# United States Advanced Battery Consortium (USABC)

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# Presentation Outline

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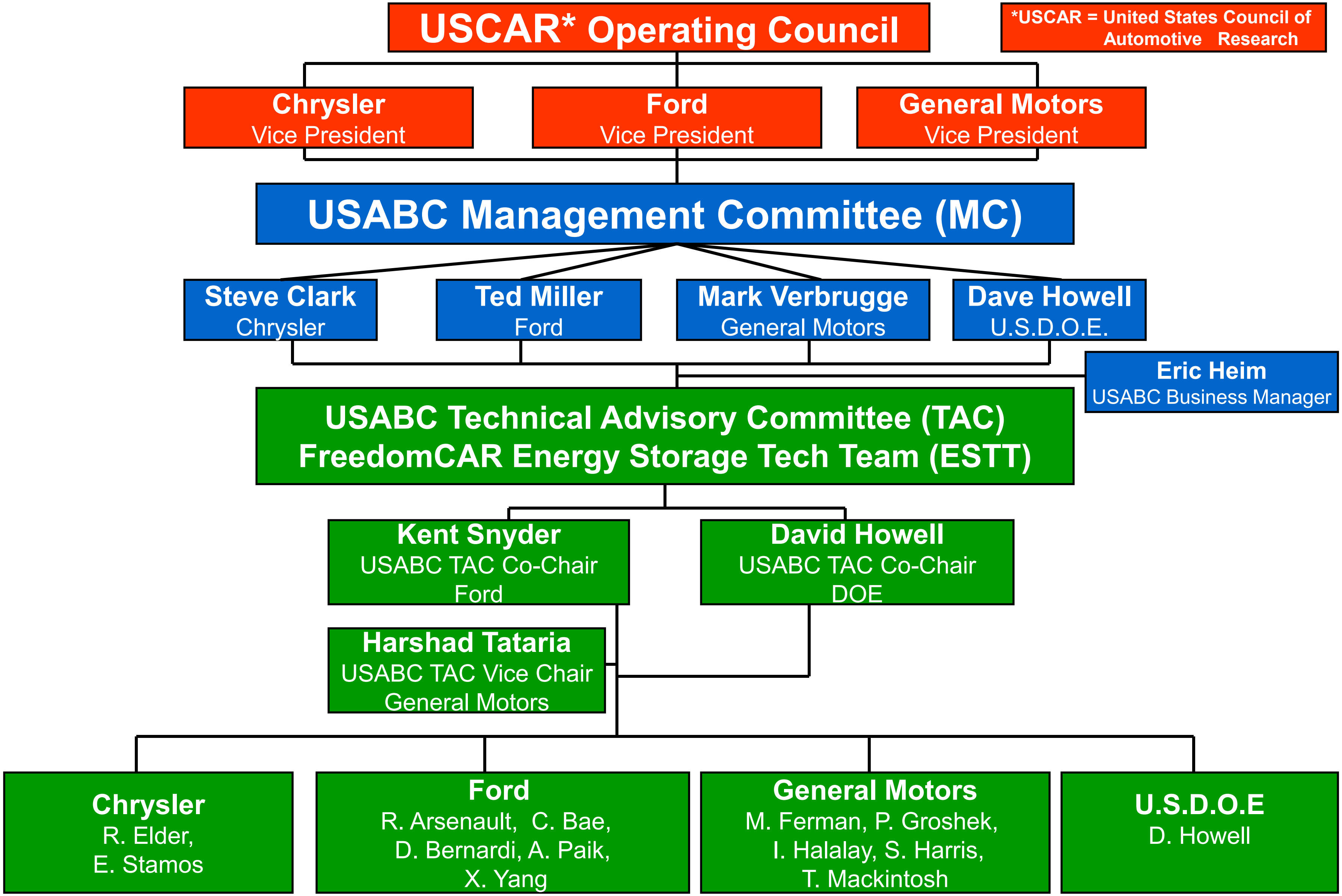
# USABC Mission

