evs 27

The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION.

Barcelona, Spain
17th-20th November 2013

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

Lee Slezak/David Howell

Vehicle Technologies Office

Organized by Fira Barcelona avele

Hosted by AVERE mea Ajuntament de Barcelona

In collaboration with EVAAP EDTA

Supported by European Commission

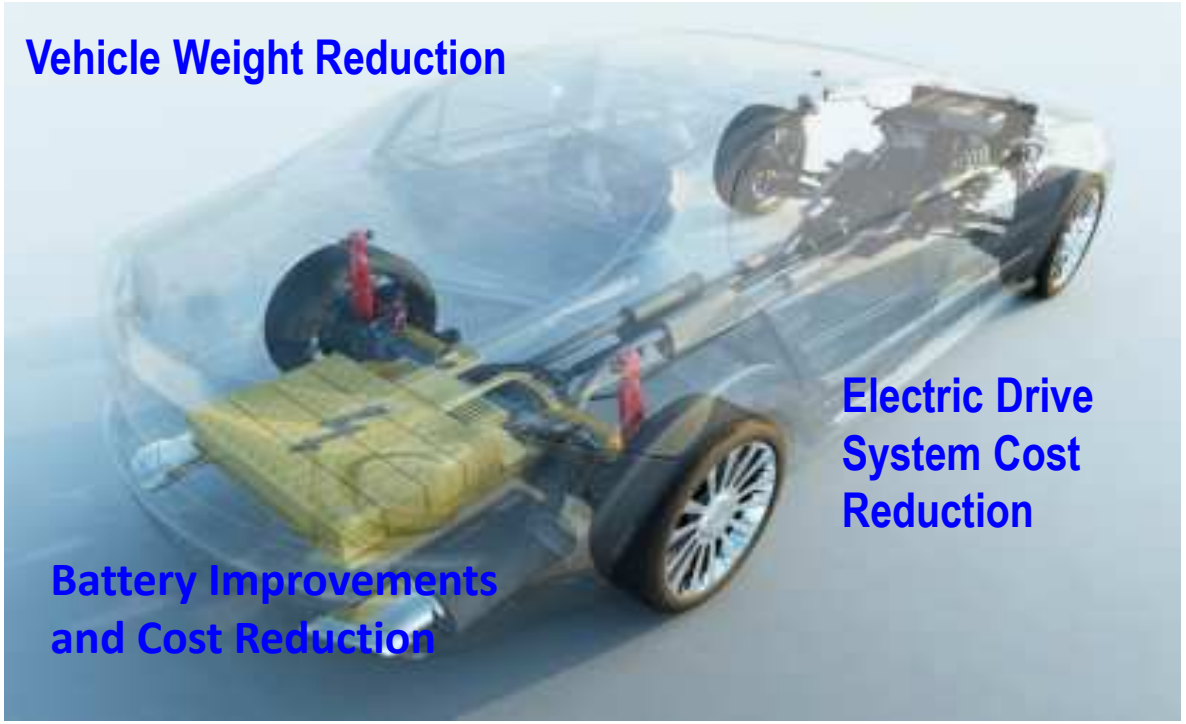
Outline

- 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

The *EV Everywhere* Grand Challenge

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.



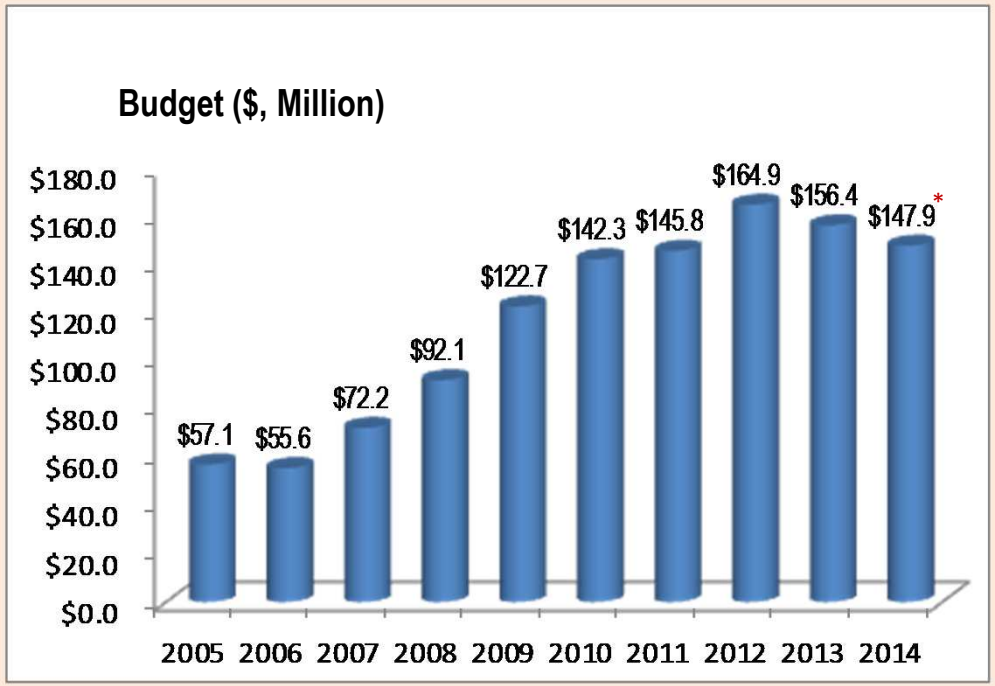
Organized by Hosted by In collaboration with Supported by

