New Energy Vehicle Drives in China

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And

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New Era of Electrical Vehicles

The research, development and deployment of electrical vehicles has become a world-wide trend.

*Toyota Prius*  *Honda Insight*  *Chevy Volt*

*Benz Smart*  *MINI E*  *BMW City*

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Rationale behind Chinese Push for Clean Vehicles

• Environmental pressure
  – Major Chinese cities are among the worst polluted cities in the world

• Energy supply
  – Large portion of imported oils for transportation consumption

• Opportunity to compete from the same starting line
  – Far behind in conventional IC technologies
  – New energy vehicles are viewed as the opportunity to compete
China’s New Energy Vehicle (NEV) Development Plan

- 2001--Pilot cars: "863 Program"
- 2008--1,000: Beijing Olympics
- 2009--10,000: "Ten City 1000"
- 2010--20,000: Shanghai Expo
- 2011--500,000: Commercialization
New Programs for Public Vehicles

“10-City, 1000” project has expanded to 25 cities:

- Beijing,
- Shanghai,
- Chongqing,
- Changchun,
- Dalian,
- Hangzhou,
- Jinan,
- Wuhan,
- Shenzhen,
- Hefei,
- Changsha,
- Kunming,
- Nanchang,
- Tianjin,
- Haikou,
- Zhengzhou,
- Xiamen,
- Suzhou,
- Tangshan,
- Guangzhou,
- Shenyang,
- Chengdu,
- Nantong,
- Xiangfan and
- Hohhot
## Incentives for Public Vehicles

### Subsidy standards for passenger cars of public service and light commercial vehicles (unit: 1,000RMB/Vehicle)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Saving Ratio</th>
<th>The Largest Electric Power Ratio</th>
<th>BSG</th>
<th>10%-20%</th>
<th>20%-30%</th>
<th>30%-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEV</td>
<td>5%-10%</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10%-20%</td>
<td>28</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20%-30%</td>
<td></td>
<td>32</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30%-40%</td>
<td></td>
<td></td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40% and more</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>EV</td>
<td>100%</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCV</td>
<td>100%</td>
<td>250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Subsidy standards for urban buses with a length of over 10 m (unit: 1,000RMB/Vehicle)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Fuel Saving Ratio</th>
<th>Hybrid System with Lead-acid Battery</th>
<th>Hybrid System with Nickel-metal Hydride Batteries, Lithium-ion Battery or Super Capacitor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Largest Electric Power Ratio of 20%-50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Largest Electric Power Ratio of over 50%</td>
</tr>
<tr>
<td>HEV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10%-20%</td>
<td>50</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>20%-30%</td>
<td>70</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>30%-40%</td>
<td>80</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>40% and more</td>
<td>42</td>
<td>45</td>
</tr>
<tr>
<td>EV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: PHEV is covered in the subsidy standards for the HEV with the electric power ratio over 30%.

Note: PHEV is covered in the subsidy standards for the HEV with the electric power ratio over 50%.

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Beijing - the first city to run 1,000 new energy vehicles

- In 2009, Beijing had put 1,000 new energy vehicles into service.
- In 2009, financial expenses for pure electric vehicles, hybrid electric vehicle reached 550 million RMB.
- Plan for 2010~2012 is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Electric Bus</th>
<th>Electric Sanitation Vehicle</th>
<th>Electric Passenger Vehicle</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>50</td>
<td>1,000</td>
<td>/</td>
<td>1,050</td>
</tr>
<tr>
<td>2011</td>
<td>50</td>
<td>1,300</td>
<td>500</td>
<td>1,850</td>
</tr>
<tr>
<td>2012</td>
<td>50</td>
<td>1,050</td>
<td>/</td>
<td>1,100</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
<td>3,350</td>
<td>500</td>
<td>4,000</td>
</tr>
</tbody>
</table>

