commission and to the UNECE. The statistics presented below compare UK emissions against 2010 emission ceilings under the Gothenburg Protocol and the National Emission Ceilings Directive, and 2020 ERCs under the amended Gothenburg Protocol and revised National Emission Ceilings Directive.

Understanding air pollutant emissions figures

The amount of emissions of the different pollutants should not be compared as their effects on health and the environment are very different.

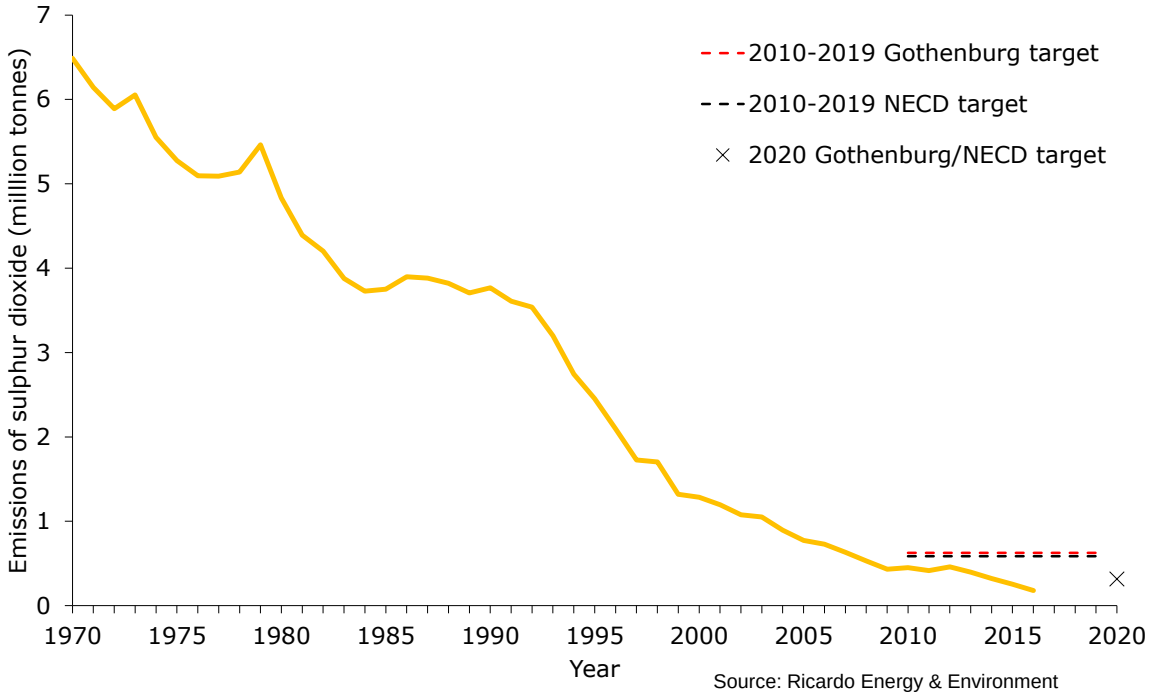
It is not practical, except for a limited number of large industrial processes, to measure emissions from all sources directly, so the NAEI is based on highly detailed calculation methods, assumptions and representative measurements on the amount of each air pollutant generated from different activities and the level of that activity in the UK. These methods and assumptions are reviewed annually as better scientific information and input data become available, for example on different fuel use and activities and updates to emission factors[6]. Refer to the NAEI[7] for more details.

There are uncertainties associated with all estimates of pollutant emissions which vary between pollutants and emission sources. Although for a given year there may be considerable uncertainties in the national emissions totals, trends over time are likely to be more reliable. The breakdown of emissions by source sector is more uncertain than the national totals.

