

Enabling e-mobility:

Overview on battery technology development for electric vehicles



2nd Mar, 2010

Who Kills my Electric Car ?



GM EV1

Range: 120 miles (100~140miles)
0~60mph: 7.4 sec
Battery: 26.4kWh, Ovonic NiMH 77Ah, 343V
Technical Issue: charging time, battery heat up during charging. 16 fire during charging.
Profitability issue: \$34,000 but actual cost \$80,000



Toyota RAV4

Range: 100~120mile, Top speed 126km/h
Battery: 27kWh, PEVE NiMH, 95Ah
Life: 150,000 mile achieved
Fuel cost: 25% of gasoline(\$3.8/gallone vs. \$0.09 / Wh)
Battery replacement cost: \$26,000
Price: MRSP \$42,000 (\$29,000)
Battery(NiMH) was not available anymore

“Battery Technology and Cost”



Problems of Previous EV Battery

In GM's view, the EV1 was not a failure, but the program was doomed when [the expected breakthroughs in battery technology did not take place within the anticipated timeline](#), citing the lack of availability of the NiMH-technology battery packs, developed by ECD, until late in the production cycle.

The batteries improved the EV1's range, but not as dramatically as expected, and came with their own set of [problems](#); a less-efficient charging algorithm had to be used ([lengthening charge times](#)), and the [batteries heated up more quickly than the lead-acid packs](#) (requiring use of the air conditioner to cool them down, wasting power).

The [weight](#) decrease by using NiMH battery is only 81kg.

It is [cost-prohibitive](#) to replace an [EV battery](#). The cost to replace the battery is more than the value of the vehicle.

Cited from Wikidepia



EV Enabler Lithium Battery

- **Light Weight: Less than half of NiMH**
- **Less Heat: Faster charging, energy efficiency, no cooling during normal charging**
- **Longer Life: Same longevity as vehicle life**
- **Cost: Affordable without big government subsidy, especially Europe, Japan and Korea**
- **Continuous Innovation: Many contenders**

