Sustainable Technology on Aircraft Design: A Review

Aishwarya Dhara 1, 2, a) and Muruga Lal Jeyan 2, b)

1Department of Aerospace Engineering, Chandigarh University, Mohali, 140 413, India,
2Department of Aerospace Engineering, Lovely Professional University, Phagwara, 144 411, India.
a)dharaaishwarya@gmail.com
b)Jvmlal@ymail.com
b) Corresponding author: Jvmlal@ymail.com.

Abstract. Next-generation air transportation is a key to influence the environment, safety, and the economy. Several programs strive to create emerging innovation towards sustainability, system integrity, and alternative fuels to guarantee a reduction of its environmental effect as greenhouse gas. Nowadays, the aerospace industry is looking forward to aviation sustainable developments across the globe. Few initiatives through a novel configuration of aircraft is established like Blended Wing Body, Flying V aircraft, Box wing Aircraft, and Double bubble Aircraft to enhance the cargo and passenger volume occupancy and cut-off the fuel burn percent. With the use of disruptive technologies, researchers are progressing the revolutionary airframe for transportation. A systematic overview and comprehensive survey of passenger-based aircraft are investigated. The objective study is to examine fuel burn and its impact on the environment by types of aircraft. In-depth literature review studies on four pillar strategies used to design an efficient airplane. In addition, this paper also serves on advancement in evolutionary technologies used in jet transport aircraft. Reflecting the benefits and challenges of different aircraft designs technologies were also highlighted. This paper highlights the future implications and managerial insights for future aircraft designers.

Keywords –Aircraft, design technology, environmental impact, emission, performance

1. NOMENCLATURE

| ACARE | Advisory Council for Aviation Research and Innovation in Europe |
| APK | Available passenger kilometre |
| ATE | Adaptive Trailing Edge |
| BLI | Boundary layer ingestion |
| CAEE | Committee on Aircraft Engine Emissions |
| CAEP | Committee on Aviation Environmental Protection |
| CAGR | Compound Annual Growth Rate |
| CAN | Committee on Aircraft Noise |
| CLEEN | Continuous Lower Energy, Emissions, and Noise |
| CORSIA | Carbon Offsetting and Reduction Scheme for International Aviation |
| CSJU | Clean Sky 2 Joint Undertaking |
| EU | European Union |
| EGTS | Electric Green Taxiing System |
| FAA | Federal Aviation Administration |
| Acronym | Description |
|---------|-------------|
| FTG     | Fuel Task Group |
| GARDN   | Green Aviation Research and Development Network |
| GHG     | greenhouse gas |
| GTF     | Geared Turbofan |
| ICAO    | International Civil Aviation Organization |
| LCA     | Life Cycle Assessment |
| LEAP    | Leading Edge Aviation Propulsion |
| LFC     | Laminar Flow Control |
| LTO     | Landing and Take-off |
| MES     | More Electric Systems |
| NASA    | National Aeronautics and Space Administration |
| NJFCP   | National Jet Fuels Combustion Program |
| NREL    | National Renewable Energy Laboratory |
| PFC     | Propulsive fuselage concept |
| RISE    | Revolutionary Innovation for Sustainable Engines |
| R&D     | research and development |
| SAF     | sustainable aviation fuel |
| RQL     | Rich-Quench-Lean |
| SAF      | sustainable alternative jet fuels |
| SEW     | Structurally Efficient Wing |
| SFC     | Specific Fuel Consumption |
| SUGAR   | Subsonic Ultra-Green Aircraft Research |
| TAPS    | Twin Annular Premixed Swirler |
| VTOL    | vertical take-off and landing |
2. INTRODUCTION

