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

Evaluation on the Demonstrative Operation Effects of Energy-saving and New Energy Vehicles

China Automotive Technology & Research Center

Mengliang Li

Nov. 21, 2014, Beijing

Outline

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**

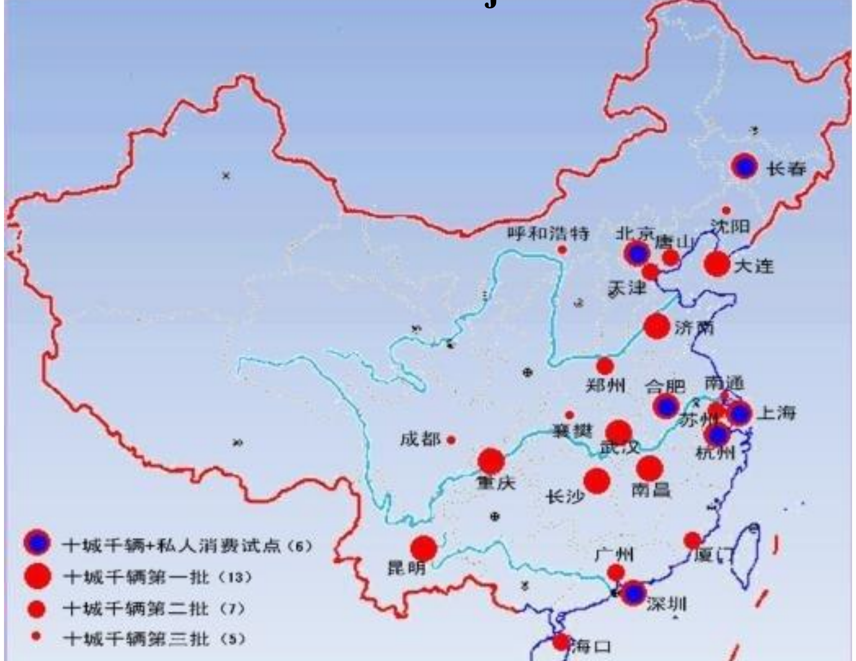
V. **Technology evaluation, charging infrastructure and users of energy-saving and new energy vehicles**

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**

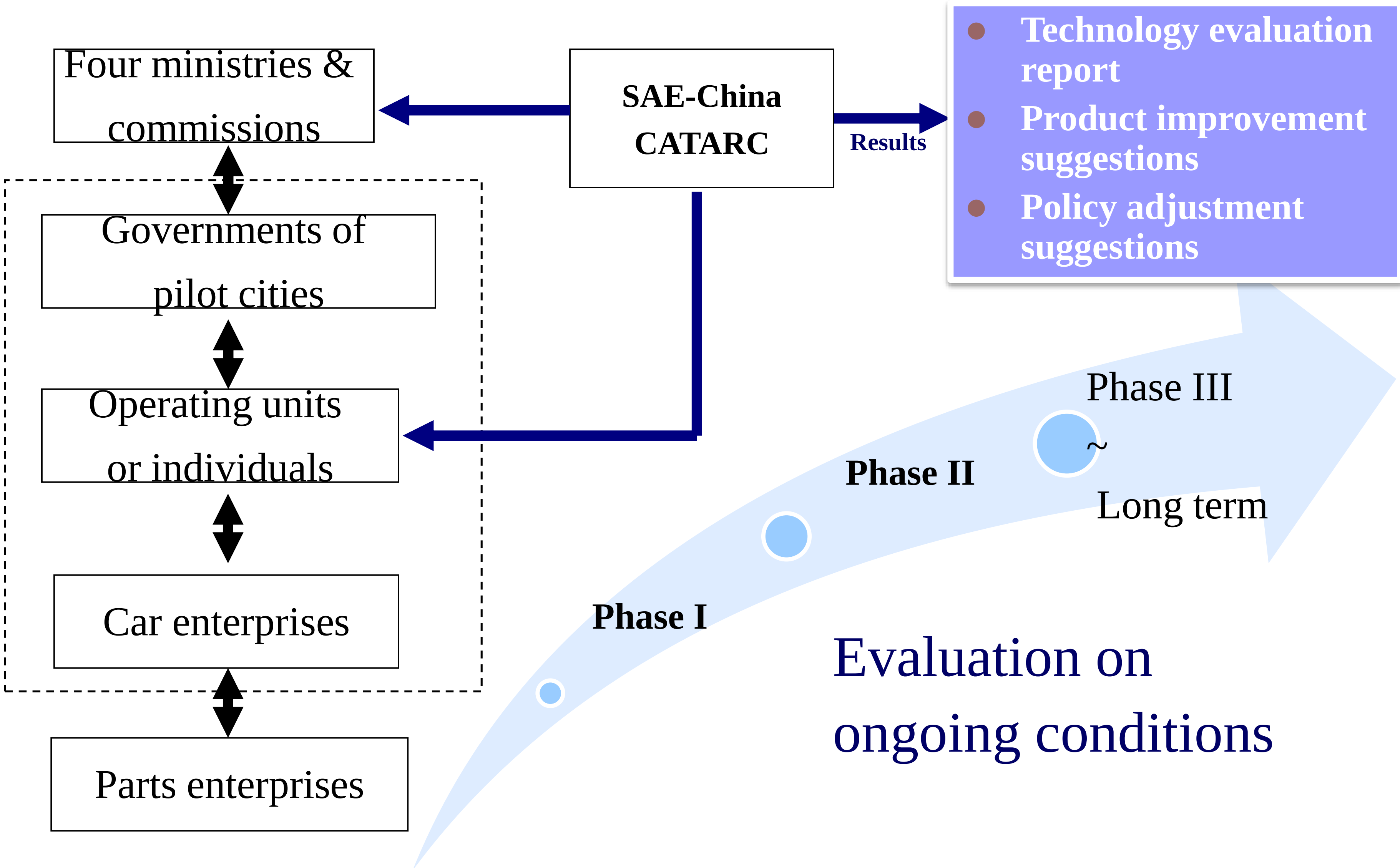
    Made clear of the main demands of drivers and potential consumers on EV product technology via demonstration evaluation

HEV, EV, PHEV

Charging infrastructure including fast and slow charging

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



Outline

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

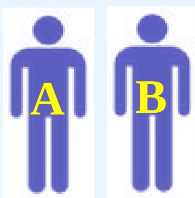
2.1 Empirical assessment of project scheme

Object, comprehensive & professional

EV test

Road test

Necessary items



Free route

Fixed route

Lab test

Necessary items

Additional items

Vehicle test

Parts test

Real operation performance

Test performance: as refere

Key parameters of vehicles

Leading to

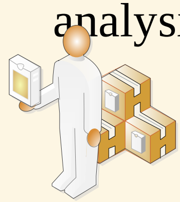
Quality evaluation system of EVs

Objective evaluation

Necessary items

Additional items

Data analysis



Vehicle performance

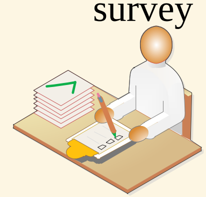
Parts performance

Subjective evaluation

Chinese users

Including active users

Questionnaire survey



Answering questions

Leaving messages voluntarily

2.1 Empirical assessment of project scheme

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

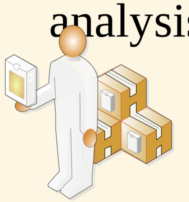
Objective evaluation index	Details	Objective evaluation index	Details
Energy consumption	Under working conditions of NEDC	Brake energy regeneration	Under working conditions of NEDC
	Under working conditions of CATARC		Under working conditions of CATARC
	With high-low temperature air conditioner on		Driving range when the function is disabled
	Under road running test		Influence on brake safety
Driving range	Under working conditions of NEDC and low speed	Charging performance	Room temperature
	Under working conditions of CATARC		Low temperature & high temperature
	With high-low temperature air conditioner on	Dynamic property	Normal
	Full load		Low temperature, special terrain, low SOC
EMC		Key part performance	

Objective evaluation

Necessary items

Additional items

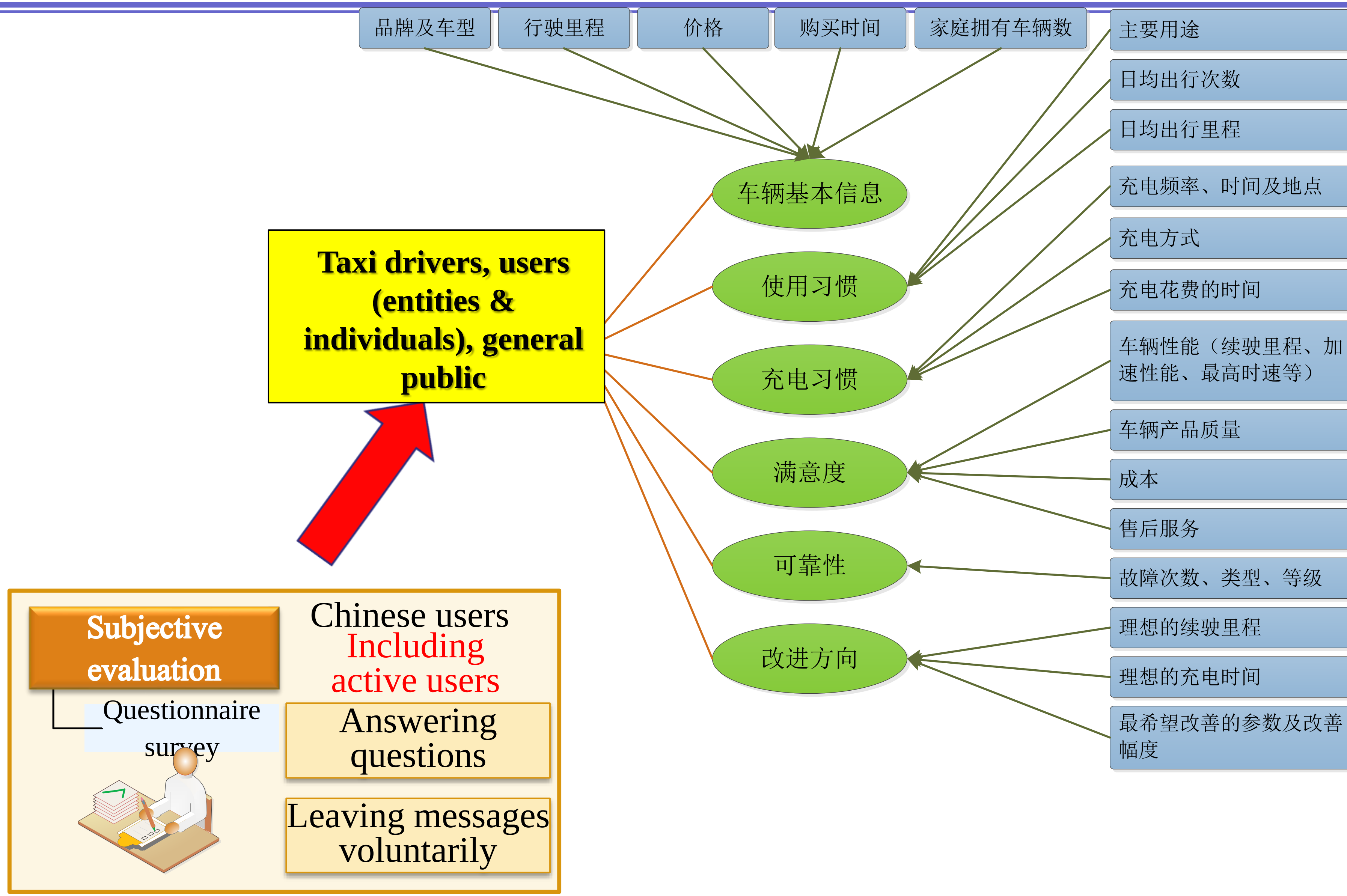
Data analysis



Vehicle performance

Parts performance

2.1 Empirical assessment of project scheme



Outline

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

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

City	Tested route
Hangzhou	187
Shanghai	43
Dalian	15
Jinan	K156
Zhengzhou	906
Wuhan	595、512
Zhuzhou	T2
Kunming	**A representative route was recombined**

- 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

Questionnaire survey

- 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.

