Energy Storage Program Overview

Tien Duong
Office of Vehicle Technologies

February 25, 2008

Overview

- Program Charter and Goals
- R&D Program Structure & Resources
- Sample Accomplishments
- Li-ion Commercialization Barriers
- HEV & PHEV Technology Roadmaps
- R&D Timeline

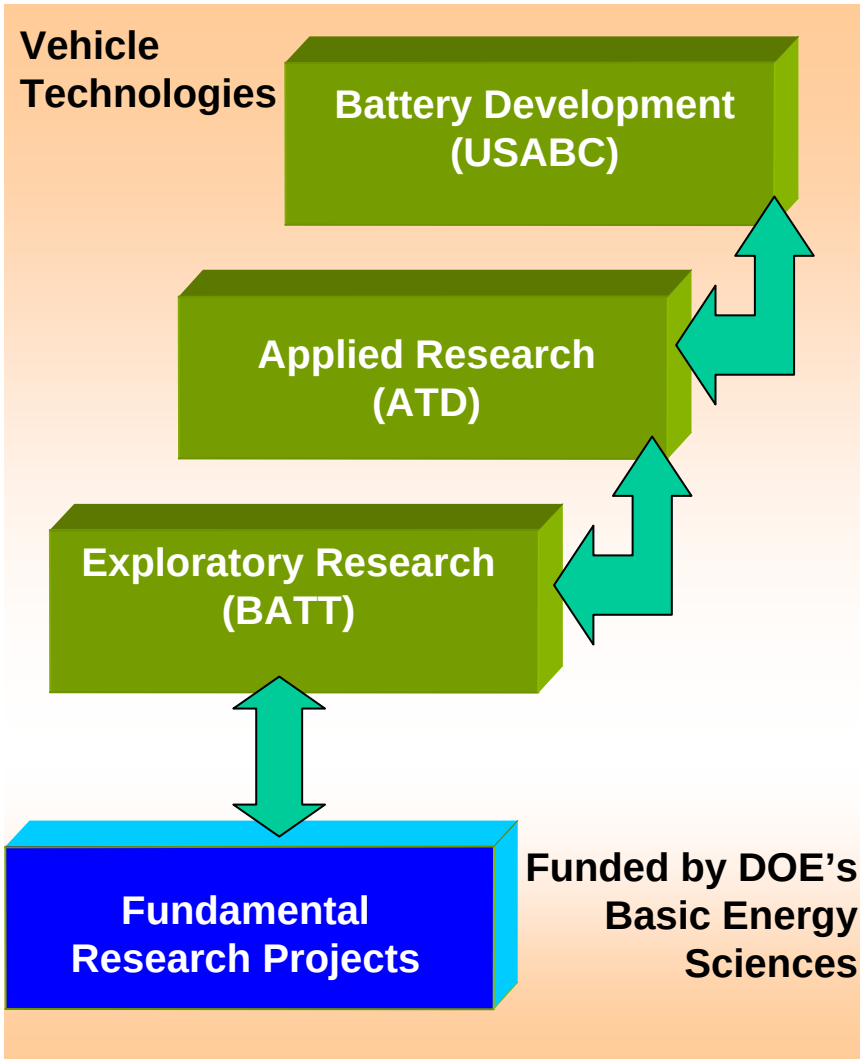
Charter

- Develop electrochemical energy storage technologies which support the commercialization of hybrid and electric vehicles
- Target Applications
  - Power-Assist Hybrid Electric Vehicles (HEVs)
  - Plug-in Hybrid Electric Vehicles (PHEVs)
  - Battery Electric Vehicles (EVs)

Research Goals

- **2010 FreedomCAR HEV Goal:**
  - Develop electric drive-train energy storage with 15-year life at 300 Wh, with discharge power of 25 kW for 18 seconds, and $20/kW.
- **2015 DOE PHEV Battery Goal:**
  - Develop electric drive-train energy storage technology with a 15-year life that enables a 40 miles all-electric range and costs $3,400.

Program Structure



Develop full battery systems through subcontracts with the USABC. (Minimum 50% industry cost share)