Air transport is anticipated to grow at a comparable rate in the coming years. Air traffic forecasts an annual rise at 3.7 percent in the coming 15th year, exceeding over 145,000,000,000 revenue passenger kilometers (RPK), far beyond doubling from 2016. The aviation industry, a significant concern because of its adverse footprint from noise, fuel burn, and, more significantly, emissions. Commercial aircraft emit a considerable emission due to rising global warming. In 2009, all airline industrialists agreed to optimistic carbon reduction objectives involving improving fuel economy by 1.5 percent per year between 2009 and 2020 and reducing net annual aviation carbon footprint half by 2050 compared to 2005 [1–3]. Meanwhile, the aviation sector begins to establish reduction in fuel burn and emission, launching many programs like Clean sky, CLEEN II EU, ICCT and many more. Europe's aviation sector has committed an alternative offer towards the global issue by lowering environmental impact whilst also offering benefits in economic competitiveness [4–6]. IATA addressed environmental targets with a "Four-pillar Strategy". ICAO recently implemented the CORSIA framework to meet the carbon footprint target. CORSIA offers a reduced CO2 plan in many ways. The idea of operating in increasingly economic planes; Make better use of emerging technology; use green technologies to reduce emission; decrease air traffic congestion. The influence of advanced techniques potential cause in environmental impacts as estimated over distinct parameters representing differing levels of configuration, air traffic volume, and structural integrity. Green technologies like sustainable aviation fuels (SAFs) have the potential tool to decrease emissions and challenges for long-range flight due to lack of appropriate energy density [7–9]. Alternative fuels are another way to encourage fuel efficiency in terms of economic measures. Financial measures indicate an airline's profitability from an operational point of view. Civil Air Navigation Services Organization (CANSO) is the international face of airport operations. Previously EU jet fuel had no taxation. But recently imposed a 15% VAT on all air transportation across Europe would cost 18 billion USD. Aviation taxation indicators to encourage flights to optimize fuel consumption. Such logistical potential to mitigate climate change provides a win-win scenario. Operational factors indicators need not necessitate the development of infrastructure or the implementation of costly technology. Instead, various methods to improve the performance of existing aircraft [10–13].

3. LITERATURE REVIEW

3.3 BACKGROUND

Air transport has become a wide sector, and continual improvement within the advancement of technology is a key for long-term prosperity. Technology is not just to enrich fuel-efficient, but also a vital aspect to boost flight ground services, providing passenger comfort, and minimizing environmental consequences. Many R&D, funded programs have taken the initiative to reduce the carbon footprints that help to increase passenger mobility, comfort, economic measures, and structural integrity. A well popular program began neutralizing the carbon footprints such as ACARE, ERA, CLEEN, GARDN, Clean sky 2, and ICAO Programme. ERA was established in 2009 as a part of NASA's program to investigate aircraft design and facilitate solutions to minimize aircraft's carbon footprint. ERA program includes new airframe innovation, advanced engines, and systems [14–17]. This program initiates new generation aircraft like N+1 in 2015 N+2 in 2020 and N+3 in the upcoming 2025. Aimed to reduce noise and emission, and improve fuel economy and performance. In the same year, the Canadian aviation industry developed the GARDN program to focus on green technologies set up in Canada. A similar program as CLEEN introduced by the FAA intended to focus on environmental impacts caused in the aviation industry. The program demonstrated that reducing the LTO cycle, fleet size, and improving advanced technology implications can reduce noise, emission, and fuel burn by 30 percent by 2015 and 45 percent by 2020. CLEEN program has collaborated with eminent companies like Aurora Flight Sciences, Boeing, MDS Coating Technologies, GE Aviation, P&W, Rolls-Royce, and United Technologies Corp. (UTC)
Aerospace Systems. The ACARE introduced FlightPath 2050 objective to improve sustainability in the aviation industry. The major challenge in sustainable development in the aviation sector is to minimize the negative effect of carbon emissions [18–21]. By 2050, advanced technology can decrease 75 percent emissions per APK, 90 percent drop in exhaust gases, and 65 percent decrease noise decibel compared to 2000's aircraft. FlightPath 2050 also aims to work on emission-free taxiing, reusable structures, and SAFs. EU’s potential CSJU Program lowers the carbon footprint and improves fuel economy and competitiveness. The International Civil Aviation Organization (ICAO) acts as a multidirectional framework on air transport sustainable development. The most efficient approach to reduce aviation emissions is to reduce the fuels consumed in maintenance and controlling for every trip, potential impacts improved through fuel efficiency often lead to lower fuel prices. ICAO Members have decided to focus on a sustainability partnership on three main elements: emissions and climate change [22–24], noise, and air quality. ICAO A40-WP/54 updated a set of possible case studies for determining potential fuel efficiency and Greenhouse gas rates. Case 1 for fuel consumption and Carbon footprint comprises the operating efficiencies required to sustain existing profitability but excluding any technological advancements application on aircraft. Case 2, 3, 4, and 5 (low, moderate, advanced, and optimistic technology) imply annual enhancement in fuel economy by 0.57 percent, 0.96 percent, 1.16 percent, and 1.5 percent for all planes flying in the early stages of 2015, in conjunction with operational advancements. Comprehensive understanding from the program objective that a four-pillar strategy can improve the economic benefits and reduce the environmental issues that arose from aviation noise and emission as shown in figure 1. A detailed study of design technology, SAF, infrastructure measures, and economic factors are studies. Table I illustrates an in-depth literature review made on the mentioned parameters.

