NREL Transforming ENERGY

Photo by Joe DelNero, NREL

Low-Carbon Fuels

Our Expertise

For Especially Difficult-to-Decarbonize Sectors (Aviation, Marine, and Rail): Fuel Property Measurement and Analysis | Fuel Original Equipment Manufacturer Qualification Experience | Fuel Quality Standards Expertise | Fuel Chemical Analysis and Properties Research | Experimental and Computational Combustion Kinetics | Engine Combustion Modeling | Exascale Computing Software Development | High-Performance Computing Optimization

The Need

Accelerate Sustainable Aviation Fuel Development and Market Entry

Aviation represents 8% of U.S. transportation-related emissions, but as more people and goods take flight, the sector's carbon dioxide emissions are expected to triple by 2050—unless action is taken. Replacing traditional petroleum jet fuel with low-carbon sustainable aviation fuel (SAF) can help lower aviation emissions, and NREL is poised to help make widespread use of SAF a reality.

Adopting SAF requires ensuring the fuel is both as safe and reliable as traditional aviation fuel, as well as fully compatible with existing jet engines. To get industry approval, companies must demonstrate that new blends meet a set of safety, performance, and operability criteria and are functionally identical to petroleum jet fuel. But proving a new fuel meets those standards traditionally requires producing thousands of gallons of SAF to perform the many ASTM International qualification tests. Making that volume of fuel is a high-risk, costly proposition for the nascent SAF industry, and producers need to be able to identify promising blends before scaling up.

The Solution

Simulate Fuel Chemistry Impacts To Achieve Industry Qualification Standards

NREL's cross-disciplinary research team is gathering fuel chemistry data to equip the industry with an ultra-detailed SAF combustion simulation powered by supercomputers. The "virtual jet engine" can predict how SAF performs during flight and provide insights on how to maximize its safety and performance using data from measurements done on preexisting fuels.

As one side of this two-pronged approach, NREL's computational science team produced modeling tools capable of predictive simulations of aircraft engine combustors. Researchers used the Pele framework, a suite of tools that provides a unique, highly accurate reacting flow modeling capability, to build a combustion simulation.

The second prong involves NREL's fuels and combustion researchers, who measure fuel properties critical for flight safety and reliability using custom equipment. Crucially, this equipment exposes SAF to punishing conditions expected in jet engines and gathers data on its response. The equipment allows SAF to be profiled with unprecedented detail using only a few milliliters of fuel.

The computational science team will incorporate the measurements into the combustion simulation to start exploring the fuel's behaviors and learning how different chemical makeups can impact its performance.

The Impact

Optimized SAF Production and Adoption

If the simulation is trustworthy, the team can start to explore parameter ranges for fuels that don't exist yet, but that industry could make. The simulation results would effectively transform into fuel chemistry suggestions that producers could realize at the lab before building expensive pilot plants to scale them up for ASTM qualification.

More fundamentally, the SAF research platform might reveal frontiers never seen before in jet fuel chemistry and qualification. It may uncover insights that could help planes fly farther, run cleaner, and perform better than ever before, as well as prove adjustments ASTM might use to loosen its blending limits for SAF, supporting deeper reductions in carbon emissions.

Partners

General Electric | Georgia Institute of Technology | U.S. Department of Energy

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