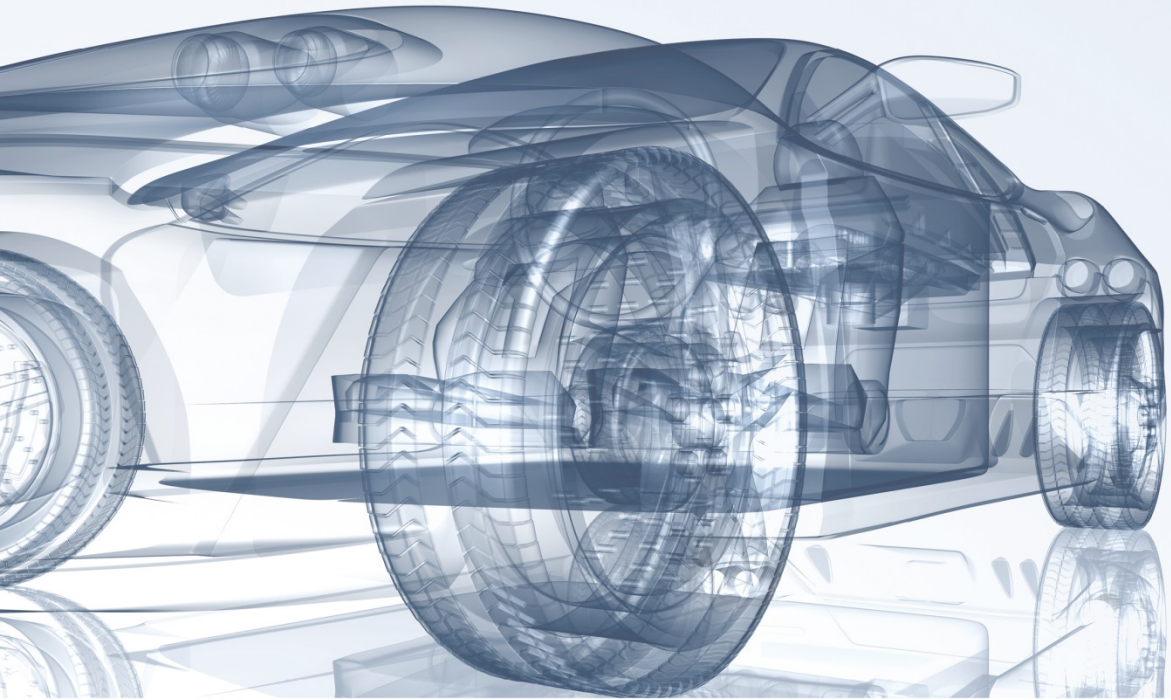
evs 30



The 30th International
Electric Vehicle
Symposium & Exhibition

October 9–11, 2017

Messe Stuttgart, Germany

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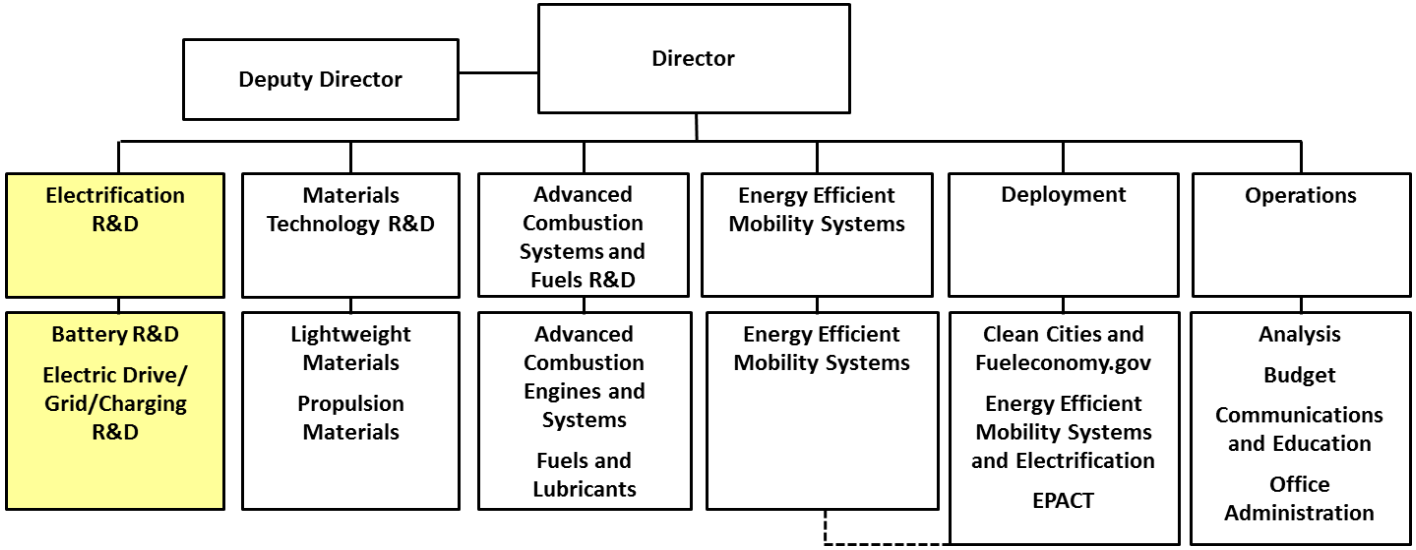
Electrification Systems R&D Overview (2016-2017)

