

Renewable Fuels and Lubricants Laboratory

State-of-the-Art Fuel and Vehicle Testing

The Renewable Fuels and Lubricants (ReFUEL) Laboratory at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) is a state-of-the-art research and testing facility for advanced fuels and vehicles. Research and development aims to improve efficiency of conventional gasoline-powered vehicles and overcome barriers to the increased use of renewable diesel and other nonpetroleum-based fuels, such as biodiesel and synthetic diesel derived from biomass.

The ReFUEL Laboratory features a chassis dynamometer for vehicle performance and emissions research, two engine dynamometer test cells for advanced fuels research, and precise emissions analysis equipment. As a complement to these capabilities, detailed studies of fuel properties, with a focus on ignition characteristics, are performed at NREL's Fuel Chemistry Laboratory.

Because the ReFUEL Laboratory is located in Denver, Colorado, it offers the additional capability of testing emissions and vehicle performance at high altitude. It also features an altitude simulation system to mimic results found at lower altitudes, including sea level.

Chassis Dynamometer

The ReFUEL Laboratory is one of the few facilities in the United States with a chassis dynamometer that operates with laboratory-grade emissions analysis equipment. The dynamometer is supported by 72 data acquisition channels along with fuel metering and combustion analysis subsystems. It can test the performance and emissions of medium- and heavy-duty vehicles—from small trucks and delivery vans to full-size buses and Class 8 tractors.



Engine on the heavy-duty engine dynamometer.
Photo by Dennis Schroeder, NREL 22745

The chassis dynamometer features the following capabilities:

- Inertial simulation range: 8,000 – 80,000 lb (vehicle classes 3–8)
- Grade simulation and optional dynamometer-assisted braking
- Tandem axle, 40 in. rolls
- Range of adjustable rolls: 42 – 56 in.
- Range of vehicle wheel base: 89 – 293 in.
- Programmable driver's aid for enhanced test repeatability.

Heavy-Duty Engine Dynamometer Test Cell

Heavy-duty engines are certified as meeting emission regulations by the manufacturer using an engine dynamometer. These protocols, known as the Heavy-Duty Federal Test Procedures (HD-FTP), are highly standardized, and results can be readily compared between laboratories.

Because NREL's heavy-duty engine dynamometer test cell performs the HD-FTP on engines up to 600 hp, advanced fuels can be evaluated in a way that is meaningful to the engine-research community. In addition to testing a wide range of engines operating at speeds up to 6,500 rpm, the test cell enables the testing of motors and transmissions as well.

Its advanced controls and data acquisition systems allow custom tests to be established beyond the FTP. In combination with a combustion analyzer that records information about cylinder pressure, fuel-injection timing, and valve position, the engine dynamometer can be used to determine the relationship between fuel properties, engine performance, and emissions.



A fleet vehicle being tested on the chassis dynamometer at ReFUEL
Photo by Dennis Schroeder, NREL 22772

Light-Duty Engine Dynamometer Test Cell

The light-duty engine dynamometer test cell was designed as a one-of-a-kind single cylinder research device for light-duty engines operating on biofuels. It utilizes a 75 hp AC dynamometer. Like the heavy-duty engine dynamometer test cell, it can run a series of transient or steady-state cycles.

It includes a single-cylinder engine with a wall-guided spark-ignition direct-injection combustion system. A maximum fuel pressure of 6,000 psi allows for the use of future-generation direct injectors while the engine controller provides flexible, independent control for fuel-injection timing, high-pressure fuel delivery, spark timing, exhaust gas recirculation, and boost pressure.



Light-duty engine dynamometer test cell. Photo by Xin He, NREL 19907

Emissions Analysis

The ReFUEL Laboratory features an advanced emissions measurement system with supplemental air and fuel conditioning to ensure repeatability. This system is based on the full-scale dilution tunnel method with a constant velocity sampling system for mass-flow measurements.

The system precisely measures a wide variety of vehicle emissions:

- Continuous measurement of gaseous emissions of total hydrocarbons, non-methane hydrocarbons, oxides of nitrogen, carbon monoxide, carbon dioxide, and ammonia via in-lab emissions benches and a portable emissions measurement system
- Particulate matter measurements
 - Ultra-micro balance: 0.1 μg readability
 - Particle size measurement range: 5.6 – 560 nm
 - Class 1000 clean room/environmental chamber with precise temperature and humidity control
 - Active vibration and static mitigation
- Additional, unregulated emissions measurements
 - Carbonyls, aldehydes, and ketones
 - Hydrocarbon speciation (C1–C12).

Although the ReFUEL Laboratory does not offer certification services, it follows Code of Federal Regulations emissions testing requirements.

About NREL's Transportation RD&D

The only national laboratory dedicated to renewable energy and energy efficiency, NREL is at the forefront of RD&D for tomorrow's sustainable transportation solutions. NREL's innovative and integrated whole-system approach helps government, industry, and other research partners develop market-ready, high-performance, low-emission, fuel-efficient vehicles, components, and systems.

Partnership Opportunities

The ReFUEL Laboratory is available to members of the research community interested in testing advanced fuels, prototype engines, and hybrid powertrains. Please contact us if you would like to explore collaborative opportunities.

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