[6] EMEP/EEA air pollutant emission inventory guidebook 2016, https://www.eea.europa.eu/publications/emep-eea-guidebook-2016
[7] http://naei.beis.gov.uk

Sulphur dioxide

Figure 2: UK Sulphur dioxide emissions and targets: 1970 – 2016

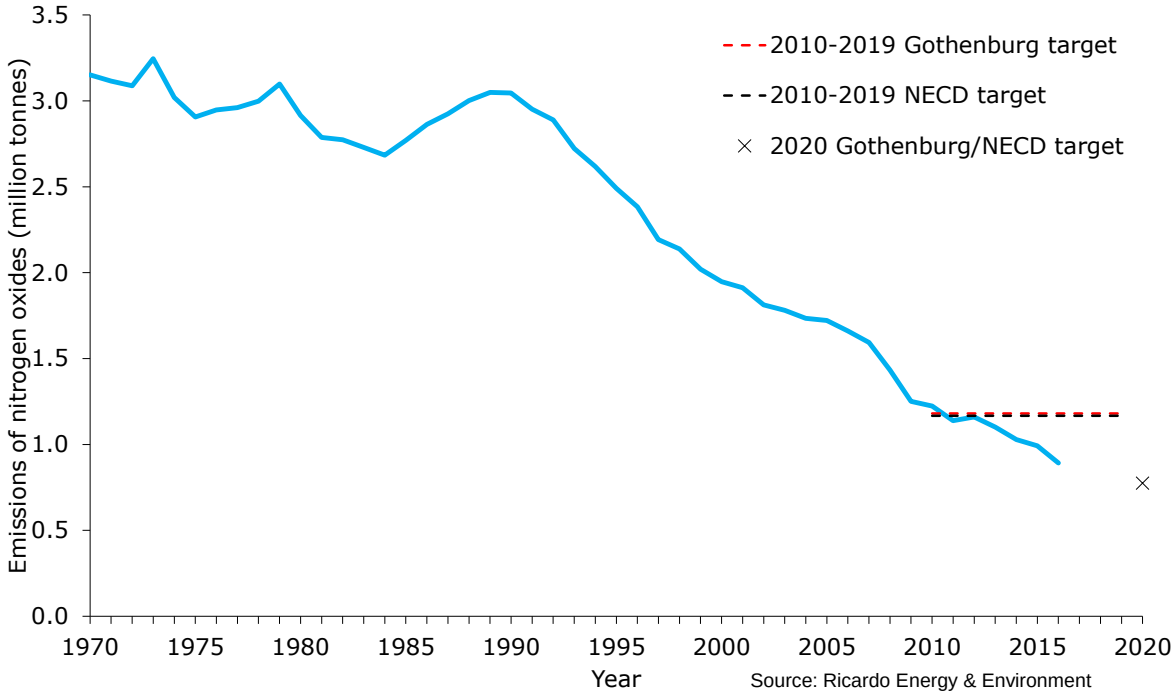


- Emissions of sulphur dioxide in 2016 have fallen by 97 per cent since 1970, to 0.18 million tonnes.
- Emissions decreased by 29 per cent from 2015 to 2016, dropping to the lowest level in the time series.
- The UK meets the 2010 ceilings for emissions in EU and international legislation. The revised Gothenburg Protocol requires the UK to reduce sulphur dioxide emissions by 2020 by 59 per cent compared to 2005 emissions.

The main source of sulphur dioxide (SO_2) emissions in 2016 was from combustion in energy production and transformation (37 per cent), followed by combustion from small stationary and non-road mobile sources (25 per cent) and combustion by manufacturing industries (22 per cent). It is reductions from the energy production and manufacturing sectors that have been the strongest drivers for the long term trend of decreasing emissions, by switching fuel use from coal to gas and the fitting of flue gas desulphurisation in the remaining coal fired plants in the power sector. The decrease in SO_2 emissions in recent years, with UK emissions falling by 61 per cent between 2012 and 2016, was largely due to the closure of a number of coal-fired power stations that had reached the end of their working lifetime. These closures, together with the conversion of a few other coal-fired units to burn biomass instead, have significantly reduced the overall coal-burning capacity.

Nitrogen oxides

Figure 3: UK Nitrogen oxides emissions and targets: 1970 - 2016



The 2020 ceiling is applicable to total emissions excluding agricultural emissions (NFR sectors 3B & 3D). These sectors form a very small proportion of emissions of nitrogen oxides (0.007 million tonnes in 2016) and are not deducted from the time series in Figure 3.

- Emissions of nitrogen oxides in 2016 have fallen by 72 per cent since 1970, to 0.89 million tonnes.

- There was a decrease in emissions in 2016 by 10 per cent compared to 2015. This is a larger decrease than the long-term trend, since emissions have fallen by an average of 4.6 per cent per year between 1990 and 2016.