![Four Pillar Strategy](image)

**FIGURE 1.** Four pillar strategy to reduce aviation carbon footprint

### 3.2 Design Technology

The introduction of innovative techniques and progressive designs is at the heart of advanced airframe design. The first pillar is design technology which comprises short-term, medium-term, and longer-term includes retrofit and upgraded production, new airframe designs, and radical airframe technologies. Aerodynamics, propulsive framework, and retrofit systems are the most significant ways to improve design effectiveness in the aviation industry briefly illustrated in figure 2.
The aerodynamic concept has rapidly grown results in innovations featuring considerably lower drag, SFC, and emission. Since the 1970s, winglet design in aircraft has shown a significant result by reducing the drag reduction technique. Raked wingtip and spiroid wingtip can be significantly capable of reducing drag and fuel burn up to 6 percent. Simultaneously a unique feature as variable camber wing came into aerospace research. Variable camber wing distinctly improves aerodynamic efficiency (L/D) and reduces drag, SFC, and noise by 2 percent. Currently, morphing systems like ATE devices are applied in the wing to lower the SFC by 2.5 percent. Research further extended to riblets to trigger shear stress reduction by 16 percent. Riblets are potential in all types of flow regimes and able to reduce fuel burn by 1 percent. Boeing collaborated with the CLEEN II program to save fuel burn. R & D developed SEW for new aircraft design and to reduce weight without compromising the fuel efficiency by 4 percent. Eminent researcher and scientist from NASA investigating SEW and Spanwise adaptive wings using shape memory alloy. This mechanism improves the aerodynamic performance enabling a reduction of the SFC by 8 percent. LFC is another aerodynamics technique explored for several generations and lately achieved advances throughout the design. LFC is presently one such technique that can significantly increase fuel efficiency by greater than 30 percent. Few case studies are studied on double bubble aircraft, joint wing, blended wing body (BWB), Flying V aircraft, and strut-braced wing. A common reason for fuel-efficiency benefits due to drag minimizing, better aerodynamic profile, improving lift and weight reduction.

