Sustainable Transportation

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Vehicle & Systems Simulation & Testing

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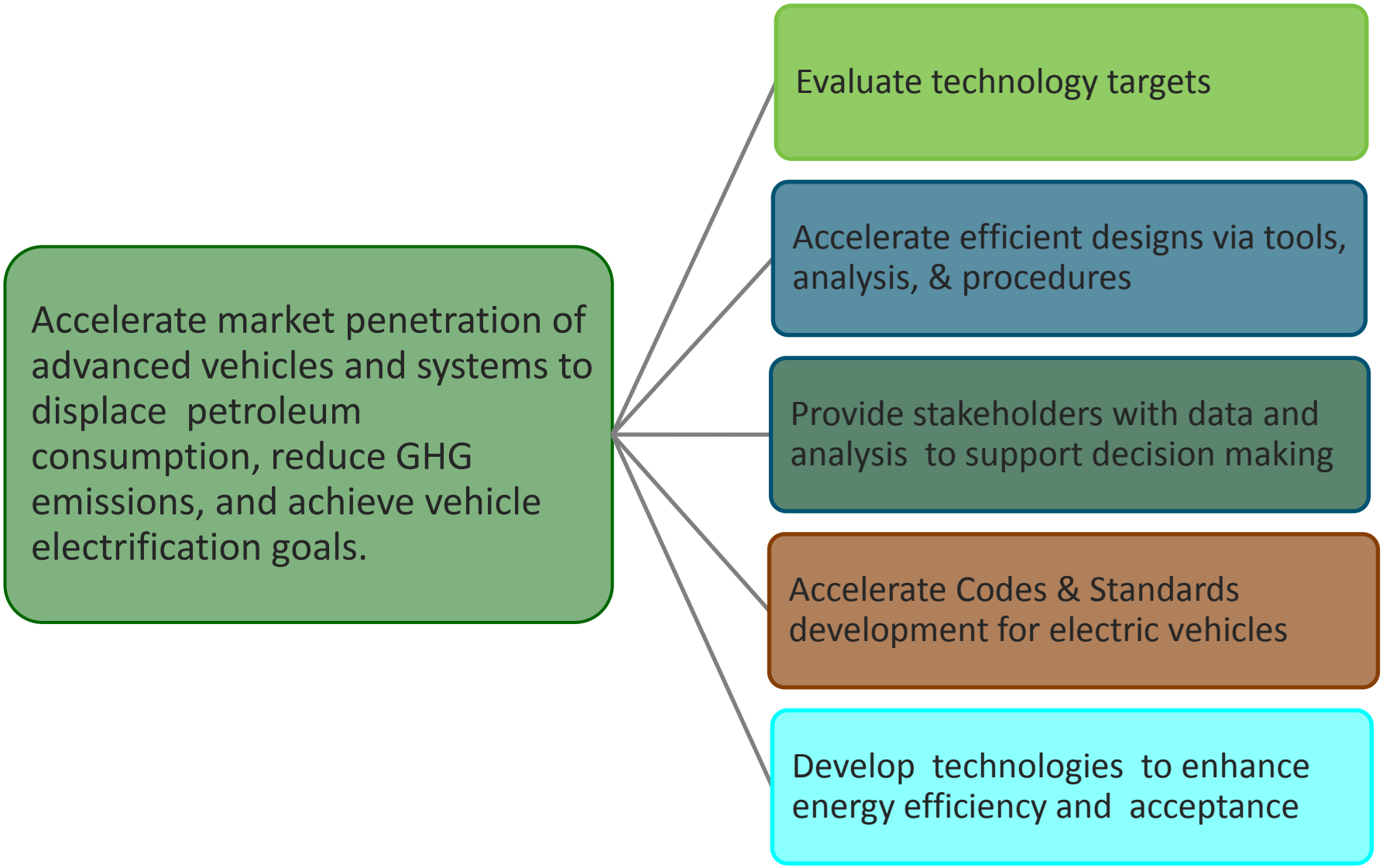
Goals and Objectives



