Development of e-mobility in China

Dr. Li Hao
Managing Director,
HCA Consulting China

Shanghai, September 6, 2012
HCA OVERVIEW

- HCA is a niche market intelligence and market research company specialized in industrial products in China
- HCA provides accurate information within the required time frame, with deep understanding of both the target industries and China by the experienced professional researchers and analysts
- The key expertise includes Market Assessment, Competitive Analysis, Manufacturing Cost Analysis, Merger and Acquisition
- Clients severed are multinational companies active in Asia Pacific
- HCA has 24 fulltime employees located in Beijing, China
- Geographic focus is in Asia Pacific
WHAT IS E MOBILITY?
## COMPARISON OF DIFFERENT TECHNOLOGIES

<table>
<thead>
<tr>
<th>Item</th>
<th>HEV</th>
<th>PHEV</th>
<th>EV</th>
<th>FCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving mode</td>
<td>Combustion engine and electric motor (minor)</td>
<td>Combustion engine and electric motor (major)</td>
<td>Electric motor</td>
<td>Electric motor</td>
</tr>
<tr>
<td>Energy system</td>
<td>Combustion engine and battery</td>
<td>Combustion engine and battery</td>
<td>Battery</td>
<td>Fuel cell battery</td>
</tr>
<tr>
<td>Type of battery</td>
<td>Ni/H and Pb</td>
<td>Li</td>
<td>Li</td>
<td>-</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Gas station</td>
<td>Charging station</td>
<td>Charging station</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>Strength</td>
<td>Mature technology</td>
<td>Low energy consumption</td>
<td>No pollution</td>
<td>High energy conversation efficiency</td>
</tr>
<tr>
<td></td>
<td>Low cost</td>
<td>Low pollution</td>
<td>Low noise</td>
<td>Zero pollution</td>
</tr>
<tr>
<td></td>
<td>Low investment on infrastructure</td>
<td>Can travel in long distance</td>
<td>High energy conversion</td>
<td>Easy to obtain raw materials</td>
</tr>
<tr>
<td>Weakness</td>
<td>Limited effect on energy conservation and pollution control</td>
<td>High cost</td>
<td>High cost</td>
<td>High cost</td>
</tr>
<tr>
<td></td>
<td>Improvement on battery technology</td>
<td>Improvement on battery technology</td>
<td>Improvement on battery</td>
<td>Battery technology is not mature</td>
</tr>
<tr>
<td></td>
<td>Inadequate infrastructure</td>
<td>Simple structure</td>
<td>Inadequate infrastructure</td>
<td></td>
</tr>
<tr>
<td>Commercial stage</td>
<td>Scaled production</td>
<td>Commercialized but not in scaled production</td>
<td>Commercialized but not in scaled production</td>
<td>Research stage</td>
</tr>
</tbody>
</table>
HISTORICAL MARKET SIZE

- Definition of E-mobility: E-cars and E-buses
  - Pure electric vehicles (BEV)
  - Hybrid electric vehicles (HEV) and plugin hybrid electric vehicles (PHEV)
  - Fuel cell vehicles (FCV)
- Key applications: Taxi and public transportation
- Technology: PHEV and BEV dominate the market

<table>
<thead>
<tr>
<th>Type</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 1-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV</td>
<td>1,645</td>
<td>2,504</td>
<td>3,780</td>
<td>5,655</td>
<td>3,021</td>
</tr>
<tr>
<td>HEV/PHEV</td>
<td>790</td>
<td>1,216</td>
<td>1,905</td>
<td>2,713</td>
<td>146</td>
</tr>
<tr>
<td>Total</td>
<td>2,435</td>
<td>3,720</td>
<td>5,685</td>
<td>8,368</td>
<td>3,167</td>
</tr>
</tbody>
</table>
**CURRENT STATUS**

<table>
<thead>
<tr>
<th>City</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total E-vehicles produced</td>
</tr>
<tr>
<td></td>
<td>The estimated total number of EV is about 25,000 units in 25 cities</td>
</tr>
<tr>
<td>Beijing</td>
<td>4,500 units</td>
</tr>
<tr>
<td>Shanghai</td>
<td>EV(cars): 200</td>
</tr>
<tr>
<td></td>
<td>EV and PHEV (buses): 1,500</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>PHEV: 1,500</td>
</tr>
<tr>
<td></td>
<td>EV (cars): 1,000</td>
</tr>
<tr>
<td></td>
<td>EV (buses): 2</td>
</tr>
<tr>
<td>Hangzhou</td>
<td>EV (cars): 25</td>
</tr>
<tr>
<td></td>
<td>Others: 1,350</td>
</tr>
<tr>
<td>Hefei</td>
<td>2,018</td>
</tr>
<tr>
<td>Chongqing</td>
<td>1,150</td>
</tr>
</tbody>
</table>
### E-MOBILITY IN CHINA

