Pacific Northwest NATIONAL LABORATORY

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PNNL biofuel solutions taking flight for aviation industry

From travel services and cargo delivery to the manufacture of aerospace products, aviation plays a vital role in America. The Federal Aviation Administration indicates the industry contributes millions of jobs and more than $1 trillion in economic activity annually.

In recent years, rising fuel costs have threatened the economic vibrancy of the industry. According to the International Air Transport Association, the price volatility of the special, petroleum-based fuel that powers jets and other aircraft continues to significantly impact operating costs. This has prompted the aviation industry to explore use of alternative fuel sources. Biofuels made from biomass (plant-derived materials) represent one such alternative to petroleum, and also offer the potential to reduce greenhouse gas emissions.

Pacific Northwest National Laboratory, working with the U.S. Department of Energy's Biomass Program and university and industry partners, is developing aviation biofuel options, with a focus on the fuel's cost-effectiveness and compatibility with the nation's existing transportation fuel infrastructure.

PNNL's strategy is to develop technology for converting a broad range of biomass sources to hydrocarbon fuels that can be readily used within the nation's existing transportation fuel infrastructure. This includes aviation, gasoline and diesel fuels.

Aviation fuels are unique

An aircraft's focal point is its propulsion system, and most everything, including fuel, is designed around that system. Aviation fuels—distinctive blends of hydrocarbons—generally are of higher quality than ground transportation fuels and are subject to rigorous regulatory standards and approval processes. Prospective replacement fuels, such as those produced from biomass, must match the specifications of the unique petroleum-based fuels they supplant.

PNNL is advancing viable aviation biofuels

With an emphasis on deploying solutions to the marketplace, PNNL and its partners are working to improve and expand the use of cost-effective, bio-based aviation fuels. Research and development focuses at PNNL include:

» **Alcohol to Jet Fuel.** Alcohols can be produced via fermentation or thermal processes. PNNL seeks to intercept the resulting alcohol at a crude state and develop technologies for the next step, conversion to jet fuel hydrocarbons.

PNNL works with industry partners on various facets of this challenge. A collaboration between PNNL, Imperium Aviation Fuels and LanzaTech, for example, is advancing biotechnology and catalytic processes for converting biomass-based alcohols to a fuel that can be blended with traditional jet fuel.

U.S. DEPARTMENT OF ENERGY

PNNL also is working with Washington State University (WSU) to convert other fermentation-derived oxygenates to intermediates that can then be converted to hydrocarbon fuels.

Additional key research activities include a project focused on gasification of biomass to produce mixed alcohols for conversion to hydrocarbon-based fuels, and an effort exploring biochemical conversions that yield hydrocarbon intermediates. The intermediates are then processed into aviation fuels, diesel, gasoline, and other hydrocarbon-based products.

» **Pyrolysis**. Fast pyrolysis involves rapidly applying heat to biomass and liquefying it into a low quality oil, then "hydrotreating" it to remove oxygen. In this discipline, PNNL won three competitively awarded DOE projects in 2010 and is working, respectively, with W.R. Grace, UOP and Battelle to advance processes for pyrolysis oil upgrading. Such processes yield hydrocarbon fuels and, depending on process conditions, the hydrocarbon product can contain up to 40 percent jet fuel, with the remainder being gasoline and diesel.

PNNL's expertise in pyrolysis was reflected in a 2009 partnership with UOP, Boeing, DOE's Biomass Program and others that achieved a unique milestone: Upgraded pyrolysis oil was used in combination with synthetic paraffinic kerosene to produce 100-percent jet fuel derived from biomass. The fuel was demonstrated in a hydroplane at Seattle's Seafair race.

PNNL capabilities also are supporting a UOP-led effort to create a pilot-scale biorefinery to produce fuel via integrated pyrolysis and hydro-conversion, and wet gasification of the water stream from the process.

» **Hydrothermal Liquefaction (HTL)**. HTL uses wet biomass slurries—along with heat and pressure —to produce an oil that's then upgraded to hydrocarbons. In this research area, PNNL co-leads DOE's National Advanced Biofuels Consortium, which is exploring use of forest and agriculture residues, and DOE's National Alliance for Advanced Biofuels and Bioproducts that's exploring algae-to-oils processes.

» **Process, Life Cycle, Business Case and Fuel Chemistry analyses**. PNNL provides key capabilities for analysis of the factors influencing the viability of aviation biofuels. These capabilities include:

- ***Process Analysis*** *for understanding the cost structure and efficient use of chemistry in conversion processes*
- ***Life Cycle Analysis*** *to evaluate the carbon footprint and other environmental issues that influence the potential of bioproducts and biofuels—as compared to fossil fuel-derived products and fuels*
- ***Business Case Analysis*** *for assessing market viability of biofuels/bioproducts in terms of biomass availability and other business, economic and technological considerations*
- ***Fuel Chemistry*** *to answer biofuel chemistry and quality questions.*

A solid track record and outstanding resources

At PNNL, award-winning research teams have been conducting groundbreaking bio-based inquiries for more than 30 years, supported by outstanding facilities and instrumentation. The William R. Wiley Environmental Molecular Sciences Laboratory, a Department of Energy national scientific user facility located at PNNL, provides capabilities in catalysis, surface science, and world-class computational chemistry—all key to bio-based product solutions. In addition, the Bioproducts, Sciences, and Engineering Laboratory (BSEL), a joint PNNL-WSU facility that opened in 2008, augments its state-of-the-art capabilities with PNNL's strong science base to develop applied technologies. BSEL offers reactors ranging in size from 1 to 100 cubic centimeters, allowing for long-term catalyst testing and production of small quantities of products. Fermentor capacities range from 2 liters to 30 liters.

PNNL possesses a hydrotreatment and distillation capability of up to 25 gallons per week of finished fuel product—an amount sufficient for evaluating fuel material performance in engines and components, and for regulatory standards testing.

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