

Solutions to environmental impacts of aviation engineering essay

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An introduction to Aviation	
3Environmental Impacts to Aviation	33.
1 Solutions to Environmental Impacts of Aviation	43.
1. 1 European Union Emissions Trading Scheme (EU-ETS)	43. 1.
2 The Use of Biofuels	63. 1. 3
Continuous Lower Energy, Emissions, and Noise	83. 2
Difficulty of Implementation	94. The
Future of Aircraft	105.
Conclusion	12

1. Executive Summary

Aviation is indispensable since its birth, it has provided rapid worldwide transportation network for tourism sectors as well as facilitating world trade and improves quality of life in innumerable ways. As air transport moves over 2.4 billion passengers yearly, we see an ever-increasing demand of flights and the output of carbon emission is growing which causes an environmental impact to the world. Today, fossil fuels are depleting a tad too fast and the gases emitted from burning of fossil fuels would alter the atmospheric concentration of greenhouse gases, triggering the formation of condensation trails and increases cirrus cloudiness, which would contribute to climate change. There is a need to identify alternative measures such as using biofuel, new guidelines, new engine and aircraft technologies so to lessen the reliance on crude oil. After identifying the alternative measures, the aim is to implement it so to reduce environmental impact. Currently, researchers are researching on designs that could meet the realistic needs of

the industry and reduce fuel intake by half while relying on existing technologies.

2. An introduction to Aviation

Aviation is the development of design, operation, production, and the use of aircraft. It is derived from avis, the Latin word for bird. (MEMIDEX, 2013) The modern age of aviation started with the Montgolfier brothers who designed the first untethered human lighter-than-air flight but the most widely accepted date of flying is December, 1903 by the Wright brothers as they were the first to fly in a powered and controlled aircraft. Since then, aviation has transformed into an essential part of the world transporting system as it provides a rapid worldwide transportation network, which makes it essential for global business and tourism. Aviation can be categorized into two major categories. Firstly, it is civil aviation, which includes all non-military flying, both private and commercial. Most countries in the world are members of the International Civil Aviation Organization (ICAO) as they seek to promote the safe and orderly development of international aviation throughout the world. It sets standard and regulations necessary for aviation safety, security, efficiency and regularity, as well as for aviation environmental protection. Secondly it is military aviation, which is the use of aircraft and other flying machines for the purposes of warfare and logistic capacity to the front liners. (Wikipedia, 2013) (International Civil Aviation Organization, 2013)

3. Environmental Impacts of Aviation

Greenhouse gases, responsible for sustaining the temperature on earth, can be found naturally in the atmosphere of the earth. Primary greenhouse gases present are carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), water (H₂O) and ozone (O₃). A natural greenhouse effect occurs when gases in our atmosphere such as CO₂, traps heat from the sun reflecting off the earth's surface. Nonetheless, proliferating human activities such as the burning of fossil fuels increases the concentrations of these gases in the atmosphere thereby enhancing the greenhouse effect. Such increase in global surface temperatures, which causes climate change, is commonly known as global warming as illustrated in Figure 1. (Kroo, 2008) Likewise, the emission of gases from the aviation industry causes severe impacts on the environment. CO₂ emission produced from the aircraft engine due to fossil fuel combustion and consumption of jet-fuel alters the atmospheric concentration of greenhouse gases. It triggers the formation of condensation trails while increasing cirrus cloudiness leading to a change in climate. Despite the reduced emission from improved engines that consumes lesser fuel and better aircraft design, air transport still contributes 2% of the human induced CO₂. Flights produce 628, 000, 000 tons of CO₂ yearly with an estimated of 1300 airports being built by 2050 as well as a doubling in the commercial aircraft fleet and expected three-fold increase in global air travel. These emissions give rise to important environmental concerns regarding the reliability, impact and effect on air quality for the future of flight. (Kroo, 2008) As such, the aviation industry will be a contributing factor to the extreme weather events in the future since global warming is likely to lead

to more natural disasters such as floods, hurricanes and drought. Apart from natural disasters, the spread of infectious diseases could increase as warmer weather allows infectious diseases such as malaria and yellow fever to spread. Global warming is also expected to cause rising sea levels of between 15 to 95cm over the next century.

