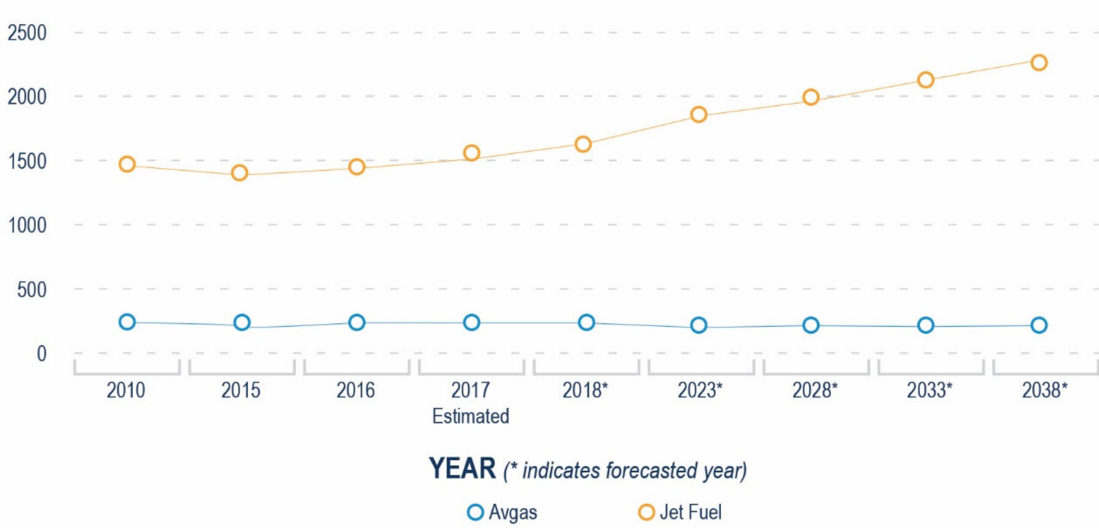
Aviation Fuels and Electrification

Introduction

Aviation has a signification impact on the modern world.

General aviation is the backbone of the national airspace system in the United States. The majority of flights globally are considered general aviation, and in the U.S., more than 5,000 airports serve general aviation traffic while scheduled airlines serve less than 400 airports. General aviation includes piston driven aircraft that use Aviation Gasoline, Avgas or 100 Low-Lead (100LL), and turbine aircraft that utilize jet fuel. The majority of Avgas produced today still contains lead, a chemical that is hazardous to both humans and the environment. As shown, jet fuel consumption in general aviation aircraft is forecasted to increase through 2038 while Avgas consumption is expected to remain relatively flat. General aviation's fuel consumption is depicted in Figure 1