① ≈ Population of 19 millions
Shanghai - more than 30 bus lines are using new energy vehicles
  - In 2009, more than 30 bus lines using new energy vehicles entered the commercial operations
  - In 2010, the demonstration scale of new energy vehicles were more than 1000.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Cell Vehicle</td>
<td>200</td>
<td>10 Fuel Cell Buses 90 Fuel Cell Passenger Cars 100 Fuel Cell Tour Cars</td>
</tr>
<tr>
<td>Electric Vehicle</td>
<td>300</td>
<td>150 Electric Buses 150 Electric Special-purpose Cars</td>
</tr>
<tr>
<td>Hybrid Electric Vehicle</td>
<td>500</td>
<td>150 Hybrid Buses 350 Hybrid Passenger Cars</td>
</tr>
<tr>
<td>Trolley Bus</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1070</strong></td>
<td></td>
</tr>
</tbody>
</table>

①≈ Population of 20 millions
Hangzhou – near 300 new energy vehicles operating on road

- In 2010, the number of new energy vehicles increased to about 300.
- There will be more than 3,000 new energy vehicles in 2012 according to its current plan.
- From 2009 to 2012, the subsidy from local government is a 2% of purchase price for electric vehicles and 1% of purchase price for hybrid vehicles.

\[ \text{Population of 6 millions} \]
Shenzhen – will reach 24,000 NEV in 2012

- 2009, Shenzhen had 101 hybrid buses in service.
- By 2012, Shenzhen will promote 24,000 new energy vehicles in the area of city bus, public car and private car.
- 4,000 hybrid and electric buses will be put to service by 2012.
- Building a management information platform for NEV trial run.
- Expect to become the first city with the number of new energy cars accounting for 1% of the vehicle population.
- Shenzhen will invest more than 2 billion RMB, and will establish the first electric taxi company with 100 electric taxis.

Footnote: Population of 4 millions
Chongqing – the first city to have a new energy vehicle industry alliance

- On June 2, 2009, headed by the Chongqing Chang'an Automobile Company, the new energy automotive industry alliance was established.
- By the end of 2012, Chongqing will adopt 1550 new energy vehicles.
Wuhan – the trial run of NEV is in full swing

- By the end of 2009, Wuhan had 400 hybrid buses operating on road.
- By 2011, Wuhan will invest 393 million RMB to build new public transport vehicles, including 89 million RMB from local government and the rest from central government.
- Put 1000 hybrid buses into service in two years, and at least 17 new hybrid electric bus routes in operation.
- Apply 500 battery electric vehicles in the area of urban purity, city construction, and tourism.

\( \approx \) Population of 8 millions
• Dalian
  – In 2009, Dalian had put 62 hybrid buses and 15 electric buses into service.
  – By 2012, Dalian will deploy more than 2,400 new energy vehicles.
• Changchun
  – In 2010, 100 gas-electric hybrid buses of Line #6 were running in the People's Avenue.
  – By 2012, Changchun City will run 1,000 new energy vehicles on its bus lines.

(sym) ≈ Dalian Population of 6 millions
(sym) ≈ Changchun Population of 7 millions

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• Government announcement on subsidizing private purchase of new energy vehicles in experimental cities
  – On June 1, 2010, jointly issued by Ministry of Finance, Ministry of Science and Technology, Industry and Information Ministry, the National Development and Reform Commission, the announcement selected Shanghai, Changchun, Shenzhen, Hangzhou and Hefei for subsidizing private purchase of NEV.

Electric passenger car with battery pack no less than 15 kWh
Plug-in hybrid vehicle with battery pack no less than 10 kWh (driving range under pure electric mode is no less than 50 km)

By the subsidy rate of 3,000 RMB/kWh, the maximum subsidy is 50,000 RMB for PHEV and 60,000 RMB for battery electric passenger vehicles.

