Progress of Research and demonstration NEV in China

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The research process and technical progress of china's Electric vehicle

The "3-vertical and 3-horizontal" technical system

"the 10th 5-year plan" 863 projects 《Electric Vehicle》 science and technology special project

"the 11th 5-year plan" 863 projects 《 Energy-Saving and New-Energy Vehicle 》 key project

"the 12th 5-year plan" 《Electric Vehicle》 key science and technology special project

Fuel Cell Vehicle	Hybrid Electric Vehicle	Electric Vehicle
Fuel Cell Vehicle Technology	Hybrid Electric Vehicle Technology	Electric Vehicle Technology
Calibration and Matching	Calibration and Matching	Calibration and Matching
Fuel Cell Engine	Engine and Transmission Electromechanical Coupling Technology	
DC/DC Converter	ISA/ISG Technology	

Multi-Source Powertrain Control System

Motor Drive System and Control Unit

Power Battery and Battery Management System

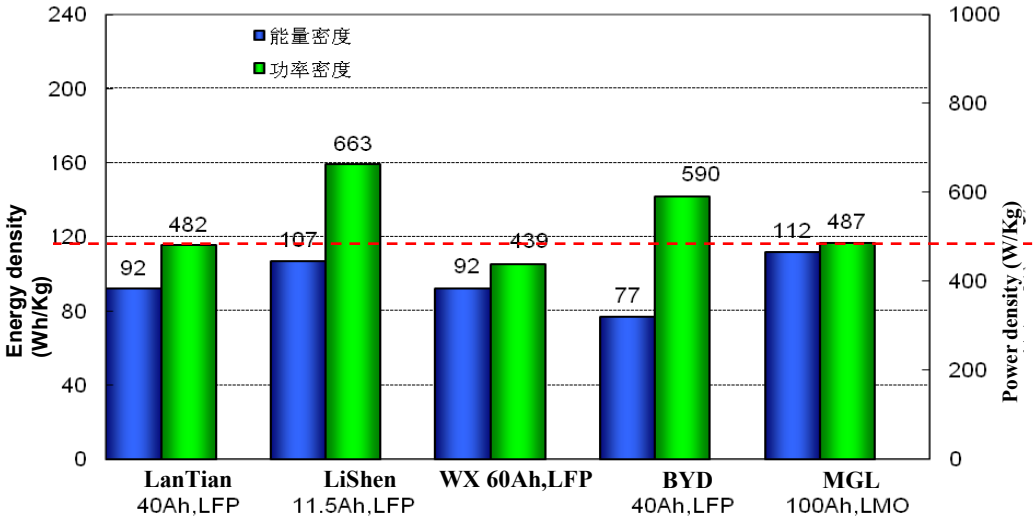
System

Contents

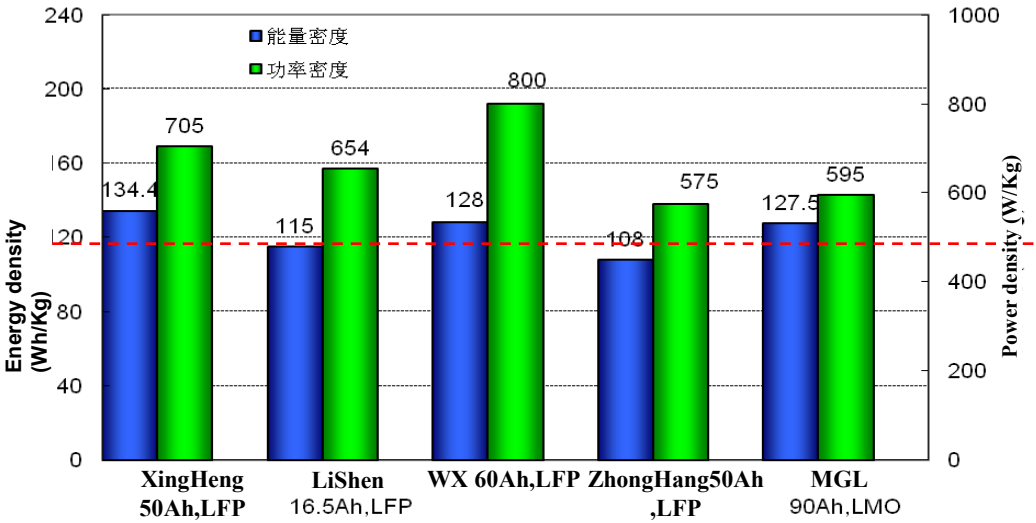
The Technical Progress of Power Battery

Electric vehicle (BEV/PHEV/REEV)

