NREL Transportation and Vehicles: Fleet DNA & Commercial Vehicle Technologies

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NREL Transportation and Vehicle RD&D Activities

**Advanced Combustion / Fuels**
- Advanced Petroleum and Biofuels
- Combustion / Emissions Measurement
- Vehicle and Engine Testing

**Advanced Power Electronics and Electric Motors**
- Thermal Management
- Advanced Heat Transfer
- Thermal Stress and Reliability

**Advanced Energy Storage**
- Thermal Characterization / Management
- Life/Abuse Testing and Modeling
- Computer Aided Engineering
- Electrode Material Development

**Commercial Vehicle Technologies**
- Technology Field Testing & Analysis
- Big Data Collection, Storage & Analysis
- Vehicle Systems Modeling
- Super Truck and 21st Century Truck
- Vehicle Thermal Management

**Hydrogen and Fuel Cells**
- Fuel Cell Electric Vehicles
- Fuel Cell Buses
- Fueling Infrastructure
- Hydrogen Systems and Components
- Safety, Codes and Standards

**Mobility Systems**
- Connected and Autonomous Vehicles
- Vehicle Systems Modeling
- Technology Adoption
- Cost of Ownership Modeling
- SMART Cities Columbus

**Infrastructure and Impacts Analysis**
- Vehicle-to-Grid Integration
- Integration with Renewables
- Charging Equipment & Controls
- Fueling Stations & Equipment

**Vehicle Deployment / Clean Cities**
- Guidance & Information for Fleet Decision Makers and Policy Makers
- Technical Assistance
- Online Data, Tools, Analysis

**Regulatory Support**
- EPAct Compliance
- Data & Policy Analysis
- Technical Integration
- Fleet Assistance
Medium- and Heavy- Vehicle Field Testing and Evaluations

Evaluate the performance of alternative fuels and advanced technologies in medium- and heavy-duty fleet vehicles - in partnership with commercial and government fleets and industry groups vehicles.

Collect, analyze and publicly report data:
- Drive cycle and system duty cycle analysis
- Operating cost/mile
- In-use fuel economy
- Chassis Dynamometer emissions and fuel economy
- Scheduled and unscheduled maintenance
- Warranty issues
- Reliability (% availability, MBRC)
- Implementation issues/barriers
- Subsystem performance data & metrics (ESS, engine, after-treatment, hybrid/EV drive focus)

Data stored in FleetDNA for security and limited public accessibility

Frequent interactions and briefings with stakeholders – fleets, technology providers, researchers, and government agencies

UPS, FedEx, Coke, Frito-Lay, Foothill Transit, PG&E, Long Beach Transit, Miami-Dade, Verizon, Walmart, Waste Management...

Proterra, BYD, Odyne, Parker-Hannifin, Cummins, Volvo, Peterbilt, Smith EV, Eaton, Allison, BAE, EDI, Altec, Navistar, PACCAR, Oshkosh, ...

Fleets

Vehicle & Equip Mfg’s

Useful Data, Analysis and Published Reports
NREL Field Data, Testing, & Analysis Tools

Collect Lab and Field Data

Capture, Store and Analyze

Laboratory Testing

Explore & Optimize

Communicate & Inform

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Data from Field Evaluations helps populate FleetDNA database

DOE Fleet Tools (DRIVE, FASTSim, AFleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Identify Barriers, New R&D Opportunities Validate Efforts

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Identify Barriers, New R&D Opportunities Validate Efforts

Partnership with Fleets and Technology Providers = Relevant Results & Optimized Solutions for Real World Applications
Objectives:

- Capture and quantify drive cycle and technology variation for the multitude of medium- and heavy-duty vocations
- Provide a common data storage warehouse for medium- and heavy-duty vehicle data across DOE activities and labs – [www.nrel.gov/fleetdna](http://www.nrel.gov/fleetdna)
- Integrate existing DOE tools, models, and analyses to provide data driven decision making capabilities

