Non-CO2 emissions FAQ

What are non-CO2 emissions?

Emissions from burning jet fuel consist mainly of carbon dioxide (CO2), then water vapor (H2O), nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide (CO), soot (PM 2.5), unburned hydrocarbons (UHC), aerosols, and traces of hydroxyl compounds (-OH), most of which are released in the atmosphere at cruise altitudes of 8– 13 km above mean sea level.

When water vapor is released from jet engines at altitude under certain high humidity conditions (ice supersaturated regions) it can condense into exhaust carbon particles as well as into atmospheric aerosols. If the air is sufficiently humid, the water vapor can condense further into crystals and a cloud can be formed. Such clouds, formed from the condensation of exhaust aircraft water vapor, are called condensation trails or contrails.

The main climate change contributions from non-CO2 emissions of aviation come from the formation of persistent contrails and particularly the resulting aviation-induced clouds, as well as from the chemical atmospheric reactions driven by NOx emissions. While the effect of these emissions has been estimated at an aggregate level, the capacity to accurately measure their climate impact at an airline or individual-flight level is very limited. Furthermore, considerable uncertainties regarding the overall climate effect of these emissions remain.

For nitrogen oxides, the amount of NO_x emitted by an aircraft depends primarily on engine design, technology, and operating conditions (idle, take-off, descent, etc.), as well as on the atmospheric conditions (temperature, pressure, and humidity) at which this engine operates. This variability also applies to the formation of contrails, which relies on atmospheric conditions, engine and aircraft design, and fuel composition.

Although contrails are not always formed, their effect depends on whether they are persistent, the location and time of the day at which they are formed, the weather conditions, the combined effect of multiple contrails, and, importantly, whether they have a cooling or warming effect. This makes calculating their net climate effect on a per flight basis extremely complex.

Why do non-CO2 emissions from aircraft matter?

The climate impact of aviation is a combination of direct aircraft engine emissions and their indirect effect on the atmosphere, particularly at high altitudes.

Some emissions can be easily estimated with fixed indices correlated to the fuel. For example, on average, 3.16 kg of carbon dioxide (CO2) and 1.25 kg of water vapor (H2O) are emitted for every kilogram of jet fuel burned. The direct climate impacts of CO2 and H2O are well quantified and understood. However, the amount of other aviation emissions, such as NOX, SOx, or soot particles, are more difficult to estimate as they depend on the engine design, ambient conditions, and fuel composition, among other variables.

The secondary climate effects of these emissions, including water vapor, vary with several factors, like the precise location of where they are released, the background atmospheric chemistry, the weather conditions at the time, and their consequent evolution. These effects are collectively known as non-CO2 effects of aviation, and there is a growing recognition that, at an aggregated level, they have a net warming impact on the climate. However, understanding the exact extent of this warming and validating these emissions on individual flights is still subject to scientific research and debate.

Are non-CO2 emissions part of the industry's net zero carbon emissions by 2050 pledge?

Non-CO2 emissions are not part of the airline industry's Net Zero pledge because carbon dioxide (CO2) is the most prevalent and long-lasting greenhouse gas emitted by aircraft. Therefore, the focus of the Net Zero pledge is primarily on addressing CO2 emissions to achieve net zero. However, addressing the climate impact of non-CO_2 emissions is no less a priority for the industry, which is determined to address these other climate impacts with robust, accurate and transparent atmospheric data. In contrast to CO2, non-CO2 emissions and their impact cannot be monitored accurately or reported on a per-flight basis today. Before policy measures and technical solutions can be sought for mitigating non-CO2 emissions, it is essential that the effects of these emissions are understood, calculated, and can be monitored and verified.

What can the industry already do to mitigate non-CO2 emissions?