Lead-acid batteries not included
• Shenzhen – the first city to launch subsidies for private purchase of new energy vehicles
  – Shenzhen will place an additional 30,000 RMB subsidy for the dual-mode electric cars and an additional 60,000 RMB subsidy for electric cars.
  – By the end of 2012, the number of private purchase of new energy vehicles will reach 25,000 under the support of this program.
  – The price of the low-carbon version of luxury electric cars F3DM has been reduced from 169,800 RMB to 89,800 RMB with a direct subsidy of 80,000 RMB.
  – China Southern Power Grid's first batch of charging stations/posts have been put into operation in Shenzhen, with two charging stations and 134 charging posts included.
  – Before 2012, Shenzhen will build 12,750 charging equipment in total, including 25 bus charging stations, 2,500 charging posts for official vehicles, 10,000 public slow charging posts and 200 public charging stations.
• Shanghai
  – Shanghai's subsidy methods for new energy vehicles include installments for auto purchase, the battery lease, pay-to-mileage and other new business models for NEV.
  – By the end of 2012, the estimate of private purchase of new energy vehicles will reach 20,000.
  – In 2012, there will be 50 charging stations and 5,000 charging posts.
• Changchun
  – It is building two large-scale electric vehicle charging stations with the capability of charging 16 electric buses simultaneously.
  – By 2012, the total number of plug-in hybrid electric passenger vehicles and electric passenger vehicles will reach 16,000.
  – By 2012, the charging infrastructure will include 15 charging stations and 5,000 charging posts.
Hangzhou

- A large charging station, five small battery charging stations, 50-100 battery replacement service outlets and 130 charging posts will be built in urban areas by the end of 2010.
- Before 2012, Hangzhou plans to build 42 charging stations and 3,500 charging posts.
- To achieve a target of 20,000 private new energy vehicles by the end of 2012, the maximum local subsidy is 63,000 RMB. With the central government subsidies included, the new record of subsidy is 123,000 RMB.
- **Hefei**
  - An additional 10,000 RMB of local subsidy is provided.
  - Hefei aims to build four charging stations, 500 charging posts by the end of 2010.
  - Hefei plans to apply 835 new energy vehicles, including 250 electric buses and 585 electric passenger cars in 2010.
  - Before 2012, Hefei will apply 22,500 new energy vehicles, including 14,500 electric cars and 8,000 plug-in hybrid cars.
  - Before 2012, to achieve the goal of "a charge for a car", Hefei will complete the construction of 20 charging stations and 22,500 charging posts.
Currently about 30 different models of electric cars can get the subsidy according to the registered directory: Directory of recommended models for energy-saving and new energy vehicles demonstration and application.
Challenges for Chinese EV Development

- Mismatch between the technological readiness and governmental push for commercialization
- Lack of vehicle system-level design, engineering and integration know-how
- Lack of standardization
- Ignorance among some senior leadership in certain OEMs
A Very Recent Bad Publicity

- As a result of a self-ignited EV disaster in Hongzhou on April 11, 2011, all EV Taxis were pulled out of service.
Extensive R&D activities are being carried out in China on key enabling technologies related to new energy vehicles.

Use the sample research projects from Shanghai Jiao Tong University as an example.
SJTU’s HEV Research & Development Platform

HEV Simulate Objects

Computer Simulation
- Modeling
- Strategy
- Arithmetic
- Design
- …

HIL-Test Bench
- Net control unit
- Start & Close
- Function Development
- Basic Application

Engine Dyno
- Emission
- Fuel Economy
- Starter-Stop
- Eng +ISG
- Calibration

Trans. Dyno
- Gear shift strategy
- Gear shift Quality
- Control reliability

Powertrain Dyno
- ESP Function
- Powertrain Dynamic Energy Management

Chassis Dyno
- Thermodynamics & Acoustics Characteristic
- Emission Confirmation

Road Test
- INCA
- Calibrating the cycles…

Performance, Economy, Emission, Drivability
Battery Pack Design and Thermal Management

NiMH Battery Pack

Square NiMH

Lithium ion Battery Pack

Circular LiFePO4
Research on High Performance Motor Control Technology

- Develop low cost and highly integrated electric drive system for rear 2WD small pure electric vehicles including:
  - Design of In-wheel electric motor
  - Motor control software design
  - Vehicle safety control software design
  - Demo vehicle development
Research on Safety Control System of Electric Vehicles

- EV can not only be “cleaner”, but also “safer”, “more comfortable”, and “more maneuverable”.
- Make full use of electric motor’s unique advantages
  - Fast torque response
  - Accurate torque feedback
  - 4WD independent control
- EV Active safety control
  - Anti-skid Control
  - Optimum Speed Pattern
  - Direct Yaw-moment Control
Research on Wireless Charging

- Battery is a key bottleneck technology for the commercialization of electric vehicle, and its environment impact is questionable.
- Our proposal: deliver electricity from the electric grid to moving vehicles in real time through wireless charging of on-board Supercapacitor.
Research on EV Integration

