In this article, the concept of aviation sustainability is discussed from three dimensions: 1. Airline Sustainability, 2. Aircraft Sustainability and 3. Airport Sustainability

Aviation Sustainability

Pillars of sustainable aviation towards drive to Net Zero Emissions

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1 THE SUSTAINABILITY OF AVIATION

Aviation is a key element of modern society that efficiently connects our world and rapidly moving people, opening new economic opportunities and transporting food and goods all over our planet. Aviation promotes global understanding, generating rich cultural exchanges and thereby contributing to peaceful co-existence. Despite the many benefits, aviation also has an impact on the environment therefore requires action on many fronts. Sustainable aviation takes into account climate impact, impact of the local environment and impact on resource depletion thereby taking significant actions to protect the planet.

In this article, the concept of aviation sustainability is discussed from three dimensions:

- Airline Sustainability
- Aircraft Sustainability
- Airport Sustainability

2 AIRLINE SUSTAINABILITY

Sustainability underpins airlines business strategy in minimising its environmental impact and improving its social impact, and is fundamental to the long-term growth of the industry. Aviation contributes to 2% of human-made carbon dioxide emissions. Aviation fuel is the No. 1 contributor to Airline's carbon footprint and should be a key focus in the efforts to reduce emissions and manage environmental impact. The industry has challenged itself to reduce net CO2 emissions even while demand for air travel and transport grows significantly.

Through the Air Transport Action Group (ATAG), the aviation industry became the world's first industrial sector to set an ambitious target: reduce CO2 emissions to half of year 2005 levels by 2050, and to limit the growth of net CO2 emissions by 2020. The industry is on track to meet those near-term commitments, including the 2019 implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program as agreed upon by the nations of the International Civil Aviation Organization (ICAO).

Within the Paris Agreement, the effort to address greenhouse gas emissions from international air traffic is under the authority of the International Civil Aviation Organization (ICAO) considering that international air traffic does not fall under any national jurisdiction. ICAO regularly reports its environmental activities to the United Nations Framework Convention on Climate Change (UNFCCC). The aviation industry has been under long-term pressure to reduce its contribution to climate change – from governments, stakeholders and the public.

Currently, ICAO has set two aspirational goals for the international aviation sector: a fuel efficiency improvement of 2% per year and carbon neutral growth from 2020 onwards, so that net carbon emissions stay level from 2020 onwards (ICAO, 2020). ICAO however recognises that these medium-term goals are not ambitious enough to reduce aviation's absolute emissions. Therefore, last year ICAO started to work on a long-term global aspirational goal for international aviation (LTAG) in light of the 2°C and 1.5°C temperature goals of the Paris Agreement. Currently, detailed studies are conducted to explore to assess the attainability and impacts of the proposed goals.

Let's analyse some actions that should be taken by airlines, and others already taking place, to reduce the negative impacts of aviation on the planet and make airlines more sustainable.

2.1 Reduce the Amount of Single-use Plastics as well as Weight Reduction

Single-use plastics and cabin waste amount to 6.7 million tons every year. Some airlines are taking note and action beyond just removing plastic straws for example, by installing lighter seats on aircraft, introducing lighter catering trolleys and optimising the space in the cabin. Plastic wraps around pillows and blankets, and headphones sets could all be exchanged with more sustainable solutions.

2.2 Aviation Biofuel is Key

Sustainable aviation fuels (SAF) such as aviation biofuel have been identified as one of the key elements to helping the air transport industry reach net zero carbon. Aviation biofuel is predicted to cut the carbon foot-print of airlines by up to 80%. Unfortunately, it still costs four times as much as regular jet fuel. Many carriers have flown one-off flights partially-powered by bio-fuel, but others are beginning to introduce it more regularly.

2.3 Younger Fleet Equals Fewer Emissions

Airlines should voluntarily cap greenhouse gas emissions at 2012 levels, retiring older aircraft and replacing them with planes that are 25% more fuel-efficient, mitigating billions metric tons of greenhouse emissions. Airlines revenue generation is a significant component of airlines sustainability strategy as this will determine the airline's ability to continuously invest into a greener future by upgrading fleets to more modern and fuel-efficient aircrafts.

