Fill 'er up with biofuel

Synthetic fuels from renewable sources reduce greenhouse gas emissions by up to 30 percent compared to fossil fuels.

By Katja Engel

People who go on a cruise want to sleep in a cozy cabin and enjoy the days at sea out in the fresh air, far from the daily grind of life on land. There is just one catch – those intruding thoughts about the climate impact that waft in with the fumes of burnt marine diesel.

That could well change with a new technology developed by researchers at the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT in Oberhausen. In this article, Dr. Andreas Menne, Head of Department Biorefinery and Biofuels, talks about synthetic diesel and gasoline made from renewable resources.

Cruise ships, container vessels, aircraft and road vehicles are sure to run on liquid fuel for decades to come. Even if up to 30 percent of the vehicles zipping through cities will be electric by 2030, that is still an awful lot of fuel. One would hope that an alternative based on something other than crude oil could be found. Every day, every adult in Germany consumes 3.5 liters of fuel for transportation alone. This adds up to around 87 billion liters for 365 days a year, accounting for around one-fifth of greenhouse gases.

This is a big burden for the climate. Menne, a mechanical engineer, and his team want to lighten that load by converting bioethanol into diesel, gasoline or kerosene that have nearly the same properties as fossil fuels. Renewables help slash the transportation sector's CO_2 emissions. "Straw, leaves, sawdust, waste wood – we can use almost anything as the raw material for bioethanol," says Menne. The new climate-friendly biofuel produces a lot less greenhouse gas.

The researchers use bioethanol made of wheat straw for the new fuel.
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A full-fledged fuel rather an additive, vehicles should be able to run on it alone. By contrast, just five to ten percent of the E10 fuel is bioethanol; the rest is of fossil origin. "We're not going to feel much of a climate effect with that," says Menne. "Electric, hybrid and fuel-cell vehicles are not going to reduce greenhouse gas emissions as quickly as this has to happen. We need a holistic approach and a diversity of solutions for tomorrow's fuels." The pressure to take action is mounting with the revised Renewable Energies Directive (RED II) calling for advanced fuels to account for a share of 3.5 percent by 2030.

The UMSICHT researchers are producing up to 20 liters of the new biofuel a week in an experimental plant. Amid the pipes and tanks and insulation, a pair of weighing scales stands on the floor. A small metal drum containing ethanol sits on one side of the scale, balanced by a bulbous glass vessel into which the finished fuel is poured. This setup enables researchers to check at a glance how much ethanol is flowing into the plant and how much fuel is being produced from it.

The feedstock is bioethanol sourced from wheat straw. "Actually, I could use any other alcohol," says Menne. The straw alcohol initially retains its liquid form as it flows from the metal barrel through the pipes of the test plant into a vaporizer. When the temperature reaches 350 degrees Celsius at a pressure of 20 bar, the gaseous alcohol flows into the heart of the plant, a tubular reactor. The reactor is filled with pieces of activated carbon coated with a newly developed catalyst material. These catalysts accelerate the condensation reaction by which gas is converted into liquid by multiplying the number of carbon bonds. This produces gasoline, kerosene or diesel, depending on how many carbon molecules are combined.

Alcohol to fuel

Menne had discovered this reaction accelerator while working on his doctorate in 2008. "A catalyst is often developed in the lab but may then turn out to be difficult to produce in large quantities. But we can buy the materials for this catalyst cheaply because it doesn't consist of precious metals or rare earths. And most importantly, it remains stable over the long term," says Menne, who submitted a patent application for it in 2012.

The biofuel packs plenty of power, as researchers at the Fraunhofer Institute for Chemical Technology ICT in Pfinztal have confirmed. They put standard commercial engines on a test bench to run trials with the new fuel.

Menne supplied a hundred liters for testing. The ICT researchers took precise measurements of engine performance and exhaust emissions in trial runs that are much like an ergometer stress test, where a person wired up with sensors pedals away to measure cardiac function. Readings were taken at different operating levels, during cold starts, under different loads and at varying engine speeds.

Lots of power, low exhaust emissions

This biofuel's energy density was found to be slightly higher than that of conventional fuels. That means a vehicle with this new fuel in its tank would have a slight advantage in a real race. The synthetic fuel's exhaust emissions were also a selling point with less carbon monoxide, carbon dioxide and hydrocarbons, and a lot less exhaust soot. This biofuel's physical properties come close to those of fossil diesel, so it can be made to comply with prevailing standards.

Venkat Aryan, a chemical engineer at Fraunhofer UMSICHT, has added up every molecule of the greenhouse gases in each process step to assess the ecological impact. A well-to-wheel analysis factors all greenhouse gases into the equation, from the extraction or harvesting of the raw materials to the fuel's conversion into kinetic energy. They include crude oil extraction from underground wells, the cultivation of plants for biofuel and the exhaust gases. He found that the CO_2 equivalents for synthetic diesel made from wheat straw amounted to 64.3 to 91.6 grams per megajoule, depending on the ethanol source. The figure for petroleum-based diesel fuel is 94 grams, which biofuel beats by as much as 32 percent. Aryan already has some ideas that could easily achieve further savings.

"Our fuel can be converted into gasoline, diesel or even jet fuel for airplanes. But the latter is the most complicated," says Menne.

Marine diesel is a much simpler matter. It does not have to be processed in a refinery. "You could simply set up our plant in a port. Our process is so straightforward that shipping companies could produce their own diesel. Then the age of the big stinkers would soon be over," says Menne.

Despite there being just the one test plant in Oberhausen, the technology is ready to go to market. Now these researchers are looking for partners to start production on an industrial scale. The Fraunhofer experts have already started talking to refineries. While the synthetic diesel is still more expensive than diesel made of petroleum, Menne is confident that this could soon change. As the new legislation takes effect, fossil fuels will no longer be as cheap to produce. "Consumers' expectations are also changing. They may not only want to truly enjoy a cruise; they may also want to know how climate-friendly the ships are that transport bananas from Colombia to Europe." ■

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