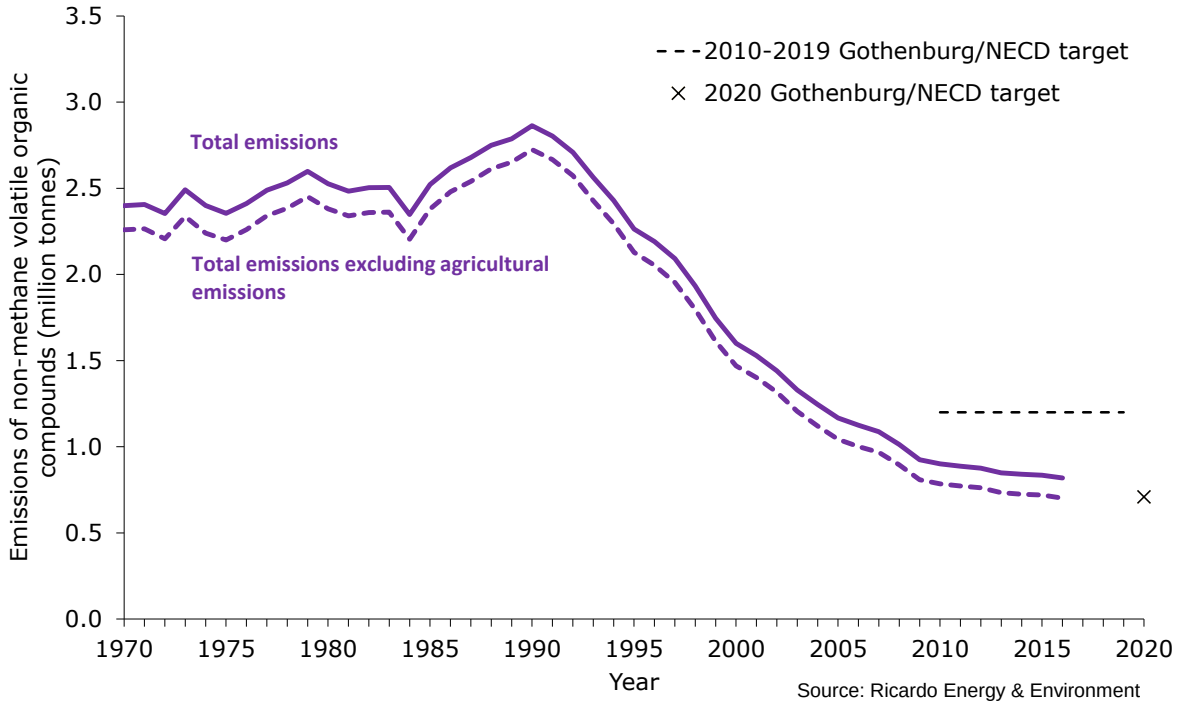
- This latest data suggests that the UK exceeded the current international and EU ceiling for nitrogen oxides for the year 2010 only, but came back into compliance from 2011 onwards. This is due to a revision to the time series of emissions, resulting primarily from improvements in understanding of emissions from shipping and agriculture sources, and emission factors applicable to road transport. This has led to an increase in historical estimates of emissions of nitrogen oxides. As permitted under the 2016 National Emission Ceilings Directive and the Gothenburg Protocol, the UK has applied for an adjustment to the national emissions inventory for NOx emissions. If this application is successful, the total NO_x emissions for compliance purposes in 2010 will reduce to below the emission ceiling.

- The revised Gothenburg Protocol requires the UK to reduce nitrogen oxide emissions by 2020 by 55 per cent compared to 2005 emissions.

Increases in road traffic account for the steep climb in nitrogen oxide (NO_x) emissions between 1984 and 1989. The introduction of catalytic converters and stricter emission regulations have resulted in a strong downward trend since 1990. However transport still accounts for 49 per cent of UK NO_x emissions in 2016 and the rate of reduction from this sector has slowed down due to the increased contribution from diesel vehicles. Emissions from power stations and industrial combustion plant have also reduced significantly, reflecting a long-term trend away from the use of coal and oil in favour of natural gas and renewable energy sources. The recent 23 per cent decrease in total NO_x emissions between 2012 and 2016 occurred due to similar reasons to those detailed for SO_2: the closure of a number of coal-fired power stations meant that emissions from the energy industries fell by 45 per cent over that period which was the greatest change for any emissions source group. Road transport, non-road transport and industrial combustion emissions, in comparison, fell by 12 per cent, 6 per cent and 20 per cent respectively.

