Vehicle Testing and Analysis Group

Center for Transportation Technologies and Systems

An NREL researcher sets up a heavy-duty engine dynamometer to test engines and fuels.

Highlights

We provide vehicle and fleet evaluations, data, and analyses to NREL, government and industry partners, and the R&D community.

Vehicle test engineers use the latest equipment and techniques to evaluate vehicle performance in the ReFUEL Laboratory—our controlled laboratory setting.

Fleet testing and evaluation engineers employ the latest hardware, software, and analysis techniques needed to capture, process, and analyze data from in-service vehicles.

NREL's vehicle systems analysts evaluate advanced vehicle technologies for their impact on fuel economy, vehicle performance, exhaust emissions, vehicle component costs, and market potential.

To help boost fuel economy and reduce U.S. petroleum imports and exhaust emissions, NREL's Vehicle Testing and Analysis Group provides expert vehicle and fleet evaluations, data, and systems analyses to government and industry partners and many others in the R&D community.

In work for the U.S. Department of Energy (DOE) Vehicle Technologies Program, the Vehicle Testing and Analysis Group's fleet testing and evaluations include on-road testing and data acquisition of in-service vehicles, data analysis and reporting, and projects to improve heavy-duty truck efficiency. Vehicle systems analysis includes studies to analyze the potential of advanced technologies and components, such as for future plug-in hybrid electric vehicles (PHEVs). As part of the National Renewable Energy Laboratory's (NREL's) Center for Transportation Technologies and Systems, we also operate and maintain NREL's ReFUEL Laboratory, which provides engine and chassis dynamometer test support for many tasks sponsored by DOE and others.

Our fleet testing and evaluation engineers have expertise in state-of-the-art vehicle and fuel data collection methods and analysis techniques. We employ the hardware, techniques, and software tools needed to effectively capture, process, and analyze data from in-service vehicles and from our heavy-duty chassis and engine dynamometers. We work alongside technical experts in power electronics, biofuels, and energy storage and in collaborations to ensure that relevant data are collected and analyzed expertly and effectively.

Our vehicle systems analysts evaluate advanced vehicle technologies to determine their impact on fuel economy; exhaust emissions; vehicle performance, component size, and cost; and market potential. Using vehicle simulation and analysis tools such as VISION, PSAT, and the Technical Target Tool, we evaluate advanced technologies in a virtual

Ken Proc, NREL/PIX15738

Data obtained in outdoor daytime heat soak tests are used to validate the accuracy of our truck cab model.

Dean Armstrong/NREL

NREL researchers use data-logging and other equipment to collect information on board an actual vehicle for later analysis.

environment before they are integrated into production vehicles. This helps to guide vehicle R&D along the most promising technology pathways for reducing petroleum consumption. Our in-house R&D focuses on overcoming key barriers to achieving DOE's technical targets for vehicle technologies.

Fleet Testing and Evaluation

NREL's Fleet Test and Evaluation Team has worked for many years with commercial and government fleets to test and evaluate the performance of medium- and heavy-duty alternative fuel and advanced technology vehicles in service. The information we gain then goes back to government and public research programs to help shape future work.

Key aspects of our work include meeting with members of industry and their customers to understand market factors and customers' requirements; assessing the performance of alternative fuel and advanced vehicles in service and comparing the results to those for their conventional counterparts; and disseminating unbiased information about the performance and durability of advanced vehicles.

Our projects involve advanced vehicle technologies, such as hybrid electric and fuel cell systems, and fuels such as hydrogen, natural gas, biodiesel, and Fischer-Tropsch diesel (produced by converting gaseous hydrocarbons to liquid fuel). We also evaluate new technologies that reduce idling in medium- and heavy-duty vehicles.

Projects and Capabilities. Recent projects include evaluating hybrid electric buses with nickel metal hydride (NiMH) or lead-acid batteries, or ultracapacitors, for energy storage; hybrid electric delivery vans with both NiMH and lithium-ion propulsion batteries; transit buses and heavy-duty vehicles operating on 20% biodiesel; and auxiliary power units operating on Fischer-Tropsch fuel. Our successful collaborations include work with New York City Transit, United Parcel Service, and many others.