Before policy measures and technical solutions can be sought for mitigating non-CO2 emissions, it is essential that the effects of these emissions are understood, calculated, and can be monitored and verified. No-one sets out on a journey without knowing the right direction, otherwise they risk wasting time going the wrong way. For the same reason, we must understand the science behind non-CO2 impacts before we can effectively tackle them. IATA and the aviation community, formed by industry, governments, universities, and research institutions are engaging in initiatives to further understand the climate impact of contrails and potential mitigation. Part of the work that IATA is leading is focused on:

- Increasing the confidence on where contrails might form and what their climate effect could be
- Equipping aircraft with humidity sensors, performing contrail avoidance trials
- Researching and testing the non-CO2 effects of Sustainable Aviation Fuels (SAF) and hydrogen

Airlines are undertaking research to improve their understanding of non-CO_2 effects. For example, some operators participate in the IAGOS program to install humidity sensors on aircraft to better understand the humidity fields in the upper troposphere (vital for contrail prediction and assessing their climate impact). Other airlines are performing contrail avoidance trials, yet others are researching the non-CO_2 effects of alternative fuels, all of which could deliver tangible contributions towards reducing the climate impact of aviation.

What is being proposed by the EU to tackle non-CO2 emissions and why are IATA and airlines concerned?

The European Commission plans to introduce a requirement for Monitoring, Reporting and Verification (MRV) for aviation non-CO2 emissions from 1 January 2025, whereby airlines will have to report the non-CO2 emissions of each individual flight. The methodology proposed by the Commission Services is feared insufficiently mature to measure non-CO2 emissions accurately, or to help address their mitigation effectively.

Unlike CO2, which can be calculated with high certainty using the fuel burn emissions factor, the estimation of non-CO2 effects relies on complex computations of different parameters involving route, weather, and climate information as well as fuel composition. The uncertainties related to all these parameters (some of which airlines do not have access to) mean that it will be extremely difficult to assess the occurrence and climate impact of non-CO2 emissions from individual flights. The accuracy of results from the proposed MRV system will be limited and is unlikely to support any reduction in non-CO2 emissions.

Why does IATA object to these proposals?

1. **A non-CO2 MRV framework will not reflect the actual non-CO2 effects of aviation, but an estimation.**

In contrast to CO2, which can be obtained by reporting one single parameter (total fuel burned), non-CO2 emissions and their impact cannot be monitored accurately or reported on a per-flight basis today. Any estimation of non-CO2 effects requires complex computations built on several parameters and assumptions, such as engine efficiency, atmospheric humidity, temperature and pressure, wind velocity, background atmospheric chemistry composition, engine-fuel particulate emission profile, and others. For this reason, the outcome can be widely different depending on the assumptions and the quality of the data used. Any estimate is analytically limited and fundamentally divorced from output based on actual observations. The proposed non-CO2 MRV framework could serve as a first-stage experiment that attempts to achieve a baseline estimation of the non-CO2 effects of aviation. However, it is currently not feasible to validate the output from the experiment to ensure that it accurately represents reality.

2. **Including non-CO2 effects of aviation in the EU ETS MRV requirements precedes today's science.**

There is scientific consensus that the non-CO2 effects of aviation, at a global aggregated and average level, are net warming. However, there is also consensus that non-CO2 emissions effects are quantified with a low confidence level, as opposed to CO2 emissions, which are quantified with a very high degree of confidence.

In the case of contrails, there is scientific maturity regarding the thermodynamic criteria (Schmidt-Appleman Criteria) that must be met for their formation. In contrast, agreement is lacking regarding the capacity to accurately forecast persistent contrails for individual flights and the climate impact of individual contrails. These are areas of active experimental and numerical modeling. Studies have shown that estimating the formation of individual contrails using past weather and trajectory data could lead to incorrect results 50-80% of the time1.

