

Effect of high altitude emissions

Some observers claim that a multiplier must be added to emissions from aviation, because the effect of high altitude emissions and contrails is stronger. The available evidence is contradictory and scientists disagree among themselves. According to those claiming a factor should be applied, best scientific evidence suggests a factor of 1.9. Yet others claim any factor applied is redundant. The effects of high-altitude emissions are surprisingly complex, as one effect is typically countered by another.

High altitude also means independence from ground infrastructure such as roads and railways, which is a source of carbon emissions both from construction, operations and maintenance.

Contrails

Contrails (condensation trails) are formed by the condensation of water vapor formed by jet engines at high altitude. Their formation depends on altitude, geographical location, time of day and season. By trapping outgoing heat radiation contrails have a warming effect. This is offset by a cooling effect as they reflect incoming sunlight. According to The National Aeronautics and Space Administration (NASA) the net effect of contrails is unresolved; some observations indicate a net cooling effect, yet others a net warming effect. In either case the effect is short-lived compared to other human-induced climate impacts such as carbon emissions. According to a computer model created by NASA's Goddard Institute for Space Studies, the change in temperature due to contrail formation is minute compared with other greenhouse effects - despite a fivefold increase in global air traffic.

High altitude emissions

All combustion engines emit NO_x, including jet engines. Contrary to CO₂, the properties of NO_x are more complex and even vary with altitude.

NO_x is a pollutant which degrades local air quality. According to scientists at Reading University studying the effects of aircraft contrails and non-carbon greenhouse gas emissions, the major effects of NO_x, from a global-warming perspective, is that it leads to the formation of ozone, a greenhouse gas, and to the formation of a hydroxyl (OH) radical that leads to the destruction of the harmful greenhouse gas methane. In addition, the hydroxyl radical acts as a detergent which cleans many of the pollutants out of the atmosphere. According to the researchers, it turns out that by emitting one greenhouse gas another is destroyed. To add complexity to the subject, methane is one of the important molecules that lead to ozone formation, so NO_x is creating more ozone but is also destroying methane, leading to less ozone.

Environmental Life-cycle assessment and infrastructure

The need for infrastructure is considerably smaller for aircraft, as being airborne means not being dependent on ground infrastructure en route. It is considerably more energy intensive to build, operate and maintain a 500 kilometer railway line than operate and maintain a 3 kilometer runway at each end of the journey.

A research paper by The University of California supports these arguments based on a comprehensive analysis of lifetime emissions from various modes of transportation. The paper finds that aircraft have the largest operational to total life-cycle energy ratios due to their large fuel requirements per passenger per kilometer and relatively small infrastructure requirement.

At the other end of the scale, rail transport has the smallest fraction of operational to total energy due to their low electricity requirements per passenger per kilometer relative to their large supporting infrastructure. The construction and operation of rail transport infrastructure results in total energy requirements about twice that of the operational energy requirement.

It is the sum of all emissions that is interesting. According to the paper, a factor must be added to the direct emissions from driving the various vehicles forward in order to reflect the overall life-cycle emissions. That factor is 2.55 for trains, 1.63 for road vehicles and only 1.31 for air traffic. These findings indicate that air travel is comparable to, and in some cases even better than, electric trains.