

Transportation Big Data

Unbiased Analysis and Tools to Inform Sustainable Transportation Decisions

Today, transportation operation and energy systems data are generated at an unprecedented scale. The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) is the go-to source for expertise in providing data and analysis to inform industry and government transportation decision making. The lab's teams of data experts and engineers are mining and analyzing large sets of complex data—or "big data"—to develop solutions that support the research, development, and deployment (RD&D) of market-ready technologies that reduce fuel consumption and greenhouse gas emissions.

NREL serves as one of the nation's most credible and complete transportation energy efficiency clearinghouses for validated and up-to-date statistics, data analysis, and tools, pairing information from government and private sector partners with expertise in analysis and applications. The lab's data processing and analysis capabilities, backed by RD&D and industry expertise, make it possible to identify the right sustainable transportation decisions, using the right technologies and approaches, at the right time to match each partner's priorities and needs.

NREL offers the nation's largest collection of unbiased, accurate, and comprehensive data and web-based tools for transportation RD&D, with a focus on alternative fuels, advanced vehicles, vehicle emissions, fueling infrastructure, travel data, and policy incentives. The lab's Peregrine supercomputer makes it possible to store and rapidly analyze massive data sets.

NREL's transportation big data capabilities include:

- Secure storage and processing of huge quantities of validated data from across the nation
- Unbiased analysis and visualization capabilities across a full range of vehicle classes and technologies, as well as fuels, in individual and fleet scenarios
- Tools for leveraging data sets and capabilities
- Integration with other NREL energy systems data sets and analysis tools
- Ability to pair data and analysis capabilities with RD&D expertise.



NREL's data experts and engineers analyze large sets of complex data—or "big data"—to develop solutions that support the research, development, and deployment of market-ready technologies that reduce fuel consumption and greenhouse gas emissions. Photos by Dennis Schroeder, NREL 35360 (top) and NREL 34455 (bottom)

Independent Analysis of Real-World Data

NREL performs independent, unbiased analysis and reporting of real-world transportation demonstration data to:

- Evaluate energy efficiency, air quality, and emissions impacts
- Compare technologies against targets
- Track benefits and performance against incumbent technologies
- Identify potential barriers to further implementation and widespread market adoption
- Reduce technology cost and development time
- Understand total cost of ownership
- Improve operating and maintenance strategies
- Match technologies with applications.

Managing Large Quantities of Complex Data

NREL maintains a cross-cutting portfolio of databases that feature real-world, on-road transportation and energy systems data, including:

- Clean Cities' Alternative Fuels Data Center (AFDC) afdc.energy.gov
- National Fuel Cell Technology Evaluation Center (NFCTEC) nrel.gov/hydrogen/nfctec.html
- Transportation Secure Data Center (TSDC) nrel.gov/tsdc
- Fleet DNA commercial fleet data clearinghouse nrel.gov/fleetdna
- BioEnergy Atlas maps.nrel.gov/bioenergyatlas/
- Geographic information system data sets for solar, wind, biomass, geothermal, and renewable hydrogen resources.

These databases contribute to numerous RD&D activities—from information analysis to technical benchmarking, outreach, and education—and can be merged with third-party data sets, providing value to a range of users and applications. The AFDC, operated by NREL on behalf of Clean Cities, acts as a one-stop-shop for vetted information related to advanced transportation technologies. The TSDC, created in partnership with the U.S. Department of Transportation, features second-by-second GPS readings for millions of miles of travel, along with vehicle characteristics and survey participant demographics. The NFCTEC is designed for secure management, storage, and processing of proprietary fuel cell data from industry, while Fleet DNA is a clearinghouse of commercial fleet vehicle operating data.

NREL works with partners to:

- Develop data collection parameters
- Set up in-field, onboard data logging equipment
- Provide templates and procedures for collecting fueling, maintenance, and operations data
- Establish password-protected file transfer protocol sites for secure data transfer
- Use in-house data processing and analysis capabilities to automate filtering, conversion, and processing of raw data
- Generate analysis results and reporting metrics that can be used for decision making.

To protect proprietary data and preserve privacy, NFCTEC and TSDC store raw data in secure repositories with no external access. Detailed data products are provided directly to the data provider or, in the case of TSDC, detailed spatial travel data are available to approved users through a secure external access portal with controlled access. NREL also publishes aggregate data products for public use.