Outline

I. Project background

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

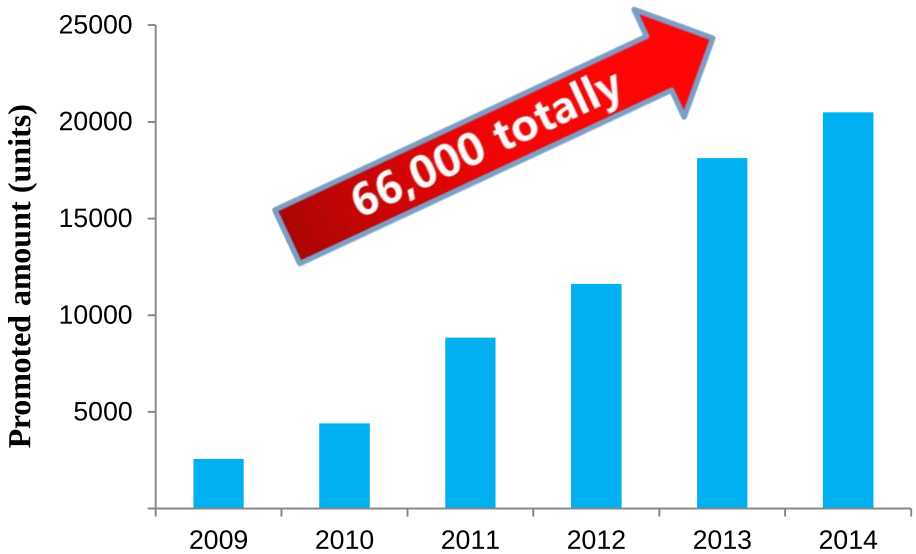
III. Review of project implementation

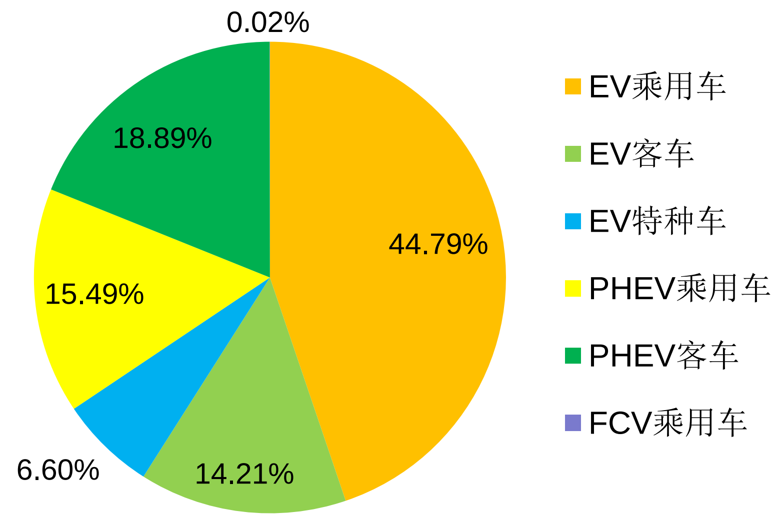
IV. Overall conditions of demonstration and promotion of energy-saving and new energy vehicles

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

VI. Summary

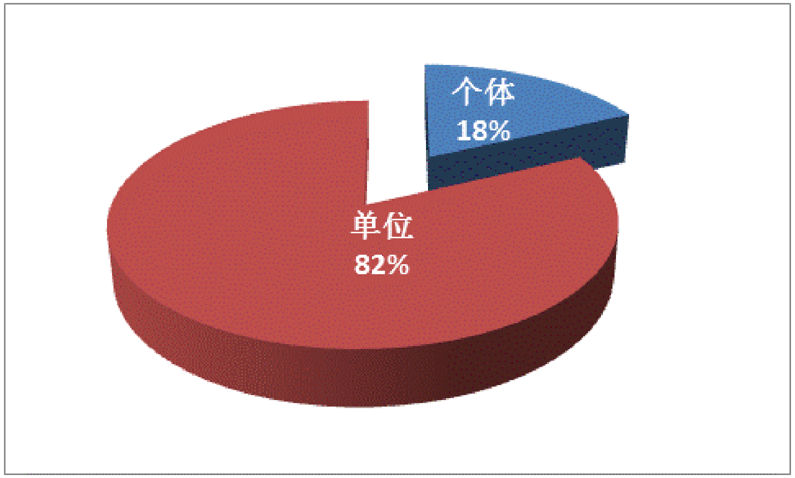
1. Status quo of energy-saving and new energy vehicle demonstration and promotion

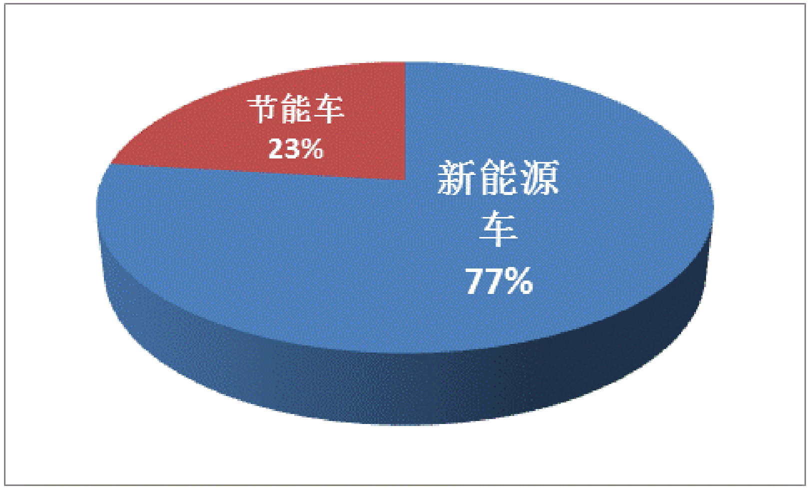




Progress of energy-saving and new energy vehicle demonstration and promotion

Promotion and application fields of NEVs since 2013

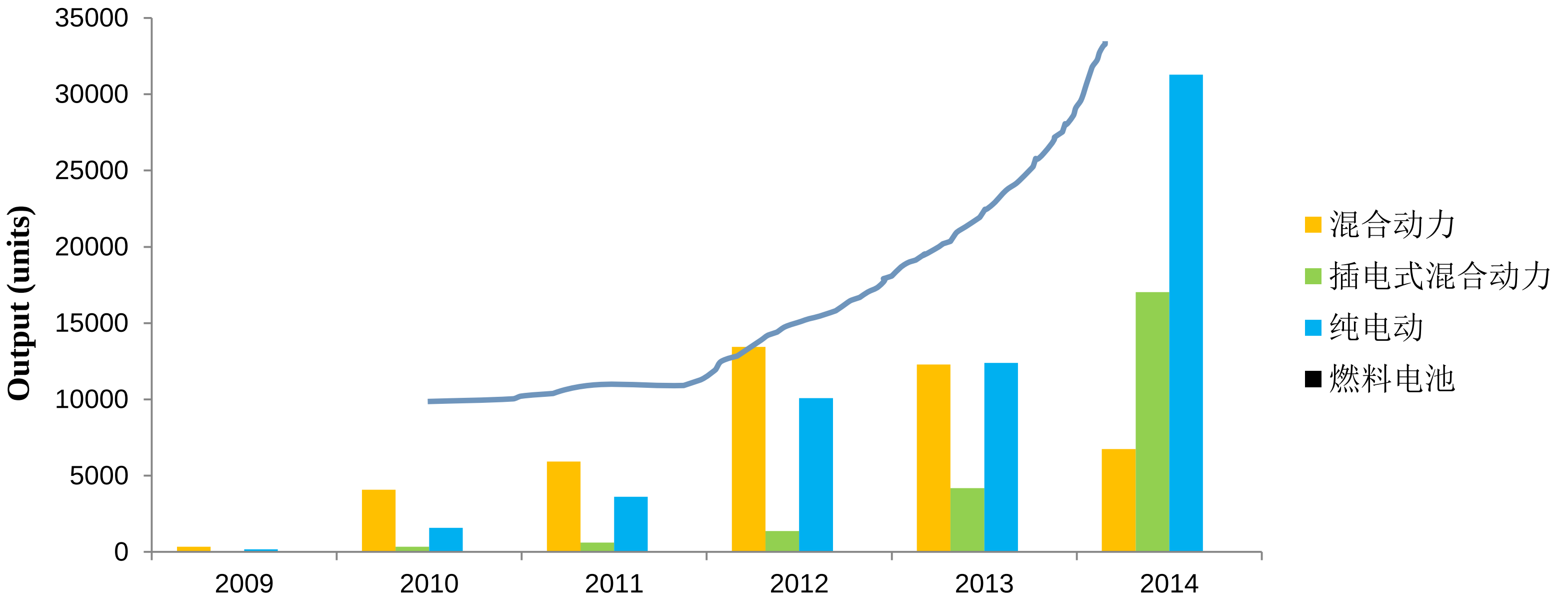




Note: Up to Sep. 2014. Since 2013, only data of PHEV and EV were included

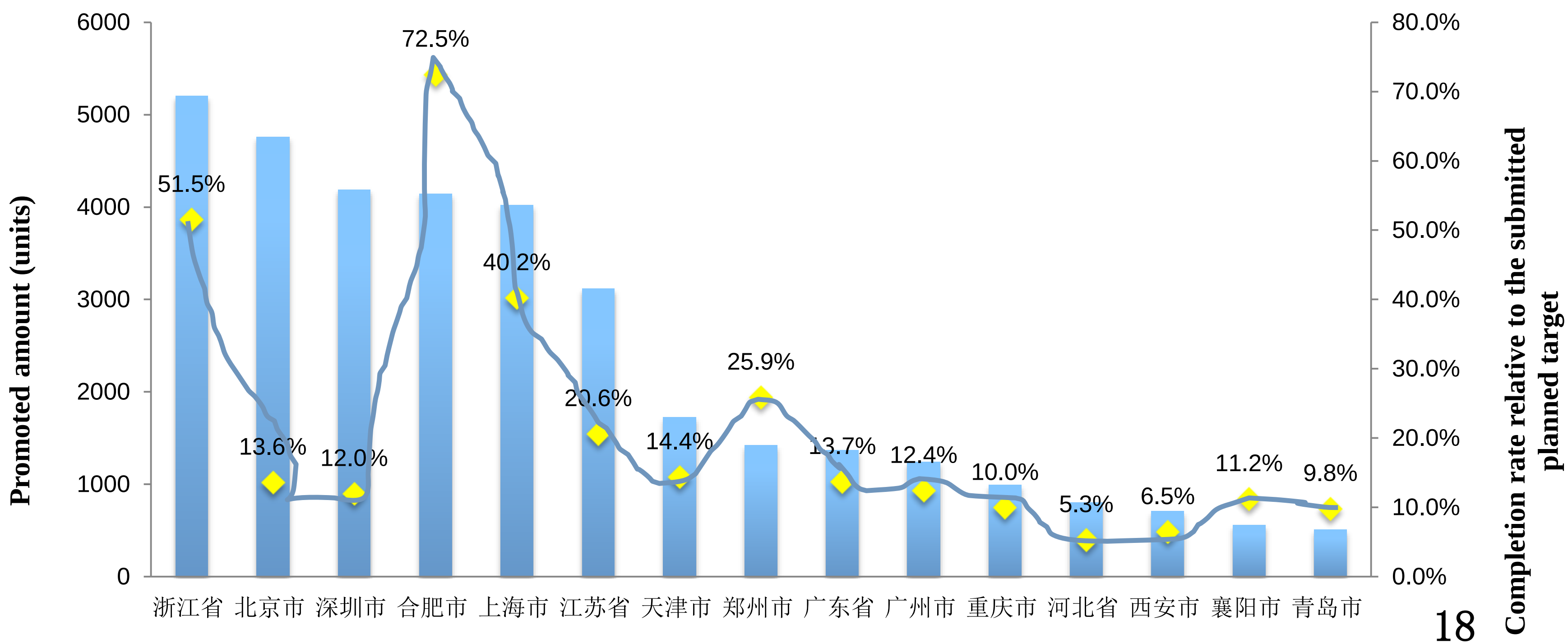
2. Status quo of commercialization of energy-saving and new energy vehicles

- By Sep. 2014, 125,600 notice vehicles (including vehicles of joint-venture brands) were produced, including 42,800 HEVs and 82,7000 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.