**Figure 2.** Aircraft design technology for reduce carbon footprints

The new engine technology and notable engine components integrate to fuel burn reduction. Any jet engine consists of movable parts like compressor and turbine, intake ducts, combustor, and nozzle. Improving component efficiency assists reduce fuel burn, noise, and emission. As a part of the CLEEN program, R-R designed and tested Dual-Wall Turbine Airfoil proved to enhance fuel efficiency by 1 percent. Under the same program, Rolls-Royce demonstrated the RQL combustion system principle based on effective fuel atomization resulting in better fuel economy. An innovative combustor system captive of low emission about 40 percent. reported that the system driven with NH3-H2 emits 99.97 percent H2O, N2, and O2, with minimal traces of NOX less than 100 ppm. investigated RP-3 kerosene-fuelled in the system and obtained better atomization related to negligible emission. As per the CAEP, noise emission creates passenger uneasiness and health issues in society. Collins Aerospace's innovative clean fan duct and short inlet can significantly improve 1 percent fuel economy and helps in noise reduction by ~2.0 EPNdB. GE experiments show the low-emission combustor SAC, DAC, and TAPS-II reduces the
emission margin by 25 percent, 35 percent, and 50 percent compared to standard CAEP (TASP-II report, 2013). Since 2012, GE and NASA have been funding and introducing TASP innovation currently used in the LEAP engine. Presently, LEAP engine technology installed in Airbus 320 neo, Boeing 737 max series, and Boeing B-777X. In addition, BLI technology is a possible way to reduce power requirements, lower carbon emission, and improve fuel economy. NASA initiated a project with MIT and Aurora to design and develop double bubble aircraft with the BLI concept. A similar progressive concept designed by the EU with Bauhaus Luftfahrt is the propulsive fuselage concept (PFC). PFC provides minimize drag, a tail-mounted fan collects flow and increases the BPR leads to improve engine efficiency. Rolls Royce, Safran adversely developing ultra-high BPR to meet demanding emissions goals and lessen environmental impact. New engine architecture like open rotor and GTF engine is a massive future demand. The open rotor is a combination of propeller and turbofan engine that enables 30 percent lower SFC compared to CFM56. A SUGAR program initiated with NASA and Boeing designed a novel aircraft with an open rotor. Open rotor portraits challenge on severe noise level and limited speed range up to 0.8 Mach speed. Whereas the GTF engine is combined with a gearbox with a fan which produces high BPR leads to reduce fuel burn significantly. June 2021, GE and Safran collaborated and initiated a CFM RISE Program to reduce carbon footprint by 20 percent. The integrated power plant is designed to run on H2 as well as SAFs.

The aviation industry has gained the responsibility for the implementation of composite processes and production technologies. The potential demand to improve the high strength to weight ratio tends to decrease SFC at a range of flight. Weight reduction triggers to reduce the SFC and improve the performance measures, fuel economy, and competitiveness. The most common material like composite material, light weight alloys, and advanced materials capable of reducing the gross weight, finally leads to decreasing fuel burn of the aircraft. Most well-known composite components like belly fairings in A380, rear pressure bulkhead in A340-600, floor beams in A350, B787, Keel beam in A340-600, nose cone, fan blades, nacelle, and many more. Further weight reduction is possible from advanced systems. The aircraft interior attempts to balance elegance, security, and passenger leisure with operational performance measures. New ideas are coupled with lightweight performance and strict quality assurance signifies fuel economy by 5 percent. Safran proved EGTS drastically saves fuel consumption on the phase of taxiing on the LTO cycle. Figure 3 illustrates a complete insight into how innovative technology can save fuel and improve fuel economy. A combination of technologies in aircraft design can neutralize the carbon footprints and reduce the environmental impacts. Engine architecture and its components like combustor, engine cooling system, and rotating system are the driving constraint to fuel consumption and carbon emission. Future aircraft can ignite more initiation to neutralize the carbon offset.

Table 1 : Literature review on aviation environmental issues

| Innovation | Category to improve fuel economy |
|------------|----------------------------------|
| Winglets   | Retrofit design                 |
|            | technology                       |
| Variable Camber | Retrofit design           |
|            | technology                       |
| ATE        | Retrofit design                 |
| Riblets    | Production Upgrade              |
| SEW        | Production Upgrade              |
| LCF        | Retrofit design                 |
FIGURE 3. Innovative technology enhance fuel efficiency in percent
3.3 Sustainable Fuels

