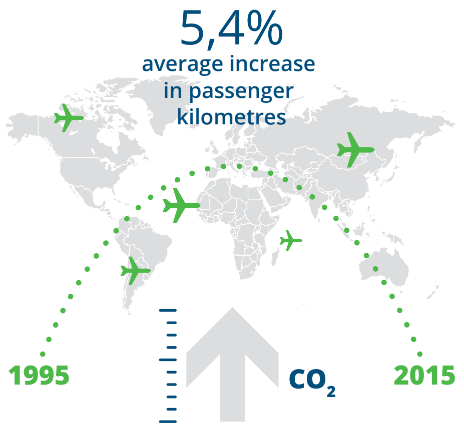
FACT SHEET SUSTAINABLE ALTERNATIVES TO KEROSENE

APRIL 2021

This fact sheet describes facts about sustainability with a focus on CO_2 emissions during flight*. This is based on data from before the corona crisis (1 March 2020).

Aircraft are becoming increasingly fuel-efficient, so why are CO_2 emissions increasing?



1. With a consumption of just over three litres per hundred passenger kilometres[1] a modern medium to long-haul passenger aircraft (such as the A330neo-900, with an occupancy rate of 80%) is more fuel-efficient[2] than a standard petrol car with two passengers.
2. Thanks to incremental, step-by-step developments and gradual fleet replacement, flying is becoming some 1.5% more fuel efficient (per passenger kilometre) each year[3-5]. The increased occupancy rate - from 70% in 2000 to over 80% in 2019[6] - also contributes to this.
3. However, between 1995 and 2015, the global number of kilometres travelled by air increased by an average of 5.4%, as a result of which CO_2 emissions are still rising every year[7].

What about the CO_2 emissions?

4. CO_2 is the largest individual contributor to the climate impact of aviation worldwide. Climate effects other than those caused by CO_2 - such as NOx (nitrogen oxides), soot particles and water vapour (resulting in condensation trails and cirrus clouds) - are not explicitly included in this fact sheet. According to the most recent estimates, the climate impact of aviation is therefore more than twice as high[8].
5. 75% of the flights from Schiphol are short flights (up to 2000 km), and account for 16% of the CO_2. The remaining 25% are long-haul flights that emit 84% of the CO_2[9].
6. Emissions from fossil kerosene at Dutch international airports contributed over 6% of the total CO_2 emissions for the Netherlands in 2018[10-12]. Globally, that contribution made by aviation is between 2 and 3%[13,14].

Is electric flying a solution?

7. Electric propulsion offers the flexibility to change the configuration - such as numbers and positions of propellers or fans - allowing aircraft to be quieter than their corresponding kerosene-powered counterparts.
8. There are several possible types of hybrid electric aircraft. For instance, by using electric propulsion only at the start. This can reduce noise and emissions at airports. The total fuel and emission savings depend on the configuration of the aircraft and the flight distance.
9. The amount of energy that can be stored in an aviation-grade battery (143 Wh per kg[15]) is currently almost 90 times less than the energy in a kilogram of kerosene.
10. Based on current battery technology, due to the high additional weight and volume of batteries, fully electric flying will most likely be used for flights of approximately 500 to 1000 km, carrying up to 19 passengers[16].

What is involved in flying on hydrogen?

11. A major technical challenge is the storage of hydrogen in the aircraft. This can be done in liquid form at a very low temperature (-253 °C[17]), or in gaseous form under very high pressure (700 bar17). A robust tank or insulation carries extra weight.
12. The advantage of hydrogen as an energy carrier is that it contains three times more energy per kilogram than kerosene[17,18]. In liquid form, hydrogen occupies up to four times more volume per kilogram, and in gaseous form under high pressure up to 10 times more volume[17], which is detrimental.
13. Hydrogen can be burned directly in a gas turbine for propulsion or converted in a fuel cell into electricity to drive an electric motor (in both cases, 40-45% energy efficiency for a large aircraft[19,20]). Depending on its configuration, a hydrogen-powered aircraft can travel up to several thousand kilometres.
14. Liquefied natural gas (LNG) can serve as a prelude to hydrogen-powered aviation[21]. This is mainly due to the high availability, the already existing infrastructure and the relatively favourable energy density[22]. It is also the only energy carrier that comes close to kerosene in terms of price[23].

What can we do with 'Sustainable Aviation Fuels' (SAF)?

15. With the current aircraft concepts/configurations, long-haul flights are only feasible with hydrocarbon-based energy carriers such as conventional, biokerosene or synthetic kerosene[20].
16. Biokerosene is obtained from the refining of biomass[24]. Sustainable synthetic kerosene is synthesised from H_2 (hydrogen) and captured CO_2 using (green) electricity[25,26].
17. Current aircraft can use SAF in a blending ratio of up to 50% with conventional kerosene without making modifications and within current regulations. Higher blending percentages may require engine and fuel system modifications[27]. According to IATA, less than 1% of the kerosene uplift worldwide is SAF[28].
18. The raw materials and production processes must meet strict sustainability criteria[29]. Over its life cycle, the CO_2 balance of SAF can be considerably lower than that of fossil kerosene (from 85% to as much as 100% CO_2 reduction for biokerosene[36] and synthetic kerosene[37].
19. The production of one kilogram of synthetic kerosene (energy content: 12 kWh) requires three to four times more energy in electricity[20,30].
20. In 2019, the aviation sector consumed approximately four million tonnes of kerosene for flights out of the Netherlands[10,11]. Producing this amount of synthetic kerosene would require almost ten times the total production of green electricity in the Netherlands (21.8 billion kWh in 2019)[31].
21. Biokerosene is currently three to four times more expensive than fossil kerosene. Synthetic kerosene is five to six times more expensive. In addition, the scale-up of production and availability of raw materials are currently limiting factors for the use of SAF[20,32-35].

** The gain to be obtained at the airports themselves - before take-off and after landing - for example by electric taxiing, is not included.*

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