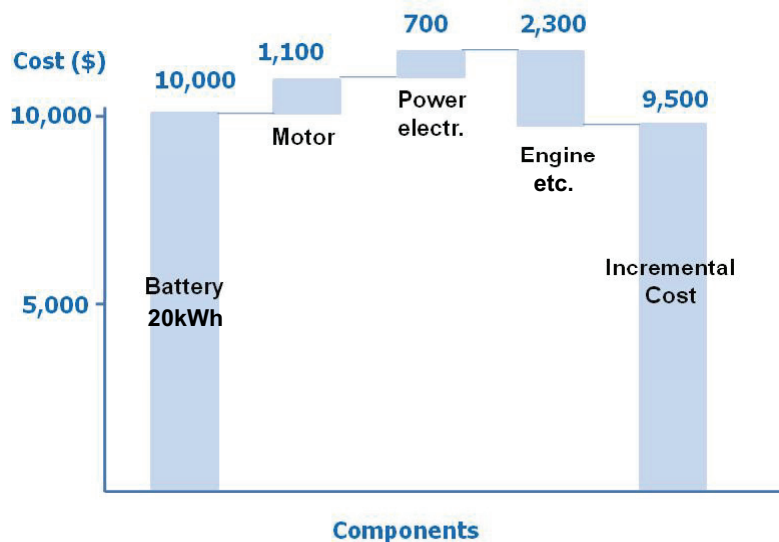


Major Contenders on EV Lithium Battery

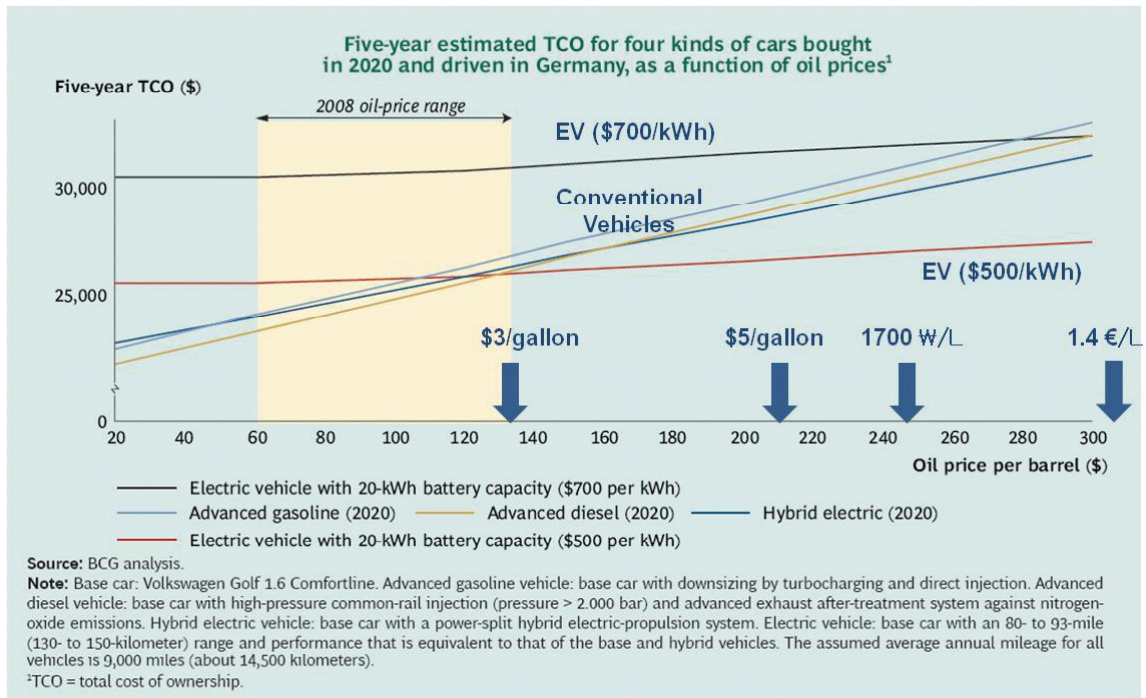


Cost of EV

- The incremental cost of EV is mostly dependant on battery cost
- Cost reduction of battery is crucial to enable EV commercially successful

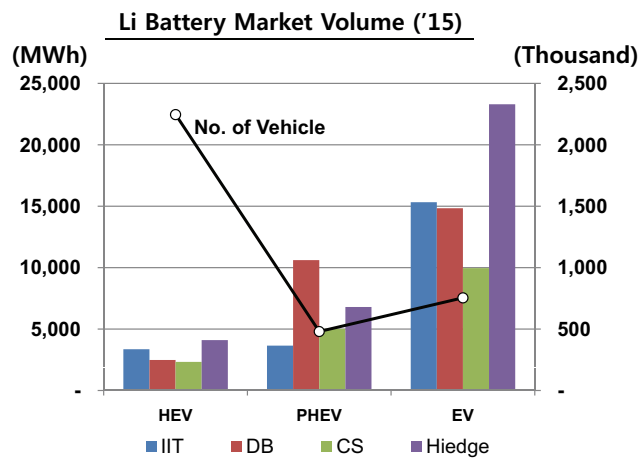


Total Cost of Ownership for EV



xEV Lithium Battery Market

- Market capacity projection of Lithium battery for EV is much larger than HEV
- NiMH battery will be used for HEV but Lithium battery will be used for the most EV and PHEV



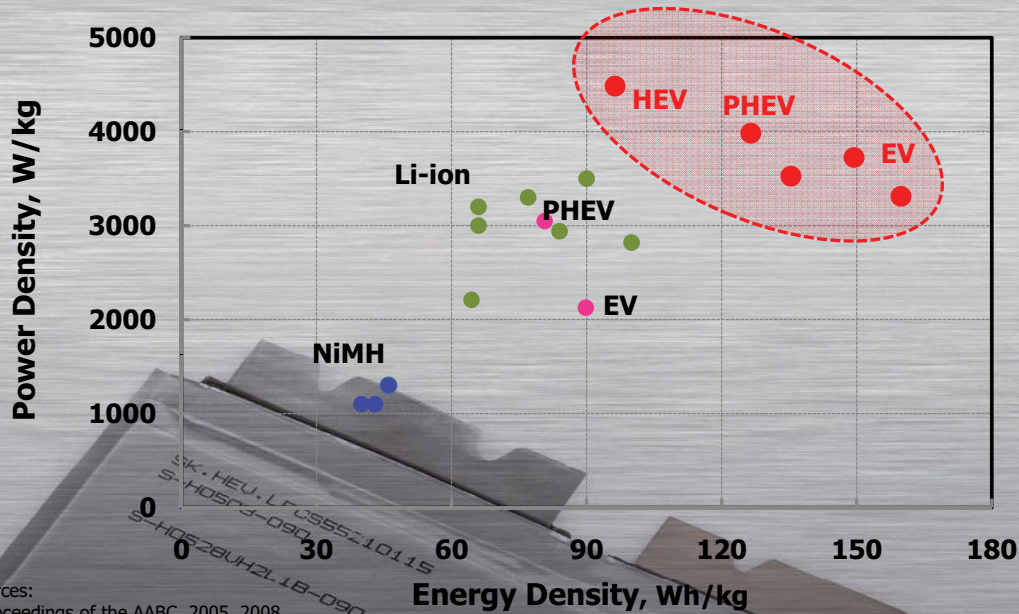
* DB(Deutsch Bank), CS(Credit Suisse)

** Battery Volume Assumption: HEV : 1.3 kwh, PHEV : 10 kwh, EV : 20 kwh



Compact and Powerful

- SK cells have high power and energy densities.
- It allows volume, weight, and cost advantages.