Program Structure and Budget

Hybrid and Electric Systems

Vehicle & Systems Simulation & Testing	Electrochemical Energy Storage	Advanced Power Electronics & Electric Machines
Lee Slezak David Anderson	David Howell Tien Duong Peter Faguy Brian Cunningham	Susan Rogers Stephen Boyd

Hybrid and Electric Systems R&D Budget



*President's Budget Request

Organized by Fira Barcelona avele

Hosted by AVERE nrel Ajuntament de Barcelona

In collaboration with EVAAP EDTA

Supported by European Commission

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

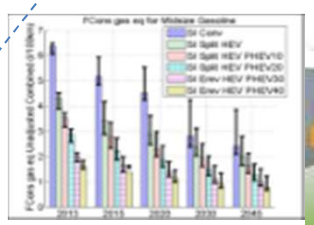
Enabling Technologies

Accelerate Market Penetration of EVs

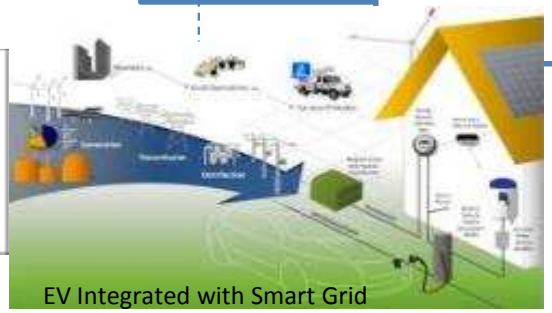
EVSE

Autonomie

Virtual Design



Predict Impact



EV Integrated with Smart Grid

Wireless Power Transfer

Organized by Fira Barcelona avele

Hosted by AVERE mea Ajuntament de Barcelona

In collaboration with EVAAP EDTA

Supported by European Commission

VSST: Participants

Project Area	Project Group	National Labs						Industry		
		ANL	INL	LLNL	NREL	ORNL	PNNL	Vehicle OEMs	Component OEMs	Regional Government
Industry Awards Technology Development and Demonstration	PHEV Technology Acceleration and Demonstration Activity							■		
	Transportation Electrification							■	■	■
	SuperTruck							■		
	Wireless Charging (Light duty)					■		■	■	
	Zero Emissions Cargo Transport									■
	Energy Load Reduction, Advanced HVAC, Cabin Preconditioning							■	■	
Laboratory and Field Evaluations	Light Duty	■	■		■					
	Medium/Heavy Duty				■	■				
Vehicle Modeling and Simulation	Light Duty	■				■				
	Medium/Heavy Duty	■			■	■				
Codes and Standards		■	■			■	■			
Vehicle Systems Optimization	Aerodynamics			■						
	Fast & Wireless Charging		■		■	■				
	Friction & Wear	■								
	Thermal Control	■								