For Aerospace Industry has committed to reducing environmental impacts to create a zero net emission and fulfill robust environmental legal limits. For decades engine manufacturers have been striving to make renewable fuels feasible for use in airplanes. Possible options, such as enhancing aero-engine effectiveness through architectural adjustments, all-electric aircraft, hybrid-electric systems, SAF, and many more, would be embraced by different aerospace technologies. Engine combustion accounts for 99 percent of airplane carbon emissions. Initiatives that employ power as a green propelling fuel source of the airplane are effective to advance. Electric engines emit zero percent pollutants during the flight, which meets the environmental carbon footprint objective for 2050. The fundamental difference between all-electric systems and hybrid-electric systems is battery only, and a combination of the turbine generator and battery. For an all-electric system example, Lilium is the first electric VTOL jet flying limited to 300km. E-Fan X is an example of a hybrid-electric system board up to 100 passengers with 16MW power. Electric-based aircraft undergo challenges like an electric requirement to complete a mission, energy density capacity, and battery safety on board. The aviation industry is dedicated to carbon footprint reduction targets. U.S Airlines reported a reduction in fuel burn by 130 percent in contrast to the last two decades. ICAO initiated a “basket of measures” to carbon offset in the coming years. The motivations of SAF are fuel economy, reduced GHG, and competitiveness for energy resources. EU reported SAF is safe, reliable, reduces GHG, and is future-proof. SAF highlighted carbon reduction objectives but the main challenge is to cut down the cost. Survey reports that clean energy fuels like SAF generally emit close to 80 percent less than aviation fuel. SAF is composed of three components: sustainability, alternative feedstock to crude oil, and fuel. The requirement of SAF is expensive synthesis and sheer in feedstock accessibility to aviation. Currently, SAF is a bit costly and R&D on SAF can be initiated to minimize the fuel cost. FTG Programme offers SAF and neutralized carbon offset in aviation fuels. The LCA is an environmental sustainability method to analyze the carbon footprint of a framework. From the standpoint of LCA, SAF minimizes the carbon footprint and maximizes fuel economy. The SAF market analysis expanded on fuel type, manufacturing technology, blending capacity, and platform at a CAGR of 72.4 percent over the forthcoming years shown in figure 4.

![SAF Market](image)

**FIGURE 4.** SAF Market segments
This live stream is predicated on publicly accessible data from airports participating in active sustainable energy contracts. The SAF process availability at the airports determines the amount of alternative fuel consumed. The lists of SAF airports are Bergen Airport, Halmstad City Airport, Kalmar Airport, Los Angeles International Airport, Oslo Airport, San Francisco Airport, Stockholm Arlanda Airport, Stockholm Bromma Airport, and Växjö Smaland Airport represented in figure 5.

4. Operational and Infrastructure Measures

Aircraft operation and infrastructure measure variants of services like maintenance of aircraft, controlling through the air traffic controller, carrying out different airport duties from ground level, and ensuring safety. The aerospace industry serves as an opportunity for developing new airplanes from an operational viewpoint to the advancement of new techniques represented in figure 6.
The International Civil Aviation Organization (ICAO) created guidelines to estimate environmental importance of implementing new performance measures. ICAO and other reputed CAEP are concerned with high fuel consumption and preventing carbon footprints. Managing operational activities like the deployment of modern communications, navigation, surveillance, and air traffic management systems would be an efficient method of carbon offset. The ICAO also conducted a worldwide HFE analysis as the first stage in a multi-part procedure to determine global flight effectiveness.

Aircraft LTO cycle lowers engine's power cuts fuel consumption and emissions during a decent flight. Combustion fumes are highest while the engine is idle. Reduced idle can also result in reduced engine operating conditions, lowering maintenance and increasing engine service life. Studies say engine deterioration as FOD on fan blades, engine core, and nacelle fairings can increase SFC by 2 percent. Aircraft towing has the potential ways to cut aircraft engine SFC and emissions.

**FIGURE 7.** Percent of CO2 emission rate by aircraft type from 2013 to 2019
FIGURE 8. Percent of CO2 emission rate by aircraft type from 2013 to 2019

