

FACTSHEET: ALTERNATIVE AVIATION FUEL

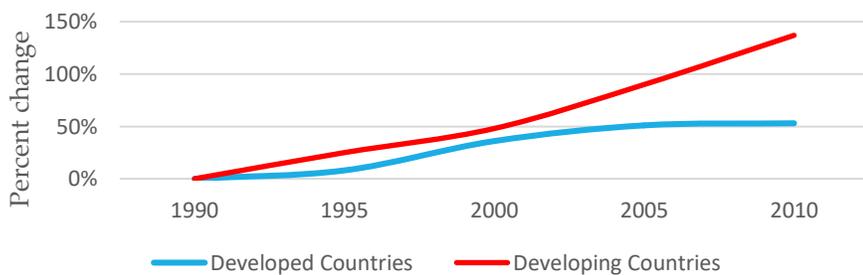
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Aviation fuel is a specialized kerosene-based fuel used to power jet engines. The fuel is derived from carbon-heavy chains which results in a higher flashpoint, or ignition temperature, and in addition to kerosene consists of other compounds like paraffin, nitrogen, sulfur, and oxygen.¹ The high flashpoint allows for aviation fuel to stay in liquid form at low temperatures; this is vital for aircrafts flying at high altitudes, where air temperatures can reach -40 degrees Celsius. Chemical additives are used to supplement the fuel to prevent static buildup problems, or to serve as anti-corrosive, anti-microbial, and de-icing agents.²

There are two main types of jet fuel (see requirements in ASTM D1655):

1. **Jet A** fuel is available mostly in the US, has a freezing point of -40 degrees Celsius
2. **Jet A-1** fuel is used in the rest of the world, has a lower freezing point of -47 degrees Celsius

Aviation Emissions Percent Growth (International)



What is the problem? International consensus was reached in response to the threat of global climate change in the Paris Agreement; to curb global warming from rising by 2 degrees Celsius, signatories of the agreement pledged to abate emissions. In July 2016, the EPA formally determined in a news release that airplane emissions contributed to climate change and endangered environmental and public health. Working in coalition with the International Civil Aviation Organizations (ICAO), the EPA proposed stricter standards on existing greenhouse gas regulations.³ The graph above exhibits the growth of international aviation emissions over a 20-year span.⁴

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¹ Hochman, Gal. *The Bioeconomy: Technology and Policy Path Forward*. 2016, *The Bioeconomy: Technology and Policy Path Forward*.

² "Aviation Fuel – Jet A/Jet A-1." *ExxonMobil Aviation*, ExxonMobil Corporation, www.exxonmobil.com/en/aviation/products-and-services/products/jet-a-jet-a-1.

³ St. Clair, Christie. "EPA Determines That Aircraft Emissions Contribute to Climate Change Endangering Public Health and the Environment." *EPA*, Environmental Protection Agency, 25 July 2016, www.epa.gov/newsreleases/epa-determines-aircraft-emissions-contribute-climate-change-endangering-public-health.

⁴ *CO2 Emissions from Fuel Combustion Highlights*. 2011th ed., IEA, 2011, *CO2 Emissions from Fuel Combustion Highlights*.

WHAT ROLE DOES ALTERNATIVE AVIATION FUEL PLAY?

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The US bioeconomy has created new demands for biofuels in the transportation sector. The aviation sector in particular offers promising headway into biofuel markets.

A foothold in alternative aviation fuels would not only result in regional fuel cost benefits, but will also result in expansive global influence on energy security and carbon emissions.



12%

Of all transport industries, aviation accounts for 12 % of CO₂ emissions.⁵

781 million tons of carbon emissions were produced from flights in 2015, globally.⁵



80%

Studies show that algae-based biofuels can reduce the aviation carbon footprint by up to 80%, from 781 million tons to about 156 million tons.⁵

The properties of clean algae-based biofuels offer wide-scale production and economic viability commercially because of algae's adaptive and regenerative qualities.