---Power battery technology has been improved significantly



First-stage of the 11th 5-year plan (2008)

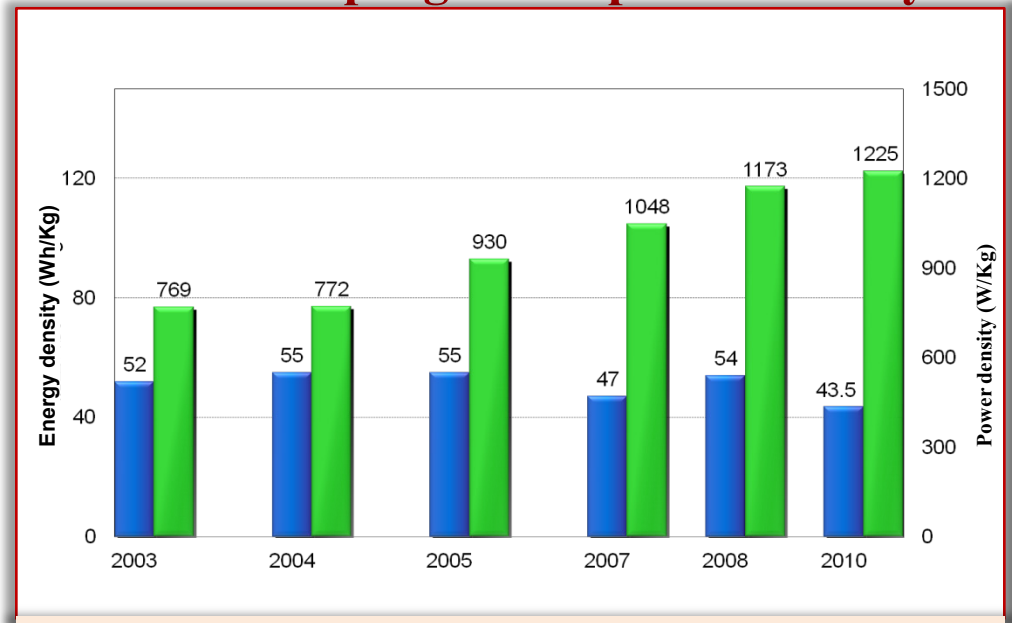


Second-stage of the 11th 5-year plan (2010)

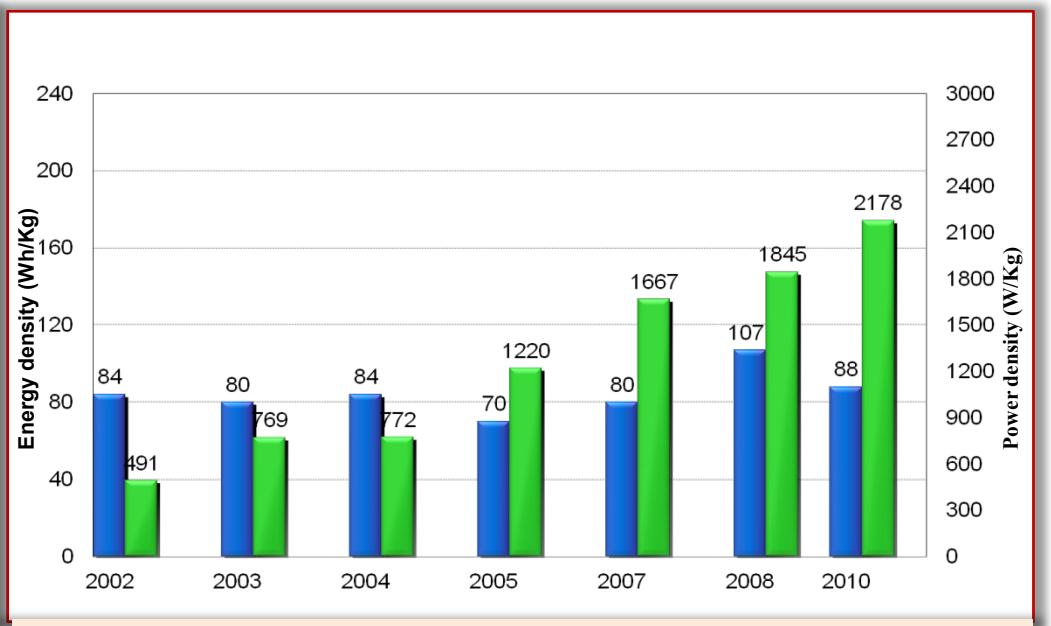
The 50-100Ah Li-ion power battery used for EV has been developed, and the energy density of the cell is up to 130Wh/kg. The battery is tested by the large scale applications in EVs used for Olympic games and World Expo. It is capable to support EVs to carry out large-scale commercial demonstration running 。