Our capabilities include on-board and on-site data collection, data analysis, and dissemination; tests and evaluations in NREL's ReFUEL Laboratory; and truck thermal testing under the CoolCab project.

Data Collection. On board, we collect Controller Area Network (CAN), Global Positioning System (GPS), and analog signals simultaneously and monitor them on site or remotely via a wireless modem; collection methods depend on project requirements. Hardware options include a portable data logger for GPS data acquisition; portable data loggers, which can be operated stand-alone or with a PC and can collect CAN, GPS, and analog sensor data simultaneously; and data loggers that feature stand-alone large channel quantity capability (both CAN and analog) for long-term, large-data-set acquisition.

We also gather and analyze long-term data from fleet managers for on-site evaluation. We developed a fleet data analysis tool that allows us to quickly gather, filter, and analyze multiple large data sets and provide both standard and custom reports. We can thus show trends and provide analyses of specific subsystems to understand the costs and benefits of a new technology.

CoolCab. This work focuses on improving the thermal efficiency of heavy trucks so drivers can be comfortable during rest stops without idling the engine. Core capabilities include evaluating truck technologies to reduce fuel use and testing truck tractor sleeper cabs to measure heating

Warren Gretz, NREL/PIX 13287

The ReFUEL Lab's chassis dynamometer gathers performance and emissions data for vehicles like these and features dynamometer-assisted braking, a programmable driver's aid, and a hydraulic hitch loading system.

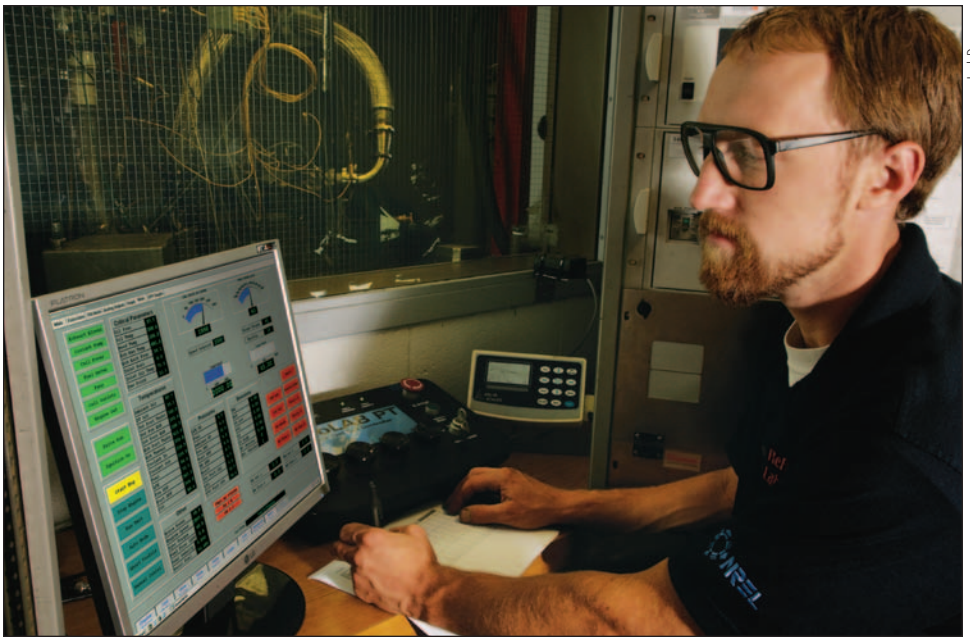
and cooling loads. Reducing the loads helps to reduce the size, cost, and weight of idle-reduction technologies and is the first step in improving fuel economy.

At our outdoor test facility and in a fully instrumented truck tractor, we measure the amount of heat required to maintain a given temperature; the resulting data are used for comparison and to provide a baseline. We investigate heat loss with tools such as infrared imaging and heat flux gauges. We also conduct solar daytime heat soak tests outdoors to quantify solar gains, and we measure interior temperatures in trucks with and without window insulation.

The CoolCab project also includes thermal analysis modeling (e.g., using FLUENT) to predict heat flows in a truck tractor sleeper cabin. We can then forecast the impact of load-reduction strategies, such as improved cab insulation and solar reflective glass.