Fleet size and services of passenger satisfaction are the keys to aviation operational measures. Detailed investigation on aircraft type and the intensity of carbon footprints from 2013 to 2019 is depicted in figure 7. It outlines that majority of the emission and environmental impacts are caused by narrow-body aircraft. Wide-body is capable of fleeting long haul range and efficient in SFC and leads less emission to the environment. ICAO enforced rules and certifications to improve operational and infrastructure efficiency. The quality measure as service, passenger comforts, incidents, and deficiencies. Passenger satisfaction is obtained from the quality of services like baggage, security check, accessibility, and adequate seating. The aircraft sector is a substantial impact on increasing in size occurs considerable growth of fuel economy. The weight of the aircraft has a direct connection with payload weight as the size of the fleet. A study was made on types of passenger-based aircraft with seat capacity shown in figure 8. This indicates that long-haul range flights with an increase in passenger capacity will be economic in terms of fuel consumption, emission and performance measures compared to narrow-body and regional aircraft. Another vital factor is the safety of passengers for that aircraft structural integrity and reliability management is essential. ICAO introduced safety management systems to enhance ground level to flying level reliability to improve operational efficiency. ICAO accident data is achieved from ICAO accident statistics. Due to pandemic drastically downfall of accident rate by 0.9 by million departures shown in figure 9. Advanced systems and instrumentations are developed to avoid circumstantial incidents and accidents.
5. Economic Measures

Air transport is providing a crucial boost to global economic progression. Aircraft design has a direct influence on cost. Aviation cost is classified into two as direct operating cost and indirect operating cost as shown in figure 10. DOC is associated with a type of aircraft, crew and fuel cost and environmental whereas indirect operating cost deals with administrative activities. The FAA will strive to encourage this tax revenue per objective to maintain safety and efficiency in the aircraft sector.

![FIGURE 10. Potential types of economic measures](image)

The economic performance measures are the sum of primary impacts and secondary impacts as shown in figure 11. Primary impacts on aviation deal with revenue generated from sales and services. Whereas secondary impact on flight and crew payroll and other managerial activities. Overall the aviation cost depends on flight, ground, and system operating costs.
A major contribution by airline ownership at 32 percent, then followed by maintenance, pilot and crew contribution, fuel cost, air traffic controller fee, and insurance. The aviation industry, economic measures depend on revenues, expenses, operating cost, and net profit. Airlines revenues depend on passengers, cargo, passenger growth, scheduled passenger, and traffic volume. Technology investigation on future aircraft reports that increasing fleet size with seat capacity can improve revenues and growth. Growth in aviation can maximize if airlines expenses are cut down. Factors that increase airline expenses are fuel price, fuel consumption, emission taxation, other non-fuel unit cost, flights, and load factors. Figure 12 illustrates several aircraft types and fuel efficiency benefits per ASK. Microanalysis on types of aircraft shows that wide-body aircraft provides better fuel economy compared to other variants. A wide-body aircraft capable of carrying numerous passenger capacity or cargo and fly for long haul flight cause substantial carbon footprint. Thus several social and economic aspects that influence aircraft fuel SFC and fuel economy. A substantial decrease in aviation fuel consumption and carbon emissions, implementing advanced technology. Noise emission additionally creates an impact on the environment as well as humans’ health issues. Social awareness about aviation environmental issues is taken the initiative via many programs. In figure 13 represents the aviation economic growth from 2010 to April 2021. The figure indicates the pandemic creates a net loss of GDP growth by -4.2 percent and gradually improved to 4.9 percent in the first phase of 2021. Presently in 2021, economic performance is improving indicates in terms of profit, RPK growth, ASK growth, and load factor by an average of 50 percent. Aviation sector struggling to thrive in a dynamic industry with rising operational expenses and financial crisis having a significant impact. Operating activities in airlines is one of the most challenging aspects of fuel-saving schemes. To improve the economic performance directly depends on operating air route, design technology, fuel consumption, and range of flight [50, 56]. All changes that increase economic performance will likewise affect the effectiveness of fuel usage in the aircraft.
FIGURE 12. Different aircraft types and its fuel efficiency per ASK

FIGURE 13. Aviation economic performance from 2010 to April 2021
6. FUTURE IMPLICATIONS

This section describes the possible future aircraft implicates in a coming era as following points.

- Presently manufacturers and designers are concerned to reduce the environmental impacts like lowering the carbon footprint.

- The researcher stated that reduction of carbon footprint is captive of improving fuel economy and reduces environmental impacts.