Non-methane volatile organic compounds

Figure 4: UK Non-methane volatile organic compounds emissions and targets: 1970-2016



Source: Ricardo Energy & Environment

The 2020 ceiling is applicable to total emissions excluding agricultural emissions (NFR sectors 3B & 3D).

- Emissions of non-methane volatile organic compounds (NMVOCs) in 2016 have fallen by 66 per cent since 1970, to 0.82 million tonnes.

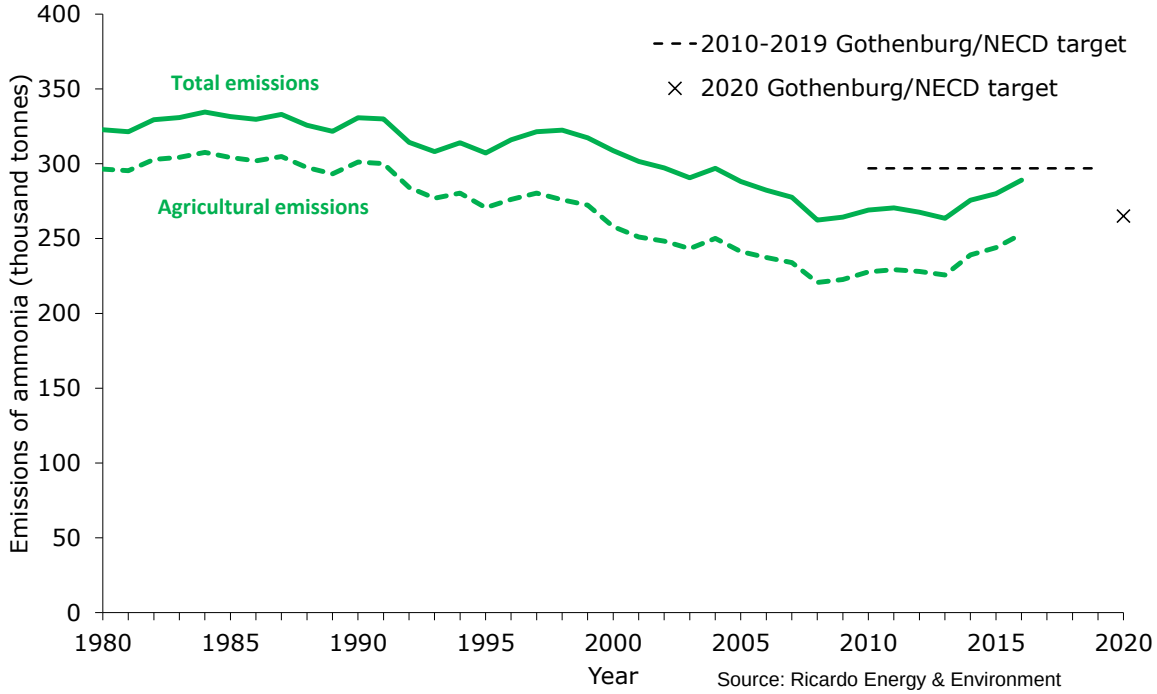
- There was a decrease in emissions of 2.0 per cent between 2015 and 2016. NMVOC emissions peaked in 1990 and then fell by an average of 5.8 per cent per year between 1990 & 2009. Since then, changes have been much smaller, averaging a decrease of just 1.7 per cent each year.

- The UK meets the 2010 ceilings for emissions in EU and international legislation to reduce emissions of NMVOCs. The revised Gothenburg Protocol requires the UK to reduce non-methane volatile organic compound emissions (excluding emissions from agricultural sources) by 32 per cent compared to 2005 emissions by 2020.

