



# Enabling e-mobility:

## Overview on battery technology development for electric vehicles



2<sup>nd</sup> 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

## Japan



Toyota-Panasonic



Nissan-NEC



GS Yuasa  
- Mitsubishi (Pseugeot)



Honda -GS Yuasa

**SANYO**

## Korea



Bosch-SDI

**EiG** Energy Innovation Group



## China



## USA

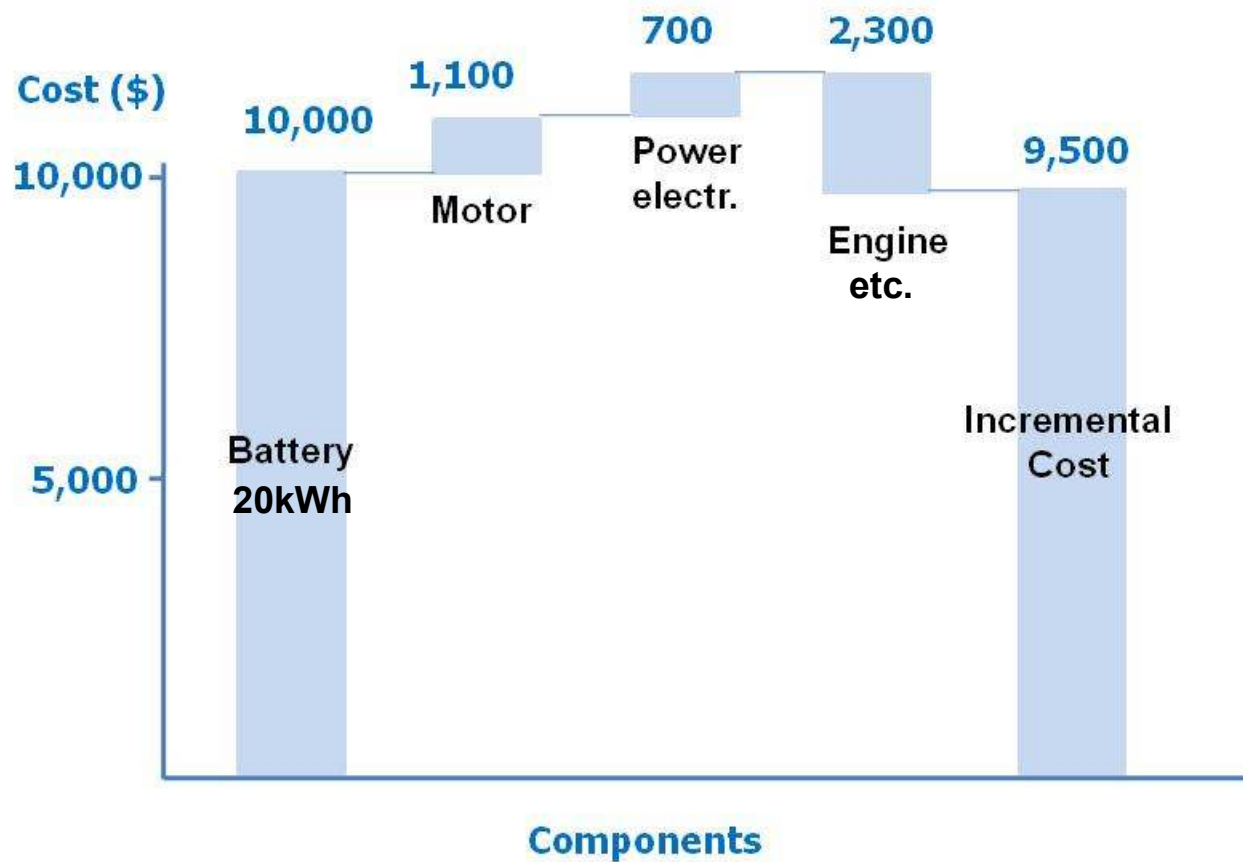


## Europe

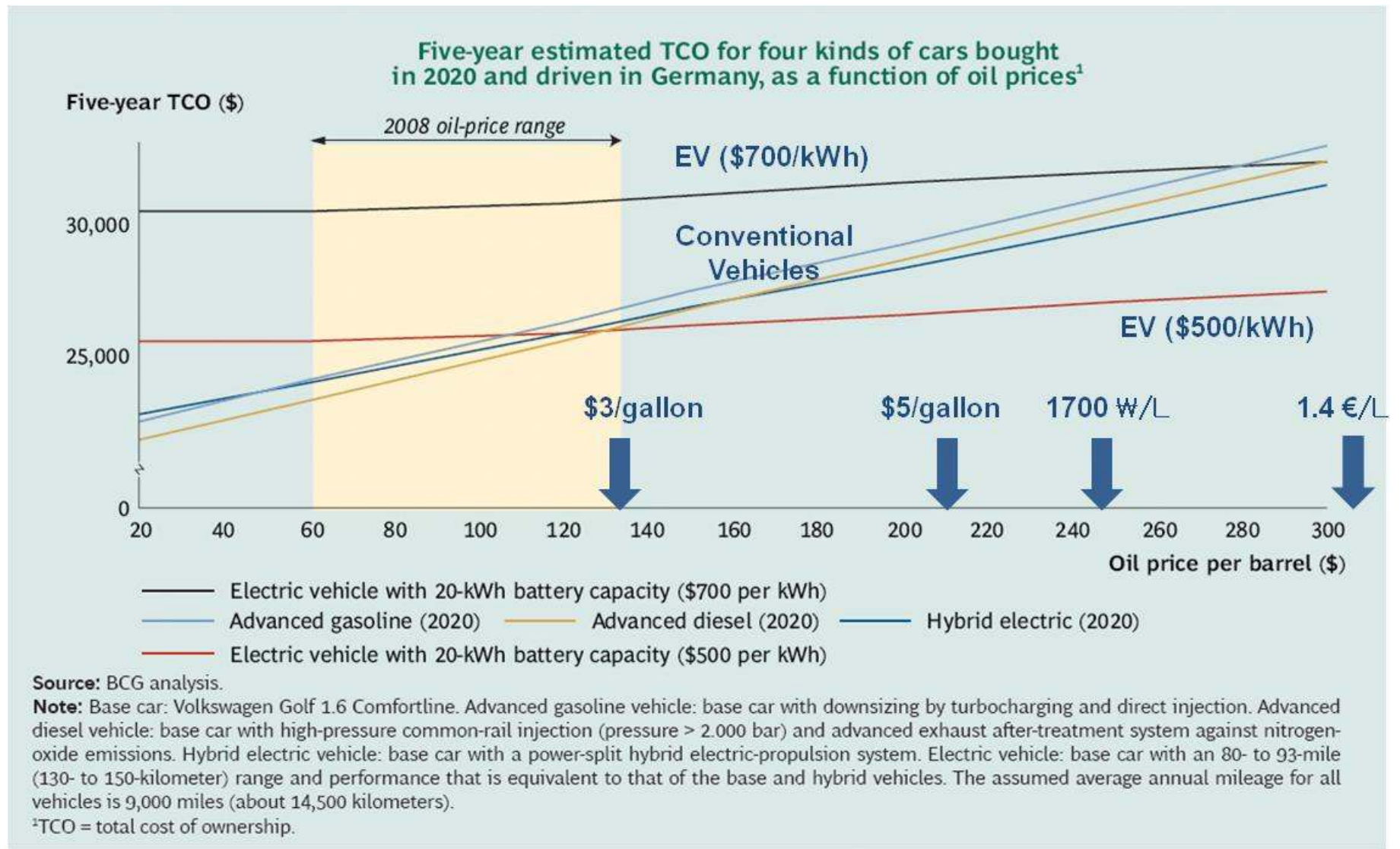


# Cost of EV

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

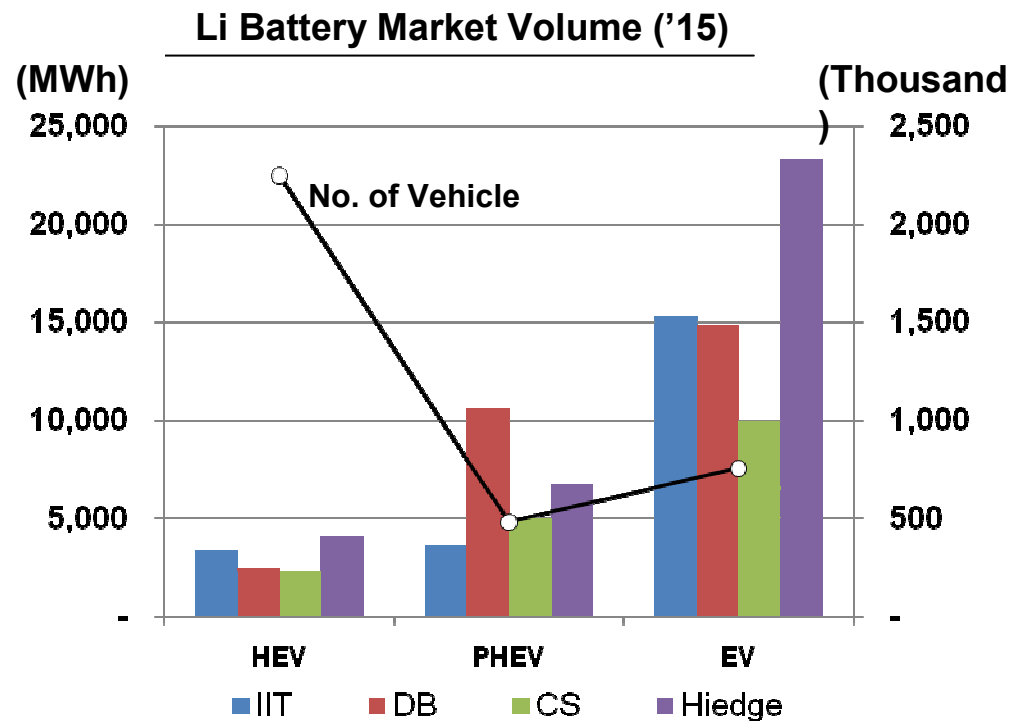