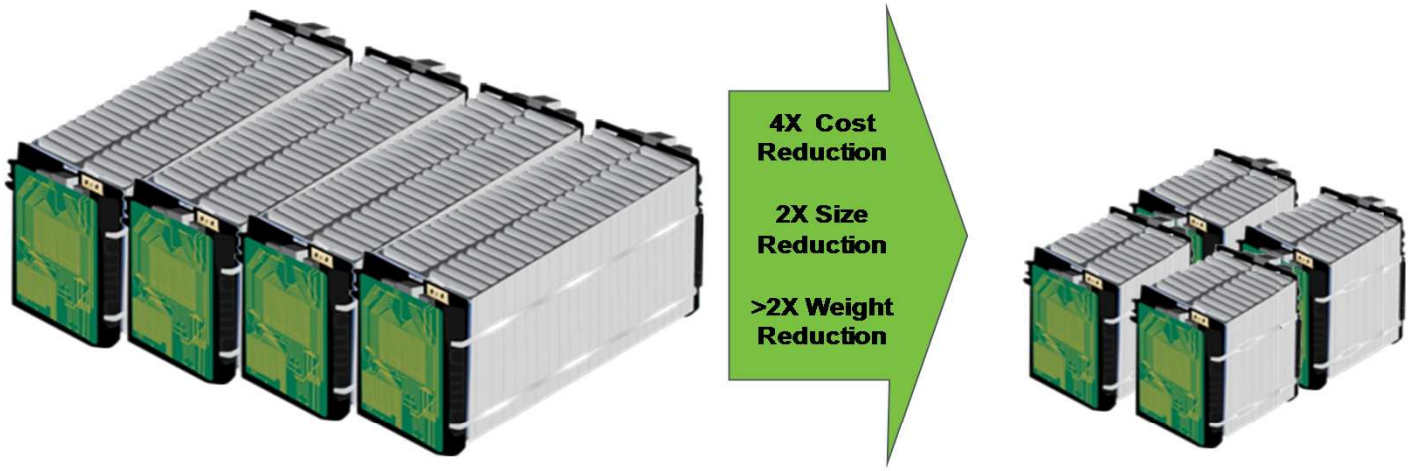
Organized by Hosted by In collaboration with Supported by

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

Energy Storage R&D: *EV Everywhere* Targets

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

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.

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

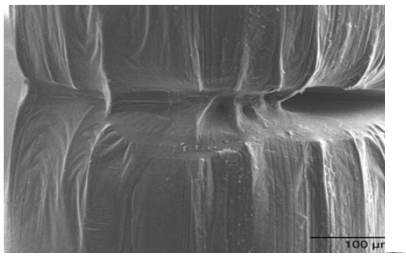
New concepts in lithium-ion technologies have the potential to more than double the performance and significantly reduce the cost. Beyond lithium-ion technologies (lithium metal, lithium sulfur, and lithium air) may also meet the challenge.

Organized by Hosted by In collaboration with Supported by

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

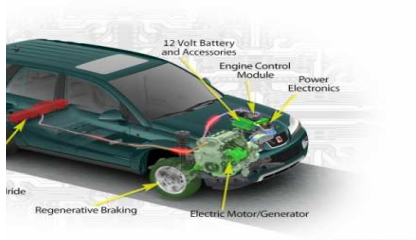
Advanced Materials Research → **High Energy & High Power Cell R&D** → **Full System Development & Testing** → **Commercialization**