Road transport, chemical processes, industrial solvent use, coal mining, and the production, refining and distribution of petroleum fuels were the primary sources of NMVOC emissions in the early 1990s, contributing approximately 80 per cent of the total emission in 1990. The marked decrease in NMVOC emissions since the early 1990s largely reflects the decline of coal mining in the UK and stricter limits placed on emissions from the rest of these sources. Emissions from these sources are now much lower and only a minor component – 37 per cent - of the UK total in 2016. Emissions from residential combustion, agriculture, food and drink manufacture, and use of solvents in consumer products have not significantly reduced and these sources now contribute a higher proportion of emissions than previously (14 per cent in 1990, and 50 per cent in 2016). As a result, the rate of decrease in NMVOC emissions has slowed.

Ammonia

Figure 5: UK Ammonia emissions and targets: 1980-2016



- Emissions of ammonia in 2016 have fallen by 10 per cent since 1980, to 289 thousand tonnes.

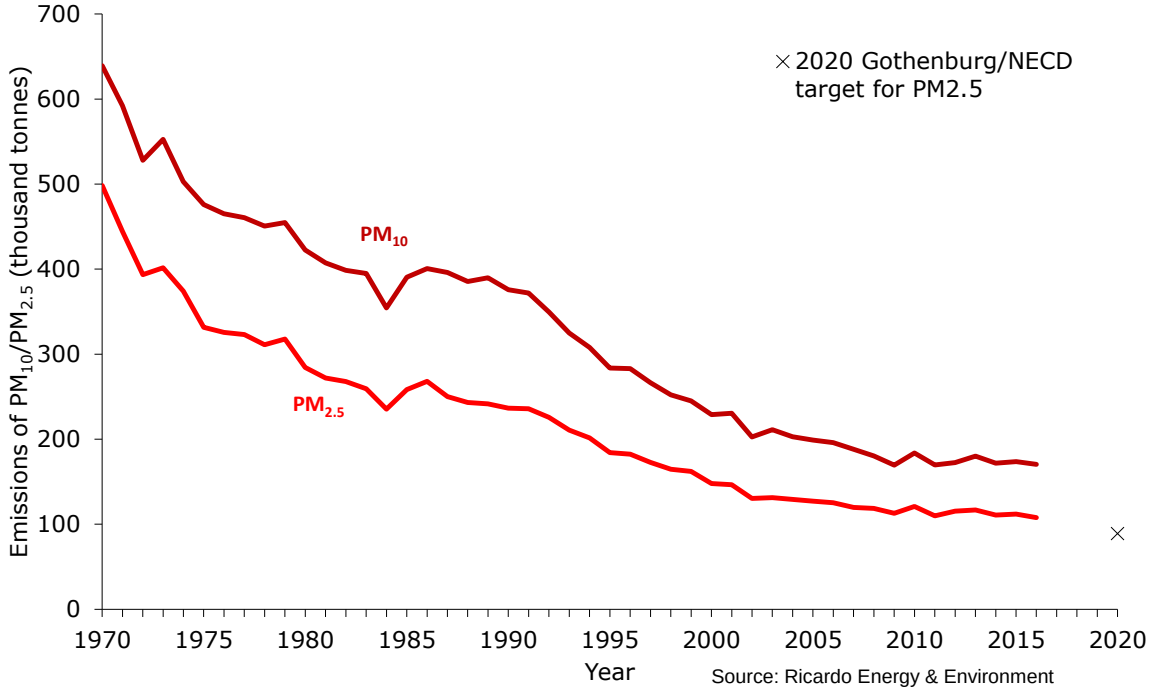
- There was an increase of 3.2 per cent in emissions of ammonia between 2015 and 2016. Increases since 2013 go against the trend of steady overall reduction observed from 1997 to 2013.

- The UK meets the 2010 ceilings for emissions in EU and international legislation to reduce emissions of ammonia. The revised Gothenburg Protocol requires the UK to reduce ammonia emissions by 8 per cent compared to 2005 emissions by 2020.

Emissions from agriculture accounted for 88 per cent of total ammonia emissions in 2016 and are the main driver for the emissions increase observed in the last three reported years, with emissions from agriculture increasing from 226 kilotonnes in 2013 to just under 253 kilotonnes in 2016. The increase in agricultural emissions over this period is mainly due to the manure management of larger dairy herds (emissions increase by 2.3 kilotonnes), and an increase of 25 kilotonnes from spreading of fertilisers. Other significant contributions to the total come from waste disposal and road transport (4 per cent and 2 per cent respectively in 2016).