- Title: DOE Electrification Systems R&D Overview for Fiscal Years 2016-2017.
- Authors: David Howell, Steven Boyd.
- Organization: Vehicle Technologies Office, U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585.
- Presented by: James F. Miller, Argonne National Laboratory.

Agenda

- Introduction
- R&D Areas
  - Electric Drive/Grid/Charging Infrastructure
  - Advanced Batteries R&D
- Optimizing Opportunities for Energy Savings

Organization Chart for the DOE Vehicle Technologies Office (VTO)



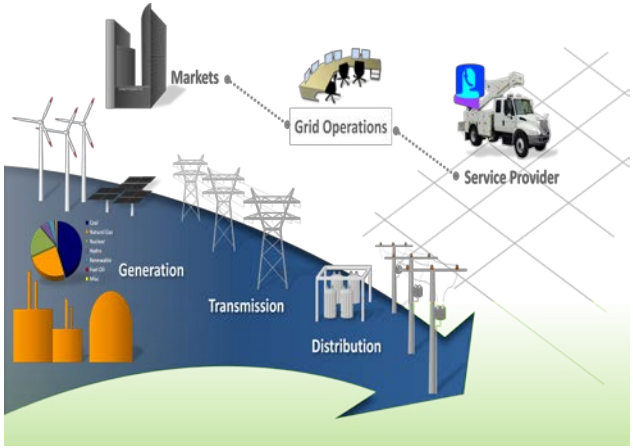
Recent Electrification Systems R&D Budgets

Fiscal Year (FY)	2011	2012	2013	2014	2015	2016	2017
Budget ($, Million)	$145.8	$164.9	$153.4	$151.3	$140.1	$173	$146

Electric Drive / Grid / Charging Infrastructure: Overview

Increase the benefits and reduce the barriers to vehicle electrification through R&D and related supporting opportunities

- Electric Drive Technologies (EDT): 100 kW Electric Drive System $6/kW in 2025
- Develop technologies that minimize the impacts of EV charging on the Nation's electric grid and support vehicle electrification
- There is significant continuing interest for vehicle electrification from the automotive industry