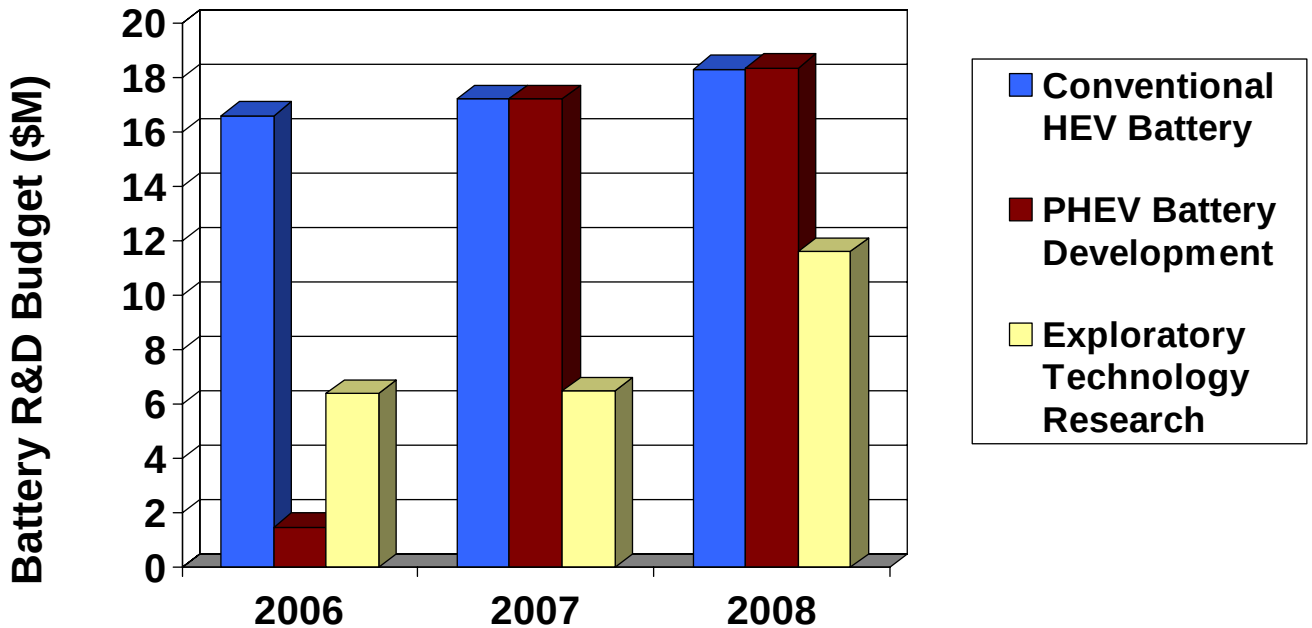
Investigate cell behavior to understand and overcome performance barriers of Li-ion battery technology. (DOE National Laboratories)

Develop novel materials (cathode, anode, electrolyte) that promise increased power and energy. (DOE National Labs and Universities)

DOE Battery R&D Resources

FY	DOE Budget
2006	$24.442 Million
2007	$40.912 Million
2008	$48.236 Million

Recent budget increases have been focused on PHEV Battery Development.



Sample Program Accomplishments

- Cobasys (supplier to GM) developed the NiMH technology with USABC support.
  - DOE/USABC receives royalties from all HEV battery sales that use NiMH IP developed with USABC funding.
- JCS will supply lithium ion batteries to Mercedes for their S Class HEV to be introduced in October 2008.
  - This will likely be the first HEV with lithium batteries.
- GM has contracted with A123, CPI/LG Chem, and JCS for prototype PHEV batteries.
- ANL developed a nano-phase Li titanate material and has transferred it to Enerdel.

Li-Ion Barriers

- Barriers to HEV commercialization include:
  - Cost: ~ 1.5 to 2 times the FreedomCAR target.
  - Abuse Tolerance: Inherently intolerant.
  - Calendar Life: Accurately predicting life is challenging.
- Barriers to PHEV commercialization include:
  - Cost of PHEV batteries >$1,000/kWh.
  - Same abuse tolerance issues as HEV batteries, yet with more available energy
  - Volume and weight are issues, particularly for 40 mile PHEV.
  - Life issues are unknown. Unclear how deep discharges will affect life.

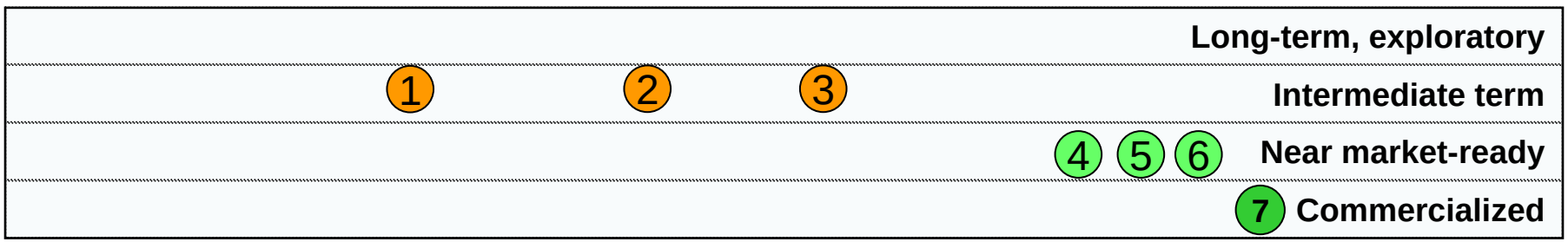
HEV Technology Development Roadmap

Performance Goal

25 kW for 10 sec, 300Wh (by 2010)
40 kW for 10 sec, 500Wh (by 2010)