2.4 Reduce Routes

Technology could play a massive role by gathering data of passengers flows and persuading airlines to reduce the frequency of certain flights. Data flows could perhaps persuade the airline to schedule a flight only five times per week instead of seven during a certain season thereby ensuring it always travel full. However this may be greeted with some scepticism as apparently airlines would rather fly empty planes, seriously unprofitable and "no-sense" routes just so that they can keep their departure/landing slots. Therefore airlines should consider the option of getting rid of these routes to reduce their emissions.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". three dimensions of the sustainable aviation Over the past few decades, dealing with the concept of sustainability has been consolidated as a major part of the agenda for almost all aviation stakeholders9 classified into 4 main categories

Aviation connects our world by efficiently and rapidly moving people, opening new economic opportunities and transporting food and goods all over our planet. Aviation promotes global understanding, generating rich cultural exchanges and thereby contributing to peaceful co-existence.

At the same time, climate change has become a clear concern for our society. Humanity's impact on the climate requires action on many fronts. The aviation industry is already taking significant action to protect the planet and will continue to do so.

Aviation contributes to two percent of human-made carbon dioxide emissions. The industry has challenged itself to reduce net CO2 emissions even while demand for air travel and transport grows significantly. Through the Air Transport Action Group (ATAG), the aviation industry became the world's first industrial sector to set an ambitious target: reduce CO2 emissions to half of year 2005 levels by 2050, and to limit the growth of net CO2 emissions by 2020. We are on track to meet those near-term commitments, including the 2019 implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program as agreed upon by the nations of the International Civil Aviation Organization (ICAO).

3 AIRCRAFT SUSTAINABILITY

There are three major technological elements to aircraft sustainability:

- Continuing to develop aircraft and engine design and technology in a relentless pursuit of improvements in fuel efficiency and reduced CO2 emissions.
- Supporting the commercialisation of sustainable, alternate aviation fuels. Around 185,000 commercial flights have already proven that today's aircraft are ready to use them.
- Developing radically new aircraft and propulsion technology and accelerating technologies that will enable the 'third generation' of aviation.

Other factors, such as efficient air traffic management and aircraft routing that minimizes fuel consumption also have a vital part to play. Our industry has demonstrated significant progress on reducing noise and other environmental impacts and will continue to do so.

3.1 Aircraft and Engine Design and Technology

For the last 40 years, aircraft and engine technology has reduced CO2 emissions by a yearly average of over one percent per passenger mile. This has been the result of significant R&D investments in materials, aerodynamic efficiency, digital design and manufacturing methods, turbomachinery developments and aircraft systems optimization.

For many years, through a variety of industry organizations and international bodies, the aviation community has voluntarily committed to meet a set of aggressive targets for enhanced airplane environmental performance. Targets set by the Advisory Council for Aeronautics Research in Europe call for a 75% reduction in CO2, a 90% drop in NOX and a 65% decrease in noise by 2050, compared with year 2000 levels.

To help achieve these aggressive goals, global agreements reached through ICAO call for a fuel-efficiency performance standard to be part of the certification process applied to every airplane. Aircraft and engine manufacturers remain committed to improving existing aircraft and engine designs to continue the trajectory of improving efficiency as much as possible. Concurrently, they note the tremendous technological challenges ahead and the likely need to include more radical ‘third generation' approaches.

3.2 Fostering the Energy Transition: Sustainable Aviation Fuels

Aviation will continue to rely on liquid fuels as the fundamental energy source for larger and longer-range aircraft for the foreseeable future. Even under the most optimistic forecasts for electric-powered flight, regional and single-aisle commercial airplanes will remain operating in the global fleet with jet fuel for decades to come. Therefore, the development of Sustainable Aviation Fuels (SAFs) which use recycled rather than fossil-based carbon and meet strong, credible sustainability standards is an essential component of a sustainable future. Five pathways for production of SAFs have already been approved for use, with commercial scale production of one of these pathways already in place. Accelerating production scale-up of all commercially viable pathways, while simultaneously developing additional lower cost pathways, is the key to success. This work is already underway at research institutions and within companies in various industrial sectors. What is needed is an expansion of government support for technology development, production facility investment, and fuel production incentives around the world.

