NASA: alternative fuels for aviation

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**Abstract**

With a growing gap between the growth rate of petroleum production and demand, and with mounting environmental needs, the aircraft industry is investigating issues related to fuel availability, candidates for alternative fuels, and improved aircraft fuel efficiency.

Bio-derived fuels, methanol, ethanol, liquid natural gas, liquid hydrogen, and synthetic fuels are considered in this study for their potential to replace or supplement conventional jet fuels. Most of these fuels present the airplane designers with safety, logistical, and performance challenges.

Synthetic fuel made from coal, natural gas, or other hydrocarbon feedstock shows significant promise as a fuel that could be easily integrated into present and future aircraft with little or no modification to current aircraft designs.

Alternatives, such as biofuel, and in the longer term hydrogen, have good potential but presently appear to be better suited for use in ground transportation. With the increased use of these fuels, a greater portion of a barrel of crude oil can be used for producing jet fuel because aircraft are not as fuel-flexible as ground vehicles.

**1. Introduction**

The airline industry has experienced substantial improvements in fuel efficiency. Demand for air travel continues to grow, so much so that the industry’s rate of growth is anticipated to outstrip aviation’s fuel-efficiency gains. Underlying this growth projection is an assumption that the industry will not be constrained by fuel availability or undue price escalations. Future crude oil production may not be able to keep pace with world demand (ref. 1), thereby forcing the transition to using alternative fuels. The purpose of this discussion is to investigate the feasibility and assess the impacts at the airplane level of using alternative fuels.

**2. Results**

The only currently known drop-in alternative jet fuel was found to be a synthetic manufactured fuel. Alternative aviation fuels synthesized by using a Fischer-Tropsch-type process, are ideally suited to supplement, and even replace, conventional kerosene fuels. Although this fuel, and its manufacturing process, does not help address global warming issues, it was found to be the most easily implemented approach.

Another possible alternative, biofuel, could be blended in small quantities (i.e., 5 to 20 percent) with current jet fuel.

This bio-jet-fuel blend can be derived from sustainable plant products, which makes it attractive as a step toward a “carbon neutral” fuel that will help address global warming issues. However, because of aviation’s high-performance fuel specification needs, direct biofuels would need to go through an additional, possibly costly, fuel processing step.

Reduced particulate emissions have been one of the benefits observed in diesel engines and smaller gas turbine engines (ref. 2), but they have not been substantiated in newtechnology, large turbine engine tests. Therefore, as aircraft use a small proportion of fossil fuels, and unless some other beneficial properties are found, it appears that biofuel will be easier to use and will offer more global warming benefits when used in ground transportation vehicles. Because of the limited availability of arable land, biofuels will be able to supply only a small percentage of most countries’ energy needs.

Other alternative fuels result in airplane performance penalties. For example, liquid hydrogen (LH2) not only presents very substantial airport infrastructure and airplane design issues, but because of the need for heavy fuel tanks, a short-range airplane would experience a 28 percent decrease in energy efficiency while on a 500-nautical-mile (nmi) mission. However, because airplanes need to carry much more fuel for a long range flight, and Liquid Hydrogen (LH2) fuel is quite lightweight the lighter takeoff weight of the airplane results in an energy efficiency loss of only 2 percent while on a 3,000-nm mission.

Ethanol takes up 64 percent more room and weighs 60 percent more compared with Jet-A fuel. This type of alternative-fueled airplane would experience a 15 percent decrease in fuel efficiency on a 500-nmi mission and a 26 percent efficiency decrease on a 3,000-nmi mission compared with a Jet-A fueled airplane.

[...]

**4. Conclusion**

To seamlessly transition to the use of alternative fuels, research and development is needed. Developing alternative fuels will help to improve each country’s energy independence, could help lessen global-warming effects, and will soften the economic uncertainty of crude oil peaking.

For most countries, it appears unlikely that enough bio feedstock (crops) could be grown to replace a sizable portion of crude oil production. Therefore, to efficiently utilize available agricultural lands, careful consideration should be given to crop selection, method of fuel processing, and the type of biofuel produced.

As jet fuel constitutes only about 6 percent of global oil consumption and requires high-performance characteristics, it makes more sense to use higher performing synthetic fuels in aviation. The lower performing biofuels should be used to help supplement 52 percent of the processed oil currently used to manufacture distillate fuel oil and gasoline for ground transportation (fig. 18).

Lastly, research and development in aviation biofuel needs to continue. If it is able to demonstrate additional benefits, such as exhaust pollutant and CO2 reduction, the fuel would become more attractive to aviation, especially in the case of carbon trading.

***Editorial Notes:*** *The full 15-page report is available online:* [*Alternative Fuels and Their Potential Impact on Aviation*](http://gltrs.grc.nasa.gov/reports/2006/TM-2006-214365.pdf) *(PDF). The report is unclassified and is approved for unlimited distribution. Contributor Matt P. writes: It's interesting to see that more and more government agencies are finally starting to "get it" regarding Peak Oil, and make plans to adapt. NASA does a good job in pointing out the problems that need to be overcome if we plan to use alternative fuels to replace declining production. They don't address any of the political ramifications, such as conflicts over corn production for ethanol vs. food, but this is a technical report, and rightfully examines only the technical aspects. This publication also references one of Colin Campbell's depletion reports.*