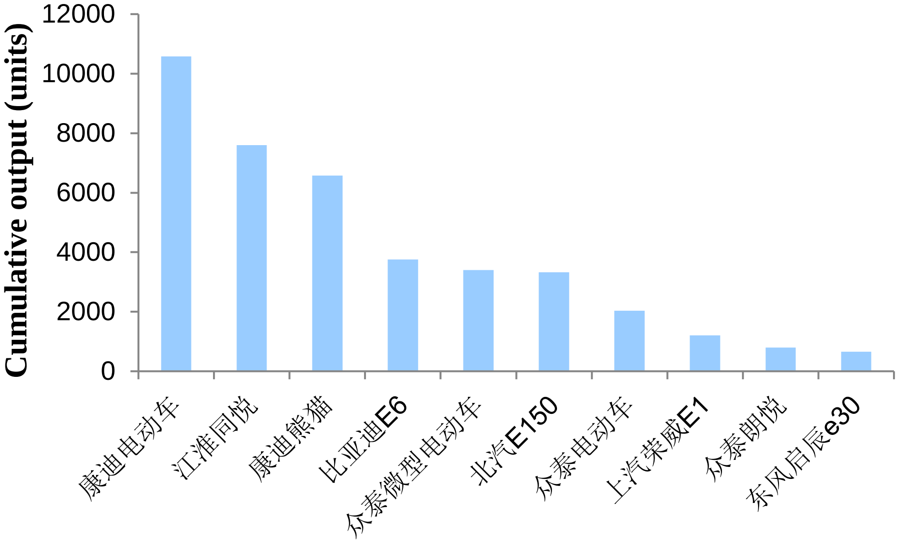
3. Progress made by NEV demonstration cities

- 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**

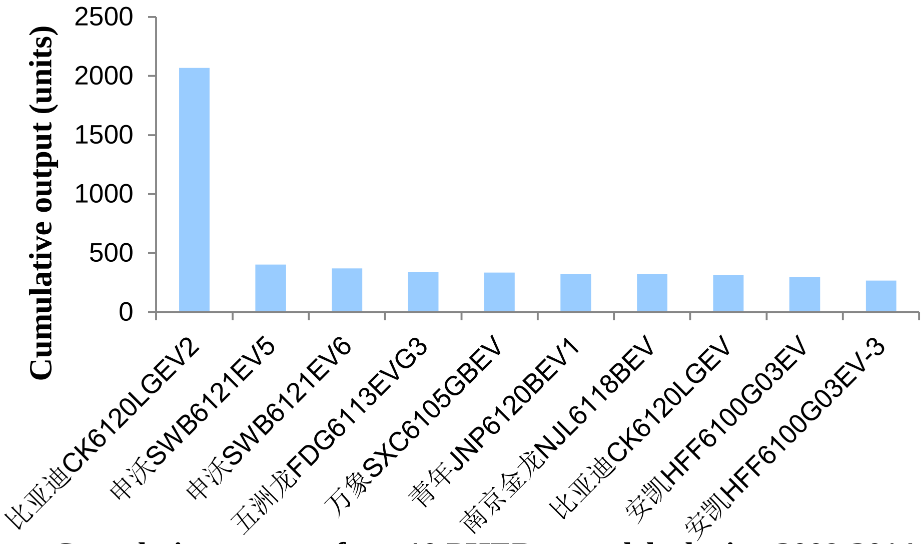


Top 10 promoted vehicle models

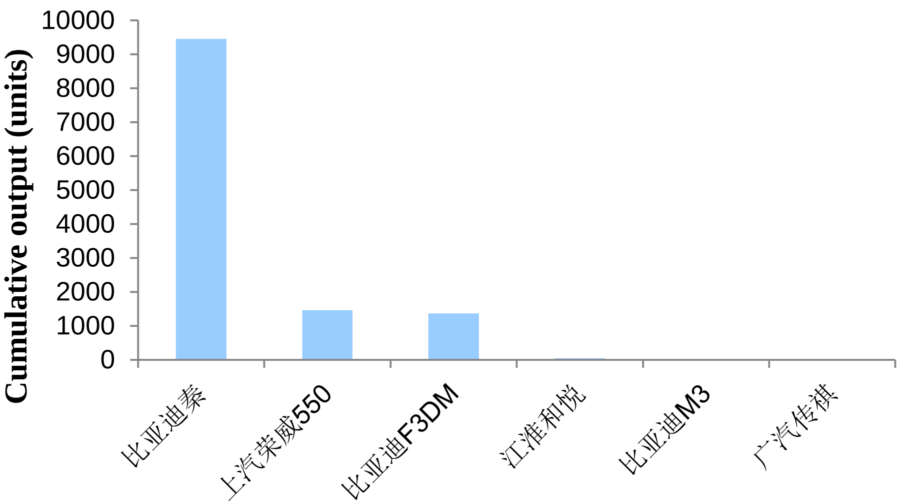
Cumulative output of top 10 EV models during 2009-2014



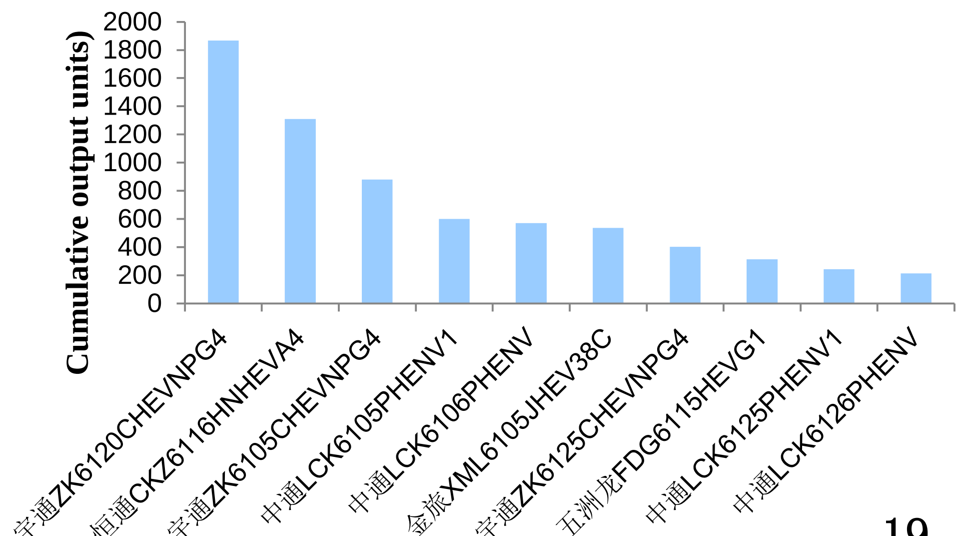
Cumulative output of top 10 EBus models during 2009-2014



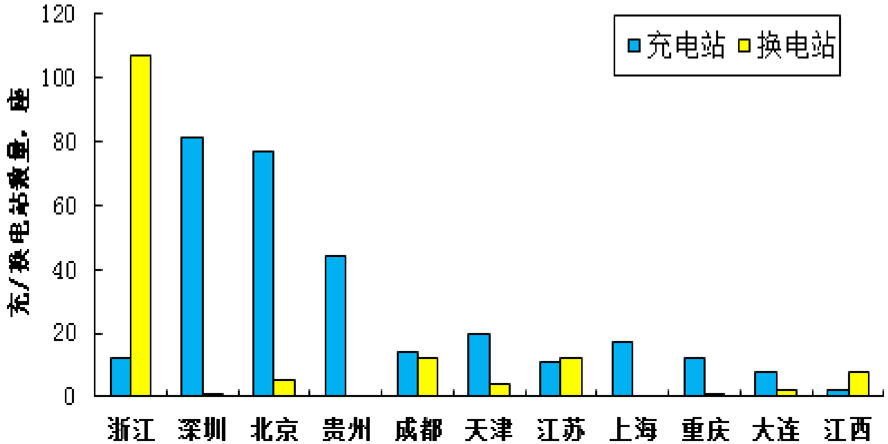
Cumulative output of top 10 PHEV models during 2009-2014

