United States Advanced Battery Consortium (USABC)

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USABC Mission

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

- **USABC and the U.S. Department of Energy (DOE) fund energy storage development through a cooperative agreement.**

- **This cooperation has allowed leveraging of, both technical and financial resources, by jointly conducting the high risk, high cost research and development associated with advanced battery systems.**

Organization

USABC/Electrochemical Energy Storage Tech Team

USABC Management Committee

Steve Clark (Chrysler)
Tien Duong (DOE)
Ted Miller (Ford)
Mark Verbrugge (GM)

Tech Team Members

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Target Applications

- **HEV (Power-Assist Hybrid)**
- **PHEV (Plug-In Hybrid)**
- **REEV (Range Extended EV)**
- **FCHEVs (Fuel Cell Hybrid)**
- **EVs (Battery Electric Vehicle)**

Program Goals

- **Research and develop electrochemical energy storage technologies for HEV, PHEV, & REEVs that are durable and affordable and the goal is to have:**
  - **Electric drive train energy storage with 15-year life and for:**
    - **HEV: Deliver 300 Wh of usable energy with discharge power of at least 25 kW for 10 seconds and costing $20/kW.**
    - **PHEV: Deliver 11.6 kWh of usable energy (or 40 miles AER) with discharge power of 38 kW for 10 seconds and costing $300/kWh (or $3400/pack) by 2015**
- **Goals are derived to ensure that HEVs and PHEVs are competitive with ICEs on a cost and performance basis.**

Technology Priorities

- **Lithium ion batteries (for EV, HEV, FCV, PHEV, REEV)**
  - Higher energy density (Lighter and smaller)
  - Potentially less expensive
  - Simplified SOC monitoring

- **Ultracapacitors (Micro/Mild HEVs & REEVs)**
  - High rate power delivery (but lower energy and higher stand loss)
  - Superior power performance at low temperature and low state-of-charge
  - Long cycle life

USABC Battery Development Activities

Activity Focus

- Develop electrochemical energy storage devices that meet USABC system goals through cost-shared projects with industry.
  - All USABC subcontracts are at least 50% cost-shared.
- Develop electrochemical energy storage performance and cost requirements for hybrid and electric vehicles
- 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 Electrochemical Energy Storage Systems for HEV

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	≤ 400	≤ 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 Electrochemical Energy Storage Systems for PHEVs