- Aircraft fuel consumption lowers in three fundamental ways (a) design technology, (b) operational and infrastructural measures, and (c) performance measures illustrated in figure 14.

- The implementation of airframe design technology as an aerodynamic profile by drag reduction, increasing BPR, lightweight structure, and disruptive techniques which trigger to reduce fuel consumption and improve the performance.

- A unique design by double bubble aircraft, Flying V, and Blended wing Body aircraft design significantly improves fuel efficiency. Thus, the future aircraft with wide-body configuration offers better fuel efficiency and financial performance as illustrated in figure 8 and 12.

- A fully electric engine has adverse challenges in terms of battery life, passenger capacity, and range of flight. Overcoming these challenges can lead to revolutionary technologies from the year 2035 onwards.

- In-addition, passenger safety, comfort, and operational factors can improve airline profitability. Thus passenger-based aircraft need to focus on passenger satisfaction in airport operations and traveling experience with the airlines.

- As per the emergency evacuation is concerned, Blended wing body design creates challenging factors in terms of safety certification. Future work can be extended to overcome the challenges into practical implications.
7. CONCLUSION

Air transport has grown into continuous progress in technological innovation to improve fuel efficiency and lower carbon footprint. Advanced technology proved to lower improving fuel consumption in many ways by improving flight ground services, providing passenger comfort, and reducing environmental effects. Globally adverse programs are initiated to reduce the carbon footprint in the aviation sector like icao, cansc, eu, caep, cleen, era, gardn, corsia, and many more. Common in all programs is a four-pillar strategy including design technology, saf, operational and infrastructures measures, and economic performance of the global aviation sector.

The most efficient aerodynamic technology is laminar flow control (lfc). An lfc is capable of drag reduction and helps to reduce fuel consumption. Further development in engine sub-systems like combustors improves fuel efficiency and reduces carbon footprint and noise as well. Aircraft with advanced combustion systems and coating technologies improve engine efficiency and reduce noise emission to the environment. Eminent manufacturers also demonstrated saf helps to decrease ghg. Engine combustion accounts for 99 percent of airplane carbon emissions. Initiatives that employ power as a green propelling fuel source of the airplane are effective to advance. Early engine deterioration can reduce fuel efficiency. Advanced systems are installed on the aircraft to avoid incidents and accidents. All these factors are indirectly associated with structures and materials used in aircraft. Lightweight structure triggers to reduce aircraft power requirement thus, drag minimizes and improves the fuel efficiency. Structural integrity strongly associates fuel consumption with financial performance.

Financial performances like operational and infrastructure measures can increase by ground operations, airport functionality, fleet size, safety, air traffic management, and passenger satisfaction. The CAEP program is committed to reducing carbon emission impact on environmental issues. Ground operations and airport functionality can improve by flight effectiveness; improve lto cycle, and interval aircraft maintenance of aircraft. Air traffic management relates to passenger satisfaction and economic performance. Studies reveal the fleet size and quality of services impact carbon emission and fuel burn.
Figure 8 illustrates that long-haul range flights with increasing passenger capacity will be financially performance in terms of fuel consumption, emission and performance measures compared to other variants. Microanalysis investigated on the types of aircraft shows that wide-body aircraft provide better fuel economy compared to other variants as well. An implementing modern technology results in a significant reduction in aircraft fuel consumption and carbon emissions. Noise pollution has an influence on the environment as well as human health concerns. Technological factors associated with a financial performance the total net profit obtained in airlines. With growing capital expenses and the financial crisis, the aviation sector is challenging to survive in a competitive market. Economic analysis shows that the pandemic causes a net loss of -4.2 percent GDP growths, which progressively improves to 4.9 percent in the first part of 2021. However, improving economic performance is closely related to operational air routes, design technology, fuel consumption, and flying range. All improvements that relate to financial performance will impact the efficiency of fuel consumption in airplanes. In a nutshell, a significant performance has been observed in wide-body in terms of fuel efficiency for long-range flight and lowering carbon footprint. It is expected that wide-body is going to be dominant in the coming aviation sector.

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