- **The United States Advanced Battery Consortium (USABC), comprised of Chrysler, Ford, and General Motors, funds pre-competitive electrochemical energy storage R&D**

- **Funding for development activity occurs through a cooperative agreement between USABC and DOE.**

- **This cooperation allows for the combined technical and financial resources of the DOE, OEM automakers, development partners, and U.S. National laboratories in jointly conducting advanced battery research and development.**

# Organization



# Group Contributions

**Development Partners**
Technical Expertise
Tangible Cost Data
Applied Research Capability
Manufacturing Capability
Hardware Deliverables
Cost-Shared Funding

**Automotive OEM's**
Technical Expertise
Funding Coordination
Program Management
Test Method Development
Industry Experience & Input
Development Partner Assistance
Real World Requirement Perspective

**COOPERATIVE GROUP EFFORT**

**National Labs**
Life Prediction
Abuse Testing
Development Partner Assistance
Long Term Fundamental Research
Performance & Benchmark Testing
Thermal Analysis & Design Support
Battery Simulation and Model Development

**DOE**
Funding Coordination
National Lab Management
Governmental Perspective

# Program Goals

- **Research and develop electrochemical energy storage technologies for hybrid and electric vehicles:**
  - **Electrochemical energy storage with 15-year life for:**
    - **HEV Example: 300 Wh of usable energy with discharge power capability of ≥ 25 kW (10 sec) at a cost of ≤ $20/kW**
    - **PHEV Example: 3.4 kWh of usable energy (or 10 miles AER) with discharge power capability of ≥ 45 kW (10 sec) at a cost of ≤ $500/kWh (or $1700/pack) by 2015**
- **Goals are intended to represent values which would be competitive with ICE vehicles on a cost and performance basis.**

# Technology Focus



- **Lithium ion batteries**

***Why Li-Ion?***

**….can provide hybrid & EV applications with:**

- Higher energy density *(lighter and smaller)*
- Inherently higher system energy efficiency
- Inherently lower heat generation
- Lower long-term cost
- Greater basic battery chemistry market longevity expected
- Lower self-discharge rates
- Greater pool of potentially viable suppliers from a pre-existing industry

# Development Activities

## Activity Focus

- Develop electrochemical energy storage devices towards USABC goals through cost-shared projects with industry.
    - All USABC subcontracts are at least 50% cost-shared with developers.
- Develop electrochemical energy storage performance and cost requirements for hybrid and electric vehicle applications
- Develop test procedures for hybrid and electric vehicle electrochemical energy storage devices
- USABC deliverables tested and analyzed against performance targets using standardized test procedures
    - Performance and benchmark testing at ANL and INL
    - Abuse Testing at SNL
    - Thermal analysis and design support at NREL
    - Battery simulation and modeling support at ANL and NREL in collaboration with VSATT

# Targets for Power Assist HEV Electrochemical Energy Storage Systems

## USABC Goals for HEV Power Assist Battery Systems

| Characteristics | Unit | HEV Power Assist Maximum USABC Goal | HEV Power Assist Minimum USABC Goal |
|---|---|---|---|
| 10s Discharge Pulse Power | kW | 40 | 25 |
| 10s Regen Pulse Power | kW | 35 | 20 |
| Available Energy | kWh | 0.5 | 0.3 |
| Efficiency | % | 90 | 90 |
| Cycle-life, 25 Wh Profile | Cycles | 300,000 | 300,000 |
| Cold-Cranking Power at -30oC | kW | 7 | 5 |
| Calendar-life, Years | Years | 15 | 15 |
| Maximum System Weight | kg | 60 | 40 |
| Maximum System Volume | Liter | 45 | 32 |
| Selling Price/System @ 100k/yr) | $ | 800 | 500 |
| Maximum Operating Voltage | Vdc | $\leq$ 400 | $\leq$ 400 |
| Minimum Operating Voltage | Vdc | $\geq 0.55\ V_{max}$ | $\geq 0.55\ V_{max}$ |
| Self-discharge | Wh/day | 50 | 50 |
| Operating Temperature Range | ºC | -30 to 52 | -30 to +52 |
| Survival Temperature Range | ºC | -46 to 66 | -46 to +66 |

