Current Fiscal Year Status of the Hybrid & Electric Systems R&D at the U.S. – DOE

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Vehicle Technologies Office
Outline

• The *EV Everywhere* Grand Challenge
• Program Structure and Budget
• Vehicle & Systems Simulation & Testing (VSST)
• Energy Storage R&D
• Advanced Power Electronics and Electric Machines (APEEM)
• Conclusions
Enable the U.S. to be the first in the world to produce plug-in electric vehicles that are as affordable as today’s gasoline-powered vehicles within the next 10 years.

- **Technology Push (R&D):** targets focus on reducing PEV costs
  - Advanced batteries,
  - Electric drive systems,
  - Lighter weight structures,
  - Enabling technologies such as advanced climate control.

- **Charging Infrastructure (Enablers):**
  Critical issues include codes and standards, siting, grid integration, permitting, and signage.

- **Market Pull (Consumer Acceptance):**
  Consumer education and exposure to PEVs, innovative PEV ownership incentives, and leadership by example among public and private fleets.
Program Structure and Budget

Hybrid and Electric Systems

Vehicle & Systems Simulation & Testing
Lee Slezak
David Anderson

Electrochemical Energy Storage
David Howell
Tien Duong
Peter Faguy
Brian Cunningham

Advanced Power Electronics & Electric Machines
Susan Rogers
Stephen Boyd

Hybrid and Electric Systems R&D Budget

Budget ($, Million)


$57.1 $55.6 $72.2 $82.1 $122.7 $142.3 $145.8 $164.9 $156.4 $147.9

*President’s Budget Request
Vehicle & Systems Simulation & Testing (VSST): Overview

Industry Awards
Develop, Integrate, & Demonstrate Advanced PEV Technologies

Laboratory and Field Evaluations
Performance benchmarking
Accelerated reliability data
Modeling tool validation

Vehicle Modeling and Simulation
Develop & use modeling tools
Assess technology potential
Component Interactions
Goal setting for R&D
Quantify System Requirements

Codes and Standards
Standards Committee Participation
Develop and Validate Technology Development

Vehicle Systems Optimization
Reduce auxiliary and parasitic loads
Enabling Technologies

Accelerate Market Penetration of EVs

Autonomie
EVSE
Virtual Design

EV Integrated with Smart Grid
Wireless Power Transfer
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Organized by: [Fira Barcelona]  
Hosted by: [AVERE, NRE, Aventurium de Barcelona]  
In collaboration with: [EVAAP, EDTA]  
Supported by: [European Commission]
VSST: Highlights

- Initiated data collection on thousands of vehicles and EVSEs deployed through Transportation Electrification:
  - 4.6 million LDV PHEV/EV charge events on 16,000 EVSE used 36,260 MWh
  - 181,477 LDV PHEV/EV miles and 9,586 charging events documented per day
  - 574,435 Medium Duty EV Truck miles documented for 339 vehicles in commercial service

- Total Advanced Vehicle Testing Activity (AVTA) Experience:
  - Shifted focus from HEV to PHEV/EV
  - 120 million electric drive vehicle test miles accumulated on 11,600 Light Duty vehicles representing 122 different models to date
  - 5.1 million test miles accumulated on 198 different MD/HD vehicles since 2002
  - Testing under varied and extreme thermal conditions
  - Evaluated 15 EVSE and DCFC hardware units, and 1 wireless charging system
  - Multiple NDAs and CRADAs protect manufacturers’ technologies and PII

- Deployed commercialized version of Autonomie vehicle modeling & simulation platform
  - Developed through CRADA between Argonne National Lab and General Motors
  - Distributed through LMS
Significant battery advancements are needed to enable a large market penetration of PEVs.

**2012 Battery Technology**
- $600/kWh, 100 Wh/kg, 200 Wh/l, 400 W/kg

**2022 Battery Technology**
- $125/kWh, 250 Wh/kg, 400 Wh/l, 2,000 W/kg

Lithium-ion batteries in today's electric drive vehicles use a combination of positive active materials based on nickel, manganese, or iron; matched with a carbon or graphite negative electrode.

New concepts in lithium-ion technologies have the potential to more than double the performance and significantly reduce the cost. Beyond lithium-ion technologies (lithium metal, lithium sulfur, and lithium air) may also meet the challenge.
Energy Storage R&D: Programmatic Structure

The energy storage effort is engaged in a wide range of topics, from fundamental materials work through battery development and testing.

- High energy cathodes
- Alloy, Lithium anodes
- High voltage electrolytes
- Beyond Li-ion couples
- High rate electrodes
- High energy couples
- Fabrication of high energy cells
- Ultracapacitor carbons
- Hybrid Electric Vehicle (HEV) systems
- 10- and 40-mile Plug-in HEV systems
- Advanced lead acid
- Electric vehicle batteries

Lab and University Focus

Industry Focus
• Current cost estimates average less than $325/kWh (useable)
• Manufacturer estimates with USABC’s battery cost model
  – Engineered prototype cells and modules that meet DOE/USABC system performance targets.
  – Production of 100,000 batteries per year.
  – Validated using established test procedures.
  – Strong correlation with ANL BatPac model projection

• These battery development projects focus on advance cathodes, processing improvements, cell design and pack optimization. Standard electrolyte & graphite anode were used.
• The NREL Clean Energy Manufacturing Initiative (CEMI) Analysis focused on similar battery technology.
Covers a range of vehicle electrification applications

**HEV**
- Blended ICE/Electric
  - Power requirement ≥ 55 kW
  - Parallel architecture
  - Intermittent short operation
- 120 V AC

**PHEV**
- Battery Charger
- Battery
- Boost Converter
- Inverter
- Electric Motor

**EV**
- Sized for Electric Only
  - Power required increases (up to 200 kW)
  - Series architecture
  - Always “on”

**Traction Drive Components**
(varies within vehicle architectures)
- Battery charger - plug-in vehicles require a battery charger
- Boost converter – step up the battery voltage to a higher output voltage when the electronic circuit requires a higher operating voltage than the battery can supply
- Inverter – convert direct current (DC) to alternating current (AC) to provide phased power for vehicle traction motors and generators
- Electric motor - provide power for driving

**Power Management**
(varies within vehicle architectures)
- Bi-directional DC-DC converter – step up or step down the high battery voltage to move power among vehicle buses to operate accessories, lighting, air conditioning, brake assist, power steering, etc
APEEM: Industry R&D Highlights

- Completed analysis of non-RE motor design.
- Magnetic finite element analysis demonstrates a feasible architecture to enable the use of non-RE magnets.
- Motor build to demonstrate feasibility.

- Evaluated multiple motor topologies – down-selected 3.
- Identified scalable manufacturing methods for advanced materials.

- Completed assessments of 3 inverter types.
- Developed understanding of cost reduction attributed to technology improvements and commonality of design.
Conclusions

• VTO’s hybrid electric systems team works with industry, universities, and national laboratories to develop advanced transportation technologies – including hybrid drive technologies, advanced energy storage, power electronics and motors, and vehicle systems simulation & testing.

• VTO works in partnership with the U.S. automakers through the United States Council for Automotive Research (USCAR) partnership, funding high-reward/high-risk research.

• Considerable progress was made and work continues with industrial, government, and scientific partners to overcome the remaining challenges to commercialization.
Thank you!

For additional Information, please contact

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