Joint research by Societies of Automotive Engineers of China and China Automotive Technology & Research Center


China Automotive Technology & Research Center
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Nov. 21, 2014, Beijing
I. Project background

II. Evaluation scheme of demonstration effects of energy-saving and new energy vehicles

III. Review of project implementation

IV. Overall conditions of demonstration and promotion of energy-saving and new energy vehicles

V. Technology evaluation, charging infrastructure and users of energy-saving and new energy vehicles

VI. Summary
Requirements for demonstration effects of energy-saving and new energy vehicles

- Since the beginning of 2009, four ministries and commissions have issued several notices on implementing energy-saving and new energy vehicle demonstration and promotion as well as demonstration and promotion of subsidizing private buyers of NEVs in the public service fields. **Research should be carried out on the promotion effects, existing problems and countermeasures**

**Pilot cities of “10 Cities & 1000 Vehicles” Project**

**Promotion and application cities (regions) of NEVs**
Significance of evaluation on energy-saving and new energy vehicle demonstration

- With “demonstration is aimed at commercialization” as the standard, major aspects related to application of NEVs were investigated, analyzed and evaluated and corresponding suggestions were made:
  - Providing support for the adjustment of demonstration and promotion policy suggestions
    Through demonstration evaluation, large amount of basic operation data were mastered, which offered support for the adjustment of demonstration and promotion policy suggestions and was conducive to the scientific formulation and promotion of relevant policies such as subsidy policies, etc.
  - Facilitating and guiding the development of product technology
    Carried out technology evaluation on new products and technologies in the demonstration process, and evaluated the direction supported by key EV technology R&D.
  - Providing the basis for enterprises to make EV product strategies
    Made clear of the main demands of drivers and potential consumers on EV product technology via demonstration evaluation.

Charging infrastructure including fast and slow charging

HEV, EV, PHEV

Taxi drivers
Entity users
Individual users
General public
Evaluation mechanism—third party as the mainstay, participated by several parties, supervising and evaluating the effects of promoting NEV demonstration.

- Technology evaluation report
- Product improvement suggestions
- Policy adjustment suggestions

Four ministries & commissions
Governments of pilot cities
Operating units or individuals
Car enterprises
Parts enterprises

SAE-China CATARC

Results

Phase I
Phase II ~
Phase III

Evaluation on ongoing conditions
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VI. Summary
2.1 Empirical assessment of project scheme

EV test

Real operation performance

Leading to

Quality evaluation system of EVs

<table>
<thead>
<tr>
<th>Road test</th>
<th>Necessary items</th>
<th>Lab test</th>
<th>Necessary items</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Free route</td>
<td>B</td>
<td>Vehicle test</td>
</tr>
<tr>
<td></td>
<td>Fixed route</td>
<td></td>
<td>Parts test</td>
</tr>
</tbody>
</table>

Test performance: as reference

Key parameters of vehicles

Object, comprehensive & professional

Objective evaluation

Data analysis

Necessary items

Additional items

Subjective evaluation

Questionnaire survey

Chinese users

Including active users

Answering questions

Leaving messages voluntarily

Vehicle performance

Parts performance

Real operation performance
### 2.1 Empirical assessment of project scheme

**Obtain comprehensive results of EV objective evaluation by a series of standard and non-standard tests**

<table>
<thead>
<tr>
<th>Objective evaluation index</th>
<th>Details</th>
<th>Objective evaluation index</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption</td>
<td>Under working conditions of NEDC</td>
<td></td>
<td>Under working conditions of NEDC</td>
</tr>
<tr>
<td></td>
<td>Under working conditions of CATARC</td>
<td></td>
<td>Under working conditions of CATARC</td>
</tr>
<tr>
<td></td>
<td>With high-low temperature air conditioner on</td>
<td></td>
<td>Driving range when the function is disabled</td>
</tr>
<tr>
<td></td>
<td>Under road running test</td>
<td></td>
<td>Influence on brake safety</td>
</tr>
<tr>
<td>Driving range</td>
<td>Under working conditions of NEDC and low speed</td>
<td></td>
<td>Room temperature</td>
</tr>
<tr>
<td></td>
<td>Under working conditions of CATARC</td>
<td></td>
<td>Low temperature &amp; high temperature</td>
</tr>
<tr>
<td></td>
<td>With high-low temperature air conditioner on</td>
<td></td>
<td>Dynamic property</td>
</tr>
<tr>
<td></td>
<td>Full load</td>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low temperature, special terrain, low SOC</td>
</tr>
<tr>
<td>EMC</td>
<td></td>
<td></td>
<td>Key part performance</td>
</tr>
</tbody>
</table>