Utility Grid Infrastructure

Intelligent Charging & Grid Services

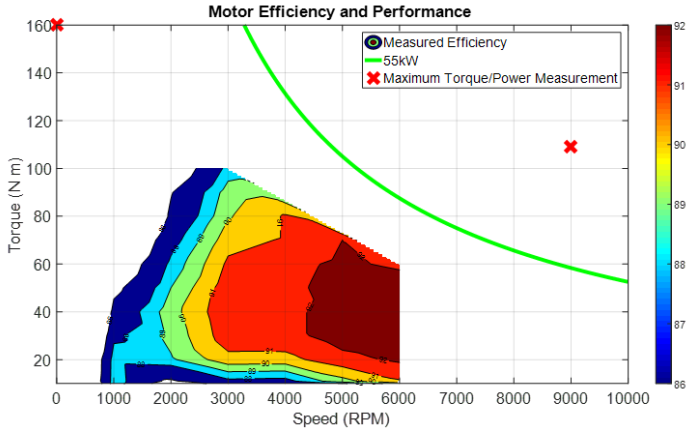
Electric Drive Technologies R&D

Advanced Batteries

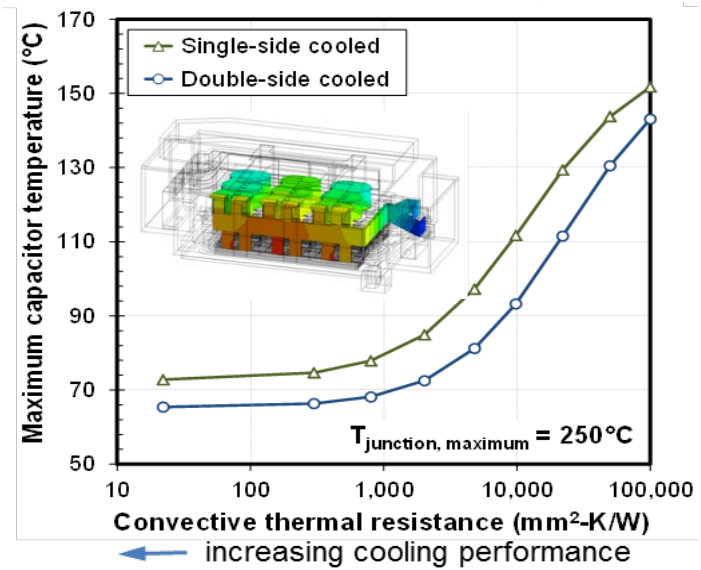
Electric Drive / Grid / Charging Infrastructure: Highlights

High Power Density Ferrite Permanent Magnet Motor

ORNL ferrite motor prototype on dynamometer



Enabling Power Dense, High Temperature Power Electronics



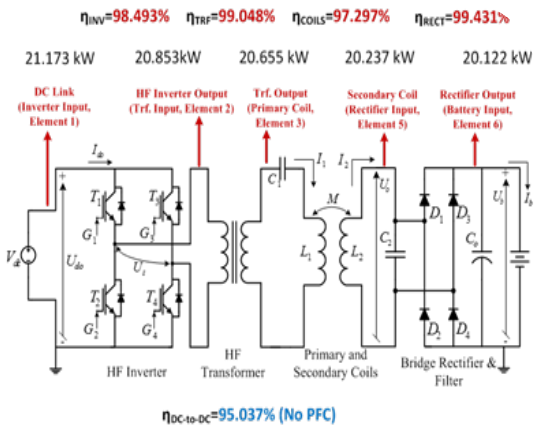
Electric Drive / Grid / Charging Infrastructure: Facilities

Energy System Integration Facility

EV Smart Grid Interoperability Center

Electric Drive / Grid / Charging Infrastructure: Accomplishments

ORNL demonstrated 20kW WPT at 90% efficiency



NREL evaluated thermal load reduction technologies for a 2016 PHEV

EV Sub-metering technology transitioned to commercial building application

Mission

Enable a large market penetration of electric drive vehicles through innovative battery research and development.

Goal

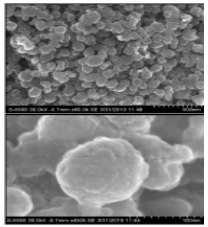
Research new battery chemistry and cell technologies that can reduce the cost of electric vehicle batteries to less than $100/kWh, increase range to 300 miles and decrease charge time to 15 minutes or less. Ultimate goal is $80/kWh.

Budget

Funding in millions	FY 2016	FY 2016	FY 2016	FY 2017	FY 2018
Battery Technology R&D	$99	$99	$103.0	$101.2	TBD

Focus Areas

Advanced Battery Materials Research
TRL 2-3

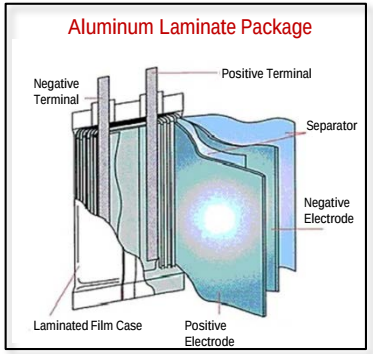


- **Budget:** $59.1M
- National Laboratories
- Universities & Industry
- Battery500 Consortium

Battery Materials Research
- High capacity/High Voltage cathodes
- High voltage electrolytes and Solid State electrolytes
- Alloy & lithium metal anodes
- Material & Cell diagnostics and modelling

Battery Materials Research
- Anode capacity > 1000mAh/g
- Cathode capacity > 300mAh/g
- High-voltage cathodes & 5V stable electrolytes
- Solid-polymer electrolytes with >10-3 S/cm ionic conductivity