Particulate Matter

Figure 6: UK PM_{10} and $PM_{2.5}$ emissions and targets: 1970-2016



- Emissions of PM_{10} in 2016 have fallen by 73 per cent since 1970, to 170 thousand tonnes.

- Emissions of $PM_{2.5}$ in 2016 have fallen by 78 per cent since 1970, to 108 thousand tonnes.

- PM_{10} emissions decreased by 1.9 per cent from 2015 to 2016. $PM_{2.5}$ emissions decreased by 3.7 per cent between 2015 and 2016. The trend for both pollutants has been fairly static in recent years, but $PM_{2.5}$ emissions in 2016 reached their lowest level in the time series.

- The revised Gothenburg Protocol requires the UK to reduce emissions of $PM_{2.5}$ by 30 per cent compared to 2005 emissions by 2020.

Emissions from road transport accounted for 12 per cent of PM_{10} and $PM_{2.5}$ in 2016 and is the third largest source after industrial processes and combustion in residential, public, commercial & agricultural sectors. The contribution from the category covering combustion in the residential, public, commercial & agricultural sectors has increased over recent years and peaked in 2013 at 53 kilotonnes PM_{10} and 52 kilotonnes $PM_{2.5}$. In 2016 estimated emissions from residential, public, commercial combustion were 48 kilotonnes for PM_{10} and 47 kilotonnes for $PM_{2.5}$.

A Defra National Statistics publication

National Statistics are produced to high professional standards set out in the National Statistics Code of Practice. They undergo regular quality assurance reviews to ensure they meet customer needs.

Responsible Defra statistician: Philip Taylor

Main notes

1. The figures presented in the text of this release have been rounded to two significant figures where appropriate.

2. Table 1 below shows the emissions figures for the six pollutants, from 1970 to 2016. The figures from this table have been rounded to three significant figures.

3. Table 2 below shows the emissions by source for 2015 and 2016. The figures in this table have been rounded to one decimal place.

4. The figures in this Defra National Statistics Release are from the National Atmospheric Emissions Inventory for 1970 to 2016, produced for Defra and the Devolved Administrations by Ricardo Energy & Environment. For further information on the Inventory see the NAEI website.

5. There are uncertainties associated with all estimates of pollutant emissions, which vary between pollutants and emission sources. For any given year there may be considerable uncertainties in the national emissions totals. However, trends over time are likely to be more reliable.

6. Results for other air pollutants will be available on the NAEI website in Spring 2018.

7. The methodology and assumptions in the NAEI are reviewed annually as better scientific information and input data become available, for example on different fuel use and activities and updates to emission factors[8]. For each inventory compilation, data for earlier years are revised based on these new assumptions to give a consistent time series.

8. Results for greenhouse gases, also covered in the NAEI, are published by the Department for Business, Energy & Industrial Strategy (BEIS) in a separate National Statistics release. For further details visit the BEIS website.

[8] EMEP/EEA air pollutant emission inventory guidebook 2016, https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