**Objective evaluation**

Data analysis

Necessary items

- Vehicle performance
- Parts performance

Additional items
2.1 Empirical assessment of project scheme

- **Taxi drivers, users** (entities & individuals), general public

- Vehicle basic information
- Usage habits
- Charging habits
- Satisfaction
- Mileage, brand and model, price, purchase time, number of family-owned vehicles, primary purpose
- Average daily journey frequency
- Average daily trip distance
- Charging frequency, time, and location
- Charging mode
- Charging time
- Vehicle performance (range, acceleration performance, maximum speed, etc.)
- Vehicle product quality
- After-sales service
- Cost
- Reliability
- Improvement direction
- Number of failures, type, grade
- Ideal range
- Ideal charging time
- Most hoped-for parameter and improvement

Subjective evaluation
- Questionnaire survey

Chinese users
- Including active users
- Answering questions
- Leaving messages voluntarily
Outline

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VI. Summary
Schedule of evaluation

Phase I:

**Time:** May, 2011-Sep. 2012

**Vehicle type:** Hybrid electric bus (HEBus)

Phase II:

**Time:** Sep. 2013.9-Sep. 2014

**Vehicle type:** Plug-in hybrid electric vehicle (PHEV), electric bus (EBus) and electric vehicle (EV)
Phase I: Energy-saving vehicles – HEBus

- The vehicle models evaluated covered the main HEBus manufacturers of China and the major models operated for demonstration and promotion: 16 HEV manufacturers, 17 HEV models and 11 hybrid power systems were involved.

<table>
<thead>
<tr>
<th>City</th>
<th>Tested route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hangzhou</td>
<td>187</td>
</tr>
<tr>
<td>Shanghai</td>
<td>43</td>
</tr>
<tr>
<td>Dalian</td>
<td>15</td>
</tr>
<tr>
<td>Jinan</td>
<td>K156</td>
</tr>
<tr>
<td>Zhengzhou</td>
<td>906</td>
</tr>
<tr>
<td>Wuhan</td>
<td>595, 512</td>
</tr>
<tr>
<td>Zhuzhou</td>
<td>T2</td>
</tr>
<tr>
<td>Kunming</td>
<td>A representative route was recombined</td>
</tr>
</tbody>
</table>

- Real route test
- Simulation test
Phase I: NEV – Ebus, EV, PHEV

- The vehicle models evaluated covered the main HEBus manufacturers of China and the major models operated for demonstration and promotion:
  - 5 models & 10 units of EV
  - 5 models & 10 units of EBus
  - 1 unit of PHEV
- 5 cities (with an scale of over 100 units)
  - Shenzhen, Hefei, Hangzhou, Shanghai, Beijing

- Real route test:
  21 units of 11 models were tested
- Lab test:
  NEDC working condition test were carried out for 3 EVs
Simultaneously with the tests, questionnaire survey were carried out among users of typical vehicle models and the general public in 8 + 5 cities, and 914 valid questionnaires were retrieved.
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VI. Summary
1. Status quo of energy-saving and new energy vehicle demonstration and promotion

Promoted amount (units)

- 2009: 1,500
- 2010: 3,000
- 2011: 4,500
- 2012: 6,000
- 2013: 7,500
- 2014: 9,000

Total: 66,000

Progress of energy-saving and new energy vehicle demonstration and promotion

Promotion and application fields of NEVs since 2013

Note: Up to Sep. 2014. Since 2013, only data of PHEV and EV were included.
2. Status quo of commercialization of energy-saving and new energy vehicles

- By Sep. 2014, 125,600 notice vehicles (including vehicles of joint-venture brands) were produced, including 42,800 HEVs and 82,700 EVs. The policy effects were shown and number of energy-saving and new energy vehicles increased greatly.