Challenges and Strategies

- Extend EV range
  - Reduce climate control loads
  - Address vehicle systems integration issues
- Improve EV charging
  - Evaluate production technologies
  - Develop advanced technologies
- Enhance Grid Integration
  - Minimize impact of EVs on the electrical grid
  - Leverage synergies with other EERE technologies
- Increase fuel efficiency for Medium and Heavy Duty Trucks
  - Reduce auxiliary and parasitic loads
  - Hybridization & Electrification

Current Portfolio

Modeling & Simulation

Light Duty
- Autonomie
- VTO Portfolio Analysis
- Powertrain
- Controls
- Combustion Engines

Medium & Heavy Duty
- Cool-Calc Thermal Load Analysis Tool

Components & Systems

Power Electronics and Electric Motors

Energy Storage Systems
- Life Cycle Characterization
- Lower Energy Energy Storage

Advanced Engines

Vehicle Evaluations

Light Duty
- Advanced Vehicle Technology Evaluation
- Comprehensive Benchmarking

Medium & Heavy Duty
- Auxiliary Loads Characterization
- Fleet Evaluations and Characterization

Codes and Standards

EV – EVSE Interoperability

Advanced Charging

Grid Integration

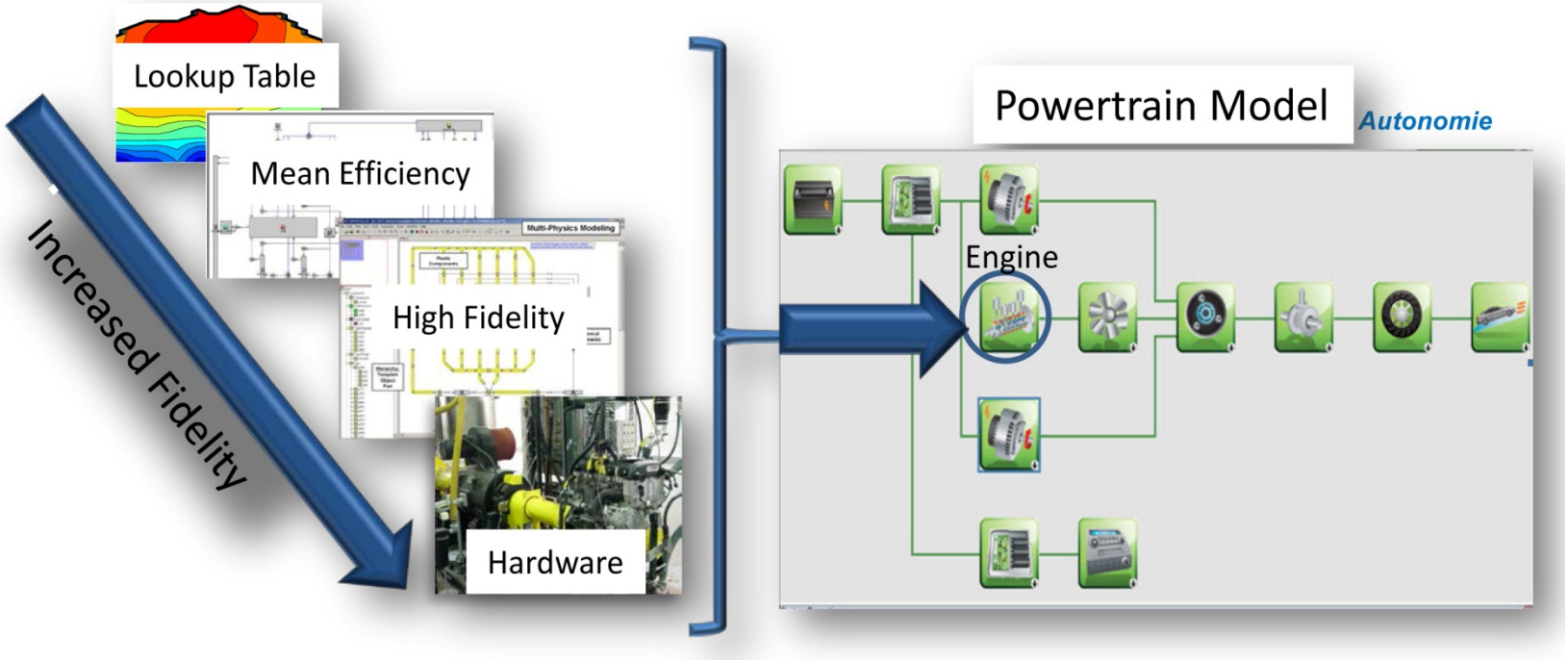
Vehicle Systems Optimization

- Fast and Wireless Charging
- Grid Integration
- Load Reduction, HVAC, & Preconditioning
- Thermal Systems
- Friction & Wear
- SuperTruck
- Aero Drag Reduction
- Zero Emission Cargo Transport

More than 40 active projects in current portfolio

Modeling & Simulation

Develop and use modeling and simulation tools to evaluate the efficiency potential of technologies, aid OEM design processes, and guide DOE R&D activities and goals



- **Model Based Design Tools**
  - Autonomie
  - Thermal System Models
  - Component Models
- **Support GPRA Reporting**

- **Vehicle & Component Simulations**
  - Configurations
  - Control Methods
  - Requirements
  - Sizing
  - Interactions

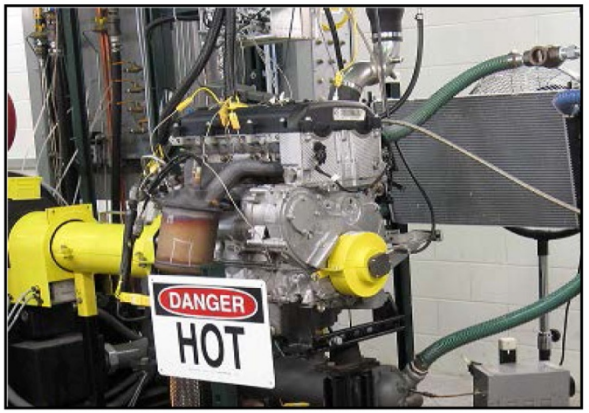
Component/Systems Evaluations

Use hardware in the loop (HIL) and advanced controls simulation to accelerate development of advanced technologies and strategies

HIL allows hardware to be tested in the laboratory at a full vehicle level without the cost and lead time of building a complete prototype vehicle