# Total Cost of Ownership for EV



# 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



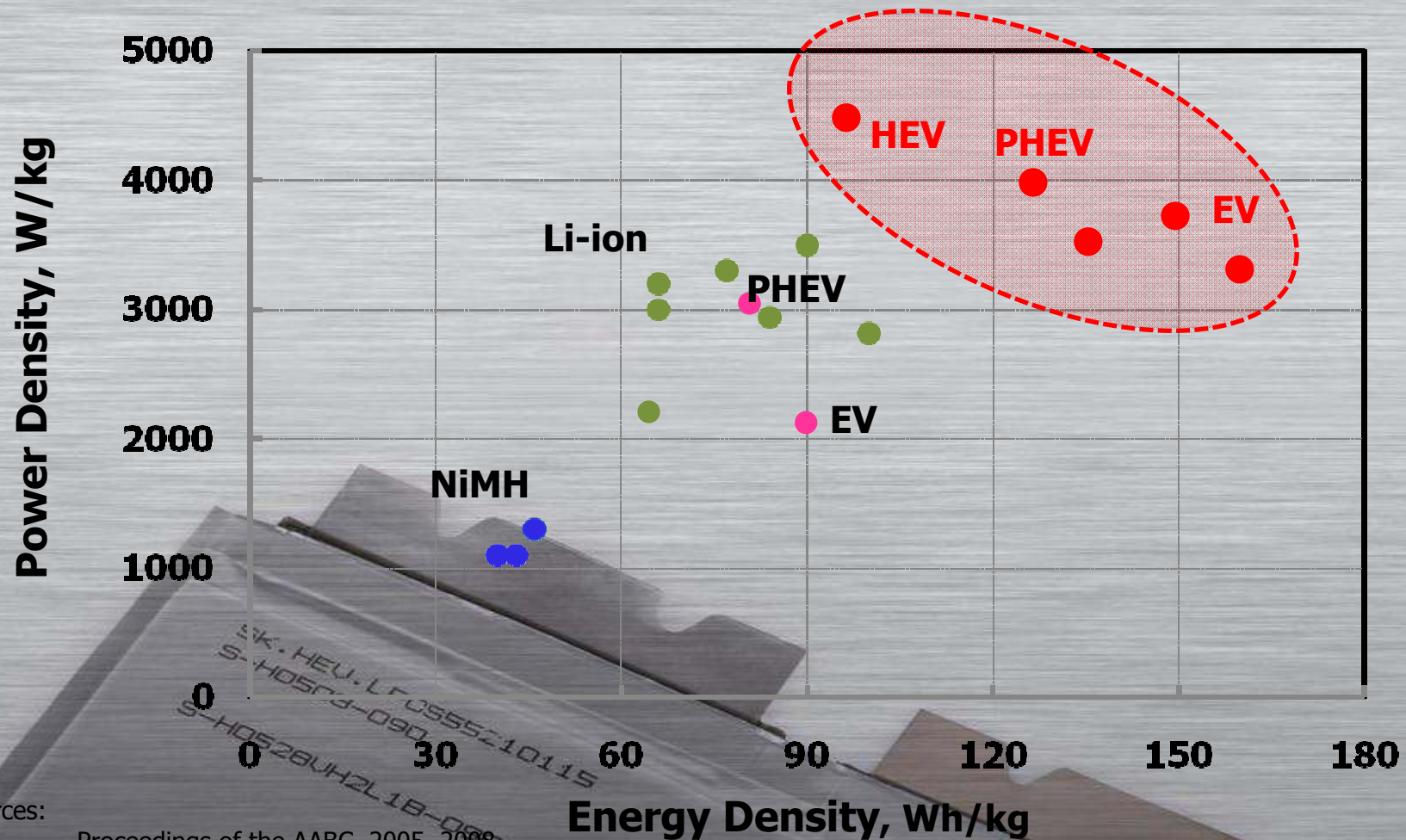
\* DB(Deutsch Bank), CS(Credit Suisse)

\*\* 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 48<sup>th</sup> 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