#### KEY BRANDS IN CHINA

- By July 2012, there are about 49 models of EV promoted by Chinese local companies

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Time to market</th>
<th>Name</th>
<th>Type</th>
<th>Time to market</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Auto</td>
<td>Benteng B50 EV</td>
<td>End 2010</td>
<td>Geely</td>
<td>Panda EV</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>VIOS B50 EV</td>
<td>End 2010</td>
<td>Huachen</td>
<td>Huachen EV</td>
<td>2011</td>
</tr>
<tr>
<td>Shanghai Auto</td>
<td>ROEWE E1 EV</td>
<td>2012</td>
<td>BYD</td>
<td>E6 EV</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>550 PHEV</td>
<td>2012</td>
<td>Foton</td>
<td>Midi EV</td>
<td>2011</td>
</tr>
<tr>
<td>Chery</td>
<td>QQ3 EV</td>
<td>2010</td>
<td>Dongfeng</td>
<td>Fengshen EV</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>S18 EV</td>
<td>2010</td>
<td>Jianghui</td>
<td>Yueyue EV</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Ruilin M1 EV</td>
<td>2010</td>
<td>Changan</td>
<td>Benben MINI EV</td>
<td>Early 2011</td>
</tr>
</tbody>
</table>
EXAMPLES OF E-CARS IN CHINA

- **Foton “Midi” EV**
  - Battery: LiFePO$_4$

- **BYD “E6” EV**
  - Battery: LiFePO$_4$

- **Gelly “Panda” EK EV**
  - Battery: Pb

- **Dongfeng Fengshen “EJ02” EV**
  - Battery: LiFePO$_4$

- **Zhongtai EV**
  - Battery: LiFePO$_4$

- **Changan Benben “MINI” EV**
  - Battery: LiFePO$_4$
EXAMPLES OF E-BUSES IN CHINA

- **Henan Xinmeijing**
  Battery: LiFePO₄

- **Zhongtong bus “LCK6128EV”**
  Battery: LiMn₂O₄

- **Dongfeng Tianyi EV Bus**
  Battery: LiFePO₄

- **Ankai “HFF6700BEV”**
  Battery: LiFePO₄

- **Nanjing Zhongda Qingshan EV bus**
  Battery: LiFePO₄

- **Shanghai Leibo EV Bus**
  Battery: LiFePO₄

- Focused on advancing industrialization of pure electric vehicles and plug-in hybrid electric vehicles, and promoting non-plug-in hybrid cars, energy-saving motor car

- Consumers purchasing BEV and PHEV during 2012-2020 will be exempted from purchase tax (10%)
- Consumers purchasing HEV during 2012-2050 will be exempted from 50% of purchase tax, consumer tax and license plate tax
- VAT paid by auto makers and component suppliers will be reduced from 17% to 13%
- Subsidies are also provided to E-cars
  - PHEV: RMB 50,000/unit (maximum)
  - BEV: RMB 60,000/unit (maximum)
  - HEV: RMB 3,000/unit (maximum)
  - Fuel cell: RMB 250,000/unit (maximum)
- Ministry of Finance will produce RMB 1-2 billion financial support to the industry with focus on technology development
COMMERCIAL TARGET - 2015-2020

Year 2015
- Accumulated sale of BEV and PHEV will reach 500,000 units
- Average fuel consumption: 6.9L/100 km
- Fuel consumption for energy efficient cars: 5.9L/100 km

Year 2020
- Accumulated sale of BEV and PHEV will reach 5 million units
- Capacity will be 5 million units/year
- Average fuel consumption: 5.0L/100 km
- Fuel consumption for energy efficient cars: 4.5L/100 km
INDUSTRY TARGET - 2020

- Promote battery scale production
- Help to form 2-3 companies with production over 10 billion WH
- One world class battery research institute
- 2-3 leading companies with focus on cathode and anode materials, separation membrane and electrolytes each
- Improve energy storage as a primary goal
- Extend driving range from 200 km to 500 km
- 1-2 auto makers with sales over 1 million units/year
- 3-5 auto makers with sales over 500,000 units/year
- Adequate infrastructure construction and other matching facilities
### DEVELOPMENT PLANS OF AUTO MAKERS