# Targets for Plug-In HEV Electrochemical Energy Storage Systems

| Characteristics at EOL (End of Life) | | High Power/Energy Ratio Battery | High Energy/Power Ratio Battery |
|---|---|---|---|
| Reference Equivalent Electric Range | miles | **10** | **40** |
| Peak Pulse Discharge Power (10 sec) | kW | **45** | **38** |
| Peak Regen Pulse Power (10 sec) | kW | **30** | **25** |
| Available Energy for CD (Charge Depleting) Mode, 10 kW Rate | kWh | **3.4** | **11.6** |
| Available Energy for CS (Charge Sustaining) Mode | kWh | **0.5** | **0.3** |
| Minimum Round-trip Energy Efficiency (USABC HEV Cycle) | % | **90** | **90** |
| Cold cranking power at -30°C, 2 sec - 3 Pulses | kW | **7** | **7** |
| CD Life / Discharge Throughput | Cycles/MWh | **5,000 / 17** | **5,000 / 58** |
| CS HEV Cycle Life, 50 Wh Profile | Cycles | **300,000** | **300,000** |
| Calendar Life, 40°C | year | **15** | **15** |
| Maximum System Weight | kg | **60** | **120** |
| Maximum System Volume | Liter | **40** | **80** |
| Maximum Operating Voltage | Vdc | **400** | **400** |
| Minimum Operating Voltage | Vdc | **>0.55 x Vmax** | **>0.55 x Vmax** |
| Maximum Self-discharge | Wh/day | **50** | **50** |
| System Recharge Rate at 30°C | kW | **1.4 (120V/15A)** | **1.4 (120V/15A)** |
| Unassisted Operating & Charging Temperature Range | °C | **-30 to +52** | **-30 to +52** |
| Survival Temperature Range | °C | **-46 to +66** | **-46 to +66** |
| Maximum System Production Price @ 100k units/yr | $ | **$1,700** | **$3,400** |

# Current USABC PHEV Programs

| | |
|---|---|
| A123 Systems | Develop batteries using nanophase iron-phosphate |
| Johnson Controls / Saft | Develop batteries using a high energy nickelate/layered electrode |
| cpi compact power, inc. / LG Chem | Develop batteries using Manganese-spinel based chemistry |
| EnerDel Lithium Power Systems | Develop cells using nano-phase lithium titanate anode and a high voltage cathode |
| 3M | Develop advanced high-energy cathode materials for PHEV applications |
| Celgard | Develop separators with high temperature melt integrity |
| Entek International | Develop separators with high temperature melt integrity |

# Recent Program Success & Accomplishments

## High-Power HEV Li-Ion

- Delivery of pack systems with practical and detailed cost models
- Delivery of functional module assemblies with incorporation of advanced abuse tolerance separator functionality
- Detailed thermal and airflow studies of cells, modules, and pack assemblies
- Detailed abuse tolerance studies of cells and modules

