Briefing
The invisible threat of ozone

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Summary

When weather conditions are sunny and still, the UK enters its peak season for ground level ozone. At ground level, ozone is a harmful air pollutant which can inflame the airways, reduce lung function and worsen pre-existing respiratory conditions such as asthma. It also damages crops, reducing yields and threatening food security.

A 'secondary pollutant', ozone is created when volatile organic compounds, such as methane along with nitrogen oxides, are together exposed to sunlight. Methane is a particularly influential precursor pollutant. While the climate impacts of methane have just begun to receive serious consideration, less attention has been given to its link to air pollution.

As UK summers get hotter, conditions for ground level ozone to form are likely to get worse.[1] In mid-August 2025, after a long period of dry and sunny weather, ozone pollution reached alert thresholds across the UK.[2]

The government should tackle this problem through its forthcoming national methane action plan and the revised Environmental Improvement Plan (EIP). Both should target reductions of methane and ozone, as well as action on other sources of air pollution.

A forgotten source of air pollution

What is ozone?

Ozone occurs high in the atmosphere and at ground level. At high altitudes, it forms a protective layer shielding the Earth from ultraviolet radiation. At ground level, it isn't emitted directly, unlike other air pollutants. It forms when sunlight interacts with various 'precursor pollutants', such as methane, nitrogen oxides (NO_x) and volatile organic compounds (VOCs), through a range of physical and chemical processes.

Causes of ground level ozone pollution

'Precursor pollutants' are primarily products of human activity, like the burning of fossil fuels, road vehicles and agricultural and waste management practices.

Methane

Methane is a greenhouse gas, roughly 80 times more powerful than carbon dioxide over a 20 year period. It has been responsible for around half a degree of global warming to date. Over half the methane emitted in the UK comes from agriculture (enteric fermentation in cows), around a third is

from waste (from landfills) and approximately a tenth is from energy (from gas pipelines and oil and gas extraction).[3]

We estimate that ozone arising from methane emissions in the energy sector is linked to around 97,000 respiratory deaths worldwide each year and, in the UK alone, ozone from methane in the energy, waste and agricultural sectors leads to approximately 1,500 respiratory related deaths each year.[4]

Ozone is more prevalent in warm weather. Methane's strong warming effect contributes indirectly to ozone formation by driving climate change and subsequent temperature rises. Research has found methane to be responsible for 35 per cent of global harmful ozone and 37 per cent in the EU alone.[5]

Nitrogen oxides

Nitrogen oxides (NO_x) are significant pollutants primarily formed during the combustion of fossil fuels, with road transport a major contributor.[6] NO_x emissions are directly harmful in several ways. In the short term, nitrogen dioxide (one of the two forms of NO_x) can irritate airways and increase susceptibility to respiratory infections. But the deposition of nitrogen in the environment also harms biodiversity and negatively affects soil chemistry.[7] NO_x also creates ground level ozone when they react with other gases such as methane in sunlight.

In the most recent annual air quality assessment, the UK exceeded the set limits on emissions of NO_x in numerous roadside locations and urban areas.[8] These breaches highlight that, despite long term downward trends in NO_x emissions, there are ongoing challenges in meeting national air quality targets.[9]

Impacts of ozone

Public health

Poor air quality is the greatest environmental threat to public health in the UK. It's linked to 29-43,000 premature adult deaths annually, particularly from respiratory and cardiovascular conditions.[10] While the government plans to phase out wood burners and electrify transportation systems, less attention is given to other sources of air pollution, such as ozone, which are becoming increasingly urgent to address in a warming climate.

At ground level, ozone can cause a range of health impacts, from coughing to throat irritation and shortness of breath, with prolonged exposure associated with reduced lung function and chronic respiratory disease. The London School of Tropical Medicine confirms that extended exposure to ozone increases the risk of death and the European Commission has reported that the warm seasons during 2015-17 resulted in a mortality of 72 annual deaths per one million inhabitants from ground level ozone pollution.[11,12]

More vulnerable groups, including people with pre-existing conditions, children and those living in deprived areas, are disproportionately affected by its impacts.