Component and control algorithm tests are developed on the bench

Components are tested in a real-world environment



Vehicle components are operated real-time in an emulated vehicle context

Lab & Field Evaluations

Utilize structured, repeatable testing methods and real world usage to benchmark and validate vehicle, system, and component technology

- Advanced Vehicle Testing & Evaluation (AVTE) in-use data collection
- Laboratory dynamometer benchmarking of production vehicles
- Medium and heavy duty operational assessment
- Climate control load reduction
- EDV charging infrastructure evaluations
- **100+ Testing partners in North America**

Baseline Performance Testing
Accurate, repeatable snapshot of vehicle performance in a controlled testing environment

Fleet Testing
Vehicular operation in normal fleet (field) operations for one to three years

Accelerated Reliability Testing
Rapid accumulation of several years or entire vehicle life of mileage on each test vehicle

Codes and Standards

Support development and adoption of codes and standards for electric vehicles

Support Standards Development

- Lead and serve on SAE committees that address communications, interoperability, security, safety, and performance of PEVs and EVSE

Standards Validation

- Identify gaps in technology and recommend enabling solutions through creation of proof-of-concept hardware/software and validation of approaches

Strategic Coordination

- Support mapping of gaps and priorities through ANSI development of Standardization Roadmaps for Electric Vehicles

International Cooperation

- Coordinate efforts to adopt international standards with a focus on interoperability validation procedures and the Smart Grid

Promote Development of Efficient Technologies in Motorsports

- Stimulate rapid vehicle technology development and education of consumers of the benefits of fuel efficient technologies through Green Racing

Vehicle Systems Optimization

Investigate systems optimization strategies and enabling technologies to enhance vehicle efficiency, robustness, and emissions performance

Aerodynamic Drag Reduction

- CFD tools/simulation model development and assessment with wind tunnel testing and fleet demonstrations of drag reduction devices