Cost Goal

HEV: $20/kW (by 2010)



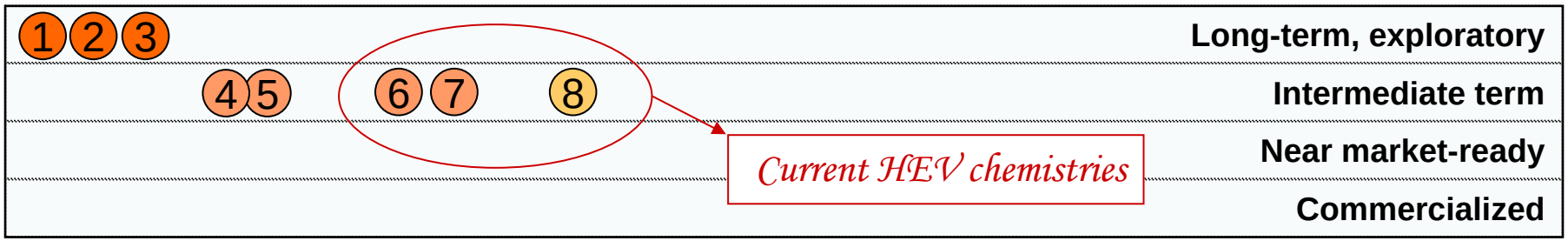
1. Li titanate/Mn spinel
2. Graphite/Iron phosphate
3. Graphite/Mn spinel
4. Graphite/Nickelate
5. Ultracapacitors
6. Low cost separators
7. NiMH

PHEV Technology Development Roadmap

Goals

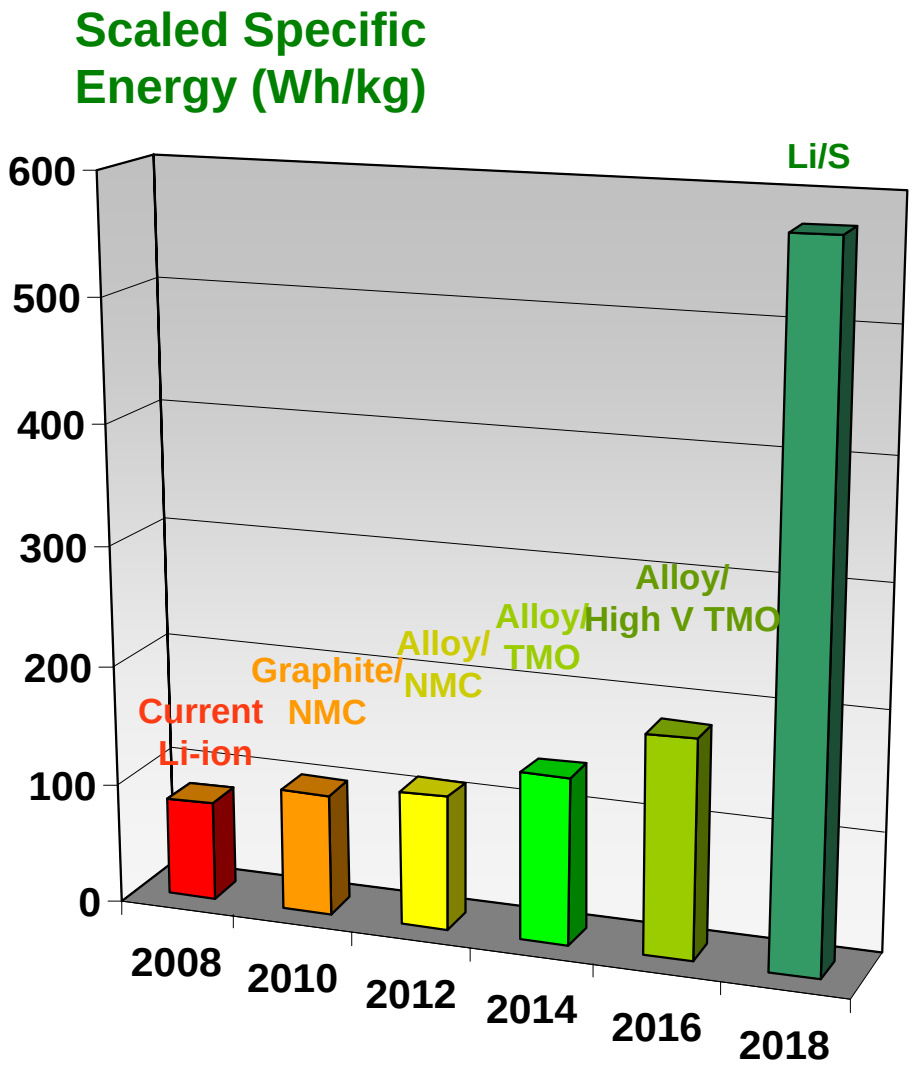
Specific Energy: 100 Wh/kg (by 2012)
150 Wh/kg (by 2015)