Crop health

Ozone pollution has a significant negative impact on crop yields as it damages plant tissue and reduces photosynthesis. It is causing global crop losses of staple foods. In 2015, the estimated total wheat production losses for Europe due to ozone pollution were 23.8 million tonnes, equivalent to 15 per cent of total production,[13,14] In 2022 crop losses across Europe due to the impacts of ozone for wheat and potato crops corresponded to a value of €1.98 billion, equivalent to over £1.7 billion.[15]

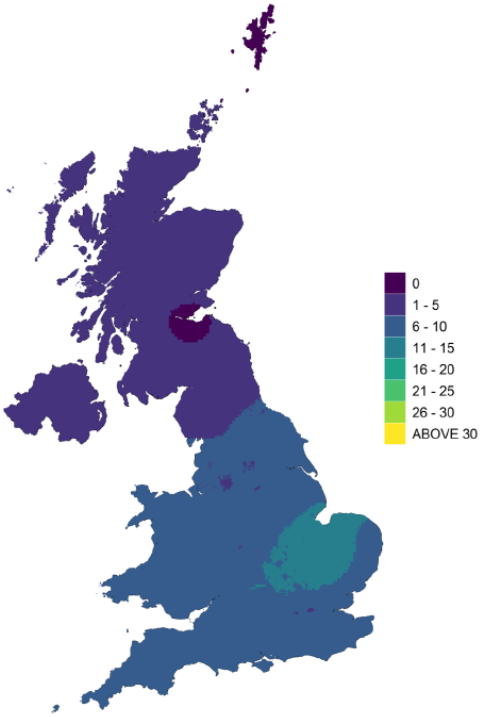
These losses have an impact on farmers' incomes as well as food security. Because methane remains present in the atmosphere for a significant period, its effect in creating ozone can spread much more widely than other forms of air pollution.

UK ground level ozone is breaching safe levels

Ozone levels tend to be higher in rural areas because certain pollutants, such as nitric oxide (NO), which can break down ground level ozone, are less prevalent. High levels around south east England are likely to be due to the region's proximity to pollution sources from Europe.[16]

Urban background ozone pollution has been rising in the UK, reaching record levels in 2023.[17] Rising ground level ozone has been linked to higher average temperatures and, as climate change drives further warming, breaches of safe ozone levels are likely to become more frequent.

Average days in 2023 when ground level ozone breached safe levels[18]



Existing commitments on air pollution

In 2023, the government issued the first Environmental Improvement Plan (EIP), as required by the Environment Act 2021.[19] This includes existing commitments relating to air pollution targets that came about through retained EU regulations.

Air pollutants and UK targets

Pollutant	EIP target	International standard
Methane	No target. Excluded from volatile organic compounds targets that contribute to ground level ozone	The global methane pledge is an initiative to reduce methane emissions by 30 per cent by 2030
Non-methane volatile organic compounds	39 per cent reduction by 2030 (on 2005 levels)	N/A
Nitrogen oxides (NOx)	73 per cent reduction by 2030 (on 2005 levels), which equates to 40mg annually	World Health Organization (WHO) 2021 air quality guidance target is 10mg annually
Ground level ozone	No target	WHO 2021 air quality guidance target is 100mg per eight hour period

While there are existing targets for NO_x emissions and non-methane volatile organic compounds, there is no target addressing methane as a source of harmful ground level ozone. The revised EIP, due be published later in 2025, provides a timely opportunity to address this. It should include quantifiable reduction targets for both methane and ground level ozone, as a concrete deliverable under the plan's goal to achieve clean air.

The government's annual EIP progress report, released in July 2025, showed that more work is needed to cut the pollution that contributes to ground level ozone, particularly highlighting ammonia, often emitted alongside methane, which contributes to the formation of NO_x and volatile organic compounds.[20]

Solutions

Many interventions are possible to reduce methane emissions which, in turn, will reduce ground level ozone concentrations across the UK.

Our research shows that a 37 per cent reduction in methane emissions is possible by 2030 (on a 2020 baseline), through cost effective interventions.[21] These include methane suppressant animal feeds, slurry acidification, increasing the consumption of taste equivalent alternative proteins to reduce meat and dairy consumption, ending routine venting and flaring across fossil fuel infrastructure and increasing the rate of landfill gas capture.