3. 1 Solutions to Environmental Impacts of Aviation

3. 1. 1 European Union Emissions Trading Scheme (EU-ETS)

The European Union devised a plan to combat climate change by reducing greenhouse gas emissions cost known as The European Union Emissions Trading Scheme (EU-ETS). EU-ETS is a cap-and-trade scheme that works on allocating and trading of emission allowances aimed at reducing emissions in a cost effective manner that would allow companies to monitor their emission status. It started out with industrial plants and power stations in 2008 subsequently airline companies are included in the list in 2012. Like industrial installations, airlines receive tradable allowances of CO₂ emissions yearly and are required to account for their total amount of emissions to competent authority at the end of year. Based on the airline company actual emissions and their free allocation of allowances, they have the flexibility to purchase additional or sell remaining allowances to other companies. The goal of the EU-ETS scheme is to reduce emissions in a cost effective approach, which would allow companies to trade emission allowances thus determining how they can reduce emissions. The EU-ETS affects all aircraft operators (as defined by their ICAO designator, or if none is available, their aircraft registration numbers) regardless of where they are based, stipulated

that operators operate flights departing from and / or arriving at an airport in the EU. The effort made by the European union is commendable and it enforces airlines to buy newer models of plane because they emit lesser emission compared to the older models. (European Commission, 2013) (PWC, 2013) Aircraft manufacturers like Airbus and Boeing has been committing to the eco-efficiency program at the earliest stages of their aircraft development program as they invested largely in research and development program that would lead to environmental benefits for the aviation sector. For example, part of their development would be developing aircraft that generate fewer emissions, while carrying more people over longer distance. Figure 1. 1 shows the improvement of fuel usage via technology since 1955 till 2010 and the efforts of manufacturers (Kroo, 2008). However this is still not sufficient.

3. 1. 2 The Use of Biofuels

As the aviation industry is looking to achieve carbon-neutral growth by 2020, a key initiative would be to use sustainability aviation biofuels. Carbon dioxide absorbed by plants during the growth of the biomass is roughly equivalent to the amount of carbon produced when the fuel is burned in a combustion engine " which simply returns the CO₂ to the atmosphere. (Qantas, 2013) This would allow the biofuel to be approximately carbon neutral over its lifecycle. When these elements are accounted for, biofuels are still anticipated to provide an estimated 80% reduction in overall CO₂ lifecycle emissions compared to fossil fuels. For example, analysis of camelina[1] feedstock use for aviation has shown even better results, with an 84% reduction in lifecycle emissions. Furthermore, biofuels contain fewer

impurities (such as sulphur), which enables an even greater reduction in sulphur dioxide and soot emissions than present technology has achieved. (Lee, 2011) The airline industry's reliance on fossil fuels means it is affected by a range of fluctuations, such as the changing price of crude oil and problems with supply and demand. Sustainable biofuel can also be made from waste products such as waste cooking oil, industrial by-products, or even municipal solid waste. In contrast, petroleum based fuels do not recycle atmospheric carbon dioxide (CO₂), but release additional CO₂ into the air. (Sustainable Aviation Fuel Users Group, 2013) Biofuels have received authorization for the usage in commercial aircraft and they can be produced at costs not above the volatile price of jet fuel. Therefore, sustainable biofuels could be an attractive alternative as their production is not limited to locations where fossil fuels can be drilled, enabling a more diverse geographic supply. Biofuels can also provide economic benefits to parts of the world that have large amounts of marginal or unviable land for food crops, but are suitable for growing second-generation biofuel crops. Many of these countries are developing nations that could benefit greatly from a new industry such as sustainable aviation biofuels. (Enviro Aero, 2009) The initiation of biofuels sparked a new era in the aviation industry in 2011, where we witness the first commercial flight running partially on algae-based and cooking oil-based fuels. Continental Airlines was the first commercial airline to fly on a blend of algae biofuels, and Alaska Airline Group was powered partly by used cooking oil. Ever since the experiment, Continental Airlines implemented the use of biofuels blend and it has improved Continental fuel efficiency by more than 32% since 1994 and they are