The ReFUEL Laboratory

The Renewable Fuels and Lubricants (ReFUEL) Laboratory supports testing and evaluation of fuels and lubricants derived from renewable and synthetic sources in advanced vehicle and engine systems. It supports the development of advanced heavy hybrid propulsion systems and consists of heavy-duty chassis and engine dynamometers with emissions measurement capability. The chassis dynamometer can test full-size buses and Class 8 trucks and can simulate from 8,000 to 80,000 lb of vehicle inertia through a combination of flywheels (mechanical inertia) and a DC motor (electrical inertia). The engine dynamometer allows us to perform the Federal Test Procedure for engine certification; it can absorb 400 hp and operate at up to 5000 rpm.



Jack Dempsey

An engineer monitors engine dynamometer controls and data acquisition in NREL's Renewable Fuels and Lubricants Laboratory (ReFUEL).

We measure emissions using procedures consistent with the Code of Federal Regulations (CFR) as it applies to heavy-duty engine certification. Using data acquisition and combustion analysis equipment, we relate the effects of various fuel properties and engine settings to performance and emissions. The emissions measurement system is based on the full-scale dilution tunnel method with a constant velocity sampling system for mass flow measurement.

The ReFUEL lab features a gaseous emissions bench updated for EPA compliance with analyzers for total hydrocarbons, oxides of nitrogen, carbon monoxide, carbon dioxide, oxygen, and nitrous oxide. Our FTIR analyzer measures additional gaseous emissions and helps us conduct more detailed hydrocarbon speciation. We can also measure raw exhaust gases.

We measure particulate matter (PM) in a Class 1000 temperature- and humidity-controlled clean room used for filter handling, conditioning, and weighing.

Warren Gretz, NREL/PIX 13290

NREL's ReFUEL lab houses emissions measurement systems that comply with federal regulations; the clean room shown here is used for particulate mass measurement.

The microbalance for weighing PM filters has a repeatability of 0.1 microgram (a CFR requirement) and features static control, a barcode reader for filter identification and tracking, and a computer interface for data acquisition.

NREL's Fast Mobility Particle Sizer provides real-time measurements at up to 1 sample per second. We have also acquired a Portable Emissions Measurement System, an Altitude Simulation System, and a Combustion Analysis System.

Vehicle Systems Analysis

The vehicle systems analysis team provides expert analyses that lead to the optimal application of an advanced vehicle or fuel technology. Our R&D projects provide analyses for advanced technologies such as PHEVs and hydrogen fuel cell and electric vehicles.

We are experienced in simulating, evaluating, and testing various hybrid and other advanced propulsion strategies and hardware components under controlled and real-world conditions. Our analysis team employs a variety of models and software tools to evaluate advanced vehicles systems—from components and design, through system integration issues, to market penetration—using a variety of simulation and component models.

We also provide modeling and analysis capabilities to support detailed simulation aspects of a project. Specific capabilities include computational fluid dynamics, one-dimensional engine cycle simulation, and vehicle-level codes and analysis.

Dean Armstrong, NREL

NREL researches, develops, and analyzes advanced components for future plug-in hybrid electric vehicles; this one is shown with our Vehicle Systems Analysis team.

Optimization Tools and Distributed Computing. NREL's vehicle systems analysts use optimization tools and distributed computing capabilities to find the best combination of vehicle components and characteristics. Optimizing often involves seeking compromises among some or all of a vehicle's characteristics, such as power and fuel economy, to find the most desirable overall effect.

Our optimization capabilities also include both gradient-based techniques (in which each value change occurs in a routine increment) and non-gradient-based techniques (in which value changes occur randomly). Our optimization tools are fully integrated with vehicle-level models to better solve vehicle system problems.

The Technical Target Tool. We have also developed a new Technical Target Tool that uses a consumer preference model to determine optimal component sizes based on a set of performance parameters, or technical targets. The process can be applied to several different technologies to determine the most promising pathways to a commercial vehicle and to evaluate design trade-offs involving performance, fuel economy, cost, and marketability for light-duty and heavy-duty vehicles.

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See our work on the following Web site:
www.nrel.gov/vehiclesandfuels/

Transportation Technologies

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