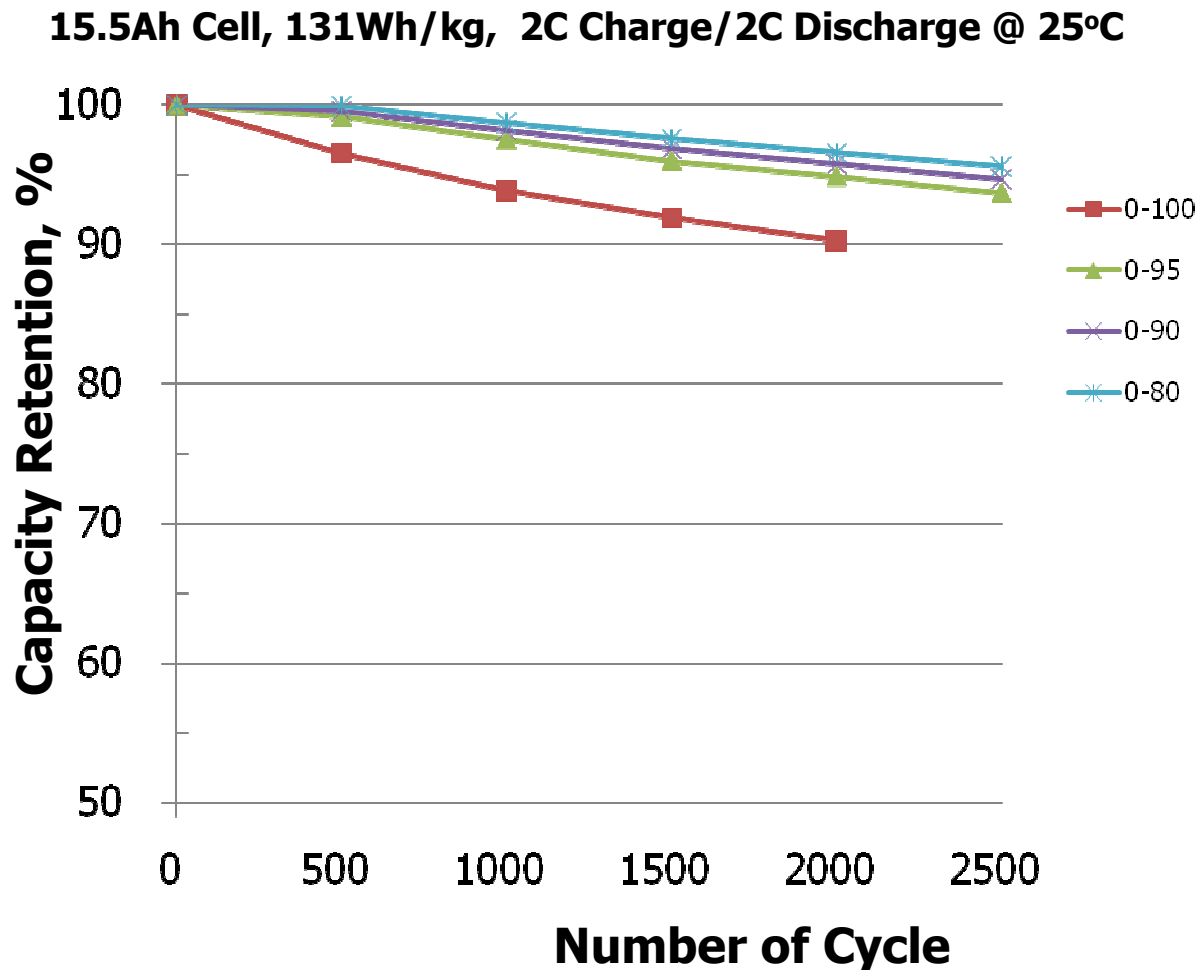
1.5m Drop



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

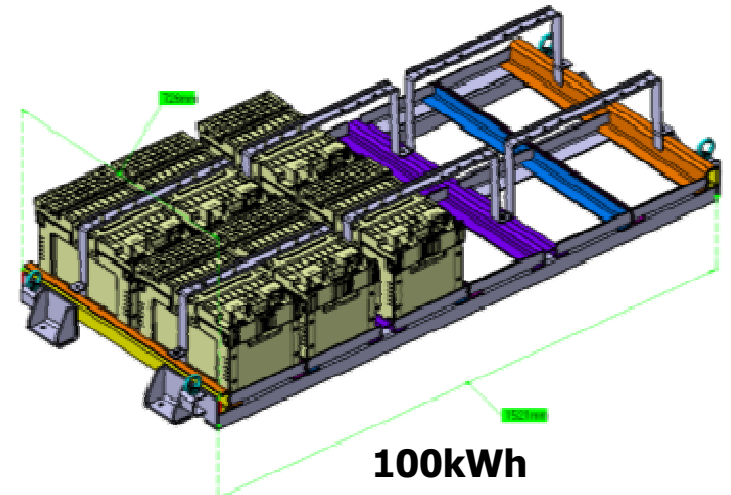


10kWh



Capacity: 2.15kWh  
Weight: 20 kg

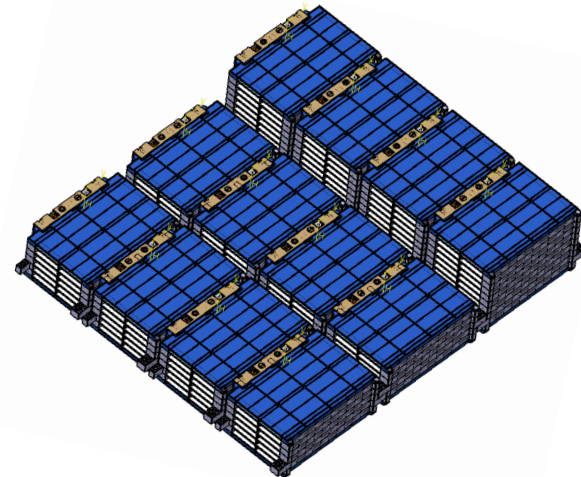
Electric Bus



# i10 EV



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



**i10 EV**

# 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