U.S. CONSUMPTION OF AVIATION FUEL

How do we decarbonize the aviation sector? According to Air Transport Action Group, based on the rate at which air travel is expanding, airplane-based carbon emissions are expected to triple by 2050.⁶ In an effort to push for more sustainable fuel efficiency, the aviation industry has explored reforming airline operations and mechanics: airplane routings, climb rates for takeoff, descent rates for arrival, taxiing with one or two engines, and airframe technology.¹ Operationally, adjustments can result in lower CO₂ emissions; mechanically, adjustments can result in increased fuel efficiency. These alterations may adjust operating costs altogether, allowing for more incentive to lower kerosene-based aviation fuel use and fuel expenditures.⁷

In 2014, US airlines collectively used more than 16 billion gallons of jet fuel.⁷

Despite any improvements made operationally, mechanically, or infrastructurally, goals of full decarbonization will not be met without proper alternative fuel implementation. The decarbonization of the aviation sector is not proportional to the growth of the aviation industry. To **significantly abate carbon emissions, aviation must rely on biofuels**; it is insufficient to rely solely on changes in aerodynamics.⁸

- 1) **Alternative aviation fuel:** Second generation biofuels are being explored as a sustainable source of clean aviation fuel, with little to no impact on food crops, land, and water. Although the status of some aviation biofuel technologies is still in its research and development stage, hydrogenated renewable jet fuel (HRJ) is said to be ready for large scale deployment by 2020 according to ICAO. HRJ is a proven technology based on vegetable and waste oils. Other aviation biofuels in development include HEFA, which is a fatty acid based compound, and Bio-SPK, or synthetic paraffinic kerosene; both HEFA and Bio-SPK are mainly based on algae oils, pyrolysis oils, halophytes, and camelina. Research and development is still under way for sugar and starch based fuels which use a direct sugar to hydrocarbon process formulate jet fuel.⁹ High performance alternative aviation fuel options are currently lacking because biomass based aviation fuel is limited by both liquidity and high-energy density requirements.
- 2) **Biomass to liquid fuels (BTL):** BTL, which is based on agricultural and municipal waste The Northwest Advanced Renewables Alliance (NARA) is currently funded by the USDA to research and create aviation biofuel using forest residue.¹ Since a large portion of the pacific northwest is covered in forestry, NARA developed a system which would optimize any forestry residue to create biofuels and bioproducts.¹⁰

By adopting this mission, NARA takes what would have been waste or sludge, and converts it for industrial usage; none of the materials taken affect nearby wildlife or land. The technology is detailed in the chart below¹¹:

⁵ "Facts & Figures." *Air Transport Action Group*, ATAG, May 2016, www.atag.org/facts-and-figures.html.

⁶ "Facts & Figures." *Air Transport Action Group*, ATAG, May 2016, www.atag.org/facts-and-figures.html.

⁷ Schipper, Mark. "Lower Airline Fuel Costs Reduce U.S. Airlines' Operating Expenses, Increase Net Profits ." *Independent Statistics and Analysis U.S. Energy and Information Administration*, EIA, 17 Feb. 2017, www.eia.gov/todayinenergy/detail.php?id=30012.

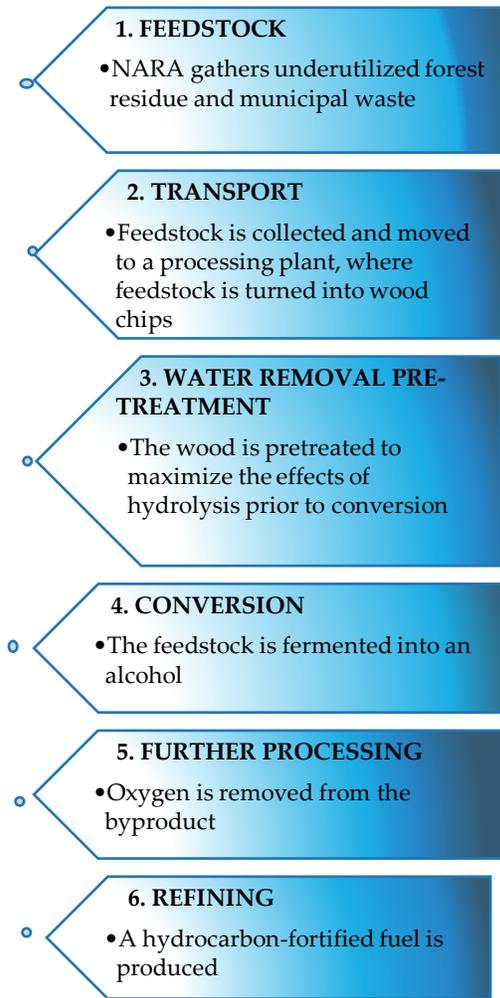
⁷ Pearl, Stephanie. "Fueling Our Future, from Wood to Wing." *U.S. Department of Agriculture*, USDA, 22 Oct. 2015, www.usda.gov/media/blog/2015/10/22/fueling-our-future-wood-wing#more-61457.