The government could also double down on the transition to alternative modes of transport. Fossil fuel powered vehicles contribute over two thirds of NO_x emissions, so increasing the proportion of journeys taken by public transport and electrifying the UK's private vehicle fleet will be crucial to improving outcomes.[22]

Recommendations

To reduce the precursor pollutants contributing to dangerous levels of ground level ozone formation, the government should:

- deliver an ambitious national methane action plan, including a target of at least a 30 per cent reduction in methane emissions by 2030;
- include methane and ozone reduction targets in the revised Environmental Improvement Plan;
- use its powers in Part 1 of the Environment Act 2021 to set new legally binding air quality targets that align with WHO standards;
- accelerate the transition to affordable and cleaner public transport by investing in regional rail services and funding transport authorities to provide every community with an hourly bus service as a minimum;
- boost the transition to zero emission vehicles by cutting VAT on public charging points and reaffirming targets under the zero emission vehicle mandate.

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Endnotes

[1] M Kendon et al, 2025, 'State of the UK climate 2024', *International Journal of Climatology,* 45, S1
[2] Department for Environment, Food and Rural Affairs, 12 August 2025, 'Air quality information / Air bulletin'; and 13 August 2025, 'Air quality information / Air bulletin'
[3] R Allen et al, May 2025, *The climate emergency brake: an ambitious plan to cut UK methane emissions*, Green Alliance
[4] Based on this calculation of the social cost of ozone estimating 760 respiratory related deaths to the methane-ozone mechanism per million tonnes of methane, combined with the latest International Energy Agency (IEA) data, estimating that 128 million tonnes of methane emissions in 2023 were produced by the energy (including bioenergy) sectors globally. According to the National Atmospheric Emission Inventory (Department for Energy Security and Net Zero), a total of around two million tonnes of methane emissions are emitted from the UK's energy, waste and agricultural sectors each year.
[5] The Joint Research Centre: EU Science Hub, September 2024, 'Cutting methane emissions key to fighting climate change and harmful ozone', produced for the European Commission
[6] At roadsides in the UK, 68 per cent of NO_2 concentrations originated from transport.
[7] Plantlife UK, 2017, *We need to talk about nitrogen: the impact of atmospheric nitrogen deposition on the UK's wild flora and fungi*
[8] Department for Environment, Food and Rural Affairs (Defra), March 2025, '*Emissions of air pollutants in the UK – Nitrogen oxides (*NO_x*)*'
[9] Ibid
[10] Public Health England, 2018, 'Health matters: air pollution'
[11] A M Vicedo-Cabrera et al, 2020, 'Short term association between ozone and mortality: global two stage time series study in 406 locations in 20 countries', *The British Medical Journal* 368
[12] European Commission, 10 February 2025, 'Over half of deaths attributed to ground-level ozone in Europe are due to ozone that originated outside the region'
[13] Based on the estimate that the total production of wheat from 2015 across Europe as of 157 million tonnes.
[14] Economic Commission, *Review of sufficiency and effectiveness of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, as amended in 2012*, 2022, p 8
[15] S Schucht et al, 2024, 'Wheat and potato yield loss in 2022 in Europe due to ozone exposure'. Based off the estimates that around 6,700 kt of wheat losses in 2022 corresponded to a value of EUR 1.3 billion, and around 3,200 kt of potatoes losses the same year corresponded to a value of EUR 680 million.
[16] London Air (Imperial College London), 'What is ozone?', accessed May 2025, www.londonair.org.uk/londonair/guide/WhatIsO3.aspx
[17] Defra, 27 June 2025, 'Accredited official statistics: Ozone (O_3)'. Record levels were reached "when the annual average of the daily maximum eight hour mean reached 66.8 μg/m³"
[18] Defra, May 2024, 'Annual air pollution in the UK report 2023'. An unsafe level, according to the World Health Organization, is 120 μg m-3 for over eight hours.

[19] HM Government, 'Environment Act 2021', Section 8
[20] Defra, 14 July 2025, *Environmental Improvement Plan annual progress report: April 2024 to March 2025*
[21] R Allen et al, May 2025, op cit
[22] Defra, 13 March 2025, 'Emissions of air pollutants in the UK – Nitrogen oxides (NO_x)'