Advanced Battery Cell Research
TRL 3-4



- **Budget:** $42M
- USABC
- National Lab Testing
- Industry FOAs
- CAEBAT

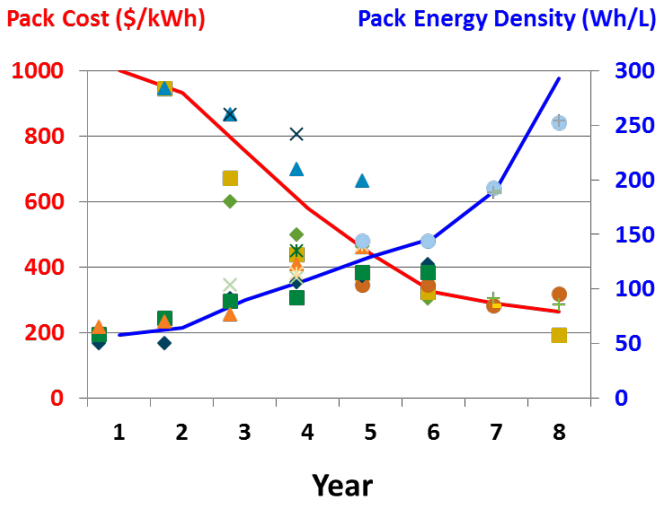
Robust EV Battery Cell Development
- Cost reduction
- Power and Capacity Improvement
- Cycle and calendar life
- Fast Charge capability

Battery Pack Targets
- $100/kWh EV pack cost
- 1,000 cycles and 10+ calendar year life
- Fast charge (20-80% SOC in under 15 min)

Battery Cost

- DOE R&D supported significant Battery Cost Reductions (3X) since 2008.
- **GM announcement: LG Chem cells cost $145/kWh (total energy)**
  - ~$170/kWh (useable)
  - Plus ~$50-65/kWh pack component and assembly cost (revised)
  - Total battery cost of ~$220-235/kWh (useable)
- **Tesla estimate: $190/kWh (total energy)**
  - Assuming 85% of the capacity is "useable", the battery cost is ~$223/kWh (useable)

$245 Includes pack component and assembly cost of $65-75/kWh

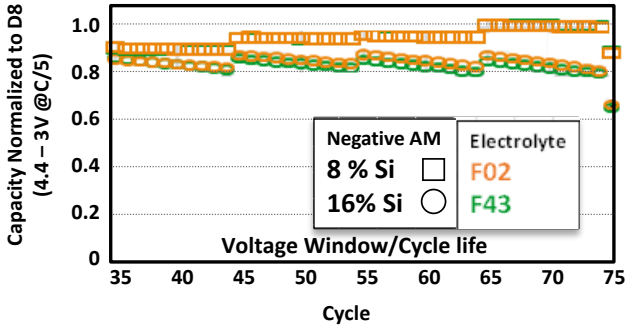


Advanced Cell Materials & Design

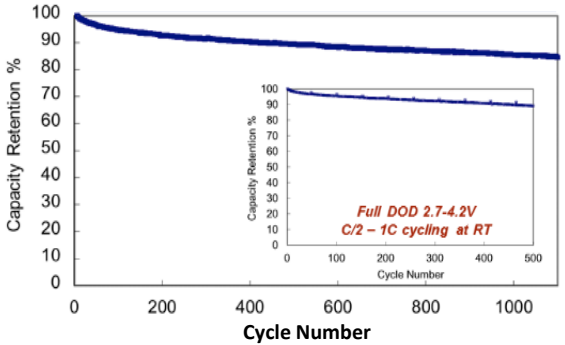
- Improved capacity retention of NCM materials for 4.4+ V operation, through both surface treatment and bulk-doping approaches.
- Improved rate capability.

- CAM-7/Si-Gr PHEV cell achieves 1,000 cycles.
- Delivers >200Wh/kg and >85% capacity retention after 1,000 cycles.
- Models predict chemistry could reach 250Wh/kg in 15Ah pouch cells for PHEV applications.
- Cells capable of >845W/kg, down to 10% SOC.