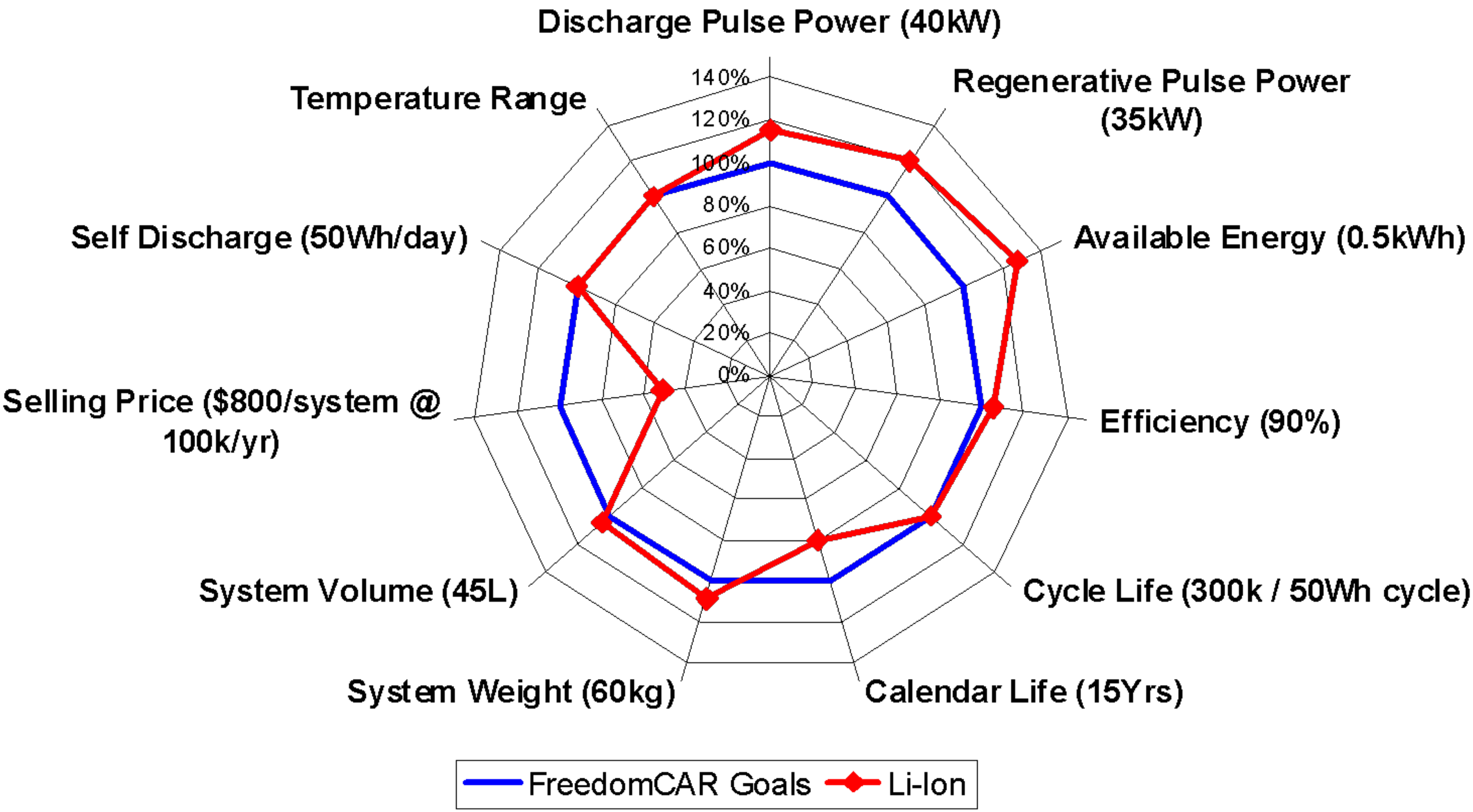
## High-Power / High-Energy (PHEV) Li-Ion