Friction and Wear Reduction

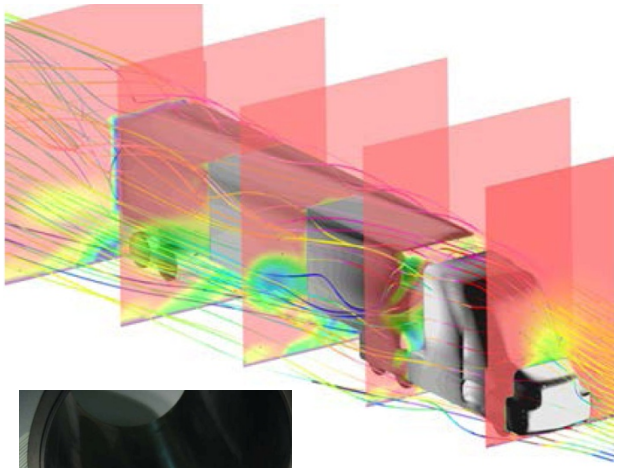
- Systems approach examining development and interaction of materials, lubricants and components focusing on boundary regime

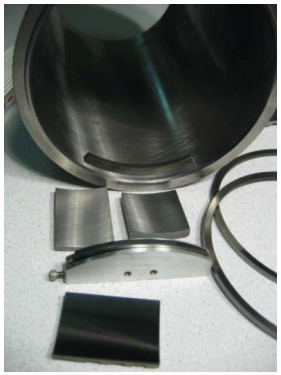
Thermal Control and Auxiliary Load Reduction

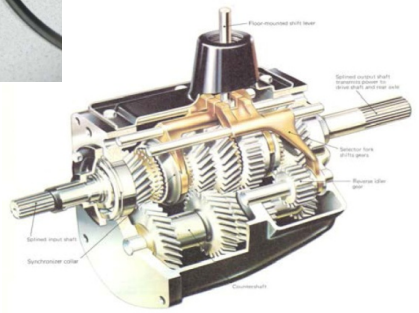
- Nanofluids and nucleated boiling analysis to optimize radiator performance, size, and pumping losses; and integrated external and underhood thermal analysis

Fast Wireless Charging and Smart Grid

- Benchmark efficiencies, safety, and cyber security of WPT systems and model and evaluate dynamic WPT scenarios and integration of fast charging with renewables





