**NREL** NATIONAL RENEWABLE ENERGY LABORATORY

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

# Medium- and Heavy-Duty Vehicle Field Evaluations

**PI: Kenneth Kelly**

**NREL Team: Jon Cosgrove, Adam Duran, Arnaud Konan, Mike Lammert, and Bob Prohaska**

June 9, 2015 • Project ID: VSS001

## SUMMARY

NREL partners with fleets and industry to provide unbiased evaluations of advanced medium-duty (MD) and heavy-duty (HD) vehicles, including test results, aggregated data, and detailed analysis.

- Third-party unbiased data provides data that would not normally be shared by industry in an aggregated and detailed manner.
- More than 5.6 million miles of advanced technology MD and HD truck data have been collected, documented, and analyzed on more than 240 different vehicles since 2002.
- Data, analysis, and reports are shared within the U.S. Department of Energy (DOE), national laboratory partners, and industry for research and development (R&D) planning and strategy.

## OVERVIEW

### Barriers

- **Unbiased data:** Commercial users, original equipment manufacturers (OEMs), researchers, and policy makers need unbiased, third-party technology evaluations and data for better understanding of state-of-the-art technology performance to overcome technical barriers.
- **Matching technologies with duty-cycles:** Real-world data and analysis are needed to address variable performance by technologies due to multiple and wide-ranging duty cycles.

### Timeline

| | Q1 | Q2 | Q3 | Q4 | Notes |
|---|---|---|---|---|---|
| UPS HHV | | | | | Completed in FY15 |
| Line-Haul Platooning Phase 1 | | | | | Completed in FY15 |
| Frito-Lay EV | | | | | Planned FY15 completion |
| PG&E PHEV Utility Trucks | | | | | Planned FY15 completion |
| UPS Renewable Diesel Test | | | | | Planned FY15 completion |
| Miami-Dade Refuse HHV | | | | | Kicked off in FY15—ending in FY16 |
| Foothill Transit Bus EV | | | | | Kicked off in FY15—ending in FY16 |
| EV V2G School Bus | | | | | Kicked off in FY15—ending in FY16 |

## APPROACH

Evaluate the performance of alternative fuels and advanced technologies in MD and HD fleet vehicles in partnership with commercial and government fleets and industry groups.

Select Fleet and Technology → Collect Lab and Field Data → Capture, Store, and Analyze → Explore and Optimize → Communicate and Inform → Identify Barriers and New R&D Opportunities, Validate Efforts

*Partnership with Fleets and Technology Providers = Relevant Results and Optimized Solutions for Real-World Applications*

### 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
- Subsystem performance data and metrics (ESS, engine, after-treatment, hybrid/EV drive focus)
- Warranty issues
- Reliability (% availability, MBRC)
- Implementation issues/barriers
- Scheduled and unscheduled maintenance

**Data stored in FleetDNA for security and limited public access**

**DOE modeling tools (FastSIM, DRIVE, AFLEET) used to investigate alternative scenarios**

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

## RELEVANCE

- This activity supports DOE's mission of improving our energy security and supporting the U.S. economy while providing valuable data and information to DOE research partners.
- MD and HD commercial vehicles are a critical part of U.S. trade, commerce, and economic growth and are the fastest growing segment of transportation energy use.
- Fleets are faced with a long menu of alternatives – including propane, natural gas, electric, fuel cells, aerodynamics devices, low-rolling resistance tires, etc. This project provides objective information on the performance of these technologies within the context of their real-world fleet operations.
- Fleets have been active partners in demonstrating advanced vehicle technologies, providing valuable performance data from highly visible applications.
- The new Phase II HD greenhouse gas regulation process acknowledges the need for improved energy efficiency for HD vehicles and will increase the demand for viable solutions.

## BUDGET

- FY14: $600K
- FY15: $600K
- Cost share: Significant cost share provided by fleets and industry participants, including baseline and advanced technology vehicles, vehicle loans for testing, technical support, data access, and data supplied to NREL
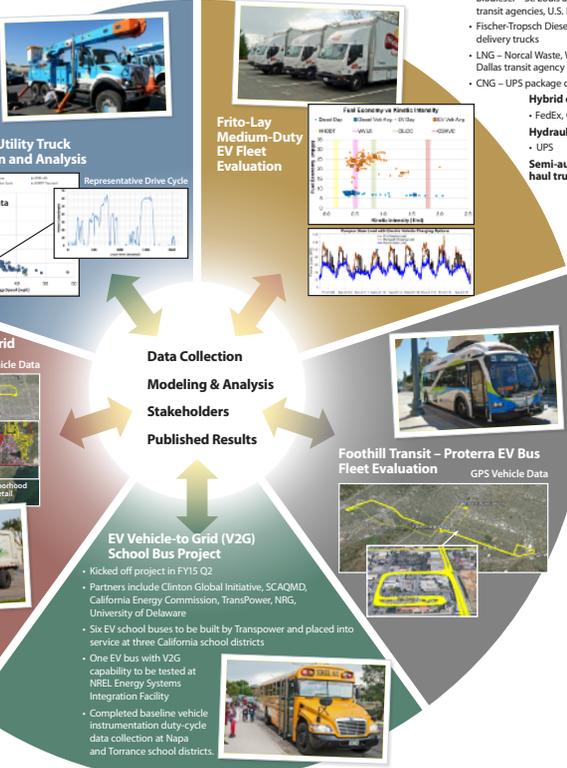
## TECHNICAL ACCOMPLISHMENTS

### FY15 Key Technical Accomplishments

- **Completed UPS Hydraulic Hybrid and Line-Haul Platooning studies** with technical reports, presented to stakeholder community, with specific recommendations made to fleets and technology providers (e.g., UPS, Peloton, others)
- Completed data collection activities, model development (FastSIM, vehicle/building energy model), and preliminary analysis on **Frito-Lay** EV project – scheduled CY15 project completion and reporting
- **Kicked off four new fleet evaluations,** including HHV refuse haulers, Foothill Transit EV buses, EV school bus, and PG&E electrified utility trucks, and UPS renewable diesel projects – leveraging substantial fleet and industry participation
- **Published and presented results** at key industry forums with data provided to FleetDNA database for further analysis and public access
- **Close coordination** with other DOE areas, including Clean Cities/ National Clean Fleet Partnership members, 21st Century Truck partnership, DOE researcher programs.