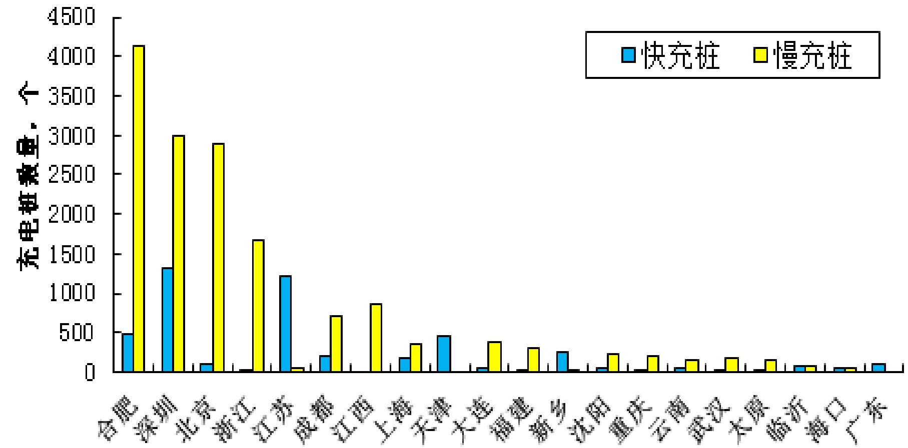


Cumulative output of top 10 PHEBus models during 2009-2014



Charging infrastructure





- 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.**

Outline

I. Project background

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

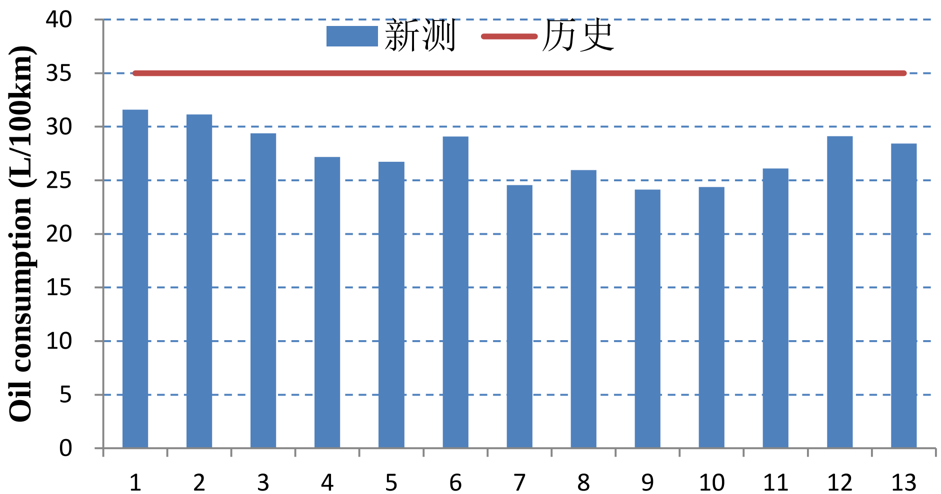
III. Review of project implementation

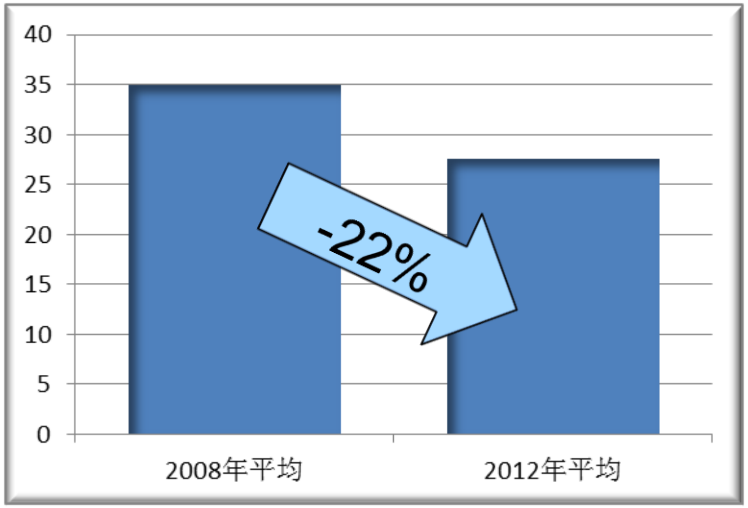
IV. Overall conditions of demonstration and promotion of energy-saving and new energy vehicles

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

VI. Summary

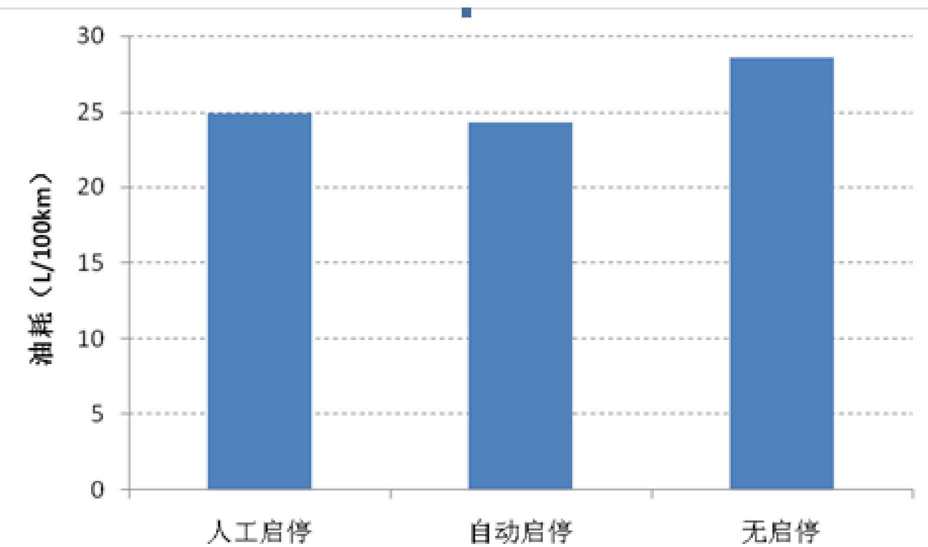
1. HEBus – fuel-saving effects

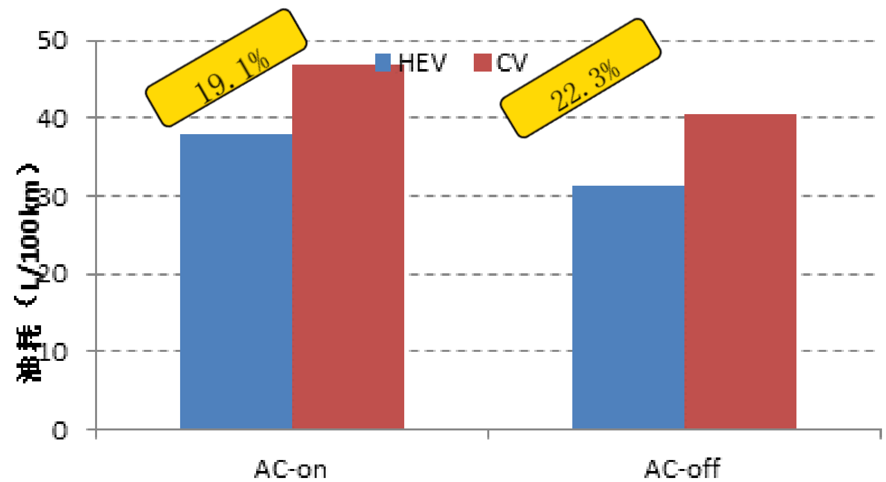




- In 2008, the fuel consumption of Beijing HEV demonstration fleet was **30～40L/100km** with an average level of around 35L/100km, while the fuel consumption of this test was 27.5L/100km; in 2008, the fuel consumption of vehicles with the best fuel -saving effects was 30L/100km while the fuel consumption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

1. HEBus – start-stop and air conditioner

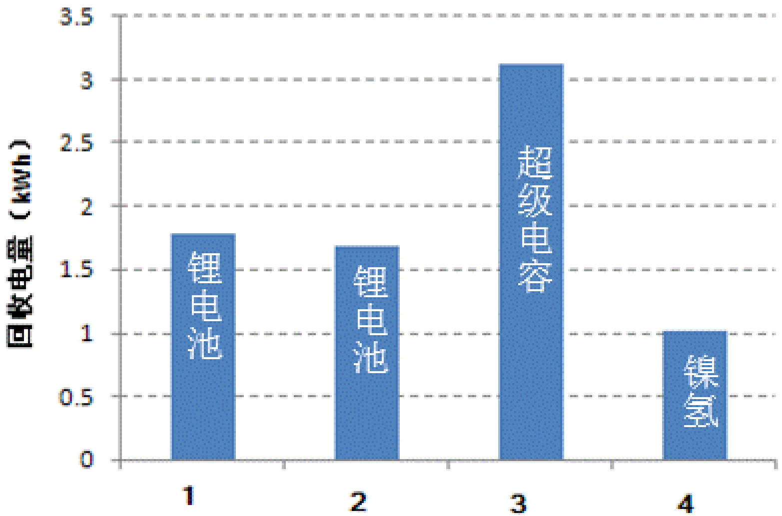




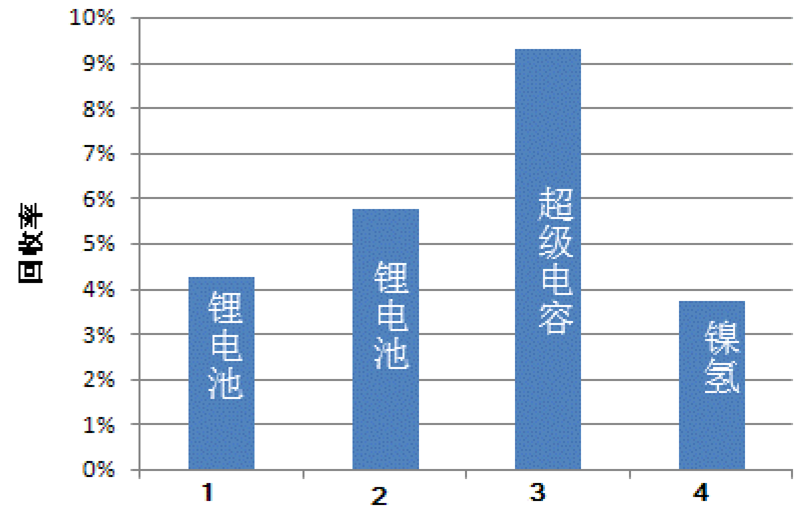
For vehicles with star-stop function, the fuel consumption levels were close to each other and about 8% lower than those of vehicles without start-stop function. **However, such vehicles are not widely applied yet.**

◆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



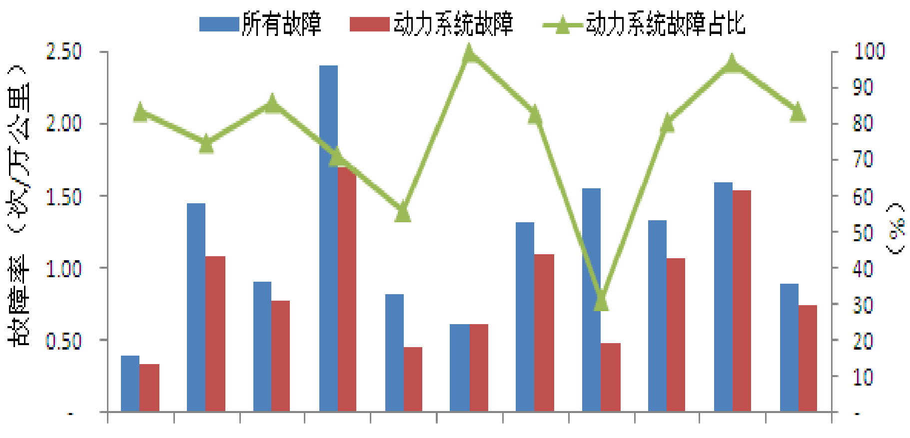
Types of energy storage devices



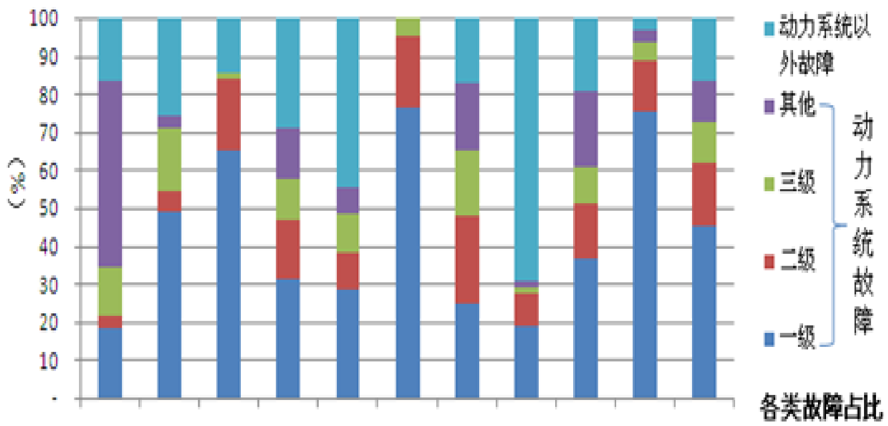
Vehicle types

- 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.