- 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

Organized by Fira Barcelona, avele

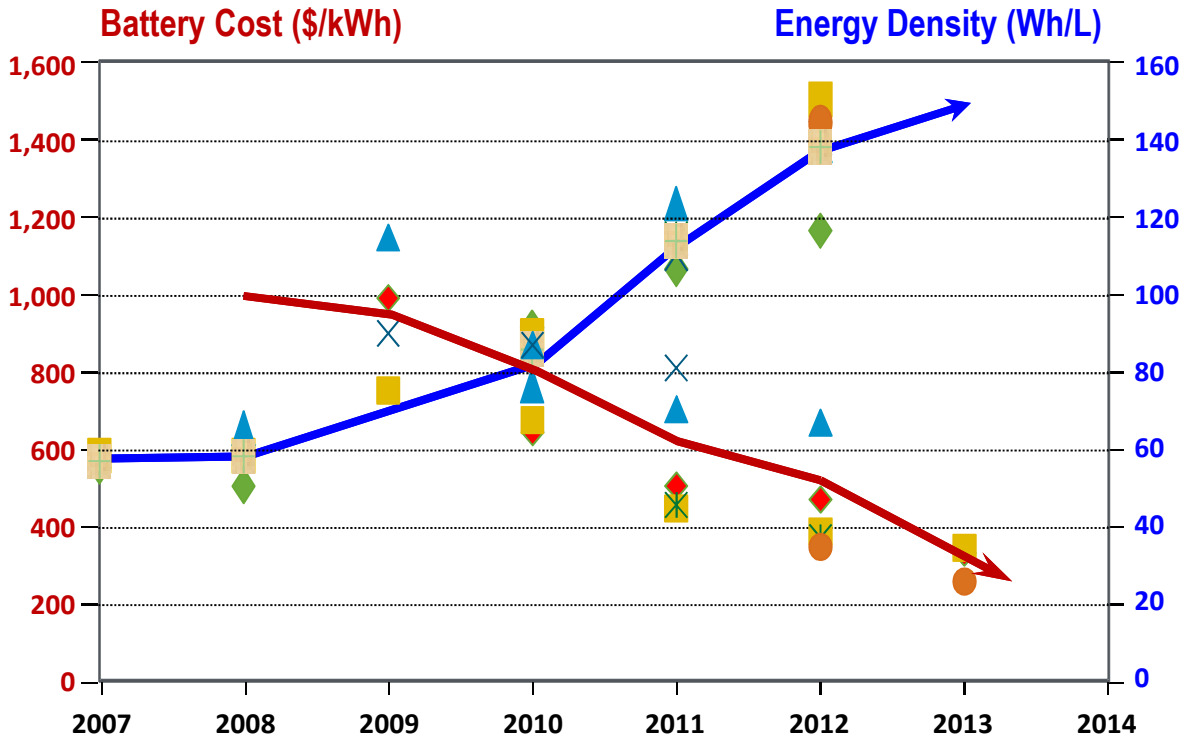
Hosted by AVERE, mea, Ajuntament de Barcelona

In collaboration with EVAAP, EDTA

Supported by European Commission

Energy Storage R&D: Battery Cost Reduction & Energy Density

- 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.**

Advanced Power Electronics & Electric Machines (APEEM): Overview

Covers a range of vehicle electrification applications

HEV

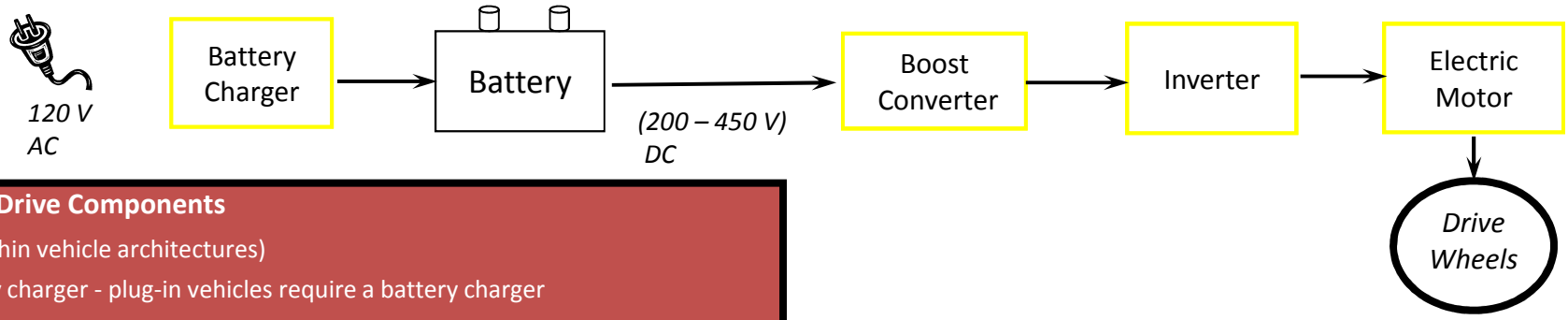
Blended ICE/Electric
- Power requirement ≥ 55 kW
- Parallel architecture
- Intermittent short operation

PHEV

EV

Sized for Electric Only
- Power required increases (up to 200 kW)
- Series architecture
- Always "on"

Traction Drive Components (generic architecture)



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

Organized by Fira Barcelona avele

Hosted by AVERE mea Ajuntament de Barcelona

In collaboration with EVAAP EDTA

Supported by European Commission

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.

UQM Motor Package

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

GE Soft Magnetic Laminates

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

Module Testing at GM

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

Lee Slezak, Vehicle Technologies Office, 202-586-2335

Dave Howell, Vehicle Technologies Office, 202-586-3148

Organized by Hosted by In collaboration with Supported by