Aircraft and engine manufacturers are fully supportive of any fuel, which is sustainable, scalable, and compatible with existing fuels. They have committed to work closely with fuel producers, operators, airports, environmental organisations and government agencies to bring these fuels into widespread aviation use well ahead of 2050.

3.3 The Third Era of Aviation

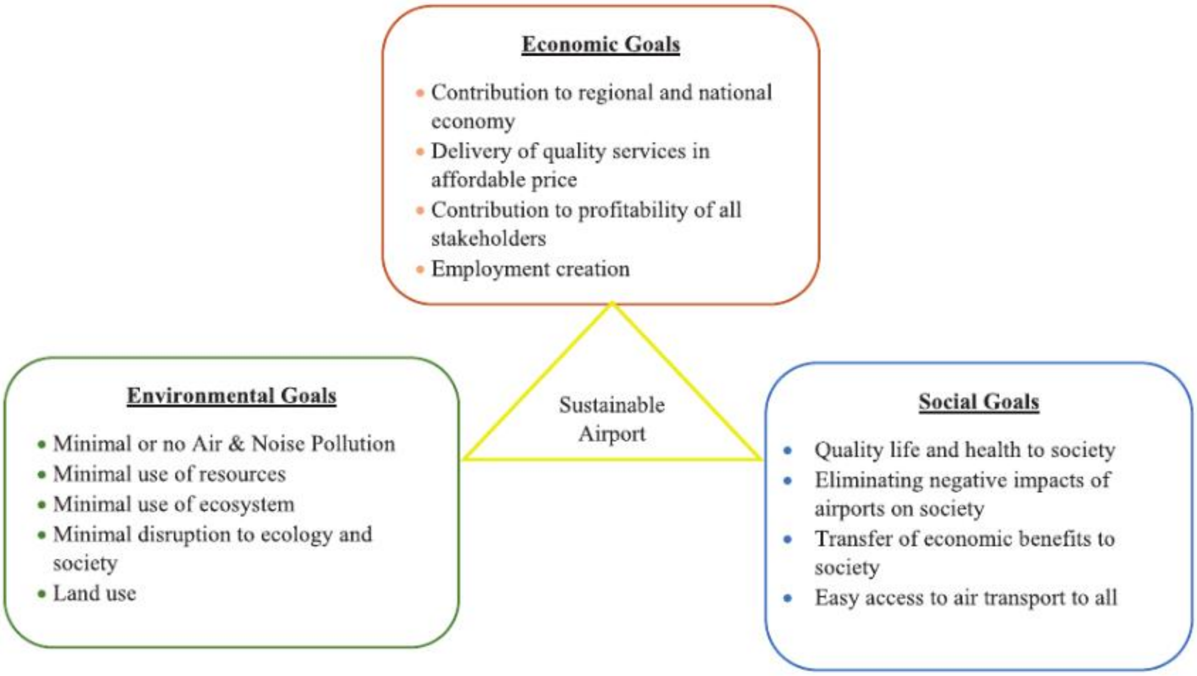
Aviation is at the dawn of its third major era, building on the foundation laid by the Wright brothers and the innovators of the Jet Age in the 1950s. Aviation's third era is enabled by advances in new architectures, advanced engine thermodynamic efficiencies, electric and hybrid-electric propulsion, digitisation, artificial intelligence, materials and manufacturing. Larger aircraft will begin to benefit from novel designs that will further improve efficiency through management of aircraft drag and distributing propulsion in new ways. New materials will enable lighter aircraft, further improving efficiency.

Aircraft and engine manufacturers are excited by this third generation of aviation and, even though all of the companies have different approaches, they are all driven by the certainty of its contribution to the role of aviation in a sustainable future. They believe that aviation is entering its most exciting era since the dawn of the Jet Age. This third era promises a transformative positive impact on lives around the globe.

4 AIRPORTS SUSTAINABILITY

Sustainable airports have three important goals: reducing environmental impact, prioritising economic growth and generating social progress. To achieve this, airports must take considerable measures to reduce emissions, decrease noise pollution, eliminate light and visual pollution, protect wildlife and natural vegetation and lower the consumption of resources like electricity, water and land.