<table>
<thead>
<tr>
<th>Name</th>
<th>Investment plan</th>
<th>Execution status</th>
<th>Available models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shanghai Auto</td>
<td>Would like to have 20% of market share in E-car segment in China</td>
<td>Had invested RMB 2 billion prior to 2011&lt;br&gt;Will invest another RMB 6 billion to develop new energy cars</td>
<td>Produced over 1,000 units of “Shanghai” PV and “ROEWE 750” HEV for Shanghai EXPO&lt;br&gt;Promoted “ROEWE 550” PHEV and “ROEWE E50” EV in 2012&lt;br&gt;Energy saving efficiency can be as high as 50% for PHEV</td>
</tr>
<tr>
<td>Changan Group</td>
<td>2020: Sell new energy vehicles to 650,000 units (30% of total sales) and BEV will be 150,000 units</td>
<td>Invested RMB 1 billion in 2012 in HEV and PV</td>
<td>Has been promoting its first EV - “BenBen Mini”</td>
</tr>
</tbody>
</table>
## DEVELOPMENT PLANS OF AUTO MAKERS (cont’d)

<table>
<thead>
<tr>
<th>Name</th>
<th>Investment plan</th>
<th>Execution status</th>
<th>Available models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing Foton</td>
<td>2015: New energy vehicles will be 15% of total output</td>
<td>Produced 1,000 units of HEV in 2010</td>
<td>Produced “Foton” EV Buses, “Midi” EV and HEV buses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Built 8,000 units/year EV and 1,000 units/year HEV capacity in 2011</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Produced “Foton” EV Buses, “Midi” EV and HEV buses</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Will invest RMB 5.35 billion in the next a few years</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Build 11,000 units/year hybrid car and 1,000 units/year hybrid buses capacity in 2012</td>
<td></td>
</tr>
</tbody>
</table>
## DEVELOPMENT PLANS OF AUTO MAKERS (cont’d)

<table>
<thead>
<tr>
<th>Name</th>
<th>Investment plan</th>
<th>Execution status</th>
<th>Available models</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYD</td>
<td>Claim it will have 15% of market share in E-vehicles in 2015</td>
<td>BEV capacity: 10,000 units/year</td>
<td>BYD E6, BYD K9, BYD F3DM</td>
</tr>
<tr>
<td>Dongfeng</td>
<td>By 2015, total HEV will reach 100,000 units and EV output will reach 50,000 units</td>
<td>Will invest RMB 3 billion in the next five years in R&amp;D and production</td>
<td>Dongfeng EJ02</td>
</tr>
</tbody>
</table>
REGIONAL PROMOTION TARGET

<table>
<thead>
<tr>
<th>City</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>2012: Promote sales of 23,000 BEV and 7,000 PHEV</td>
</tr>
<tr>
<td></td>
<td>2015: Accumulated E-cars will reach to 200,000 units</td>
</tr>
<tr>
<td>Shanghai</td>
<td>2012: Total accumulated e-cars will reach to 20,000 units and build 25,000 charging poles and 50 charging stations</td>
</tr>
<tr>
<td></td>
<td>2015: Sales will reach to 300,000 units</td>
</tr>
<tr>
<td>Guangzhou</td>
<td>2020: Sales of new energy vehicles will reach to RMB 240billion or 15% of market share</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>2012: Sales of new energy cars will be 25,000 units</td>
</tr>
<tr>
<td></td>
<td>2015: The accumulated new energy cars will be 100,000 units</td>
</tr>
<tr>
<td>Wuhan</td>
<td>2020: Sales will reach 500,000 units</td>
</tr>
</tbody>
</table>
KEY BARRIERS

- High price due to high cost of battery
- Lack of charging facilities
- Battery safety
- Battery life

DEVELOPMENT OF E-MOBILITY IN CHINA
CAN CHINA REACH THE GOAL?

- ?????????????

