Garbage could replace a quarter of petroleum-based jet fuel every year

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Credit: Pixabay

Every year, the nation's aviation industry uses around 22 billion gallons of jet fuel, which produces about 1 billion tons of carbon dioxide—or 3% of the world's carbon dioxide emissions. Because of this, researchers and policymakers alike are eyeing aviation as an industry ripe with opportunity to lower emissions.

One way to reduce emissions? Reuse society's waste and turn it into sustainable aviation fuel (SAF). In a new paper, a team of researchers from the Department of Energy's Pacific Northwest National Laboratory (PNNL) found that if waste-to-fuel refineries were built today near major travel hubs, the United States could produce 3–5 billion gallons of SAF from waste every year. Those gallons could replace 15–25% of the nation's annual supply of jet fuel.

"We've identified places in the United States where large airports are close enough to major waste-producing centers where you could build these SAF refineries right now," said Timothy Seiple, a computational scientist at PNNL and lead author on the paper, which published in summer 2023 in *ACS Sustainable Chemistry & Engineering*.

Producing jet fuel from waste

Waste produced by modern society—such as household garbage, food scraps, sludge from water treatment plants, or unused plant matter from farming—contains the same organic molecules as in crude oil found deep below Earth's surface. Crude oil is formed over millions of years as intense heat and pressure chemically alter ancient algae and tiny marine organisms. Today, scientists have developed technology that condenses those millions of years into mere hours, producing "biocrude" oil that can then be refined into fuels for diesel trucks or airplanes.

But researchers are still studying how the technology could be scaled and remain cost-effective. One barrier to producing a significant amount of SAF is the supply of waste itself, known as feedstock. In the United

States, waste is abundant.

In 2018, Americans produced nearly 300 million tons of trash, or 4.9 pounds per person per day. Much of that trash is organic, including food scraps like fruit and vegetable peels and thrown-out leftovers. On top of that, the nation's wastewater treatment plants generate 7.6 million tons of organic-rich biosolids per year.

One cost to consider is environmental: would the carbon emitted by transporting SAF cancel out the carbon saved in the waste-to-fuel process? To tackle this question, the researchers looked at major waste-producing hubs and how close they are to major travel hubs.

"If cities build waste-to-fuel facilities closer to major airports, it's less likely that additional infrastructure will be needed to get SAF to airports," said Karthikeyan Ramasamy, chief chemical engineer at PNNL and co-author on the paper. Moreover, "recycling garbage into fuel means that that garbage won't be trucked miles away to landfills and won't decompose, which releases methane," he continued.

Replacing petroleum fuel at major airports

The researchers homed in on two classes of waste: wet waste, which includes sludge from water treatment plants or manure from farms, and dry waste, including food scraps, wood, paper, yard waste, plastics, and other material typically thrown in the garbage.

The amount of both types of waste tends to increase with population size, which means the most populated parts of the country are also producing the most waste. The researchers looked at the proximity of these waste-producing centers to large airports that use a lot of fuel. Examples include airports in Los Angeles, New York, San Francisco, Chicago, and Atlanta.

Los Angeles's airport LAX, for example, uses about 2 billion gallons of jet fuel per year. Based on the analysis, 131 million gallons of SAF production potential occurring within a 60-mile radius of LAX could replace around 7% of LAX's annual jet fuel.

In Chicago, meanwhile, the ORD airport uses less jet fuel—about 1.1 billion gallons—but the surrounding area produces more waste, which could be used to create 236 million gallons of SAF or 22% of the airport's annual jet fuel.

Overall, the researchers found that waste-based SAF refineries at up to 100 sites around the United States could be built close enough to airports to produce and transport 3–5 billions of gallons of SAF every year, lowering the carbon intensity of the aviation industry by 10–18%.

"The top five airports all use over one billion gallons a year of jet fuel," Seiple said. "We don't have enough waste to replace all the jet fuel, but this could be an immediate opportunity for decarbonization that could steer us further toward more sustainable fuels."

Sustainable aviation fuel's future

SAF could help decarbonize the aviation industry, but challenges still remain.

In the paper, the researchers looked at two emerging methods of SAF production: one called hydrothermal liquefaction, which uses intense heat and pressure that mimics the natural process that produces crude oil thousands of miles below Earth's surface. The other is galled gasification, which uses steam and oxygen to create organic-rich gases from feedstock that can be further refined.

The SAF created from these two pathways must first be rigorously tested and formally qualified by ASTM, a global organization that develops standards for jet fuel and other products.

Aside from the technical challenges, social challenges also arise. Manufacturers would have to carefully consider where to build refineries to minimize impact on surrounding communities. There could also be some opposition to new energy projects.

One way to win over the public? Remind them that garbage trucks already rumble through cities every day, but in the case of SAF production, "moving waste to a refinery near an airport is a better solution than sending it to a landfill," Seiple said.

More information: Timothy Seiple et al, Cost-Effective Opportunities to Produce Sustainable Aviation Fuel from Low-Cost Wastes in the U.S, *ACS Sustainable Chemistry & Engineering* (2023). DOI: 10.1021/acssuschemeng.3c02147

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