- Seen from the output, number of HEVs and EVs increased rapidly in 2012; HEVs started to decrease since 2013; number of EVs and PHEVs increased significantly, especially in 2014; fuel cell vehicles (FCVs) have not been put into production yet. The increase or decrease was closely linked with policies: EVs and PHEVs were mainly impacted by traffic control, purchase tax exemption, subsidies and other policies, and the decrease of number of HEVs was also a result of policy factors.
3. Progress made by NEV demonstration cities

- By Sep. 2014, there were 15 cities with more than 500 vehicles promoted and applied, among which 6 cities (regions) were with more than 3000 vehicles promoted and applied, respectively: Zhejiang, Beijing, Shenzhen, Hefei, Shanghai and Jiangsu, accounting for 67% of the total promoted amount.

- Compared with the planned target, only Zhejiang and Hefei had a completion rate of over 50%; Shanghai also had a completion rate of 40%. Their results benefited from the business models and local policies.
Top 10 promoted vehicle models

Cumulative output of top 10 EV models during 2009-2014

Cumulative output of top 10 EBus models during 2009-2014

Cumulative output of top 10 PHEV models during 2009-2014

Cumulative output of top 10 PHEBus models during 2009-2014
The State Council issued Guiding Opinions on Accelerating Promotion and Application of New Energy Vehicles on Jul. 21, 2014. “Secondly, speed up the construction of charging infrastructure. Charging infrastructure is an important foundation for NEV development.” It is expected that the construction of charging infrastructure may boost and the actual effects remain to be observed thereafter.
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VI. Summary
1. HEBus – fuel-saving effects

- In 2008, the fuel consumption of Beijing HEV demonstration fleet was $30 \sim 40 \text{L}/100 \text{km}$ with an average level of around $35 \text{L}/100 \text{km}$, while the fuel consumption of this test was $27.5 \text{L}/100 \text{km}$; in 2008, the fuel consumption of vehicles with the best fuel-saving effects was $30 \text{L}/100 \text{km}$ while the fuel consumption of vehicles with the worst fuel-saving effects was only $31 \text{L}/100 \text{km}$;

- By comparing the historical data and the data of this test, it can be seen that fuel-saving level of HEVs was about $22\%$ with significant technological progress.
For vehicles with star-stop function, the fuel consumption levels were close to each other and about 8% lower than those of vehicles without start-stop function. **However, such vehicles are not widely applied yet.**

- With the air conditioner on, fuel-saving effects were also quite significant with the average level up to 19.1%; **compared with the results with the air conditioner off, fuel-saving effects were slightly lower.**
1. HEBus – brake energy regeneration

- Electricity regenerated in a single cycle:
  - Supercapacitor > lithium battery > nickel metal hydride battery
- Average regeneration rate of brake energy was between 4% and 9% with the average level being 5.6%
- There were large differences among different vehicle types.
1. HEBus -- reliability

- As for failure rate, compared with traditional diesel vehicles, the failure rate of HEBus remained high; compared with foreign systems, the failure rate of domestic systems was still relatively high.
- As for failure level, probability of failure levels 1, 2 and 3 was the lowest and most of them could be fixed in a short time; for domestic systems, probability of failure levels 1 and 2 was high.
- As for failure items, main failure-prone parts were three key ones: power battery, drive motor and electronic control.
1. HEBus – brief summary

- HEBus technologies were relatively mature and obvious fuel-saving effects could be achieved.
- In terms of use cost, reliability and maintenance cost, etc, HEBus could basically satisfy the needs of bus company users, and the requirements for large-scale promotion and application had been met.
- Core technologies were still weak: electronic control, idling start-stop and brake energy regeneration technologies.
- Compared with traditional diesel vehicles, reliability of HEVs remained to be improved.
- Select outstanding models and promote and apply them concentratively.
- Remove regional restrictions.
- Provide proper policy support and totally withdraw from those policies that could destroy the outcomes obtained through years of efforts.
2. EV
Blind use of high-capacity batteries and high-power motors does not necessarily regenerate more brake energy.