The adoption of sustainable development practises in airports improves the financial and operational benefits of the airports and provides social benefits to the society. Sustainable airports should be part of an integrated transport planning system. It should fit into the sustainable mobility of the city so that the airport will be connected to other modes of transport. Moreover, it should also fit into sustainable aviation so that the airport can provide the adequate infrastructures for sustainable airplanes. There should be an appropriate balance between Economic, Ecological and Social goals.



Triangle of sustainable airport

In the process to make the airport sustainable, some major issues are faced by the airport operators which may be managed by the recommendations mentioned hereunder.

4.1 Emissions

Greenhouse gases and other emissions are produced during the aircraft operation on ground as well as sky which lead to numerous undesirable impacts on air quality. Not only the aircraft emission but also the emission of ground vehicles and service equipment which are required for the operation, contribute to the degradation of local air quality within the vicinity of airports. Emissions from the aircraft movement can be managed by:

a. Adopting the procedures and technologies to reduce aircraft emission at landing and take-off,

b. Using alternative fuel source for ground support vehicle/equipment, power heating, etc.,
c. Adopting hybrid, electric or solar powered vehicles for airport operation,
d. Fixing permissible limits of emission by the regulatory authorities and to issue guidelines to control the emission.

4.2 Noise Pollution

The aircraft noise is the most critical problem in and around an airport. The aircraft noise is related to the occurrence of activities, that is, take-off, landing and movement of the aircraft. Noise pollution due to aircraft operation can be managed by:

a. Adopting new aircraft technologies and design that reduce the degree of noise produced,
b. Restricting the operation of specific air-craft that makes more noise,
c. Incorporating the guidelines related to noise pollution in urban planning near to the airport,
d. Implementing land use planning and management along with operational improvement at airport, and
e. Redistributing the noises by managing runways.

4.3 Land Use, Ground Congestion and Waste Management

The utilisation of land by airports for operating different activities of the airport refers to "land use". Improper land use due to poor planning lead to congestion inside and outside the airport, overutilisation of resources and unfriendly arrangements in the airport. Similarly, wastes generated due to different activities of the airport are hazardous to the environment. Land use, Ground congestion and Waste can be managed by:

a. Making proper plans for the airport structures so that efficient utilisation of land can be achieved,
b. Reducing the waste generation by effective utilisation of land use and available resources,
c. Using waste/sewage treatment plant,

d. Planning and coordinating with local body for discharging the waste so that it does not contaminate the water source and aquatic life, and
e. Installing rain water harvesting system and to consider necessary steps to recharge under-ground water.

4.4 Wildlife Management

Wildlife management is an accountability of the airport. The safety concern of commuters, flora and fauna are also elemental for the airport authority. Wildlife can cause serious incidents and accidents. Wildlife hazard management plan can be adopted to avoid serious accidents and incidents and to protect flora and fauna

5 SUSTAINABLE AIRPORT INFRASTRUCTURE

Airport sustainability incorporates the 'triple bottom line' concept with a fourth pillar focused on operational efficiency. Airport infrastructure is a vital component of the drive to Net Zero Emissions. There are several sustainable aircraft configurations: (hybrid)-electric aircraft, Hydrogen powered aircraft and conventional aircraft – for the latter it is assumed that SAF is used. In fact, these configurations come down on three different categories of energy carriers: batteries, Hydrogen and SAF. The fuelling process, whether that is charging or either changing the battery or really fuelling the aircraft with SAF, is for each category different. This means that in the transition towards Net Zero Emissions, airports need to be ready to accommodate the different ways of fuelling the aircraft. This will have a huge impact on the current airport infrastructure and operations, imposing new challenges in the very near future.

5.1 Electric Aircraft Infrastructure

Electric or hybrid-electric aircraft need to be charged (and refuelled) during stops. Facilitating an aircraft with a full battery can be done in two ways; either by charging the on-board battery of the aircraft or by swapping batteries. The main challenge for plug-in charging an aircraft is the charging time, as an operational constraint is the turnaround time. Using (multiple) fast chargers could compete with turnaround times of conventional aircraft. However, it would impact peak power, required from the grid. Battery Swapping Stations (BSSs) could overcome the limitations of charging time and temperature constraints, where depleted batteries can be swapped for fully charged ones. However, BSSs are costly as you will need a robotic infrastructure for the station as well as much more space than a regular charging point. Besides you would need multiple batteries, which is an investment. Fast charging or battery exchange systems would require significant changes to the airport infrastructure.