For Government: Provide in-use data for standard drive cycle development, R&D, tech targets, and rule making

For OEMs: Real-world usage datasets provide concrete examples of customer use profiles

For Fleets: Vocational datasets help illustrate how to maximize return on technology investments

For Funding Agencies: Reveal ways to optimize impact of financial incentive offers

For Researchers: Provides a data source for modeling and simulation
Zero Emissions Cargo Transport (ZECT)

• Objectives
  o Develop and demonstrate zero emission drayage truck technologies in real world cargo transport operations – Port of LA/Long Beach
  o Measure and analyze vehicle performance (NREL)
  o Accelerate the deployment of zero emission technologies in port drayage operations

• Includes Heavy-duty EV, Fuel Cell range extenders, and CNG hybrids

SCAQMD - NREL FleetDNA Roadmap

• Objectives – apply NREL FleetDNA approach to:
  o match powertrains and advanced technology with observed duty cycles of medium- and heavy-duty trucks.
  o enable intelligent deployment of advanced technology to maximize fuel economy and emissions reductions in the South Coast air basin
  o Currently collecting vehicle duty-cycle data on port drayage, transfer trucks, and delivery vehicles
NREL Baseline Data Collection - Port Drayage

- Instrumented 32 Class 8 Tractors
- 588 vehicle days of 1Hz GPS and vehicle CAN data
- Multiple OEMs
  - Navistar, Volvo, Mack,
    - Freightliner, Peterbilt & Sterling
  - 2 CNG vehicles (not included in fuel analysis)
- Mixture of automatic, automated and manual transmissions
Port Drayage Example

- 71,243 Miles
- 557 Operating Days
- 30 Unique Vehicles
- 3 Operating Companies
- Port of Long Beach & Port of Los Angeles

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NREL Drive Cycle Analysis - Clustering

Characteristic Acceleration vs Aerodynamic Speed

Cluster 1: Creep/Queue Drive Cycle

Cluster 2: Port/Near Dock Drive Cycle

Cluster 3: Local Drive Cycle

Cluster 4: Metro Highway Drive Cycle

Maximum Speed vs Average Driving Speed

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Exploring Options – NREL FASTSim

**Future Automotive Systems Technology Simulator (FASTSim)**

**Step 1:** Input Vehicle & component details -
- Powertrain type
- Power rating
- Energy storage
- Vehicle size & weight
- Wheel/Tire info
- Auxiliary loads and more....

**Step 2:** Select a Standard or Custom Drive Cycle

**Step 3:**
Use real world, duty cycle data for model tuning
- Drive cycle based results
- Fast and easy to use

**Step 4:**
Evaluate outputs -
- Fuel Economy
- Driving Performance
- EV Range
- Drive cycle matching
Develop and evaluate integrated V2G systems, which can reduce local peak-power demands and access grid service value potential.

Explore strategies for enabling the export of vehicle power to assist in grid outages and disaster-recovery efforts.

Leverage charge system power electronics to monitor and enhance local power quality and grid stability in scenarios with high penetration of renewables.

Managed Charging
Evaluate functionality and value of load management to reduce charging costs and contribute to standards development.

Local Power Quality

Emergency Backup Power
Explore strategies for enabling the export of vehicle power to assist in grid outages and disaster-recovery efforts.

Bi-Directional Power Flow
Develop and evaluate integrated V2G systems, which can reduce local peak-power demands and access grid service value potential.

Can functionality be added with little or no impact on battery and vehicle performance?

Information Flow and Control
How is information shared and protected within the systems architecture?

What role will vehicles play and what value can be created?

Vehicle-to-Grid Challenges

Managed Charging

Local Power Quality

Emergency Backup Power

Bi-Directional Power Flow

Life Impacts

Information Flow and Control

Markets and Opportunities
NREL Fleet Evaluations Website
http://www.nrel.gov/transportation/fleettest.html

Fleet DNA Website
www.nrel.gov/fleetdna

DriveCAT
www.nrel.gov/transportation/drive-cycle-tool