Figure 1: General Aviation Aircraft Fuel Consumption

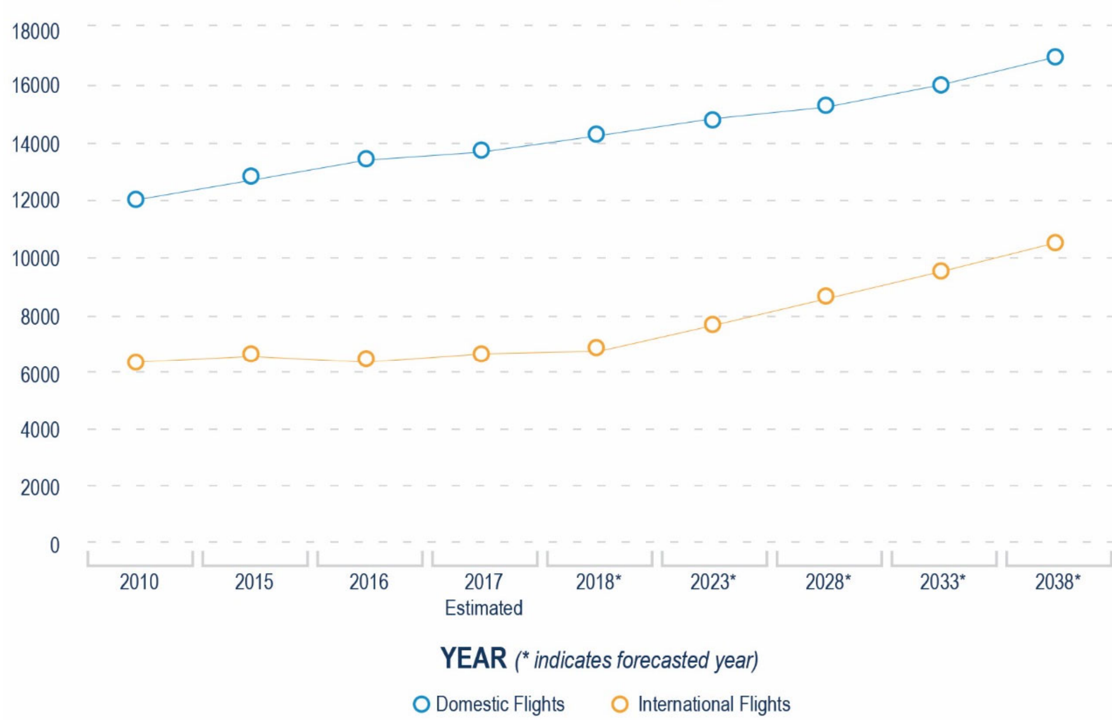


Commercial airlines (air carriers) fly passengers around the World for business and pleasure. U.S. Airlines are forecasted to fly 880 million passengers in 2018. These airlines relay almost solely on jet fuel to transport these passengers. Turbine aircraft have become more fuel efficient in the last few decades. Jet fuel is a contributor to greenhouse gas (GHG) emissions and industry leaders have begun researching ways to reduce the impact that commercial aviation has on the environment.

Initiatives to reduce GHG emissions industry wide have already begun. Aircraft manufacturers have realized the potential of electric engines and have begun research on electric propulsion for aircraft. Electric propulsion could significantly reduce GHG emissions that aircraft produce. Alternative fuels and ways to reduce carbon emissions with biofuels are currently available to the aviation industry on a global scale. A number of fuel producers, industry stakeholders and governmental agencies have begun to research and produce alternative fuels for use including the reduction of lead in Avgas and the use of biofuels to replace jet fuel.

The annual fuel consumption by U.S. air carriers is shown in Figure 2. According to the FAA, jet fuel consumption is expected to increase through 2038.

Figure 2: Total Jet Fuel Consumption by U.S. Air Carriers (in millions of gallons)[1]



This paper will discuss the various ways that the aviation industry is working to reduce the impact aviation fuels have on the environment.

Avgas Fuel Replacement

Avgas is the only transportation fuel that still contains lead, which is a toxic substance that can be inhaled or absorbed into the blood stream. More than 167,000 piston-engine aircraft operating in the United States rely on Avgas to power their aircraft. Lead has been used in fuel as an antiknock agent, which helps prevents sudden engine failure Avgas emissions are the largest contributor to the low levels of lead emissions produced in this United States. In recent decades, the desire to reduce the environmental impacts of general aviation and piston engine aircraft has led to the development of alternative fuels and more fuel-efficient aircraft. The FAA, Environmental Protection Agency (EPA), and the aviation industry are collaborating to remove lead from aviation fuels.

The Federal Aviation Administration (FAA) has initiated programs like the Piston Alternative Fuels Initiative (PAFI) test program to help reduce the environmental impacts of aviation gasoline. The PAFI test program was initiated in 2013, when the FAA issued a request[2] for fuel producers to submit unleaded fuel formulations to be evaluated as replacements for 100LL. This began a multi-year research and development program to select the unleaded fuel(s) with the least impact on the general aviation fleet. The FAA received proposals from multiple fuel producers and assessed the viability of each of the candidate fuels in terms of their impact on the existing fleet, the production and distribution infrastructure, their impact on the environment, their toxicology, and the cost of aircraft operations.

In 2014, the FAA selected four fuels for further evaluation in Phase 1 of the PAFI test program, which included laboratory and rig tests. In early 2016, the FAA completed Phase 1 of the PAFI program, and selected fuels from Shell and Swift Fuels to participate in Phase 2, an extensive and complex engine and aircraft test program. The PAFI test program anticipates completion and issuance of all final test reports by the middle of 2020.

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1 FAA Aviation Forecast 2018-2038, https://www.faa.gov/data_research/aviation/

2 Solicitation #DTFACT-13-R-00015-0003

Barriers to a new fuel in the marketplace and challenges to manufacturer and user acceptance of a new fuel type have been noted by the FAA. The PAFI test program is working with the aircraft and engine manufacturers, fuel producers, the EPA and industry associations to develop and deploy a new unleaded fuel and to address these concerns. Another goal of the PAFI test program is to reduce the economic impact of transitioning to an unleaded Avgas.

The FAA continues to facilitate other unleaded Avgas approvals by working directly with other fuel producers seeking unleaded Avgas engine and aircraft approvals through traditional procedures.[3] Unleaded UL94 Avgas is commercially produced in the United States and is certified for use in over 50% of the US piston fleet4. The fuel is made from the same components that 100LL is made from, without the addition of lead, allowing it to be used in the existing distribution and supply chain network. Studies indicate longer spark plug life, decreased engine wear and tear and decreased deposit build up as compared to 100LL. As of early 2019, UL94 Avgas can be found at two Minnesota airports.

Jet Fuel Alternatives

Commercial airlines, and ultimately passengers, face challenges related to fuel costs and environmental impacts of petroleum based jet fuel. In 2016, it was estimated that 12% of U.S transportation GHG emissions and 3% of total U.S. GHG emissions were from aircraft[5]. Governmental agencies around the world have begun to address the environmental concerns related to aviation.