looking to invest in new airplanes that would use 20% lesser fuel. (Bio Jet Fuel Blog, 2011) Alaska Airlines and sister airline, Horizon Air implemented the use of biofuel, which is a mixture of used cooking oil. The company estimates the 20% mixture will reduce greenhouse gas emissions by 10%. Bill Ayer, ex Alaska Air Group CEO deems that sustainable biofuels are the key to aviation's future. His comments, " Commercial airplanes are equipped and ready for biofuels. They will enable us to fly cleaner, foster job growth in a new industry, and can insulate airlines from the volatile price swings of conventional fuel to help make air travel more economical. What we need is an adequate, affordable and sustainable supply. To the biofuels industry, we say: If you build it, we will buy it." (Bio Jet Fuel Blog, 2011) Last year, we saw the world's first flight powered entirely by biofuel that meet petroleum specifications and it has raised hopes for a cleaner air travel and upped the prospects of a boon for farmers whose oilseed crops, which could replace kerosene. (Fougeres, 2012) Until now, biofuel flights have been limited to a 50% blend with petroleum but the research and development team made a tremendous effort and in no time we would be able to see airlines switching to biofuels thoroughly. We are able to see the trend of the aviation industry shifting to a cleaner carbon footprint. (Bio Jet Fuel Blog, 2011) As such, airport operators should work hand in hand with sustainable jet fuel companies to offer airlines with a blend of jet fuel that has been significant and rising in the proportion of sustainable bio jet fuel. This would drastically reduce emissions from flights and airlines, which can benefit from a genuine and cost-effective emission reduction strategy, which might attract environmentally conscious flyers. (Caldecott, 2012)

3. 1. 3 Continuous Lower Energy, Emissions, and Noise

Besides channeling into alternate fuel usage to solve emission reduction. It is important to look at aircraft manufacturers and industry partners who play a significant role in the evolution of aircrafts. In 2010, Federal Aviation Administration (FAA) initiated the Continuous Lower Energy, Emissions, and Noise (CLEEN) program as a NextGen effort to accelerate development and commercial deployment of environmentally promising aircraft technologies. It is a collaborative partnership with Boeing, General Electric, Honeywell, Pratt & Whitney and Rolls Royce as they constantly look to find ways to develop and improve aircraft and engine technology, which would reduce emissions and fuel burn. (Federal Aviation Administration, 2013) As of financial year 2011, the CLEEN program is accelerating development of aircraft technologies that reduce fuel burn. Boeing completed adaptive trailing edge wind tunnel test and it demonstrated improvements in aerodynamic efficiency, which leads to an estimated 2% reduction in aircraft fuel burn and emission. General Electric completed an open rotor wind tunnel test and it shows at least a 26 percent reduction in fuel burn for a single aisle class aircraft. Rolls Royce completed a turbine blade component test and it shows a reduction in weight and increase in engine efficiency. The initiation of the program certainly leads to a faster implementation of the program objectives, as environmental impact is an urgent issue we need to solve. (Federal Aviation Administration, 2013)

3. 2 Difficulty of Implementation

Airline companies from both the EU and non-EU countries have criticized the implementation of EU-ETS. Mr. Goh Choon Phong, CEO of Singapore Airlines

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Ltd, said that the EU-ETS is unfair as it only charges airlines for a single sector of a journey in and out of Europe. “ Under the system, an airline that makes its passengers fly with a halt somewhere close to Europe will pay less than an airline that flies non-stop, even though the former would have used more fuel,” he said. Mr. Frank Puttmann, director of group communications at Lufthansa AG said, “ The current scheme is neither global nor fair.” Mr. Puttmann added on saying “ European airlines would suffer unreasonably from the scheme because rival airlines that only use EU airports for a single sector of a journey in and out of Europe will be in a better position to spread the costs.” Lufthansa is expected to incur an additional expenditure of 130 million euros. “ This additional cost for emission certificates will reduce our financial ability to invest in new eco-efficient technology, for example modern and fuel-efficient or engines,” said Mr. Puttmann. (China Daily, 2012)Next, relatively to fossil fuels, sustainably produced biofuels would result in a reduction of CO₂ emissions across their lifecycle. However, there are emissions produced during the production of biofuels, from the equipment needed to grow the crop, transport the raw goods, refine the fuel and so on. (Qantas, 2013)Major air hubs around the world may not be keen to implement and provide biofuel in the near future as there is only a handful of airlines using biofuel. It is not economy sustainable for the air hubs but plans are on the way when the shift of major carriers start implementing it. It will take some time before airport operators provide airlines with jet fuel blend. (Caldecott, 2012)