NREL's Insight Center uses advanced visualization technology to provide on-site and remote viewing of experimental data, high-resolution visual imagery, and large-scale simulation data. Photo by John De La Rosa, NREL 34672

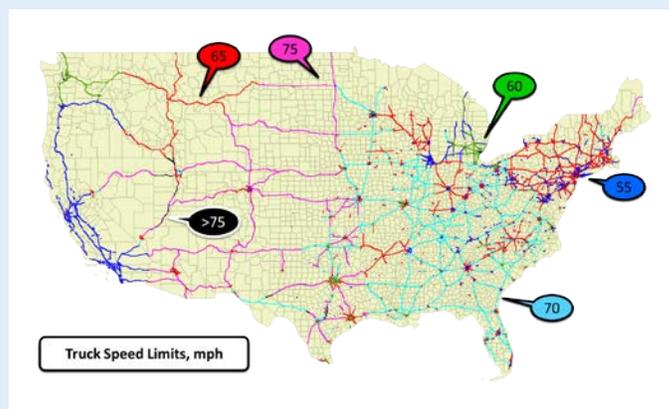
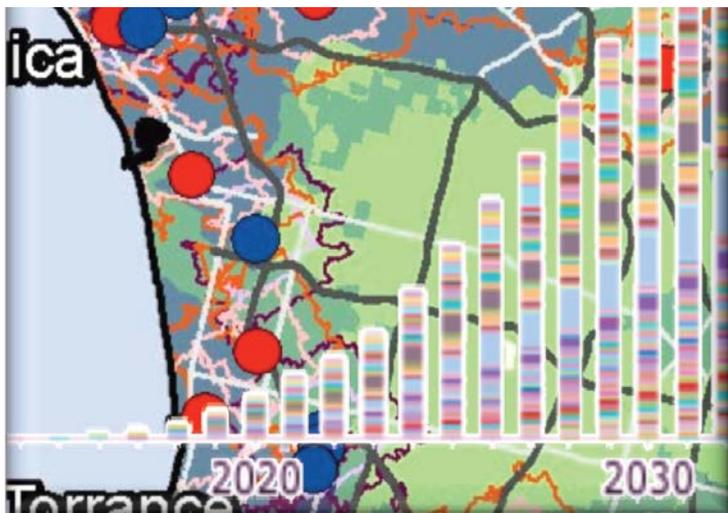


Figure by Eric Wood, NREL

Success Story: Analysis Helps Define New Medium- and Heavy-Duty Vehicle Emission Regulations

Activity: NREL partnered with the U.S. Environmental Protection Agency (EPA) to refine drive cycles for greenhouse gas certification of medium- and heavy-duty vehicles by analyzing road grade characteristics experienced by U.S. trucks on controlled access highways. To perform this analysis, NREL investigated national road grade data sets from sources such as TomTom and the U.S. Geological Survey and compared them to a detailed local road grade data set generated by the Southwest Research Institute.

Impact: EPA plans to use the nationally representative road grade profiles that NREL developed as part of its official test procedures.



Hydrogen infrastructure simulation models provide insights into investment decisions and policy support options. *Figure by Marc Melaina, NREL*

World-Class Analysis and Simulation Capabilities

NREL's unbiased analysis experts apply in-depth understanding of transportation industry needs and priorities to mine these big data sets, extract insights, and develop sustainable transportation solutions that meet end-user needs and expectations.

The lab has developed a number of specialized and technology- and fuel-neutral tools grounded in real-world experiences and RD&D expertise. NREL analysts and external stakeholders use these tools to evaluate performance data and analyze the impact of emerging technologies on efficiency, performance, and cost for a full range of vehicle classes.

Using tools such as the Future Automotive Systems Technology Simulator (FASTSim) and the Automotive Deployment Options Projection Tool (ADOPT), NREL conducts technical and market analyses of promising vehicle technologies to find cost-competitive solutions that maximize energy savings and reduce greenhouse gas emissions. The Drive-Cycle Rapid Investigation, Visualization, and Evaluation (DRIVE) tool produces representative, testable drive cycles at record speed from large amounts of real-world vehicle data gathered via onboard logging devices, cutting testing and analysis time. And the Hydrogen Financial Analysis Scenario (H2FAST) tool provides in-depth financial analysis for hydrogen fueling stations.

Other NREL analysis models combine performance and cost data with geospatial data to demonstrate local, regional, and even global impacts over time. For example, the Scenario Evaluation, Regionalization, and Analysis (SERA) model can help determine optimal production, delivery, and infrastructure build-out scenarios for hydrogen.