Cost: $500/kWh (by 2012)
$300/kWh (by 2015)



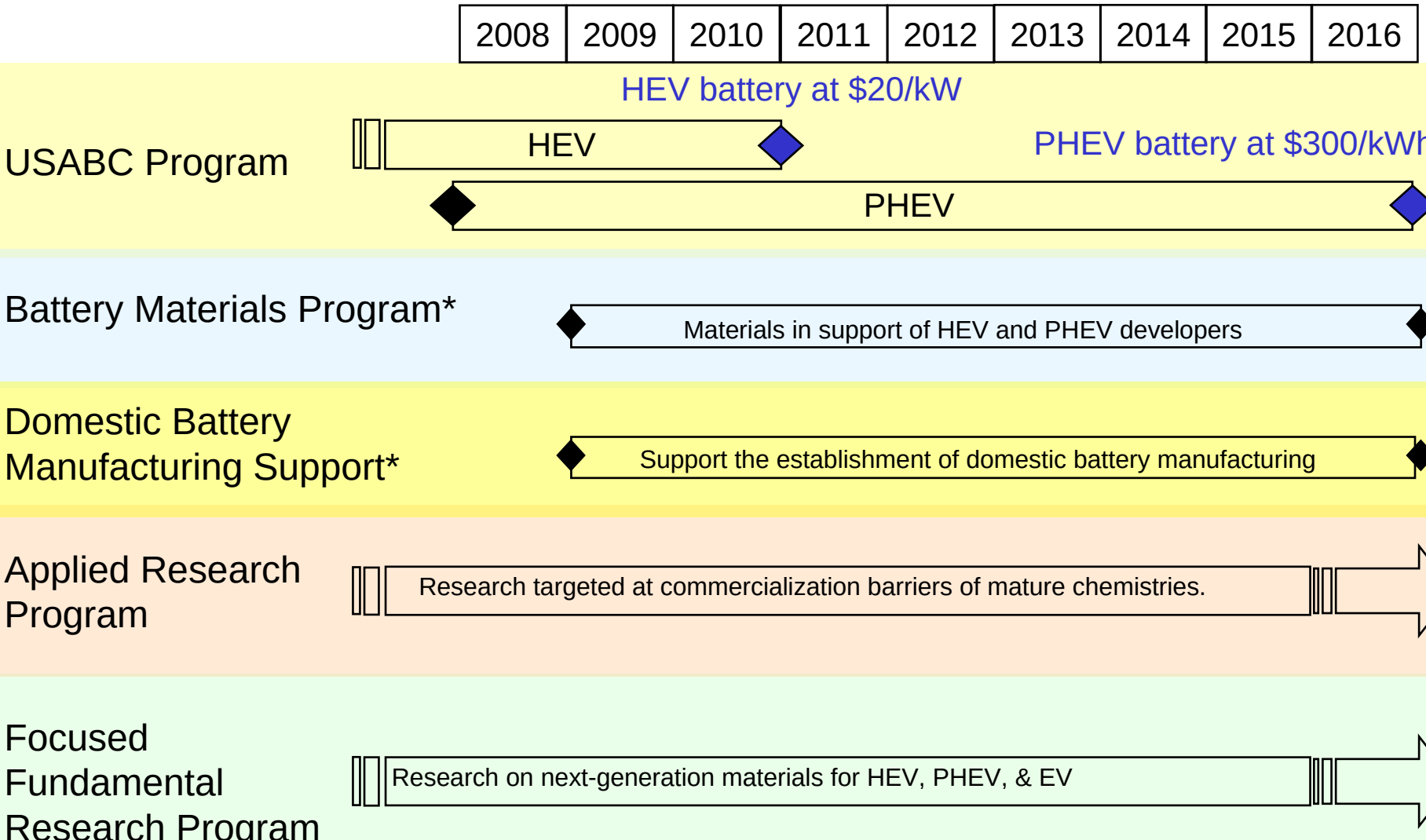
1. Li Metal/Li Ion Polymer
2. Li/Sulfur
3. Li alloy/High Voltage Positive
4. 1/3 Cathode Development
5. Li titanate/High Voltage Nickelate
6. Graphite/Mn Spinel
7. Graphite/Iron Phosphate
8. Graphite/Nickelate

R&D of New Materials



- New materials with increased energy density mean
  - Fewer cells
  - Fewer materials
  - Less hardware
  - Less weight
  - Less volume
  - Reduced cost

Program R&D Timeline



*pending availability of resources