CASE STUDY

Climate change due to anthropogenic activity is pressing matter in daily lives with numerous impacts such as sea level rise and changing weather patterns (in some cases weather intensification) with knock on effects on different populations. In 2016, the Paris Agreement was signed by the world's nations with the goal of limiting climate change to a global average temperature increase of well below 2 degrees Celsius when compared to pre-industrial levels. It also laid out the primary pathway to achieve this goal: reduce anthropogenic greenhouse gas emissions to net-zero by 2050 (Paris Agreement).

In 2019, in the pre-Covid peak of aviation travel, aviation accounted for 12.6% of the transport sector's CO_2 emissions (IEA CO_2 emissions). As of February this year, the volume of aviation travel has returned to this peak and is expected to grow by over 10% over the course of this year alone (IATA Global Outlook Report). In response to the need to reduce CO_2 emissions inline with the Paris Agreement, and considering the forecasted growth (with the expectation of 3 times the demand of 2019 by 2050; Dray et al. 2022), the International Air Transport Association has pledged to make commercial aviation carbon net-zero by 2050 (IATA Net-Zero Roadmap). 88% of aviation's impact on the climate comes from burning fuel for propulsion, with 99% of the fuel used in the industry being from geological sources (fossil fuels; Dray et al. 2022, IATA Net-Zero Roadmap). This clearly makes the energy used for propulsion the prime target for reaching net-zero emissions.

However, providing an energy solution to achieve this goal for the aviation sector is a monumental task. To demonstrate this, the Airbus A350-900ULR (ultra long range), the current Airbus long haul passenger aircraft powered by two Rolls Royce Trent XWB-84 turbofan engines, can fly 19 hours straight and cover almost 16000 km (almost 40% of the Earth's circumference). Singapore Airlines uses this aircraft to its maximum potential with a non-stop flight between New York City and Singapore (JFK to SIN; Singapore Airlines SQ 24). For the A350-900ULR to achieve this, it carries ~165000 liters of Jet A fuel, or in other words, it consumes about 2 kg/s of fuel (or 85.6 MW of power; Exxon Jet A fuel) on average during the flight, and more than double this for takeoff (5.2 kg/s; HK Int'l Airport). With the same amount of fuel for one long haul flight, you could drive a Renault Clio about 70 times the circumference of Earth (assuming ~6 L/100km; IEA France vehicle consumption). Meanwhile, the A350 operates at an altitude of 11km and carries around 400 people, along with all that fuel. Any suitable pathway to net-zero emissions will have to maintain this standard of capability.

Your challenge is to meet this difficulty head on and **find a solution to reduce the aviation sector's carbon emissions by 75% by 2045 (excluding external carbon capture)**. **Four main aspects should be considered:**

- methods to influence the demand of air travel (such as through regulation or taxes),
- the use of alternative energy supplies (e.g. sustainable aviation fuels),
- the improvement of current technology or the innovation of new technology (such as the use of more efficient turbojet engines or propfan engines),

- and the feasibility of the presented solution (including but not limited to: technical, economical, and social acceptability).

Multiple aspects will need to be investigated, such as the compatibility of alternative fuels with existing propulsion technology (aircraft have service lives of typically over 20 years) or the cost of transitioning to new technologies (such as hydrogen based propulsion). You will need to consider how different technological or energy options are produced and the emissions produced from the required infrastructure, such as the production of electrical energy required for the synthesis of e-fuels from captured carbon and hydrogen. You will also need to consider knock on and societal effects, such as for biofuels, which compete with food crops for prime agricultural land and could induce food security challenges to meet fuel demands (European Commission Land Use Study, Ahmed et al. 2021). You will also need to investigate the advantages/disadvantages of encouraging/discouraging other forms of transportation (such as requiring land transportation for domestic travel). All of these things should be considered and addressed in some way when proposing your solution (these examples are not all encompassing).

Sources:

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