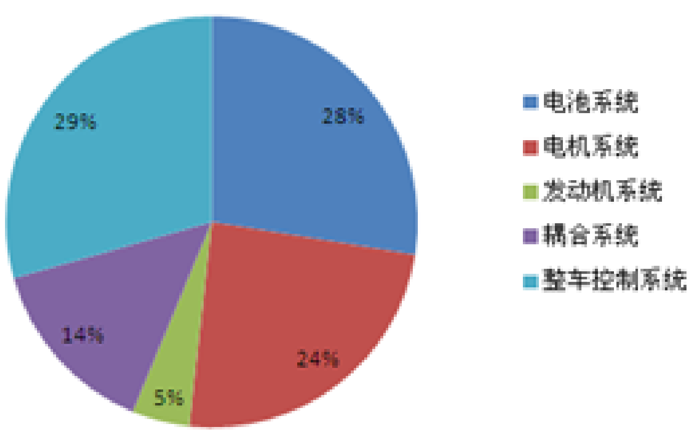
1. HEBus -- reliability



Vehicle types



Vehicle types

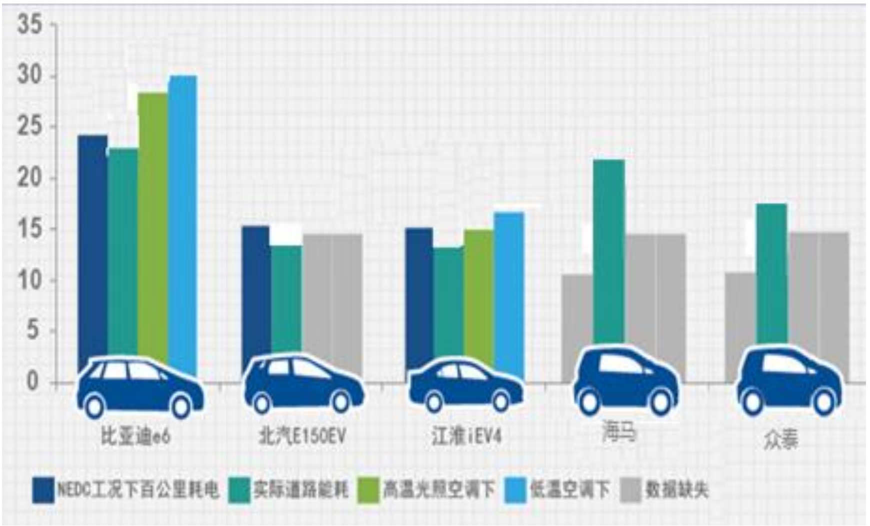


- As for failure rate, compared with traditional diesel vehicles, the failure rate of HEBus remained high; compared with foreign systems, the failure rate of domestic systems was still relatively high.
- As for failure level, probability of failure levels 1, 2 and 3 was the lowest and most of them could 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.

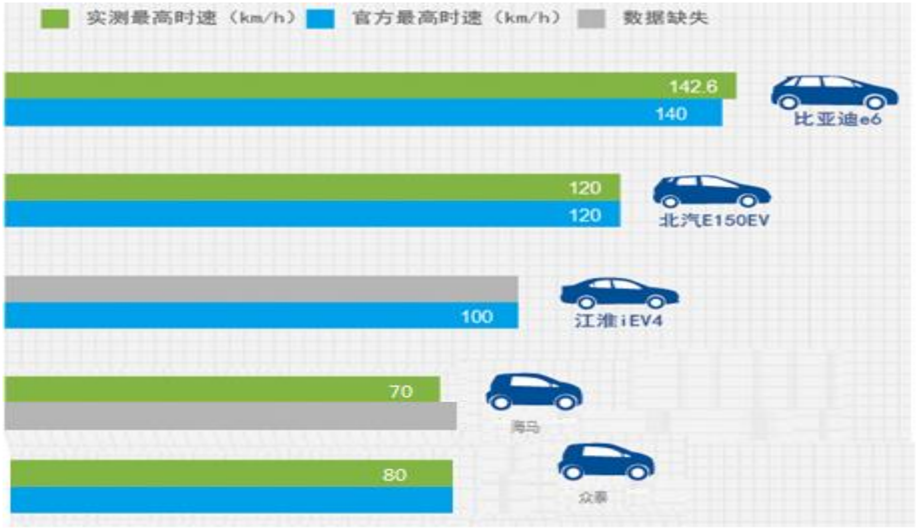
1. HEBus – brief summary

- 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.

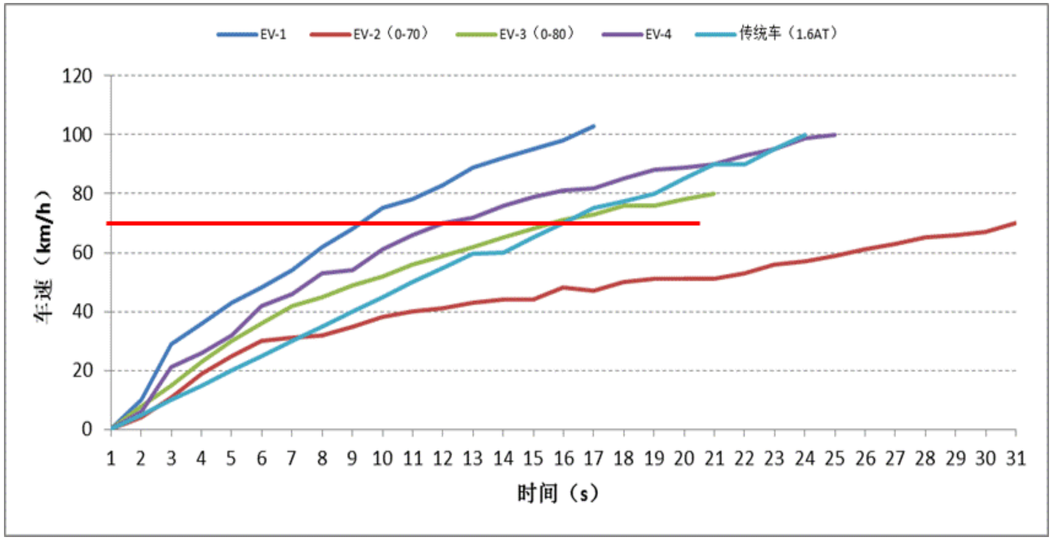
2. EV



35
30
25
20
15
10
5
0
比亚迪e6
北汽E150EV
江淮iEV4
海马
众泰
NEDC工况下百公里耗电
实际道路能耗
高温光照空调下
低温空调下
数据缺失



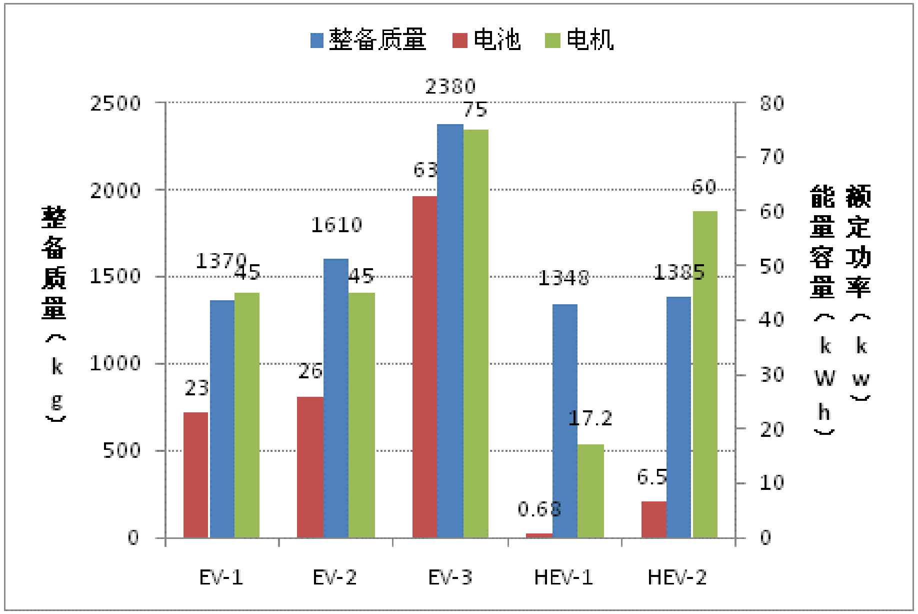
实测最高时速（km/h）
官方最高时速（km/h）
数据缺失
142.6
140
比亚迪e6
120
120
北汽E150EV
100
江淮iEV4
70
海马
80
众泰

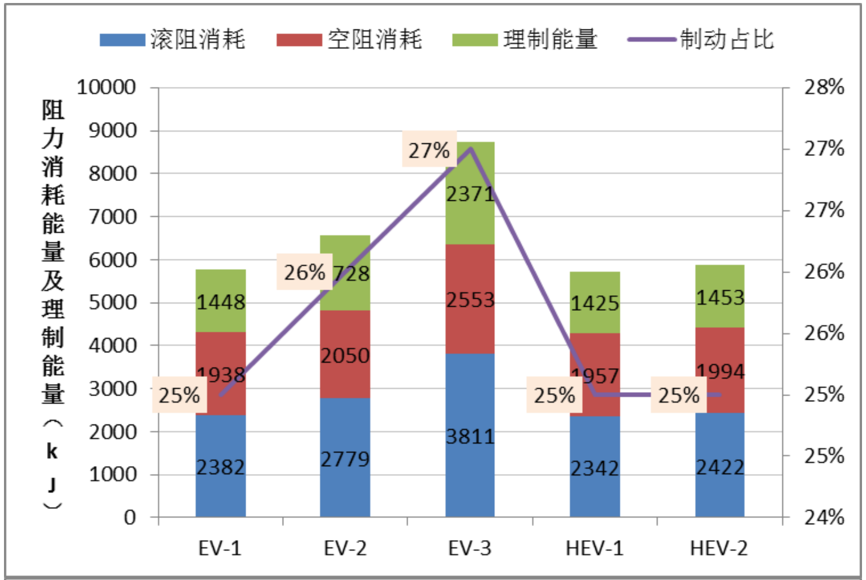


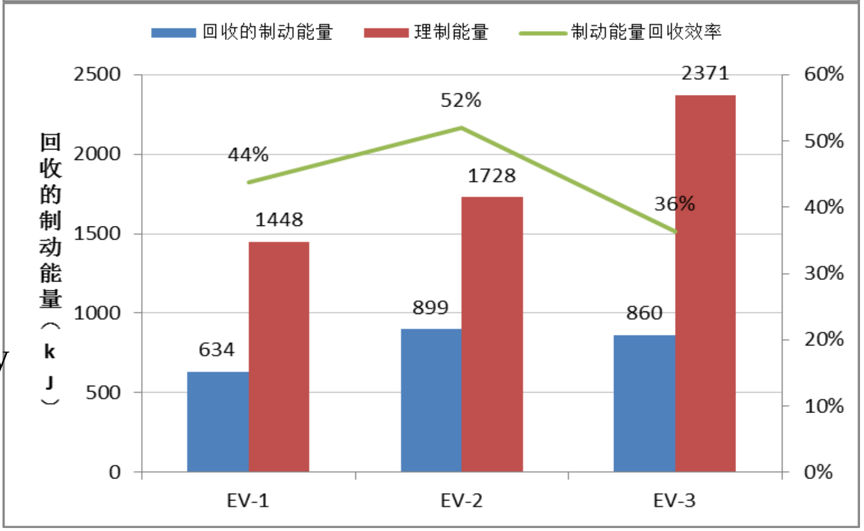
EV-1
EV-2（0-70）
EV-3（0-80）
EV-4
传统车（1.6AT）
120
100
80
60
40
20
0
车速（km/h）
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
时间（s）