Farasis Gen2 EV Testing Cell Performance



CAM-7/Si-based Anode 18650 Cells – 2.7–4.1V RT Cycling

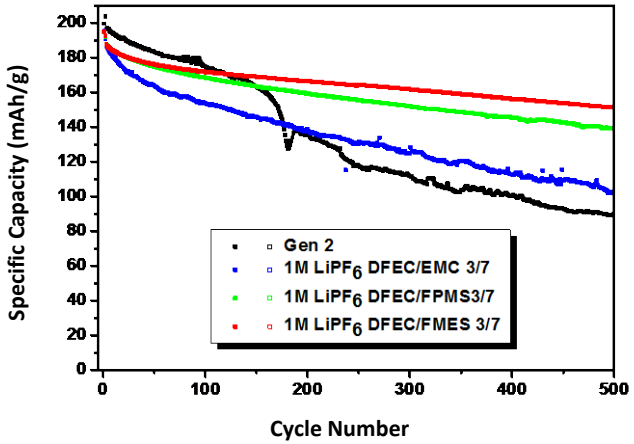


High Voltage Electrolytes

Argonne NATIONAL LABORATORY

NMC532/Graphite Cells with ANL Fluorinated Sulfones as Additives

(C/3 for 500 cycles, cut-off voltage 3.0-4.6 V)



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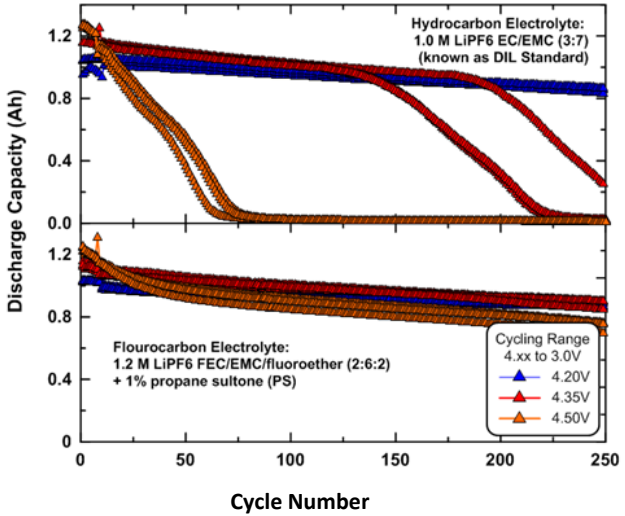
Fluoro Carbon Electrolytes for High Voltage Operation

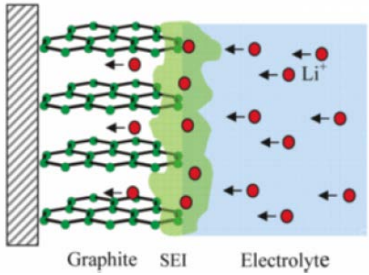


Cycle life showing capacity of 1Ah NMC/graphite cells with both standard carbonate (top) and fluorinated (bottom) electrolytes at cycled at a Vmax of 4.2, 4.35, and 4.45V.

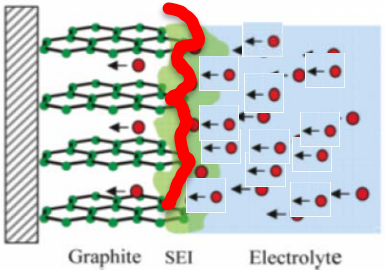
Battery R&D: Highlights

Extremely Fast Charging (XFC): 350-400 kW

- Combination of fast charge batteries and a network of high capacity chargers can minimize range anxiety and promote the market penetration of BEVs and increase total electric miles driven.
- **FY 2017 Study**
  - Assess the knowledge base of the fast charging capability of automotive batteries
  - Identify technical gaps for fast charging
  - Identify R&D opportunities
- **Issues Identified regarding Fast Charging**
  - Higher cost cells: (2X) compared to today's lithium-ion cells.
  - Cycle Life & Durability of Cells
    - Lithium plating/deposition occurs on the anode above a threshold current density.
    - Cell temperature rise during charge



Plated lithium due to fast-charging



Optimizing Opportunities for Energy Savings

- The Energy Efficient Mobility Systems (EEMS) program within VTO supports technologies that encourage future transportation systems that are automated, connected, electric, shared (ACES)
  - supports R&D to investigate disruptive forces (e.g., ACES) impacting energy consumption
  - helps communities determine how they can increase energy efficiency increases in mobility
- A VTO-funded paper (*Technical Report NREL/TP-5400-67216, November 2016*) showed that in 2050, disruptions from connectivity/automation to the transportation sector could result in a:
  - potential 200% increase baseline energy consumption, or a
  - potential 60% decrease in energy use (under different scenarios)
  - factors include ride sharing, drive smoothing, vehicle resizing, etc.
- EEMS coordinates its works with electrification R&D managers within VTO as well as with researchers and different stakeholders and communities to better understand how to make use of ACES technologies to make mobility more energy efficient.

Thank You