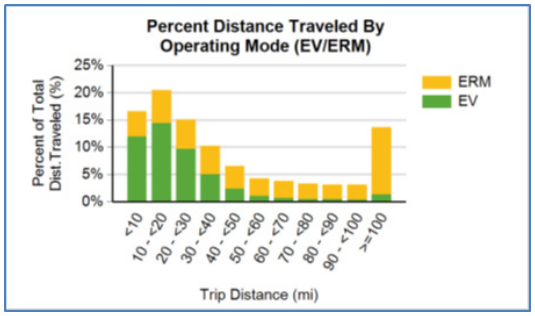


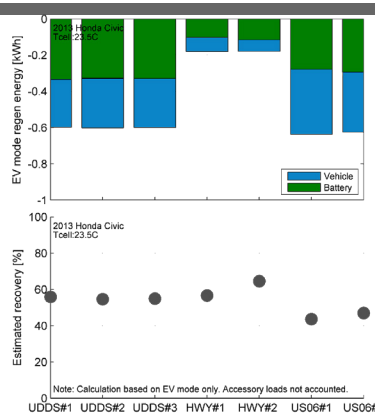
Budget FY 2013-15

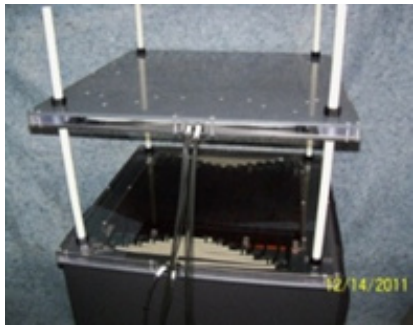
Project Areas	FY 2013 Funding ($Millions)	FY 2014 Funding ($Millions)	FY 2015 Request ($Millions)
– Modeling and Simulation	6.67	4.49	5.00
– HIL & Component Evaluations (* Merged into Modeling & Simulation in FY 2015)	2.66	1.38	-
– Laboratory & Field Evaluations (FY 2015: Vehicle Technology Evaluations)	11.18	7.08	5.50
– Codes & Standards	4.83	5.06	4.80
– Vehicle Systems Optimization (FY 2015: Vehicle Systems Efficiency Improvements)	5.01	5.38	7.70
Projects Competitively Awarded through FOA			
– Advanced Vehicle Testing & Evaluation	-	3.00	4.00
– Super Truck	4.09	3.00	5.00
– Wireless Charging	6.27	-	-
– Zero Emission Cargo Transport	-	4.00	-
– Advanced Climate Control/Auxiliary Load Reduction	4.08	5.00	-
– Multispeed Gearbox	-	3.00	-
– Friction and Wear	-	1.00	
– Grid Integration	-	1.00	5.00
– PHEV TADA	0.47	-	-
– Autonomous Vehicle Technologies	-	-	2.50
Total, Vehicle Systems	**45.21**	**43.39**	**39.50**

Accomplishments

- Provided stakeholders with analysis of usage data on 11,500 PEVs and 17,000 charging stations
- Developed & used procedures to evaluate regenerative braking effectiveness and improve regen controls
- Deployed commercialized version of Autonomie vehicle modeling & simulation platform
- Achieved 10 KW Wireless Charging at 88% efficiency in Lab Demonstration
- Quantified benefits of HD Aero Retrofit Devices. Fuel efficiency increase of 5.5% - 7.5% demonstrated during Fleet Testing
- OEM R&D collaboration identified climate control configurations & strategies that cut energy consumption by up to 41.3%.
- Developed commercial ready technologies to enable Smart-Grid Communication & Control





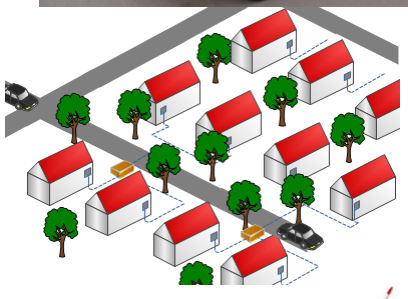


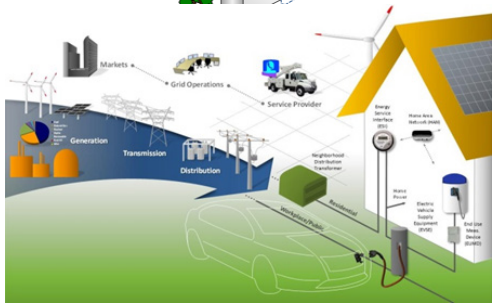
Status

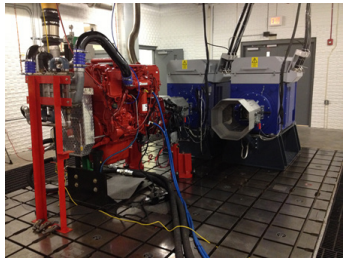
- 144 million test miles and data for 6 million charge events accumulated on 11,500 PEVs representing 72 PEV models
- Autonomie Vehicle Modeling & Simulation Software licensed by 750 users at 150 companies worldwide

2013 Progress

- Extend EV range
  - Performed R&D projects on Climate Control Load Reduction
  - In-depth benchmarking of PEVs, development of accurate vehicle models to understand benefits of new technologies
  - Evaluated advanced ESS technologies (INL, NREL)
- Improve EV charging
  - Conducted analysis on production and advanced EVSE, including wireless charging solutions (ANL, INL)
  - Supported EV Codes and Standards Development (SAE) & Roadmap 2.0 (ANSI)
- Grid Integration
  - Established the Smart Grid Interoperability Center to accelerate international standards development (ANL)
  - Coordinated with other EERE/DOE Offices to develop strategy and identify opportunities
- Increase fuel efficiency for Medium and Heavy Duty Trucks
  - New development and test capability at Vehicle Systems Integration Lab (ORNL)
  - Developed technologies to reduce parasitic loads (ANL, LLNL)
  - Continued to Build Fleet DNA Database to assist partners with vehicle technology adoption (NREL, ORNL)