4.0 The Future of Aircraft

Aircraft are more efficient than they used to be. The first Boeing 737 was launched in 1967 and could carry 100 passengers and fly a distance of 2,775km (1,725 miles). The modern version of Boeing 737-800 can carry nearly twice as many passengers and fly twice the distance compared to the first Boeing 737, while burning 23% less fuel (48% less on a per-seat basis). It has more efficient turbofan engines, lighter frame structures, various aerodynamic tweaks and the development of sophisticated flight-management systems have brought about this development. The aircraft look the same as they always do: a cigar-shaped fuselage with a big tail or fin also known as vertical stabilizer with rudder, powered by pod-like engines hanging from a pair of extended wings. A group of aircraft designers now believe just about the efficiency gains available have been warped from this traditional shape, and if reducing fuel consumption is the plan, a new design of airliner is needed. Despite all these restrictions, researchers at Massachusetts Institute of Technology (MIT) are working on designs of future aircraft that could meet the practical needs of the industry and reducing fuel consumption. These MIT researchers rely largely on existing technologies for many of their designs. If a B737-800 were transformed into the shape of one of the D-series of aircraft (Figure 1.3) on which Dr. Mark Drela is experimenting in MIT's wind tunnel, it would still be about the same size as a B737-800. The D8.1 aircraft constructed conventionally from aluminum could fly the exact same routes and carry a similar number of passengers as a B737-800 but would use 49% less fuel. Similarly, the D8.5 aircraft constructed from composite materials expected to be available by 2035

would burn 71% less fuel. Dr. Drela's D-series aircraft differ from existing ones in a number of ways. Instead of having a single cylindrical fuselage[2], he uses two partial cylinders joined together shown in Figure 1. 3. This provides additional lift for the aircraft and the nose of the aircraft would slants upwards to increase lift. It means the wings of the aircraft can be thinner thus saving weight. The three engines are mounted at the rear, flush with the fuselage. Placing the engines at the rear has a number of benefits, says Dr Drela “ Most notably, allowing the tail or fin to be smaller. One reason for the tall, vertical tail or fin on an airliner is to allow the pilot to compensate with the rudder for the yaw created when a wing-mounted engine fails. Mounting the engines at the back (a design popularized in the 1950s by Sud Aviation's Caravelle, but subsequently abandoned on large aircraft) means that yaw is much reduced, and with it the need for a large tail.” The D-series’ twin tails or fins are 70% lighter than a B737's single one. The rear of the fuselage is shaped to sweep air into the engines making use of a process known as boundary layer ingestion. Frictional drag means the air closest to the surface of the fuselage moves more slowly than the rest. Ingesting slower air would allow the engine to burn its fuel more efficiently while generating the same amount of thrust. However, by employing boundary layer ingestion means the airflow into the engine is not uniform. The further the air is from the fuselage, the faster it moves, it would cause undesirable stress on an engine's components. Pratt & Whitney, an aircraft-engine maker who is involved in the MIT project, is trying to overcome that problem by redesigning and strengthening the components in the jet engine. The other alternative is to fly slower thus putting less strain on the

components. As a consequence, the D8. 1 aircraft would cruise at a speed of Mach 0. 72 (seven-tenths of the speed of sound) and the D8. 5 at Mach 0. 74, compared to the B737-800 cruising speed at Mach 0. 79. Dr. Drela says the D-series' wider fuselage would compensate for the speed as it permits an extra aisle, which makes boarding and alighting much faster than the single-aisle B737. On short-haul routes the D-series would still have a faster gate-to-gate passage time than a B737. (Economist, 2011)

5. 0 Conclusion

Sustainable biofuels may be the best solution for now as it provides economic benefits while decreasing carbon emission as compared to jet fuel. We might not have to wait long to see new initiatives from researchers given the technologies in our current world today provided all major stakeholders agrees to put in collective efforts to sustain the environment.