5.2 Hydrogen Powered Aircraft Infrastructure

Switching to Hydrogen fuel would have major implications for the fuel supply chain, airport infrastructure and operations, and the air travel system as a whole. In the early years given the amount of refueling required, a major overhaul of the refueling infrastructure at airports is not likely to be needed as the primary focus will be the use of refueling trucks. The number of refueling trucks required is roughly double the number needed for kerosene but comprises only a small share of the total existing refueling fleet in this time frame, so the implications on ground traffic would be limited.

Liquid Hydrogen (LH2) refueling trucks are very different to existing conventional refueling trucks and would require a different training and a safety assurance framework for operations, but these are manageable challenges to overcome. In addition, refueling times would likely stay within the required turnaround times of shorter-range aircraft. LH2 hoses could attain the same flow rate in the short-term as kerosene hoses – about 900 litres per minute – if the right investments are made to accommodate the hoses' heavier weight and lower maneuverability.

Given LH2's lower volumetric density, LH2 refueling would still be much slower, but if the amount of hoses were doubled from one to two, the refueling of a short-range airplane would take 20 to 30 minutes, which would still be within turnaround times. The major remaining question concerns safety and taking the necessary precautions when refueling, which could potentially compromise the ability to conduct parallel operations during the turnaround. This could potentially have a major impact on operations: Losing more than 10 minutes of turnaround time three to four times per day means that short-haul aircraft could lose the ability to perform a flight sector during an 18-hour operating period per day, which has a negative revenue impact.

Also, if Hydrogen production happens off-site then additional space will be required for liquefaction and storage. The size of the mandated safety perimeter around this storage space is not yet known, therefore not all airports may have enough extra space to be able to accommodate this additional infrastructure. However, additional capacity may be needed if refueling lots must be installed away from gates and/or gate space is locked for longer periods due to longer refueling times. Airport box sizes may not always be able to accommodate the additional 10 to 15 meters in length needed for the suggested LH2 medium-range and long-range aircraft designs, which could potentially lead to the need for sizable infrastructure investments. Alternatively, this could lead to constraints on aircraft gate assignments, which would further increase turnaround times and reduce overall infrastructure flexibility.

Finally, in early years when not all airports have an LH2 infrastructure, it is worth noting that flights that are diverted may get stuck at an airfield waiting for LH2 resupply by truck if that airfield is not cleared for LH2 refueling.

5.3 Sustainable Aviation Fuel (SAF)

SAF are the most promising near-term options and these fuels can use the same fuel distribution infrastructure already in use, with the advantage of reduced emissions. SAF are blended with traditional Jet A-1 fuel, so it is safe to use as a drop-in fuel and there are no infrastructure changes required by aircraft or airport infrastructure. SAF is a clean substitute that reduces the impact of air travel while delivering the same characteristics and specifications as fossil jet fuel.

Due to the strict quality control conditions for aviation fuels, the introduction of fuels from different sources requires the implementation of the "drop-in" fuel concept. Therefore, a "drop-in jet fuel blend" is a substitute for conventional jet fuel that is completely interchangeable and compatible with conventional jet fuel when blended with conventional jet fuel. A drop-in fuel blend does not require adaptation of the aircraft/engine fuel system or the fuel distribution network, and can be used "as is" on currently flying turbine-powered aircraft.

The requirement that a fuel be “drop-in” is essential for the aviation industry because a drop-in SAF does not need to be handled separately from any other aviation fuel. Any “non drop-in” fuel would present safety issues associated with risks of mishandling, and would require a parallel infrastructure to be implemented in all airports, imposing additional higher costs.

5.4 The Challenge

The major challenge for a sustainable airport will likely be in ensuring the required coordination between fuel providers, airports, aircraft manufacturers, and airlines as they develop the new industry in tandem.

The challenges affecting the airport refueling infrastructure and operations are unique and will require significant development and planning to overcome. They include searching for scalable refueling technology, optimising refueling practices and re-configuring airport infrastructure to introduce parallel fuel systems.

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