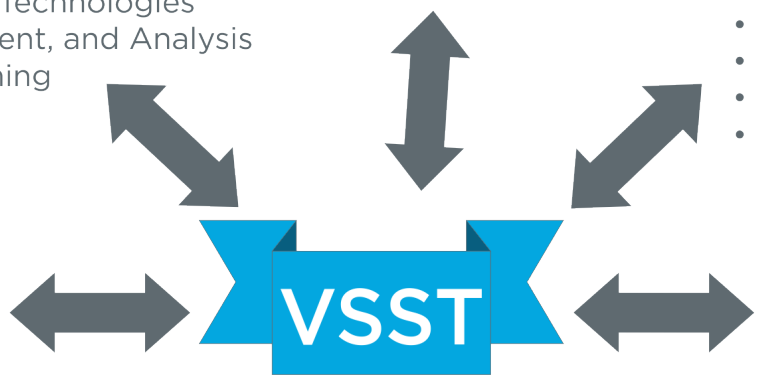
Collaborations -VSST Supports Partners

VTO
- R&D Programs
  - Hybrid Electric Systems
  - Materials Technology
  - Advanced Combustion Engine R&D
  - Fuel and Lubricant Technologies
  - Outreach, Deployment, and Analysis
- Office Strategic Planning

Industry
- Automobiles, Medium and Heavy Vehicles
- US Drive Tech Teams
- OEMs, Suppliers

Government
- DOT
- EPA
- DOD
- NIST

EERE/DOE
- Vehicle Electrification
  - Grid Interaction
  - Renewables
  - Buildings



Domestic/International Partners
- SAE, UL, ANSI, IEEE
- ISO, IEC, DIN, JARI, CATARC
- Universities

- Predictive modeling and assessment of advanced vehicle options
- Component, system, and vehicle simulation, optimization, and validation
- R&D of advanced enabling system technologies
- Codes and Standards development support and validation
- Deployment/Market insights

Competitively Awarded Projects

Transportation Electrification (ARRA)

- Develop, demonstrate, and assess electric vehicle technologies and infrastructure to accelerate implementation nationwide

Super Truck (ARRA)

- Develop and demonstrate 50% total increase in vehicle freight efficiency through systems-level optimization

Wireless Charging (FY12)

- Develop WPT system with greater than 85% efficiency, power transfer >6.6 kW, and maximum positioning tolerance while meeting emissions guidelines

Zero Emissions Cargo Transport (FY12, FY14)

- Develop and demonstrate zero emissions truck technologies in real world cargo transport operations

Advanced Climate Control/Auxiliary Load Reduction (FY13, FY14)

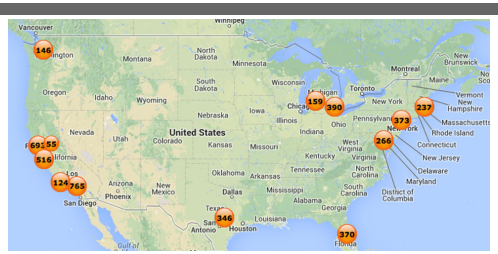
- Develop and demonstrate advanced technologies to reduce the energy impact of ancillary systems on electric vehicles

Multispeed Gearbox (FY14)

- Develop advanced gearbox technologies to increase efficiency and performance of electric-drive trucks

Friction and Wear (FY14)

- Develop methods to predict the impact of friction and wear mechanisms in internal combustion engines on vehicle fuel economy



Summary

- VSST's goal is to accelerate market penetration of advanced vehicles and systems
  - Evaluate impacts of technologies at the vehicle systems level
  - Develop tools, analysis, and procedures
  - Provide stakeholders with data and analysis
  - Support Codes & Standards development
  - Develop technologies that enhance energy efficiency and acceptance
- More than 40 active projects working to achieve real world impacts

Contacts

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