TechXplore

The motivation for sustainable aviation fuels

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PNNL developed a proprietary catalyst to convert ethanol, produced from waste carbon, to a jet fuel approved for use in commercial aviation. Credit: Andrea Starr | Pacific Northwest National Laboratory

Global air travel consumes more than 100 billion gallons of jet fuel annually. That's expected to more than double by 2025 to 230 billion gallons. Despite the current pandemic, these projections reflect future anticipated passenger demand. Airlines want to meet market demands while simultaneously reducing their carbon emissions.

In fact, airlines around the world have committed to carbon-neutral growth beginning in 2021. As part of that commitment, U.S. airlines have set a goal to reduce carbon dioxide emissions by 50 percent by 2050 compared to 2005 levels.

Reaching that goal will not be easy. Electric planes won't make much of a dent because the batteries can only power the smallest of light planes. The only way to achieve emission reduction goals is with liquid fuels that have a lower carbon footprint: Sustainable Aviation Fuels (SAF).

Pacific Northwest National Laboratory's John Holladay co-authored a recent report that presents a pathway to low-cost, clean-burning, and low-soot-producing jet fuel.

"Today, there are seven approved SAF pathways, but their use is limited. Airlines really want to use SAF but it needs to be cost-competitive with petroleum-based fuels, since fuel makes up about 30 percent of the operating cost of an airline," said Holladay, the transportation sector manager at PNNL who helped develop a waste-carbon-based fuel used in a Virgin Atlantic flight.

The report, Sustainable Aviation Fuel: Review of Technical Pathways, was authored by PNNL, National Renewable Energy Laboratory, and University of Dayton for the Bioenergy Technologies Office (BETO) in the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. It outlines research needs for producing more jet fuel from renewable and wasted resources.

The report presents new insights resulting from a study of the aviation industry, commercial jet fuel, its composition, specifications and certification process, and the challenges and successes with approved chemical pathways that convert biomass to jet fuel. The report also assesses process improvements, technoeconomic analysis, and supply chain issues.

Solving another problem

As detailed in the report, the cost of sustainable raw materials can likely be reduced by looking at non-traditional biomass. The classic idea of corn or specific crops grown to produce fuels is giving way to using non-traditional waste materials. Environmental problems like municipal solid waste, sewage, waste gasses like carbon monoxide, and even deconstructed plastics are rich sources of carbon that can be converted into jet fuel.

Fats and agricultural waste or forest residues are other types of discarded material, which can be treated with existing biological or thermal processes to produce high-quality intermediates.

"It costs cities and companies money to manage and treat these wastes, but when we can convert these liabilities into a high-value product, the value proposition changes altogether," said Holladay. "When we include these low-cost feedstocks, there becomes enough biomass to scale to industrial levels of production. Some feedstocks are even free, and that reduces the cost of SAF significantly."

Optimizing jet fuel properties

In the near-term, expanding production capacity of existing approved fuels is critical. But eventually, providing a fuel that has improved properties, within the bounds of specifications, further improves the possibility for market pull, according to the report.

"We don't have to just mimic petroleum-based fuel," said Holladay. "If we're going to make a new fuel, we might as well make a fuel that's better. And with the additional research and development suggested in this report, we can."

The report calls for a deeper understanding of the critical fuel properties of the four hydrocarbon families that make up jet fuel. These families are described in chemical terms as aromatics, n-alkanes, iso-alkanes, and cycloalkanes. The latter two families of molecules provide all the properties needed in jet fuel. The first two, aromatics and n-alkanes will often be coproduced; however, their primary production is not an optimal research area for SAF.

SAF must first and foremost must be safe for use in air travel. This includes producing a clean fuel that doesn't harm the jet engines, that doesn't freeze at high altitudes, and has a low flashpoint for safely refueling on the ground. With safety in mind, there are new opportunities for reducing soot formation by reducing the amount of aromatics in the fuel.

"In the end, we need SAF that are safe, inexpensive, and have high energy content," said Holladay." The report recommends that research focus on ways to make low-cost iso-alkanes and cycloalkanes that can enable better SAF performance."

Blending the two can give fuel higher energy content than jet fuel while meeting the density specification required, so planes can fly farther on less fuel. They also can burn cleaner by diluting the aromatics in fuel. Aromatics create soot and the tell-tale contrails that contribute to atmospheric warming.

There are many types of iso-alkanes and cycoalkanes that could be used in jet fuel, but they are expensive and some cycloalkanes may freeze in extreme cold temperatures experienced at cruising altitudes. Recommended research goals include better understanding combustion and molecular properties of cycloalkanes and how they could be produced inexpensively and approved for use in jet fuel.

It's the fuel… and a lot more

The report also notes the critical fuel properties required for certification processes. Jet fuel certification is time consuming and expensive and can only be accomplished by understanding the critical fuel properties required and their impact.

The authors also note that biorefineries, which will convert low-cost biomass and wastes, must be versatile and produce a variety of jet and other fuels. Technology must enable these refineries to be cost-competitive when operated at a much smaller scale than petroleum refineries. Supply chains—from feedstocks and infrastructure to storage and delivery—must also be accounted for when considering the full cost of the fuel. Those topics need to be addressed in research and in analysis of technical and economic benefits to the SAF industry.

The report encourages U.S. researchers to engage with partners in Canada and Mexico to take advantage of synergies across North America. Canada is home to a third of the world's certified sustainable forests, and Mexico has a warm climate that facilitates growth of sustainable feedstocks. Both countries can contribute to biomass feedstocks and offer unique opportunities for collaboration.

More information: Sustainable Aviation Fuel: Review of Technical Pathways Report. www.energy.gov/eere/bioenergy/ … ical-pathways-report

Provided by Pacific Northwest National Laboratory