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**

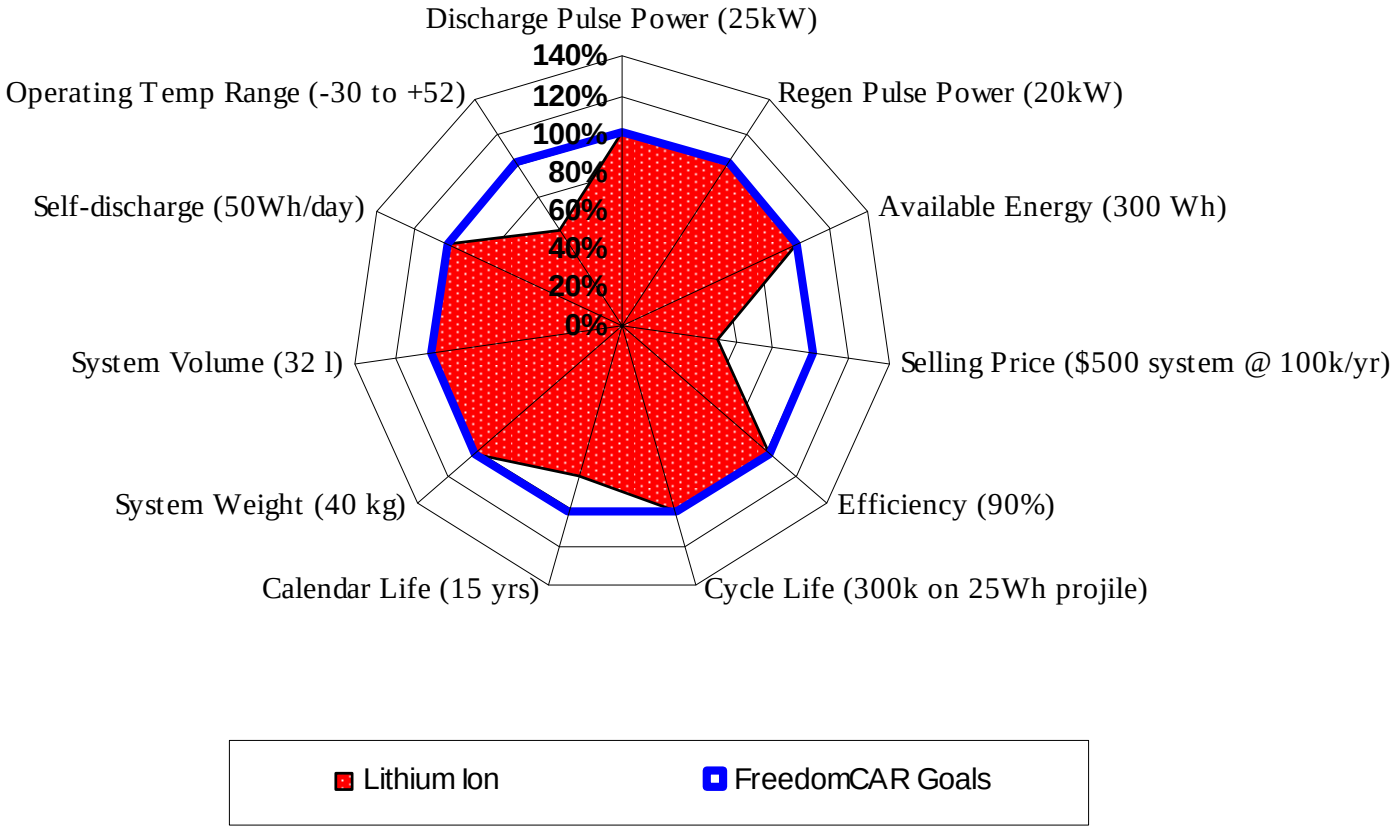
Current USABC Programs

Current USABC-FreedomCAR Energy Storage Programs & Focus Areas
(As of January 2008)

		Programs	Focus Areas
HEV (Hybrid EV)	1	A123	LiFePO4 based Cathodes (High Power)
	3	CPI-LG Chem	Mixed Mn-Oxide Cathodes (High Power)
	4	JCS (Johnson Controls - Saft)	Mixed Metal-Oxide Cathodes (High Power)
	5	EnerDel	Li-Titanate Anodes (High Power)
PHEV (Plug-In-Hybrid EV)	6	A123*	LiFePO4 based Cathodes (Increase energy density)
	7	CPI-LG Chem	Mixed Mn-Oxide Cathode (Increase energy density)
	8	JCS (Johnson Controls - Saft)*	Mixed Metal Oxide Cathode (Increase energy density)
	9	EnerDel*	Li-Titanate Anode (Increase energy density)
	10	3M*	Advanced cathode-material development
Ultracapacitors	11	NessCap	High Power Ultracaps for 42 V Start/Stop Systems
Separators	12	Celgard	Low Cost Separators
DOE Support Programs		ATD (Adv. Technology Development)	DOE Program on Applied Battery Research
		BATT (Battery for Adv. Transprt Tech)	DOE Program on Long Term Fundamental Research

*These programs are in the evaluation stage

HEV Battery Status
(High Power Batteries)



Challenges

- **Calendar Life:** Achieving 15-year life and getting accurate life prediction extremely challenging
- **Cost:** Current cost of lithium ion batteries about 2-3 times the USABC goal
- **Abuse Tolerance:**
  - **Lithium battery response** to overcharge, crush, and high temperature exposure
  - **Low Temperature Performance:** Reduction in discharge power and potential lithium plating during charge
  - **Manufacturing defects** leading to internal cell shorts

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