Sources:

- Proceedings of the AABC, 2005, 2008
- The 48th Battery Symposium in Japan, 2007
- EVS22, 2007
- EV Forum 2008

Benefits of High Power Energy Battery

- Reduced heat generation and cooling load
- Air cooling or no cooling instead of liquid cooling
- Higher energy efficiency
- Increased cycle life
- Better quick charge acceptance
- High power at low SOC
- High power at low temperature
- Reduced battery capacity installation to meet vehicle required power requirement
- Reduced total system cost & saving the vehicle space

Abuse Test Results of 50Ah cell

Hot box	PE separator	130℃, 10min	Pass
Overcharge		1C charge to 5V	Pass
Nail		Center, Tab	Pass
Internal Short		Center	Pass
Drop		SOC100% cell, 1.5m / 6 side	Pass
		SOC100% cell, 15 m	Pass



Center penetration



1.5m Drop

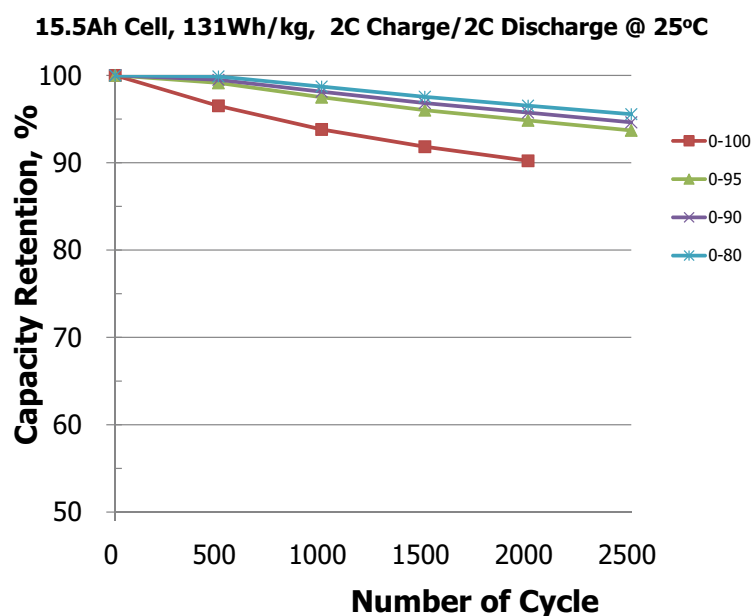


15m Drop



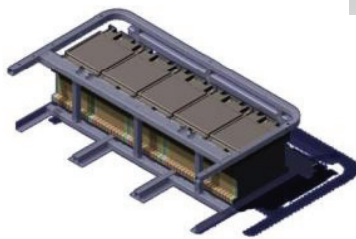
Cycle Life

- 2000 cycle is equivalent to 250,000 miles (125mile/charge)
- SOC bounding to 95% shows improved cycle life



Seoul Metropolitan EV Program

City EV

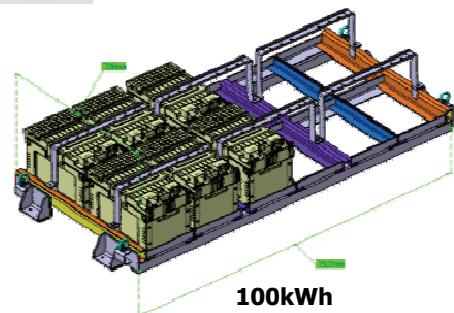


10kWh



Capacity: 2.15kWh
Weight: 20 kg

Electric Bus



100kWh

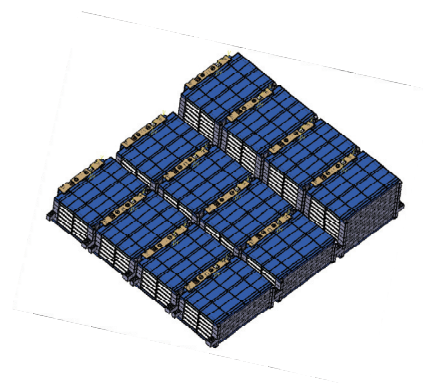


i10 EV



i10 EV

Capacity, Ah	140
Energy, kWh	16
Motor, kW	50
Charge	100%@220V, 5hr 85%@430V, 15min



Advanced EV Services with Smart Grid

- Quick charge and wireless communication is essential for EV to address its range limitation issue. Smart grid is the backbone of EV infrastructure
- Battery quick & smart chargers, rental and maintenance program
- GPS based charging spot & emergency information/services