⁸ "Why Introduce Alternative Fuels in Aviation?" *ICAO Environment*, International Civil Aviation Organization, www.icao.int/environmental-protection/GFAAF/Pages/FAQs.aspx

⁹ "Bio Aviation Fuel Feedstock Supply - Challenges, Strategies, and Recent Developments." *ICAO Aviation and Sustainable Alternative Fuels Workshop*, Oct. 2011, https://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/2011-SUSTAF/19_ThiloZelt.pdf.

¹⁰ NARA. "Wood to Wing: the Economics of a Wood-Based Biorefinery in Longview, Washington." <https://Nararenewables.org/Documents/2017/07/woodtowingenvironmental2.Pdf/>, USDA, 2016, nararenewables.org/documents/2017/07/woodtowingenvironmental2.pdf/.

¹¹ *Pacific Northwest Wood-Based Biofuels: Preliminary Scoping*, vol. 1, NARA, pp. 1–37, *Pacific Northwest Wood-Based Biofuels: Preliminary Scoping*.



Environmental benefits: The NARA supply chain from feedstock to jet fuel is an environmentally beneficial process. From the beginning, waste wood is not left to decompose but is instead harvested; instead of burning the remaining wood after timber harvests, the forest residue is used as feedstock.¹¹ Greenhouse gas emissions are reduced, and regional air quality is improved when the residue is not burned. A Washington State University analysis of the Alaska Airlines’ biofuel initiative claims that if the airline replaced 20 percent of its fuel supply with jet biofuel at the Seattle Airport, it would cut carbon dioxide emissions by almost 142,000 metric tons.¹² NASA confirmed that biofuels reduced jet engine pollution in March 2017 upon testing particle emissions of jets powered partially by camelina-based biofuel.¹³

NARA claims that there is a **70 percent drop in global warming potential** when petroleum jet fuel is substituted with wood-based jet fuel.¹⁰ Efforts are being made to advance the jet biofuel production process to be completely carbon neutral in the future.

Economic benefits: As of 2016, close to 63 million jobs are supported by the aviation sector worldwide, and of that 9.9 million people are employed directly in the aviation sector.⁶ The adoption of wood-based jet fuels would have a strong impact on regional employment, along the supply chain as well as in the aviation industry.

Additionally, biofuels may offer a long-term solution for decreased jet fuel prices, especially in regions where the land is not suitable to food crops, but may be cultivated for biofuel feedstock growth and harvest.¹⁰

Supply chain problems: As with most biofuel initiatives, there is still work needed to optimize the supply chain and cut collection and transportation costs.¹⁴ Costs can be cut by increasing the density of the residue collected prior to transport and better genetically assessing which feedstocks to harvest for the most optimal fuel production; assessing forest coverage and density logistics prior to feedstock-collection would lead to a more efficient transport system.¹¹ Research is ongoing to develop genetic testing on residue sources to improve long-term production.

Similarly, ICAO has expressed concerns of technology readiness for large scale deployment; considering its only finished-status jet biofuel technology is HRJ, there will be an unmaintainable demand for vegetable oil. Technologies are being explored for mass vegetable oil production using annual and perennial plants. According to Leuphana University Luneburg’s Platform for Sustainable Aviation Fuels, there are almost 150 oil tree projects around the world, most concentrated in Latin America, Africa, and Asia.⁹

IN 2016, ALASKA AIRLINES BECAME THE FIRST COMMERCIAL FLIGHT IN THE US TO USE A WOOD-BASED BIOFUEL TO PARTIALLY POWER ITS TRIP. ¹⁰

¹² “Forest-Powered Biofuel Flight Heads to Washington, D.C.” *Washington State University News*, WSU Pullman, 14 Nov. 2016, news.wsu.edu/2016/11/14/forest-powered-biofuel-flight/.

¹³ Northon, Karen. “NASA Study Confirms Biofuels Reduce Jet Engine Pollution.” *NASA Green Aviation*, NASA, 15 Mar. 2017, www.nasa.gov/press-release/nasa-study-confirms-biofuels-reduce-jet-engine-pollution.

¹⁴ NARA. “Feedstock.” *NARA / Washington State University*, USDA, nararenewables.org/feedstock/.