Aim: Low cost and high system level integration

- Low-Cost Hybrid Electric Propulsion System (a OEM Project)
- EQ 7200 HEV Hybrid Car Development (National “863” Project)
- Hybrid Car Multi-Energy Powertrain Control System Development (National “863” Project) ……

Architecture Design  Performance Analysis  Test and Validation
National “863” EV Program
Battery System Development Lab

Battery Emulation
- High-Voltage Battery Tester
- Single Battery Tester

Battery Testing
- Battery Pack Test System
- Vibrating Table
- Temperature Chamber

Output: 20 V ~ 750 V, -500 A ~ +500 A
Power: ±250kw; Power Factor: > 98%
Precision: Voltage 0.5%, Current 0.1%, Power 0.1%
Response: 50 ms

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**High Speed Motor Testing Bench**

<table>
<thead>
<tr>
<th>Power (kW)</th>
<th>Torque (Nm)</th>
<th>Speed (rpm)</th>
<th>Max.Speed (rpm)</th>
<th>Speed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 ~ 250</td>
<td>220 ~ 250</td>
<td>7000 ~ 8000</td>
<td>10000 ~ 12000</td>
<td>±1.0rpm</td>
</tr>
</tbody>
</table>

**Low Speed Motor Testing Bench**

<table>
<thead>
<tr>
<th>Power (kW)</th>
<th>Torque (Nm)</th>
<th>Speed (rpm)</th>
<th>Max.Speed (rpm)</th>
<th>Speed Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>170 ~ 200</td>
<td>650 ~ 800</td>
<td>2300 ~ 2500</td>
<td>2500 ~ 3000</td>
<td>±1.0rpm</td>
</tr>
</tbody>
</table>
Green Race: U.S. Strength and Weakness

• Strength:
  – Profound knowledge base and technical foundation in automotive engineering and manufacturing
  – High concentration of automotive R&D talents, particularly in Michigan
  – Strong fundamental research and innovations in universities
  – Government investment in clean energy technologies

• Weakness
  – Lack of supply chains for critical systems
  – Inefficiency in establishing new public policies to promote the early adoption of clean vehicle technologies
Green Race: China’s Strength and Weakness

• Strength
  – Significant government support for clean vehicle technologies to make up for their lagging in conventional IC automotive technologies
  – Efficiency in government to establish incentives for adopting new clean vehicle technologies
  – Mass production capability to make products cheaply
  – Strong applied research at universities
  – Abundant labor and skilled resources

• Weakness
  – Lack of vehicle engineering and system integration capability
  – Weak in system-level design and optimization
  – Lack of skills to compete in global markets
By the end of 2009, China has achieved the following stunning new energy developments:

- **Hydro-electrical power generation**: 197 GW (#1 in the world)
- **Wind power generation**: 22 GW (#3 in the world)
- **Nuclear power generation**: 9.17 GW from 11 power stations
  - 30 newly approved power stations: 32.7 GW
  - 23 power stations under construction (#1 in the world)
- **Solar water heating capacity**: (#1 in the world)
- **PV solar cell production**: 4 GW/yr (#1 in the world, 40% worldwide production)
- **Biomass electrical generation**: 4.5 GW
Green Race: Opportunities for Collaboration

- Complimentary strengths in clean vehicle technologies
  - U.S. innovations, system engineering and integration
  - Chinese productions, battery technologies and supply chains

- U.S. and Chinese auto markets are big enough for both countries to win.

- It might be easier for certain regions in China to be early adopter of clean vehicle technologies, which could serve as a pilot ground for wide adoption back in U.S.
Summary

• Chinese government agencies, particularly the Ministry of Science and Technology, have made a big push for NEV in recent years.
• Under the heavy government subsidy, fierce and overly aggressive competition is expected.
• Truthfully speaking, Chinese OEMs are still lagging behind due to their lack of vehicle system-level design, engineering and integration capabilities.
• There is a lack of standardization efforts.
• There are still real opportunities for US OEMs to compete in this green race.
• Go for range-extenders, not pure electrics.
Thank You

and

Welcome to the Beautiful Michigan!