The Technical Progress of Power Battery

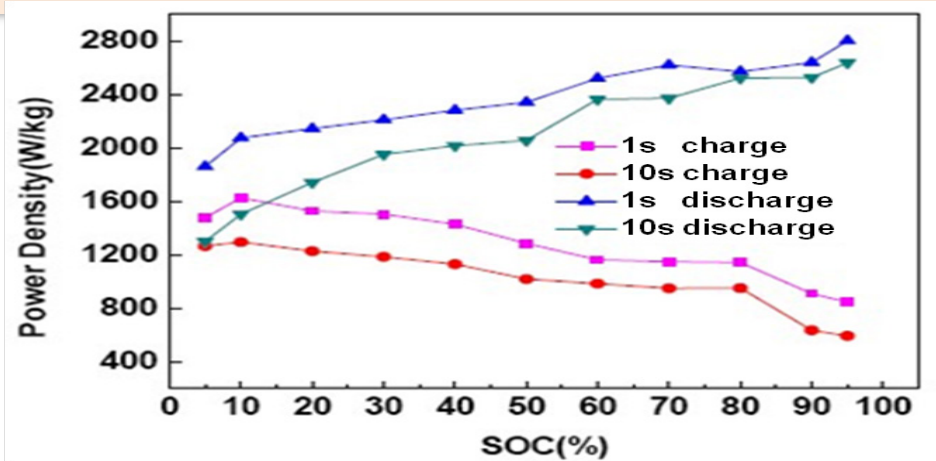
The technical progress of power battery for HEV



Power density of nickel-metal hydride battery is being improved steadily



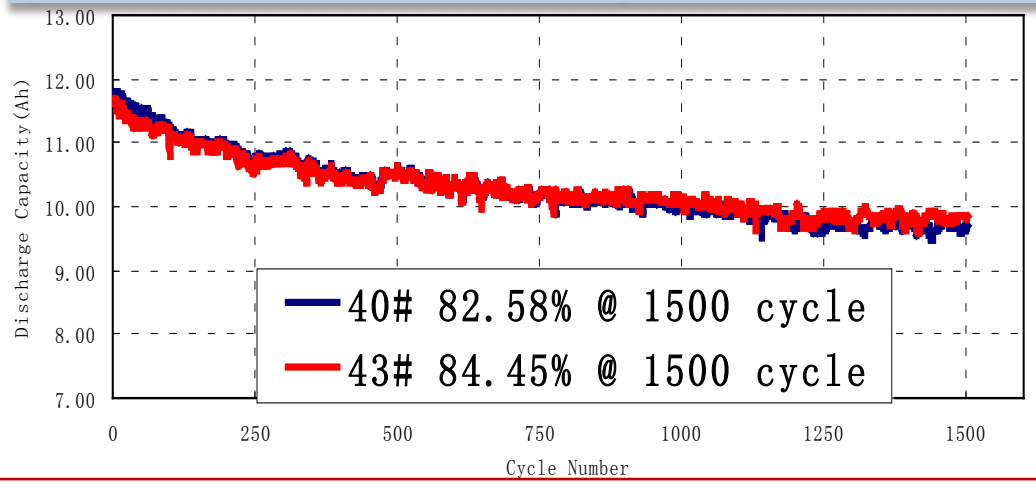
Power density of Li-ion power battery has been improved greatly