An MRV system for non-CO2 emissions today could support further research thanks to additional data, but the science is not mature enough to allow confidence in its implementation at a policy level. Any policy or regulatory framework that precedes scientific understanding risks producing erroneous and undesirable outcomes, including unintended climate consequences. **It is conceivable that by attempting to avoid the formation of contrails and reduce reported non-CO2 emissions, operators could inadvertently increase their CO2 emissions**. Given that CO2 and non-CO2 emissions affect the climate through different effects and timeframes (CO2 lasts for centuries in the atmosphere, while most non-CO2 effects are short-lived), scientific consensus is still required on the metrics and timeframes for comparison. The complex and likely trade-offs amongst different non-CO2 emissions, and between these and CO2 emissions are still poorly understood.

3. The non-CO2 MRV framework is unlikely to deliver a positive climate impact.

Considering all the challenges and uncertainties mentioned above, introducing an MRV system as early as January 2025 would not serve to mitigate aviation's non-CO2 effects under EU ETS. Under the MRV framework, airlines are requested to participate in a large-scale experimental project to set a non-CO2 baseline, with no established mechanisms for scientific validation or improvement of the MRV output. This risks diverting resources to an area whose results are highly uncertain and potentially inaccurate, at the expense of other actions that could mitigate CO2 and non-CO2 climate effects more effectively in the near term.

The EU ETS legal text indicates the possibility of expanding its scope to include non-CO2 effects as a mitigative measure. Taking mitigative action based on estimations rather than observations risks being ineffective and potentially counterproductive.

What does IATA recommend instead?

IATA recommends that, given the experimental nature of the MRV framework, airlines' participation framework should be voluntary.

The MRV framework, as it currently stands, should address the following concerns:

- Participation in the framework should be voluntary, and a first pilot phase should be established to test the process, accuracy, and effectiveness of the system, as well as allow operators to explore other measures.

- There should be clear pathways for scientific validation of reported non-CO2 effects and a roadmap for reducing the differences between the modeled estimations and reality.

- The application scope of non-CO2 MRV provisions should be strictly intra-EU to mirror that for CO2. Any intention to expand beyond the current EU ETS application scope for aviation would imply a legal risk of extraterritorial impact and would work counter to any MRV implementation. Furthermore, the probability of contrail formation is highly dependent on the region: mid-latitudes have a higher probability of contrail formation than the tropics or the equator, so contrails affect different regions differently.

- Data gaps for volunteering airlines should be filled with average values and not worst-case scenario data, which induce unwarranted bias in the data, particularly on fuel properties.

- The timeframes and metrics chosen for combining CO2 and non-CO2 into single reports should be aligned with the latest scientific understanding and should avoid over-representing short-lived non-CO2 effects against the long-lasting effects of CO2.

- Safeguards should be included against unnecessary collection of sensitive data and their misuse.

- Airlines should be encouraged to conduct their own research and participate in new and existing activities to understand non-CO2 effects better and to explore potential mitigation opportunities.

How do you respond to criticisms that IATA is attempting to weaken environmental regulations under the guise of scientific uncertainty?

Aviation has always made decisions based on objective data to ensure that risks are mitigated effectively, whether these be safety, security, airworthiness, or environmental impact. The approach, as currently proposed by the Commission, moves away from this successful approach in aviation. To reduce the climate risks related to non-CO2 effects, we must work in a collaborative, voluntary approach to ensure that future activity across the industry results in effective mitigation through the maturity of science and the development of well-established and proven technological and operational approaches.

Importantly, key climate scientists agree with us. For example, a recent Royal Society of Chemistry paper from Prof. David Lee et al states: “The effects of soot and sulphur emissions on cloudiness are very poorly understood and studies indicate forcings that range from large negative through to small positive”. Furthermore, we agree with Professor Lee and his colleagues when they say: “It is clear that there is an appetite amongst some stakeholders for non-CO2 mitigation of aviation effects on climate, but we have serious reservations over recommending definitive courses of action until there is better quantification of the actual effects, and further studies of the tradeoffs between non-CO2 reductions vs. potential CO2 increases”.