To perform and support geospatial analysis, NREL develops, maintains, and disseminates data sets and maps on renewable energy resources, energy infrastructure, demographics and land ownership, and the earth's physical geography. Transportation analysts can fuse these geographic data sets with vehicle operation and efficiency data to examine the integration of sustainable transportation technologies with the larger energy system.

Other NREL energy analysis tools allow users—from consumers to energy professionals—to explore alternative fuel stations and production facilities; analyze hydrogen demand, resources, infrastructure, and cost; and investigate the market potential for various technologies.

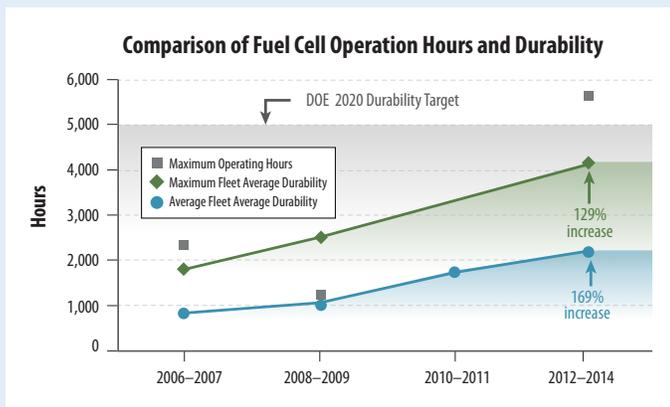


Figure by NFCTEC, NREL

Success Story: Analysis Shows Progress in Fuel Cell Electric Vehicle Durability, Fuel Economy, Range

Activity: NREL has analyzed nearly 3 million fuel cell operation hours, more than 7 million vehicle miles, and nearly 400,000 fueling events on more than 1,500 fuel cell units across transportation, stationary power, and niche market applications. Results from the last decade of NFCTEC-analyzed fuel cell electric vehicle (FCEV) operation show steady and significant improvement in fuel cell durability. On-road fuel economy has also improved by about 30%, and the median distance driven between fuelings has more than doubled.

Impact: These performance results provide an independent assessment of FCEV technology that decision makers can use for RD&D direction, modeling, funding, and reporting.

Tools to Leverage Data Sets and Capabilities

NREL provides innovative, user-friendly tools and applications to help researchers, analysts, planners, and manufacturers leverage the lab's data resources to weigh energy- and emission-reduction options.

Calculators, interactive maps, and other online tools provide external access to analysis results and make it easy for fleet operators, fuel providers, and other transportation decision makers to assess the potential economic, operational, and environmental impact of different energy-saving strategies.

Online users can quickly access cleansed, composite data from the TSDC, NFCTEC, and Fleet DNA databases and use interactive data visualizations to explore the aggregate results.

The AFDC offers more than a dozen interactive online tools to help fleets and drivers select the most efficient, cost-effective transportation options.

NREL is continually updating its capabilities to process additional types and sources of data; develop, refine, and apply new models; and develop new analyses and tools.

High-Performance Computing and Visualization

NREL's Peregrine supercomputer—the largest high-performance computing system in the world exclusively dedicated to advancing renewable energy and energy efficiency technologies—provides the capacity and speed needed to store large data sets and quickly run complex analyses.

Researchers use Peregrine and the Research Electrical Distribution Bus at the Energy Systems Integration Facility to test and simulate the interface between a wide range of vehicle, infrastructure, and power source scenarios at up to the 1-megawatt scale.

Advanced visualization capabilities at NREL's Insight Center allow researchers to effectively convey complex information and illustrate research findings to stakeholders and partners through interactive visual imagery and large-scale simulations.



The Peregrine supercomputer is capable of 2.2 quadrillion calculations per second and operates in the world's most energy efficient data center.

Photo by Dennis Schroeder, NREL 24358

Working with NREL

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www.nrel.gov/transportation/fleettest.html

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www.nrel.gov/hydrogen/systems-analysis.html

NREL's Sustainable Transportation RD&D

As the only national laboratory solely dedicated to renewable energy and energy efficiency, NREL spearheads the RD&D needed to put sustainable transportation solutions on the road. The laboratory's innovative and integrated approach helps government, industry, and other partners develop and deploy the components and systems needed for market-ready, high-performance, low-emission, fuel-efficient passenger and freight vehicles, as well as alternative fuels and related infrastructure.

For more information on NREL's transportation RD&D capabilities and successes, go to www.nrel.gov/transportation.

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