- The most important factor is the EV battery development in China
DEVELOPMENT TRENDS OF BATTERIES IN E-MOBILITY

**Battery development trend**

1. Ni/Zn and Ni/Cd batteries
   - High pollution
   - Short lifetime
   - Exited market

2. Pb-acid batteries
   - Low cost
   - Low energy density
   - Environmental pollution
   - High self-discharge rate
   - Will exist market in 1-2 years
   - Geely Panda and Jinlong Bus

3. Ni/MH batteries
   - Low energy and power density
   - Short life time
   - Memory effect
   - Widely commercialized in HEV currently

4. Li-ion batteries
   - Long cyclic time
   - No memory effect
   - Low self-discharge
   - Low weight and volume
   - Relative high energy and power density
   - Largely promoted in the next five years by the industry and government

5. Fuel cell batteries
   - Good performance
   - Environmental friendly
   - Very high price
   - Still at the research stage
   - Can be developed in the next five years
E-MOBILITY IN CHINA

Ni-MH BATTERIES

Policies
- Government still provide subsidy to HEV but favors Li-ion batteries

Local suppliers
- Chunlan Group
- Jonjee Hitech
- Hunan shenzhou
- Korun New Energy
- Zhejiang Kan

Ni-MH batteries are widely commercialized and have achieved maturity in the HEV sector
- It will be soon replaced by Li-ion battery in China

Substitutes
- Li-ion batteries particularly LiFePO4 batteries

Customers
- Chana’s Jiexun
- Chery’s A5
- FAW’s Besturn
- Shanghai GM’s LaCrosse
E-MOBILITY IN CHINA

Li-ION BATTERIES

**Policies**
- Strong support in R&D
- Subsidy to BEV and HEV powered by Li-ion batteries

**Local suppliers**
- BYD, Lishen, Shenzhen BAK, Harbin Guangyu, Wanxiang, Beijing MGL, Suzhou Philion, Luyang Sky, etc.

**Li-ion batteries have been developed rapidly in China due to its good performance and government support**
- Many companies entered the sector due to potential market

**Market**
- Although the claimed capacity is huge, no scaled production yet

**Customers**
- BYD, Geely, Chery, Lifan, Zhongxing, Dngfeng, Changan, Foton, etc.
**Li-ION BATTERIES (cont’d)**

<table>
<thead>
<tr>
<th></th>
<th>钴酸锂 (LiCoO₂)</th>
<th>三元材料 Li(Ni Co)O₂</th>
<th>锰酸锂 (LiMn2O₄)</th>
<th>磷酸铁锂 (LiFePO₄)</th>
</tr>
</thead>
<tbody>
<tr>
<td>高能量密度</td>
<td>高能量密度</td>
<td>好安全</td>
<td>好安全</td>
<td>好安全</td>
</tr>
<tr>
<td>小体积</td>
<td>无限制充电和放电</td>
<td>低成本容易生产</td>
<td>好循环性能</td>
<td>好安全</td>
</tr>
<tr>
<td>低安全性</td>
<td>低安全性</td>
<td>低成本容易生产</td>
<td>低成本容易生产</td>
<td>好循环性能</td>
</tr>
<tr>
<td>适合小型电气设备</td>
<td>适合小型电气设备</td>
<td>低成本容易生产</td>
<td>低成本容易生产</td>
<td>好循环性能</td>
</tr>
</tbody>
</table>

- **钴酸锂 (LiCoO₂)**
  - 高能量密度
  - 小体积
  - 低安全性
  - 适合小型电气设备

- **三元材料 Li(Ni Co)O₂**
  - 高能量密度
  - 无限制充电和放电
  - 小体积
  - 低安全性
  - 用于小型电气设备

- **锰酸锂 (LiMn2O₄)**
  - 好安全
  - 低成本容易生产
  - 好循环性能
  - 用于小型电气设备

- **磷酸铁锂 (LiFePO₄)**
  - 好安全
  - 低成本容易生产
  - 好循环性能
  - 低成本容易生产
  - 环保
  - 总体成本甚至比 LiMNO₄ 便宜
  - 考虑为中国的未来主流产品

- **备注**: Li-ION BATTERIES (cont’d)
Li-ION BATTERIES (cont’d)

- LiFePO4 can be accessed locally
- Product quality is inconsistent
- Many players entered the market

- Can be produced in China
- The key raw material, Lithium Hexafluorophosphate LiPF6, is mainly imported from Japan

- Mainly rely on imports
- Gross profit margin can be high: > 50%
- Only several local companies are trying to develop the products

- Graphite is used
- Supplied locally

Cost of battery

- Cathode
- Separation membrane
- Electrolytes
- Anode

30%

10-20%

5-15%

30-40%
Li-ION BATTERIES (cont’d)

**Strength**
- Strong government support
- Heavy investment with large capacity
- Raw materials can be sourced locally

**Weakness**
- No scaled production
- Immature technology and quality inconsistency
- Potential patent issue
- Unsatisfactory battery management systems
- High production costs