- Significant demonstrated progress towards cycle life goals

# Program Focus Trends

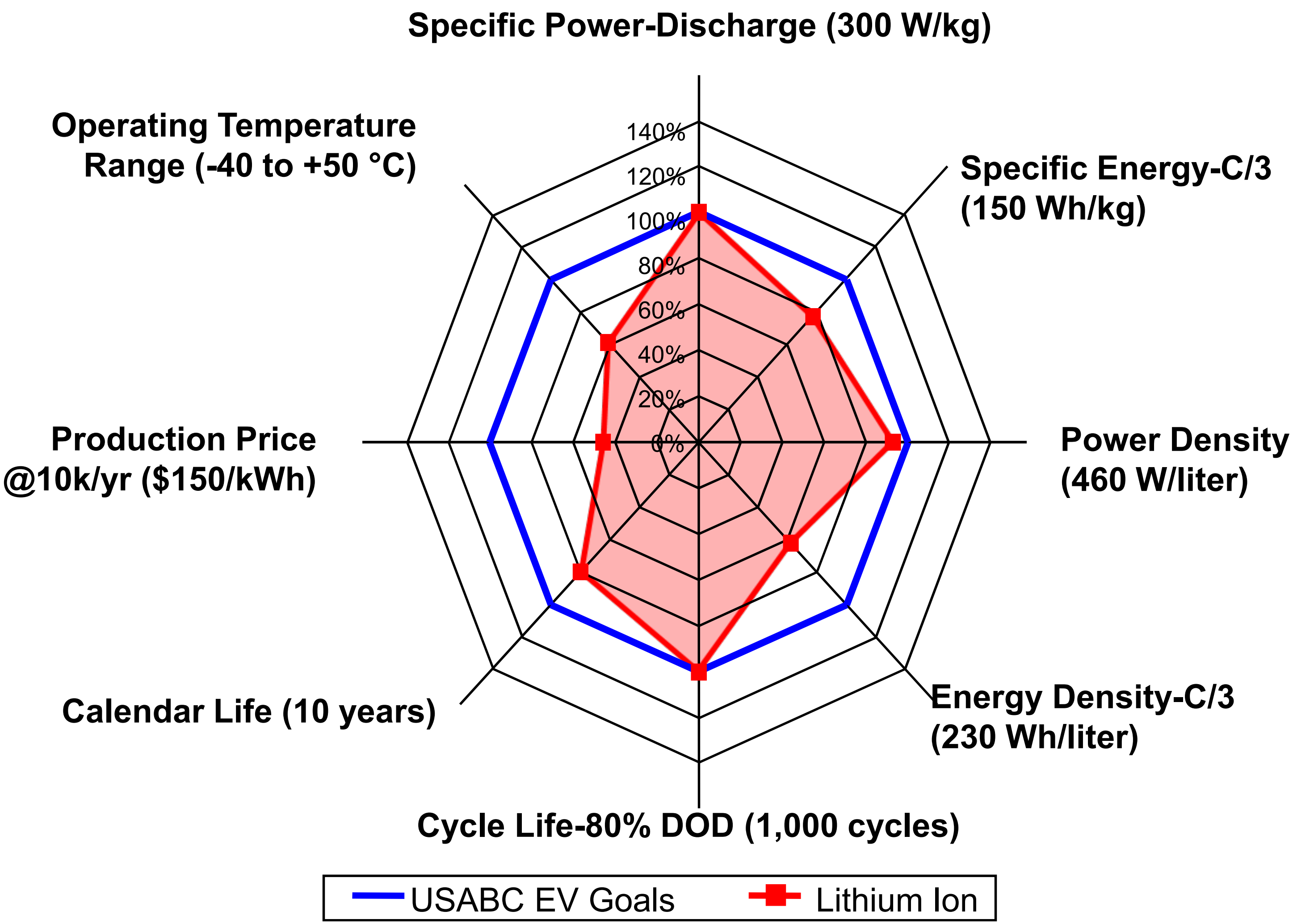
| From | To |
|---|---|
| HEV Battery Development Progress/Success | Higher energy EV and/or PHEV battery development |
| Low-Cost Separator Development Progress/Success | Improved Abuse Tolerance Separator Breakthroughs |
| | Improved Active Materials |

# HEV Battery Status
## (High Power Batteries)



# EV Battery Status

## EV (High Energy) Batteries



# Challenges

- **Calendar Life:**

  - 15-year battery life in automotive environment

  - Accurate and directly comparative cycle/calendar life determinations/predictions

- **Cost:**

  - Goals are aggressive for any market

  - Raw material price fluctuations can have significant impact on cost estimations over course of multi-year programs

- **Abuse Tolerance:**

  - Varying cell formats/sizes complicate the achievement of directly comparative abuse response results

  - Simulation of internal short circuit as a potential failure mechanism

- **Public Perception:**

  - Media and other promotion of unrealistic expectations for battery capabilities present a powerful negative distraction from focus on practical progress for battery development programs

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