2. EV – brake and brake energy regeneration

---Energy distribution in brake energy regeneration





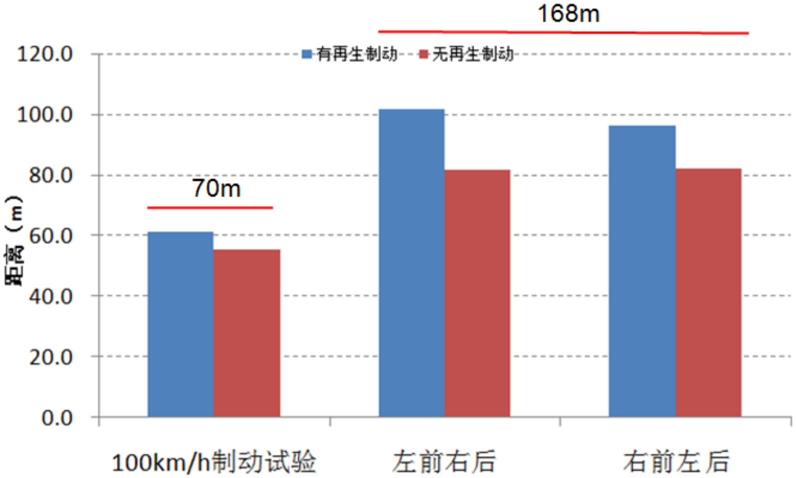


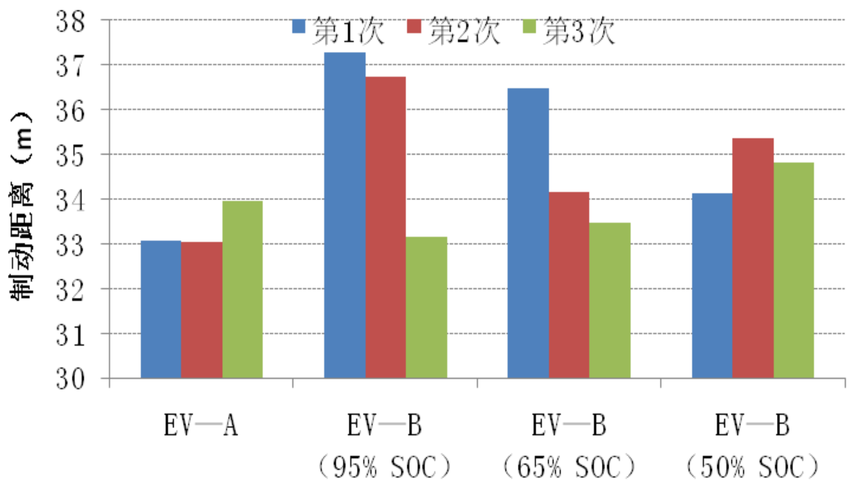
- Blind use of high-capacity batteries and high-power motors does not necessarily regenerate more brake energy.
- Manufacturers should equip batteries of proper capacity and motors of proper power in line with different EV models; appropriate drive control strategy should be adopted to improve brake energy regeneration efficiency on the premise of guaranteeing driving safety of the vehicle, thereby enhancing the energy utilization efficiency of the vehicle.

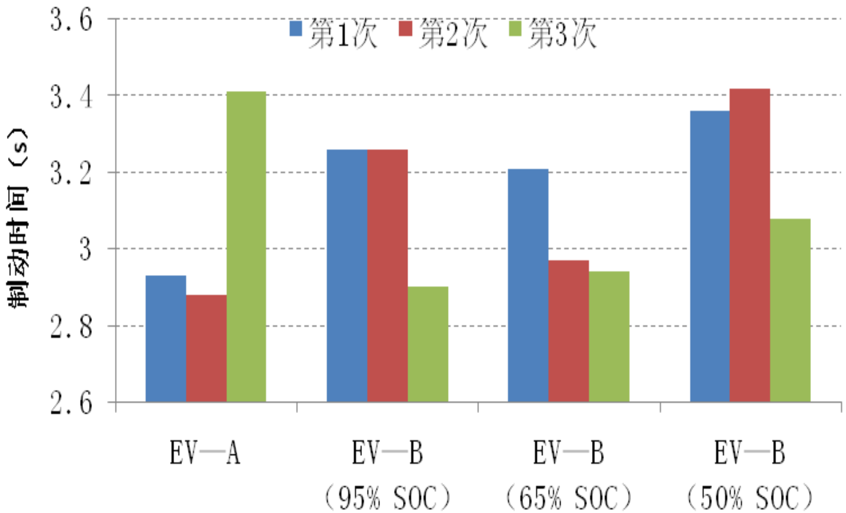
2. EV – brake and brake energy regeneration

---Influences of brake safety in EV brake energy regeneration

Standard: GB 21670 Technical requirements and testing methods for passenger car braking systems



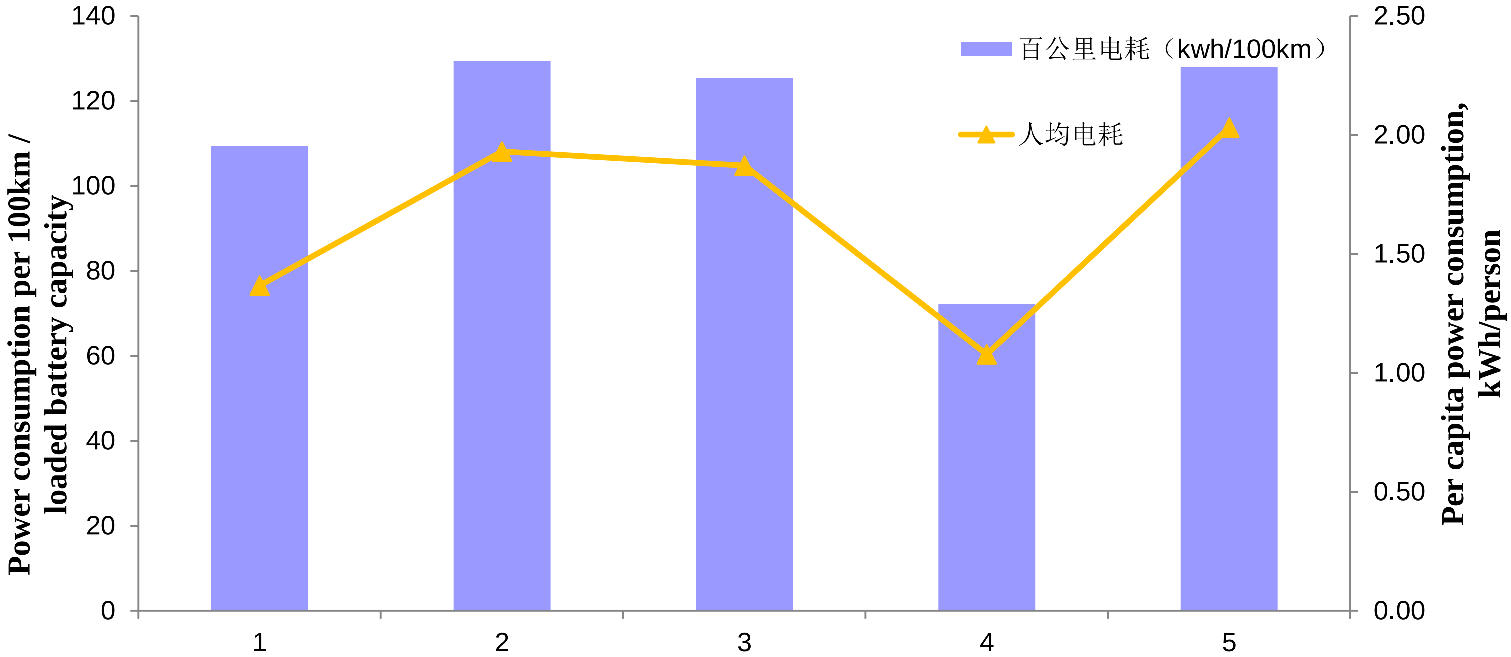




- With regenerative braking, the brake performance of vehicles is relatively unstable and generally becomes poorer.
- In the standard, the braking system of EVs is turned off without taking its influence on brake safety into consideration. Therefore, it is recommended to be revised.