**PG&E – PHEV Utility Truck Data Collection and Analysis**

Field Data / Representative Drive Cycle



**Miami-Dade Hydraulic Hybrid Fleet Evaluation**
GPS Vehicle Data

Covanta Waste-to-Energy Plant / Neighborhood GPS Detail



### Synergistic Activities

- USEPA – vocational vehicle analysis supporting Phase II greenhouse gas rulemaking
- South Coast Air Quality Management utilization of fleet DNA approach and capabilities to provide vehicle vocational analysis
- Zero Emissions Cargo Transport – data collection and analysis
- California Air Resources Board – hybrid vehicle incentive program testing and evaluation; aerodynamic device testing and analysis
- Eaton Corp. – multi-speed gearbox for commercial delivery MD plug-in electric drive vehicles
- Clean Cities – National Clean Fleet Partnership – natural gas refuse hauler fleet studies (Indianapolis, Denver, Columbus, OH); PG&E PHEV field data collection and analysis
- DOE Energy Storage – battery ownership model
- Recovery Act – MD EV data collection and analysis

**Frito-Lay Medium-Duty EV Fleet Evaluation**



Data Collection
Modeling & Analysis
Stakeholders
Published Results

**Foothill Transit – Proterra EV Bus Fleet Evaluation**
GPS Vehicle Data



### EV Vehicle-to Grid (V2G) School Bus Project

- Kicked off project in FY15 Q2
- Partners include Clinton Global Initiative, SCAQMD, California Energy Commission, TransPower, NRG, University of Delaware
- Six EV school buses to be built by Transpower and placed into service at three California school districts
- One EV bus with V2G capability to be tested at NREL Energy Systems Integration Facility
- Completed baseline vehicle instrumentation duty-cycle data collection at Napa and Torrance school districts.



### Previous Published Results

**Alternative fuels:**
- Biodiesel – St. Louis and Boulder, CO, transit agencies, U.S. Postal Service
- Fischer-Tropsch Diesel – Yosemite Waters delivery trucks
- LNG – Norcal Waste, Waste Management, Dallas transit agency
- CNG – UPS package delivery

**Hybrid electric vehicles:**
- FedEx, Coke, UPS

**Hydraulic hybrids:**
- UPS

**Semi-autonomous line-haul truck platooning**

## MILESTONES

| Month/Year | Milestone | Description | Status |
|---|---|---|---|
| FY14 Q3 | Milestone | Status report on all projects | Complete |
| FY14 Q4 | Milestone | Final report & data on all projects | Complete |
| FY15 Q1 | Milestone | Status report on all projects | Complete |
| FY15 Q2 | Milestone | Status report on all projects | Complete |

In addition to the above milestone reports, the following project reports were published in FY15:
- UPS Hydraulic Hybrid Technical Report – October 2014
- Frito-Lay EV Implementation Report – September 2014
- Peloton Truck Platooning Final Report – August 2014
- Miami-Dade HHV Implementation Report – May 2015
- Foothill Transit Implementation Report – June 2015
- EV School Implementation Report – June 2015
- Frito-Lay Final Technical Report – December 2015

### FY16 proposed work will include:

1. Continued fleet analysis approach (3–4 new projects per year) of new emerging technologies based on highest potential for fuel reduction, need for data/information, and fleet interest.
2. Emerging areas of interest include:
   - MD/HD electrification including grid/building integration technologies
   - Wireless power transfer demonstrations,
   - Validation of cost-effective HEV retrofits
   - Autonomous vehicle technology in commercial fleet applications
   - Evaluation of latest alternative fuel technologies.
3. More "cross-cutting" vocational analysis rather than a single fleet. For example:
   - Use existing data to evaluate trade-offs for a given technology across vocations, e.g., HHV technology in package delivery compared to refuse haulers
   - Evaluate "best" vocations/duty cycles for MD/HD EVs
4. Deep-dive analysis using existing data to address issues discovered in assessments
5. Continued coordination with 21st Century Truck and Clean Cities/ National Clean Fleets Partners to align data, analysis, and industry partnerships
6. Additional coordination and data sharing to enable technology development across VTO offices. For example:
   - Field battery data to inform VTO battery research efforts and technology requirements in MD/HD industry needs
   - Field demonstrations of grid/building integrated EV and HD/MD accessory load requirements.

**Capture Baseline**
Conventional Gasoline/ Diesel Trucks + Daily Facility Operations

**Assess PEV Impacts**
Fuel Savings + Facility Electricity Demand Increase

**Develop Advanced Integration Business Case**
Simulate V2G Peak Shaving Integrate On-Site Renewables Model Battery Size/Life Impacts

**Analyze Demand Management Potential**
Ensure Proper Charging + Reduce Facility Demand Charges

## COLLABORATION AND ACKNOWLEDGMENTS

Additional information can be found at:
http://www.nrel.gov/transportation/fleettest.html