In 2009, the International Air Transpiration Association (IATA) committed the airline industry to achieving carbon neutrality by 2020 and reducing carbon emissions by 50% by 2050. IATA recognized that technology has slowed emissions; however, a reduction in carbon emissions was needed. In the last decade, alternative jet fuels have entered the market place and are in use commercially around the World.

In the United States, the FAA has been working towards the use of one billion gallons of drop-in sustainable alternative jet fuel a year[6]. Drop-in fuel is chemically similar to a petroleum-based fuel made from renewable sources. Drop-in fuel can be used in existing jet aircraft and engines without modification.

In 2006 the Commercial Aviation Alteration Fuels Initiative (CAAFI) was established. CAAFI is a combination of airlines, aircraft and engine manufactures, energy producers, researchers, international bodies and U.S. government agencies working together to bring alternative jet fuels to the marketplace. Alternative fuels are being researched and developed using natural oils, cooking oil, seaweed, agricultural waste and municipal waste.

United Airlines was the first airline globally to use sustainable aviation fuel on a daily basis with flights from its Los Angles Hub. Fuel produced by AltAir Fuels, is created using agricultural waste and non-edible natural oils and has reduced GHG emissions by more than 60 percent[7]. While United Airlines is an example of a domestic airline that currently uses an alternative fuel, international carriers such as SAS, Norwegian Airlines, KLM and Lufthansa are currently using alternative fuels internationally[8]. In late 2018, sustainable alternative jet fuels were available at the Los Angeles, Bergen, Oslo, Stockholm and Brisbane airports for use in commercial aircraft.

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3 Aviation Gasoline. http://www.faa.gov/about/initiatives/avgasAvgas/

4 https://swiftfuels.com/fuel/unleaded-ul94-avgasAvgas/

5 EPA Regulations for Greenhouse Gas Emissions from Aircraft, https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-aircraft

6 FAA Sustainable Alternative Fuels, https://www.faa.gov/about/office_org/headquarters_offices/apl/research/alternative_fuels/

7 https://www.united.com/ual/en/us/fly/company/global-citizenship/environment/sustainable-fuel-sources.html

8 IACO Global Framework for Aviation Alternative Fuels, https://www.icao.int/environmental-protection/GFAAF/Pages/default.aspx

Hybrid-Electric Aircraft

The move towards electric vehicles is growing not only in the automotive industry but in the aviation industry as well. The potential advantages of electric propulsion for the aviation industry include fuel savings, and reduced CO_2 and noise emissions. Electric and hybrid-electric propulsions are seen today as among the most promising technologies for addressing these challenges. As technology advances, electric propulsion is gradually becoming a viable technology for the aviation sector.

The first demonstration of a hybrid-electric manned aircraft was in 2010, which was developed by Robertson from the University of Cambridge in association with Flylight Airsports Limited. In 2011, Embry-Riddle's Eagle Flight Research Center (EFRC) built a second hybrid-electric aircraft. Since 2011, there has been an increasing number of developments to electrify the propulsion systems for aircraft. In 2016, Airbus joined with Rolls-Royce and Siemens to develop a hybrid-electric propulsion technology for commercial airplanes. Their plan is to develop a hybrid-electric technology demonstrator, the E-Fan X. The E-Fan X is scheduled to fly in 2020 after a comprehensive ground test campaign. Airbus and its partners believe the electrification trend may lead to a 50 to100-seat hybrid-electric regional airliner entering service by 2030 to 2035.[9] Additionally, in 2016, Siemens successfully demonstrated a 260 kW continuous power motor in a light sport aircraft which will soon be incorporated into aircraft co-development activities with Airbus. In 2017, Boeing announced an investment in a hybrid-electric aviation start-up Zunum Aero, and EasyJet announced it is partnering with startup Wright Electric to bring an all-electric aircraft to market.[10]

The Pipistrel Alpha Electro was the first all-electric airplane to receive an airworthiness certification from the FAA in early 2018. The Pipistrel Alpha Electro was already certified in Australia and Canada. Pipistrel indicates the airplane can stay in the air for an hour, with 30 minutes of reserve. The FAA classifies Pipistrel Alpha Electro as a Special Light Sport Aircraft (LSA), which is defined as an aircraft with a maximum gross takeoff of 1,320 pounds and a maximum of two seats.[11] The reduced operational cost associated with the aircraft combined with lower requirements to receive a Sport Pilot License potentially allows for a larger number of people to receive a pilot license.

However, there are still a significant number of barriers for electric aircraft to enter into large-scale production. The availability of non-conventional fueling infrastructure and charging stations at airports may be a contributing barrier to the growth of this fleet. As alternative fuels and hybrid aircraft enter the market, airports and aviation stakeholders will need to continue to develop their infrastructure to support these environmentally conscious options.

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[9] http://www.airbus.com/newsroom/press-releases/en/2017/11/airbus--rolls-royce--and-siemens-team-up-for-electric-future-par.html

[10] http://fortune.com/2017/04/05/zunum-aero-boeing-jetblue-electric-planes/

[11] https://www.pipistrel-usa.com/alpha-electro/