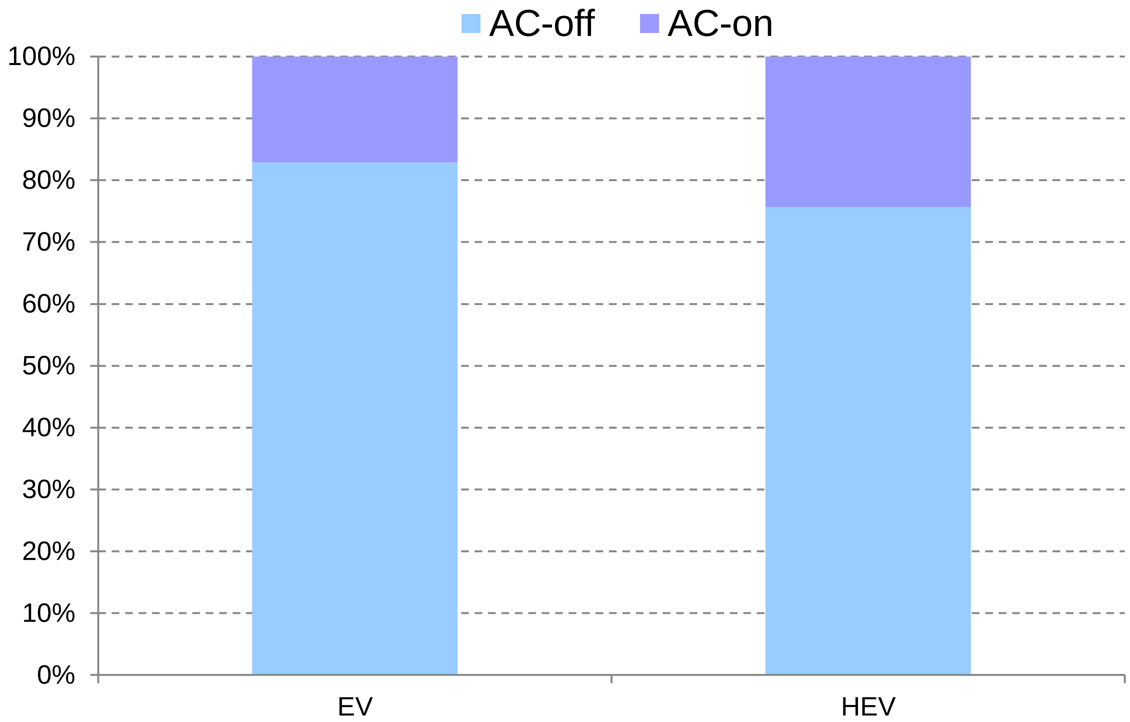
3. Ebus – energy consumption

- 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



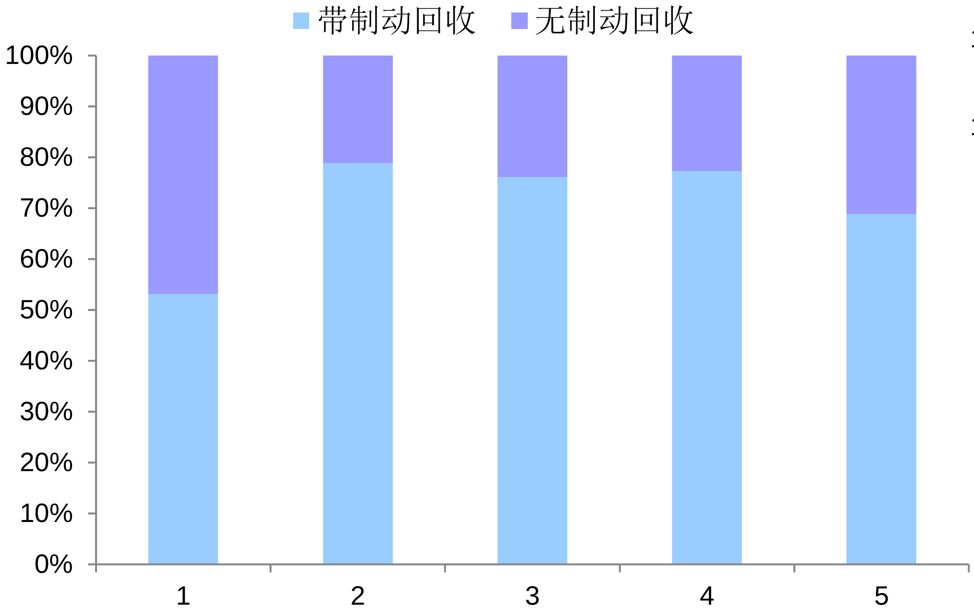
3. Ebus – influences of air conditioner

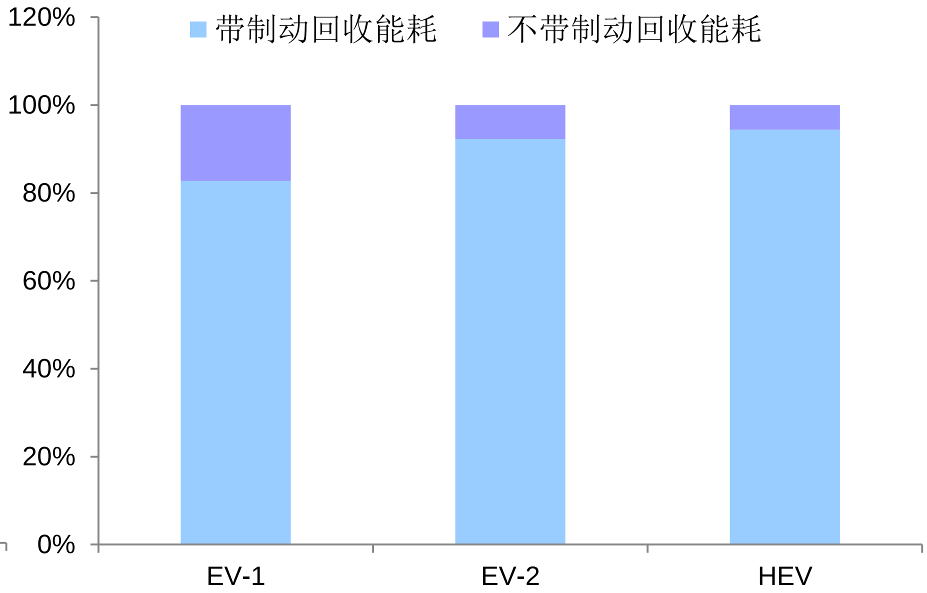
- When the ambient temperature was 28℃, the influence of air conditioner on EV was about 10% lower than that on HEV if it was set to 24℃
- As EV adopted electric air conditioner, it had higher efficiency than HEV which used mechanical air conditioner.



3. Ebus – brake energy regeneration

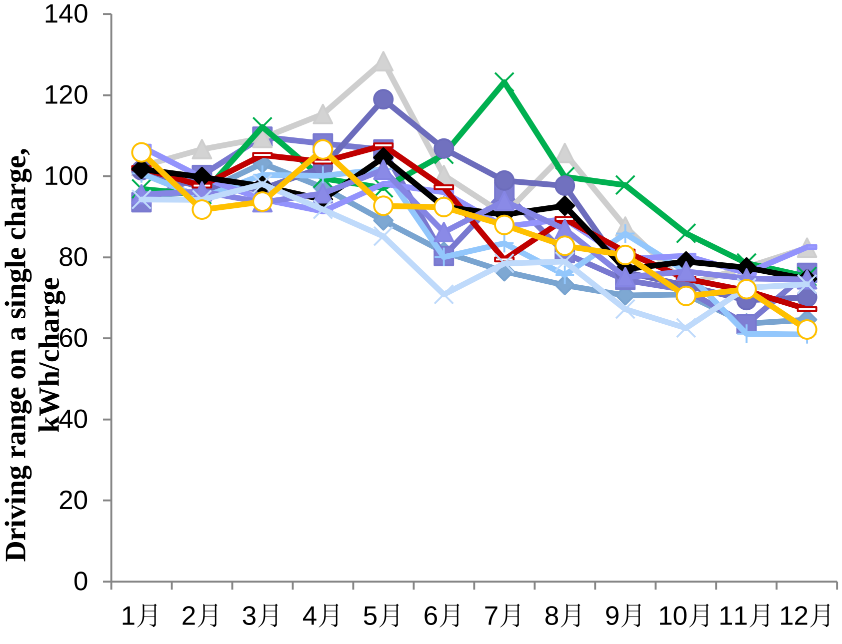
- Apart from model 1, brake energy regeneration facilitated reduction of bus energy consumption of about 20%~30%.
- Compared with HEBus, Ebus was equipped with motor of higher power, and its contribution rate to brake energy consumption was therefore higher than HEV. Some models performed very well.



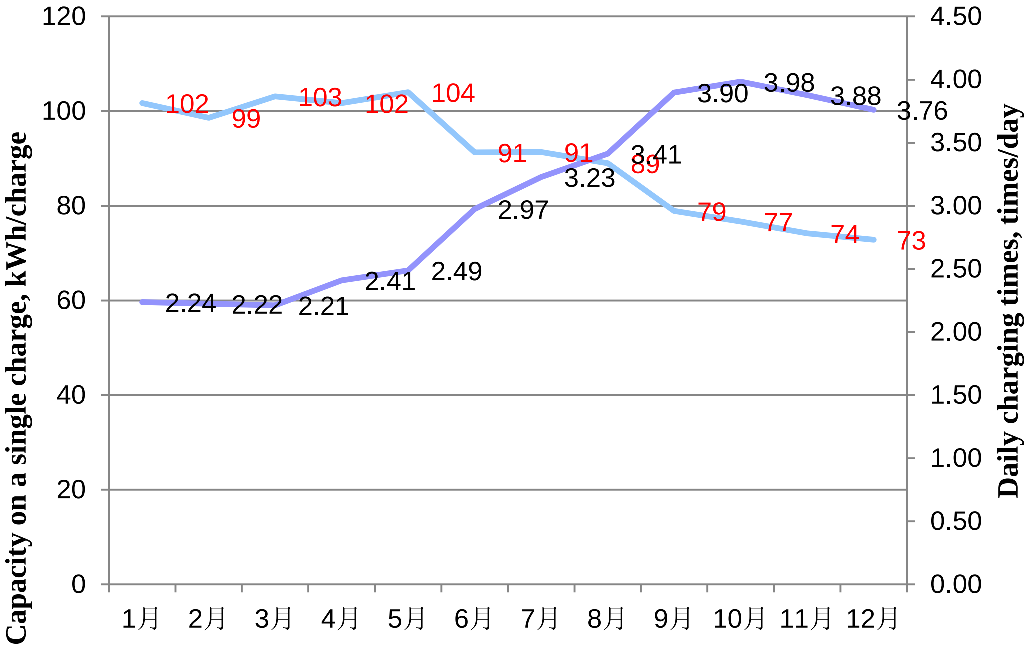


Battery attenuation was still serious

- 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



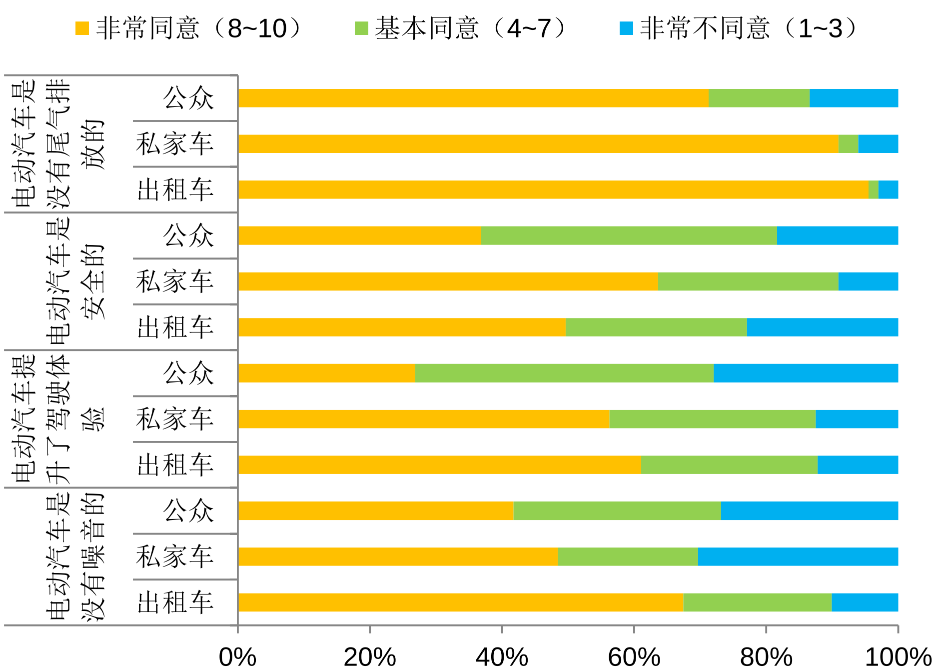
Whole-year charge conditions of 12 vehicles in a fleet

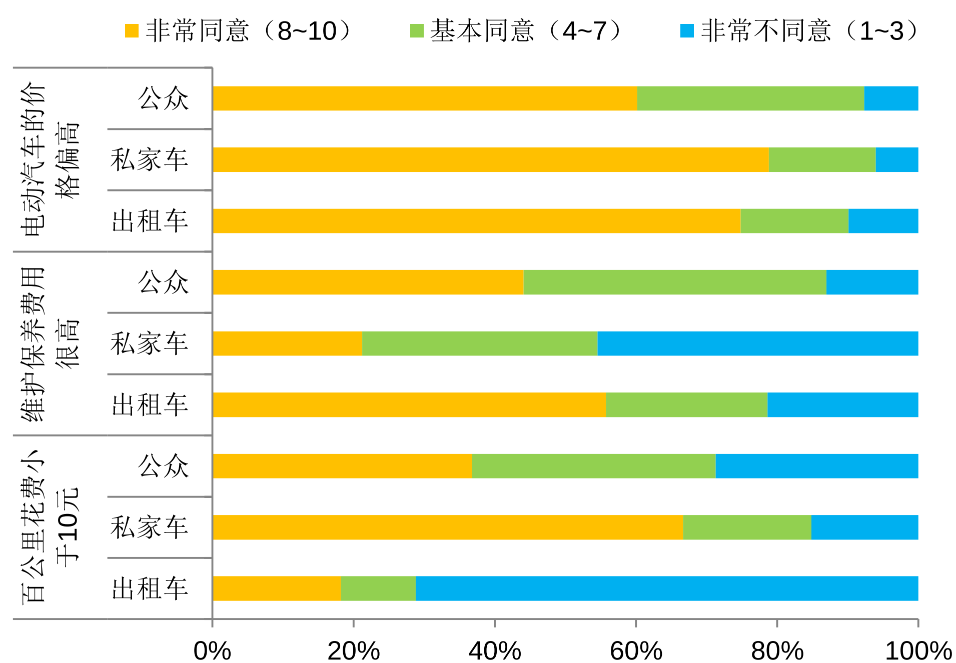


Whole-year average charge conditions of 12 vehicles in a fleet

4. Survey on NEVs – cognition

- 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.