Manufacturers should equip batteries of proper capacity and motors of proper power in line with different EV models; appropriate drive control strategy should be adopted to improve brake energy regeneration efficiency on the premise of guaranteeing driving safety of the vehicle, thereby enhancing the energy utilization efficiency of the vehicle.
Influences of brake safety in EV brake energy regeneration

With regenerative braking, the brake performance of vehicles is relatively unstable and generally becomes poorer.

In the standard, the braking system of EVs is turned off without taking its influence on brake safety into consideration. Therefore, it is recommended to be revised.
The vehicle models tested covered different urban working conditions and different model configurations. There were three energy consumption levels of Ebus: 125kWh/100km, 100kWh/100km, 79kWh/100km.

Calculated according to maximum busload, compared with model 1, mode 2 and model 3 had higher energy consumption per passenger and the energy utilization efficiency was lower; model 4 had the lowest power consumption per 100km and per capita power consumption, and the latter was almost half of vehicles with highest per capita power consumption.
3. Ebus – influences of air conditioner

- When the ambient temperature was 28°C, the influence of air conditioner on EV was about 10% lower than that on HEV if it was set to 24°C.
- As EV adopted electric air conditioner, it had higher efficiency than HEV which used mechanical air conditioner.
Apart from model 1, brake energy regeneration facilitated reduction of bus energy consumption of about 20%~30%.

Compared with HEBus, Ebus was equipped with motor of higher power, and its contribution rate to brake energy consumption was therefore higher than HEV. Some models performed very well.
Battery attenuation was still serious

- Annual average attenuation of total batteries was about 8%. (Slow charging mode was commonly used)
- For several models, the capacity on a single charge reduced to 73kWh/charge at the end of the year from 100kWh/charge at the beginning of the year. The number of charging times increased from 2.24 at the beginning of the year to 3.8 at the end of the year.

![Driving range on a single charge, kWh/charge](chart1)

**Whole-year charge conditions of 12 vehicles in a fleet**

![Capacity on a single charge, kWh/charge](chart2)

**Whole-year average charge conditions of 12 vehicles in a fleet**
The cognition of users with driving experience was as expected. The general public as a whole had an unclear cognition of EVs and particularly low cognition in terms of driving experience, safety and noises.

The general public had low cognition of EV use cost and private car owners did not care much about EV use cost.
Survey on NEVs – satisfaction

- The aspects that users were most dissatisfied with concentrated on number & distribution of charging infrastructure, queuing time of charging, charging time, and driving range.
- Users were highly satisfied with acceleration performance, air conditioner, and maximum speed. (air conditioning refrigeration had small impacts on the performance – guaranteeing the charged capacity.

### Satisfaction survey results of taxis

<table>
<thead>
<tr>
<th>Aspect</th>
<th>8~10 (非常满意)</th>
<th>6~7 (基本满意)</th>
<th>1~5 (基本不满意)</th>
</tr>
</thead>
<tbody>
<tr>
<td>充电设施分布</td>
<td>5%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电设备数量</td>
<td>7%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电消耗时间</td>
<td>5%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电排队时间</td>
<td>9%</td>
<td>84%</td>
<td>76%</td>
</tr>
<tr>
<td>续驶里程</td>
<td>12%</td>
<td>48%</td>
<td>47%</td>
</tr>
<tr>
<td>售后</td>
<td>40%</td>
<td>48%</td>
<td>25%</td>
</tr>
<tr>
<td>成本</td>
<td>44%</td>
<td>47%</td>
<td>25%</td>
</tr>
<tr>
<td>电缆使用便利性</td>
<td>65%</td>
<td>25%</td>
<td>10%</td>
</tr>
<tr>
<td>加速性能</td>
<td>79%</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td>空调性能</td>
<td>80%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>最高时速</td>
<td>83%</td>
<td>8%</td>
<td>8%</td>
</tr>
</tbody>
</table>