Table 1: Emissions of air pollutants in the UK, 1970 to 2016

Year	Sulphur dioxide (Million tonnes)	Nitrogen oxides (Million tonnes)	Non-methane volatile organic compounds (Million tonnes)	Ammonia (excluding natural sources) (Thousand tonnes)	PM_{10} (Thousand tonnes)	$PM_{2.5}$ (Thousand tonnes)
1970	6.49	3.15	2.40	no data	639	498
1971	6.14	3.12	2.41	no data	592	444
1972	5.89	3.09	2.35	no data	528	394
1973	6.05	3.25	2.49	no data	553	402
1974	5.55	3.02	2.40	no data	503	374
1975	5.27	2.91	2.35	no data	476	332
1976	5.10	2.95	2.41	no data	465	326
1977	5.09	2.96	2.49	no data	461	323
1978	5.14	3.00	2.53	no data	451	311
1979	5.46	3.10	2.60	no data	455	318
1980	4.83	2.92	2.53	323	423	284
1981	4.39	2.79	2.48	321	407	272
1982	4.20	2.77	2.50	329	399	268
1983	3.88	2.73	2.51	331	395	259
1984	3.73	2.68	2.35	335	354	235
1985	3.75	2.77	2.52	332	391	258
1986	3.90	2.86	2.62	330	401	268
1987	3.88	2.92	2.68	333	396	250
1988	3.82	3.00	2.75	326	385	243
1989	3.71	3.05	2.79	322	390	242
1990	3.77	3.05	2.86	331	376	237
1991	3.61	2.95	2.80	330	372	236
1992	3.54	2.89	2.71	314	349	226
1993	3.20	2.72	2.56	308	325	211
1994	2.74	2.62	2.43	314	308	202
1995	2.45	2.49	2.26	307	284	184
1996	2.10	2.38	2.19	316	283	182
1997	1.73	2.19	2.09	321	266	173
1998	1.70	2.14	1.93	323	252	165
1999	1.32	2.02	1.75	317	245	162
2000	1.29	1.95	1.60	309	229	148
2001	1.20	1.91	1.53	302	231	146
2002	1.08	1.81	1.44	297	203	130
2003	1.05	1.78	1.33	291	211	131
2004	0.89	1.73	1.25	297	203	129
2005	0.77	1.72	1.17	288	199	127
2006	0.73	1.66	1.12	282	196	125
2007	0.63	1.59	1.09	278	188	120
2008	0.53	1.43	1.01	262	180	119
2009	0.43	1.25	0.92	264	169	113
2010	0.45	1.22	0.90	269	184	121
2011	0.41	1.14	0.89	271	170	110
2012	0.46	1.16	0.88	268	172	115
2013	0.40	1.10	0.85	264	180	117
2014	0.32	1.03	0.84	276	172	111
2015	0.25	0.99	0.84	280	174	112
2016	0.18	0.89	0.82	289	170	108

Source: National Atmospheric Emissions Inventory

Table 2: Emissions of air pollutants by source in the UK, 2015 and 2016 (Thousand tonnes)

Source	2015						2016					
	SO_2	NO_x	NMVOC	NH_3	PM_{10}	$PM_{2.5}$	SO_2	NO_x	NMVOC	NH_3	PM_{10}	$PM_{2.5}$
Energy industries (Combustion in power plants & Energy Production)	127.4	267.7	4.4	0.1	6.3	4.2	66.8	199.7	4.0	0.2	4.6	3.6
Manufacturing Industries and Construction	51.6	155.6	21.4	2.2	20.0	19.2	38.7	139.1	19.4	2.1	18.0	17.4
Road Transport	1.2	309.8	34.6	4.9	20.6	14.2	1.3	299.8	31.8	4.4	19.9	13.4
Non-road transport	13.7	141.1	12.3	0.0	3.9	3.8	13.4	137.9	12.5	0.0	3.9	3.7
Small Stationary Combustion and Non-road mobile sources & machinery (Commercial, residential , agriculture and fishing)	44.9	92.0	50.9	2.1	47.9	46.8	45.8	91.8	50.4	2.2	47.6	46.6
Other, Mobile combustion (military Aircraft and naval Shipping)	1.6	13.1	0.7	0.0	0.2	0.2	1.5	12.5	0.6	0.0	0.2	0.2
Fugitive emissions	4.6	2.2	145.3	0.2	2.2	1.2	2.5	2.0	129.3	0.2	1.9	1.2
Industrial Processes	7.5	1.6	439.8	3.5	51.8	14.5	8.6	1.3	443.0	3.8	53.2	13.9
Agriculture	NA***	7.1	115.8	244.0	16.7	4.2	NA***	7.2	117.5	253.0	17.0	4.3
Waste	0.7	1.4	6.4	10.0	3.9	3.6	0.7	1.4	6.5	10.1	4.0	3.6
Other (included in national total for entire territory)	NA***	0.2	3.6	12.9	0.2	0.1	NA***	0.2	3.6	12.9	0.2	0.1
NATIONAL TOTAL	253.3	991.9	835.1	280.0	173.7	112.1	179.2	892.9	818.6	289.1	170.4	107.9
Memo items	76.9	747.4	136.0	13.3	51.1	29.3	79.2	749.7	133.5	13.1	51.2	28.9

* Memo Items reported, but EXCLUDED from protocol totals. Includes: International&National Aircraft (cruise), International Shipping, forest fires, natural emissions, and NH3 emissions from wild animals and humans.

***NA (Not applicable - the source exists but relevant emissions are considered never to occur)

Source: National Atmospheric Emissions Inventory