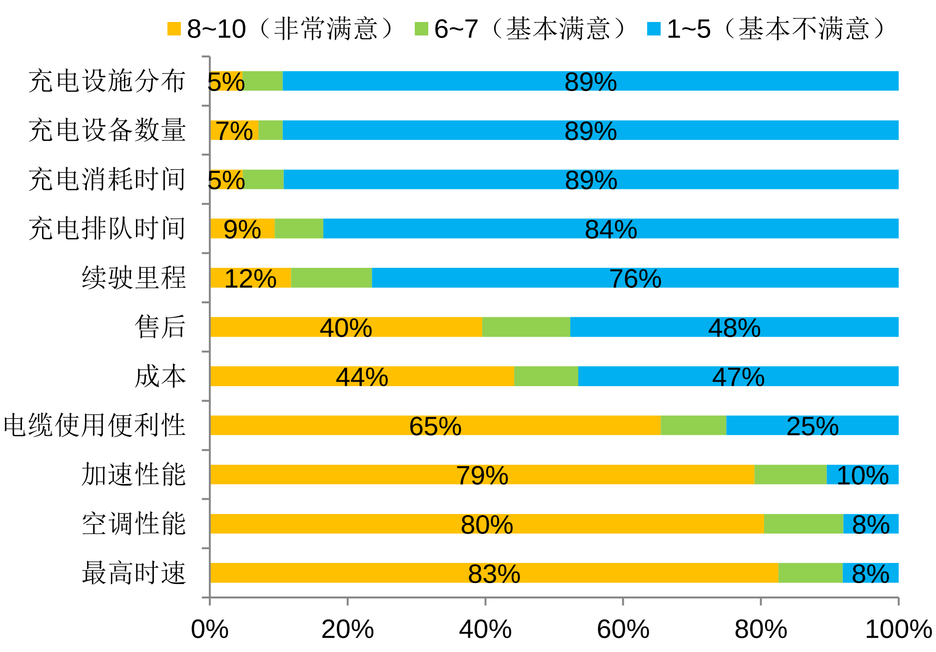




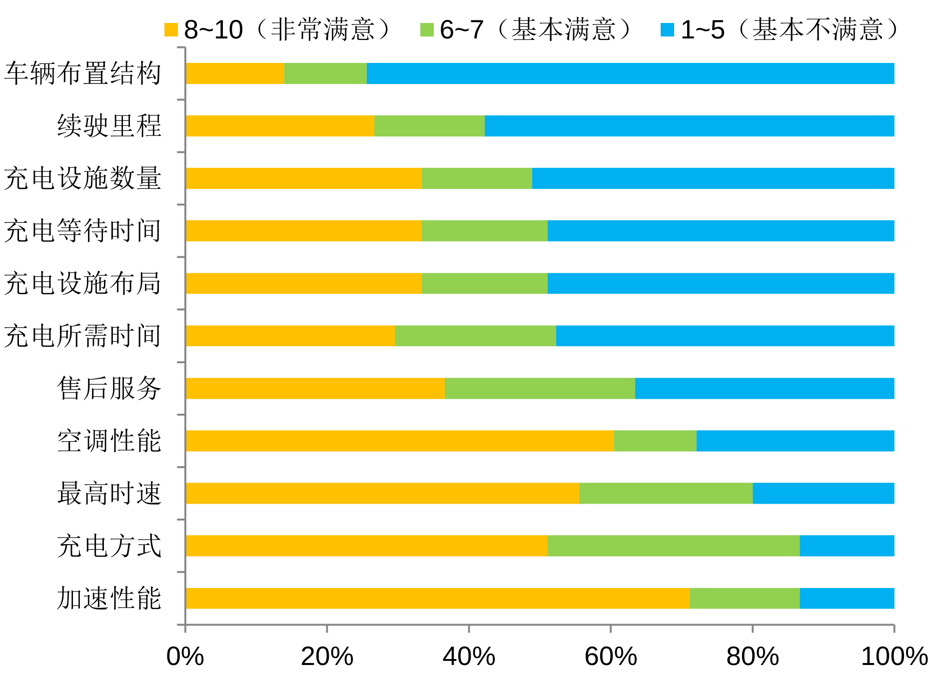
Survey on NEVs – satisfaction

- The aspects that user 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

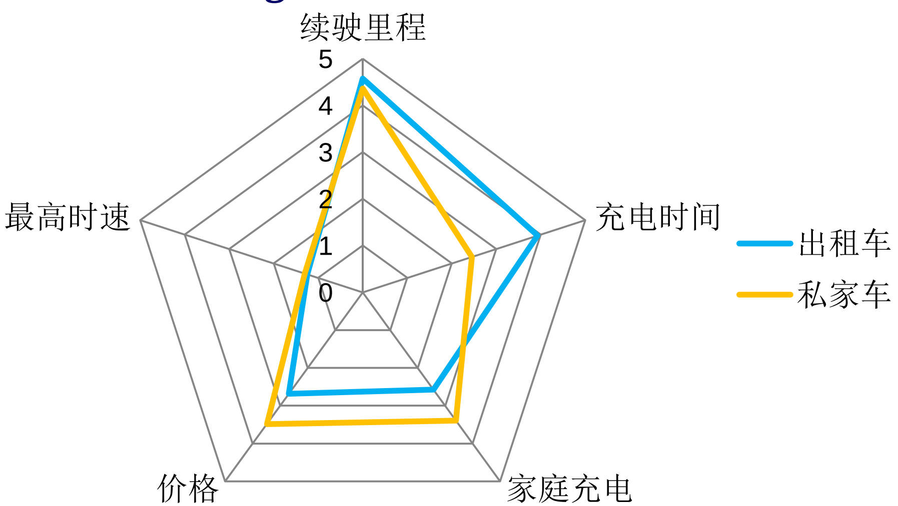


Satisfaction survey results of buses

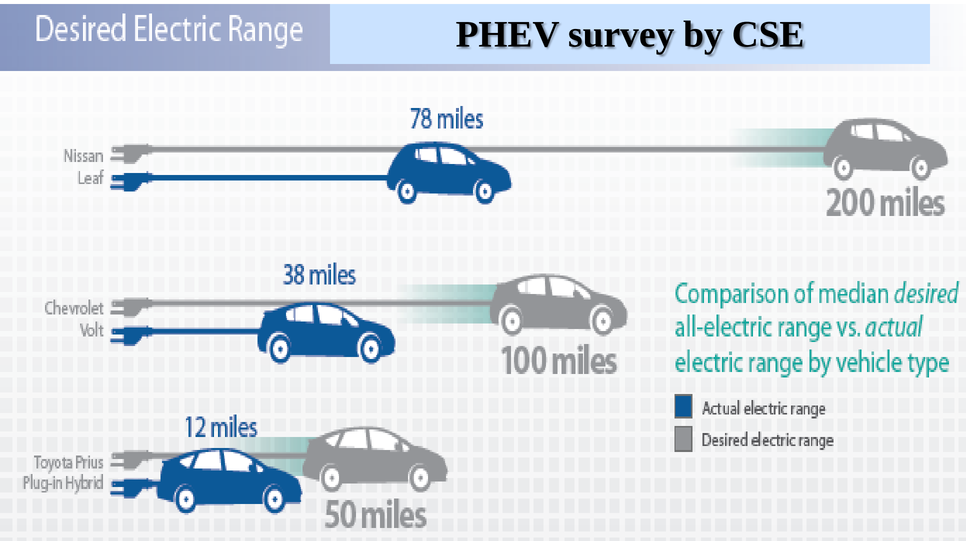


Survey on NEVs – improvements wanted

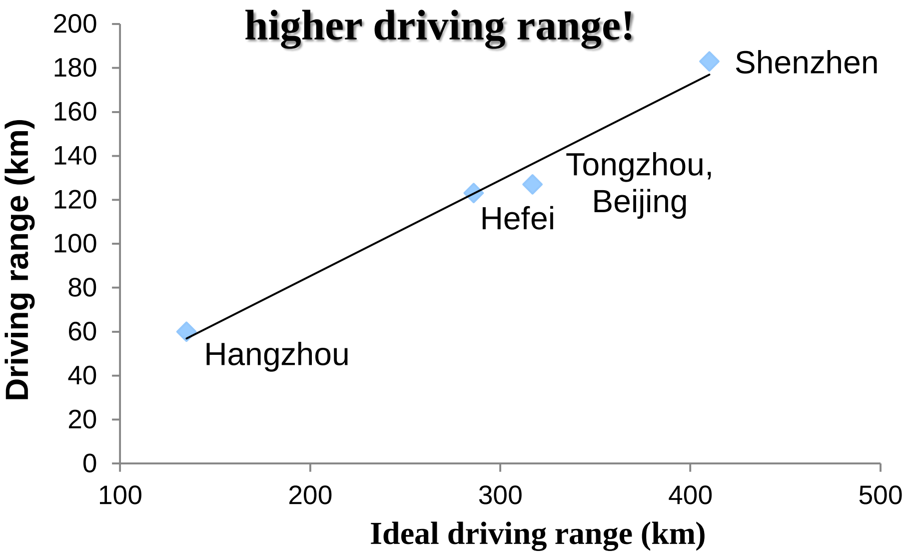
- The questionnaire designed existing model parameters in accordance with the various passenger vehicle models in different cities. Ranking of improvements wanted in terms of cost reduction, driving range increase, charging time reduction, availability of charging at home, maximum speed increase, etc.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

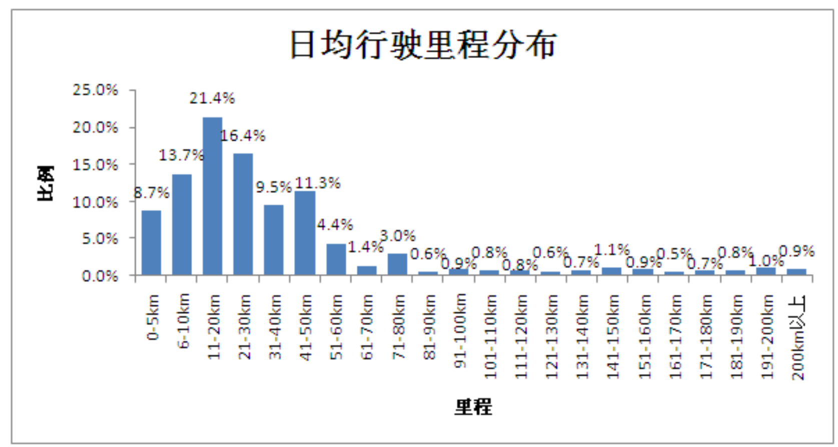


People are always expecting higher driving range!



Using features and ideal parameters of taxis and private cars

	Taxis	Private cars
Daily mileage	85%: 200~300km	**About 25%: more than 50km**
Vehicle driving range	<200	-
Ideal driving range	>300	>50
Charging time	1.65	5~8
Ideal charging time	0.65	75%: over 2 hours



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

Outline

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

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!
ACME ELECTRONICS