### Satisfaction survey results of buses

<table>
<thead>
<tr>
<th>Aspect</th>
<th>8~10 (非常满意)</th>
<th>6~7 (基本满意)</th>
<th>1~5 (基本不满意)</th>
</tr>
</thead>
<tbody>
<tr>
<td>车辆布置结构</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>续驶里程</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电设施数量</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电等待时间</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电设施布局</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>充电所需时间</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>售后服务</td>
<td>80%</td>
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</tr>
<tr>
<td>空调性能</td>
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<td>89%</td>
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<td>最高时速</td>
<td>80%</td>
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<td>充电方式</td>
<td>80%</td>
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</tr>
<tr>
<td>加速性能</td>
<td>80%</td>
<td>89%</td>
<td>89%</td>
</tr>
</tbody>
</table>
Survey on NEVs – improvements wanted

- The questionnaire designed existing model parameters in accordance with the various passenger vehicle models in different cities. Ranking of improvements wanted in terms of cost reduction, driving range increase, charging time reduction, availability of charging at home, maximum speed increase, etc. was investigated, and the ideal improvement degrees were also investigated.

- The parameters that taxi drivers wanted to improve most were driving range and charging time.

- Unlike taxi drivers, the parameters that private car owners wanted to improve most were driving range, price, and availability of charging at home, and charging time and maximum speed were the least important for them.

- The daily average mileage of taxis in the four cities were all around 180~200km. Reasons for differences of EV driving range of taxi drivers were mainly the differences in terms of vehicles themselves, charging mode, and driving features.
Driving range, daily mileage and vehicle types

Using features and ideal parameters of taxis and private cars

<table>
<thead>
<tr>
<th></th>
<th>Taxis</th>
<th>Private cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily mileage</td>
<td>85%: 200~300km</td>
<td>About 25%: more than 50km</td>
</tr>
<tr>
<td>Vehicle driving range</td>
<td>&lt;200</td>
<td>-</td>
</tr>
<tr>
<td>Ideal driving range</td>
<td>&gt;300</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Charging time</td>
<td>1.65</td>
<td>5~8</td>
</tr>
<tr>
<td>Ideal charging time</td>
<td>0.65</td>
<td>75%: over 2 hours</td>
</tr>
</tbody>
</table>

People are always expecting higher driving range!

Driving range should be dealt with in accordance with the commercial uses
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Main conclusions

- For commercialization of EVs, **priority** should be given to construction of **basic** charging infrastructure network.
- Policy effects were strong, and policies should maintain their continuity, balance and diversity
  - Commercialization of energy-saving and new energy vehicles was closely linked with policies – increase or decrease of HEBus & EV; increase of individual users, purchase tax exemption. Policy effects were clearly shown in 2014
  - Range of commercialized models had distinct regional characteristics and also was greatly affected by business models and local policies
  - HEVs are still in need of policy support to facilitate the reinforcement and enhancement of HEV technologies;
  - Effects of charging infrastructure incentive policy should be closely monitored, yet it is expected that the effects would be optimistic
- Passenger car market is the mainstay and foundation of commercialization of energy-saving and new energy vehicles, and policies should lay particular stress on it.
**Main conclusions**

- Energy conservation and environmental protection performances of energy-saving and new energy vehicles were apparent, energy consumption levels of some models were especially low, and the per unit energy utilization efficiency was high.

- However, the following questions should be addressed urgently:
  - Cost should be reduced to adapt to commercial competition
  - The overall energy consumption levels were high and the vehicles were too heavy (high load battery capacity)
  - Core technologies were not mature enough: electronic control (energy utilization mode), brake energy regeneration and start-stop, etc.
  - Reliability remained to be improved
  - Electric heating by air conditioner in winter consumed large amount of energy, severely impacting driving range of EVs

- Great attention should be paid to deterioration rate and durability of power batteries
Thank you!