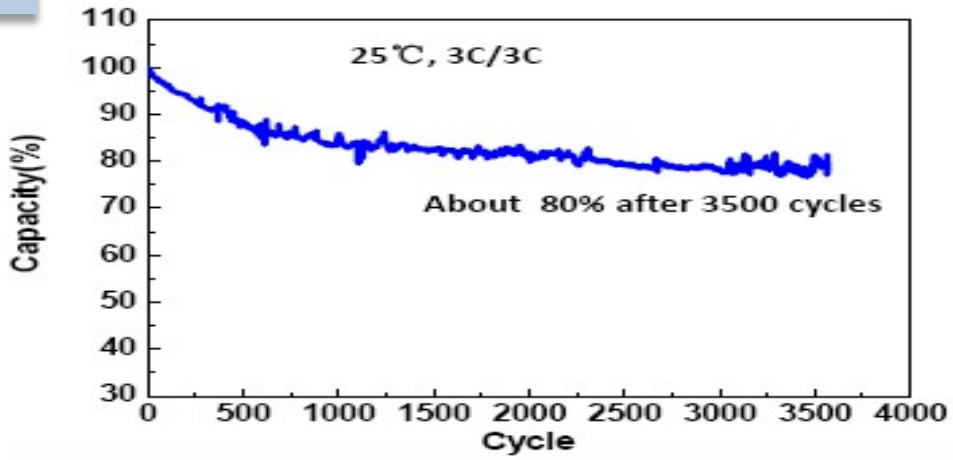


The Technical Progress of Power Battery

Cycle life of power battery increases greatly:

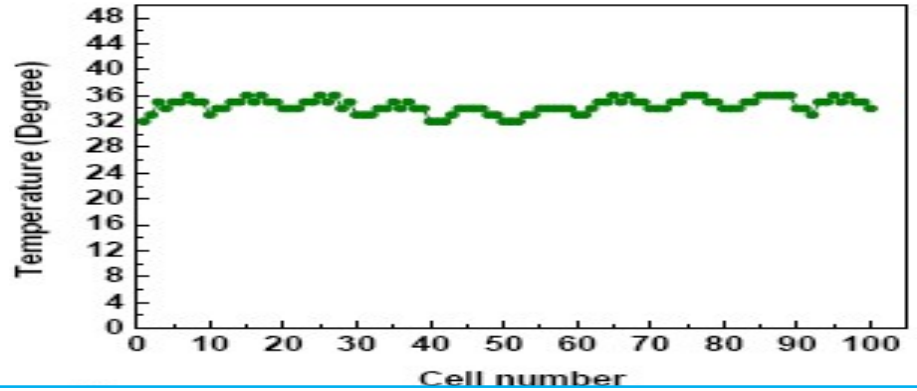
LiFePO4 battery (cell): increase from 1500 (the year 2010) to 2500-3500 (the year 2011).

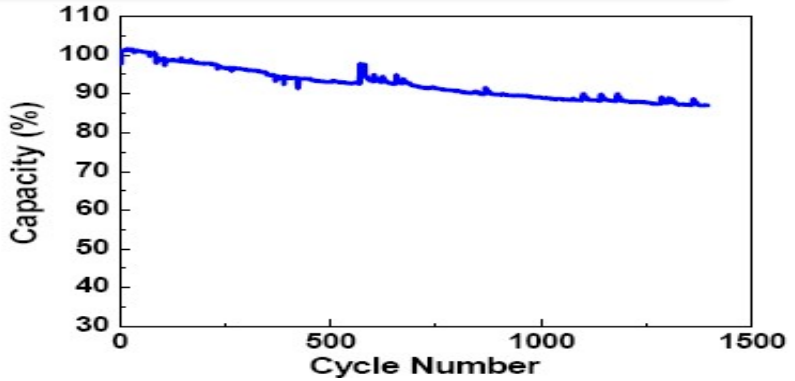




LiFePO4 battery pack: capacity is more than 87% after 1390 cycles

***Experiment condition:** 25° C; 1C @ 100% DOD; serious connection with 100 cells; no balancing technique.





The Technical Progress of Power Battery

Safety technology of power battery:

Safety criteria and testing rules become more and more critical

- **Safety performance**

- Physical performance test

- **Extrusion**
- **Nail**
- **Crush**

- Electric performance test

- **Overcharge**
- **Over-discharge**
- **Short circuit**

- Thermal performance test

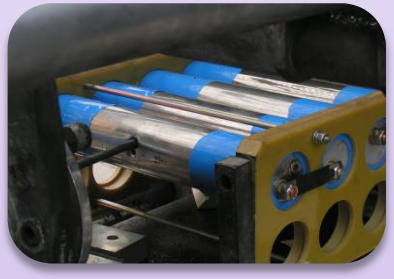
- **high-temperature character**
- **Thermal shock**

- **Safety protection performance- Electric performance test**

- **Overcharge**
- **Overdischarge**
- **Short circuit**

Short circuit

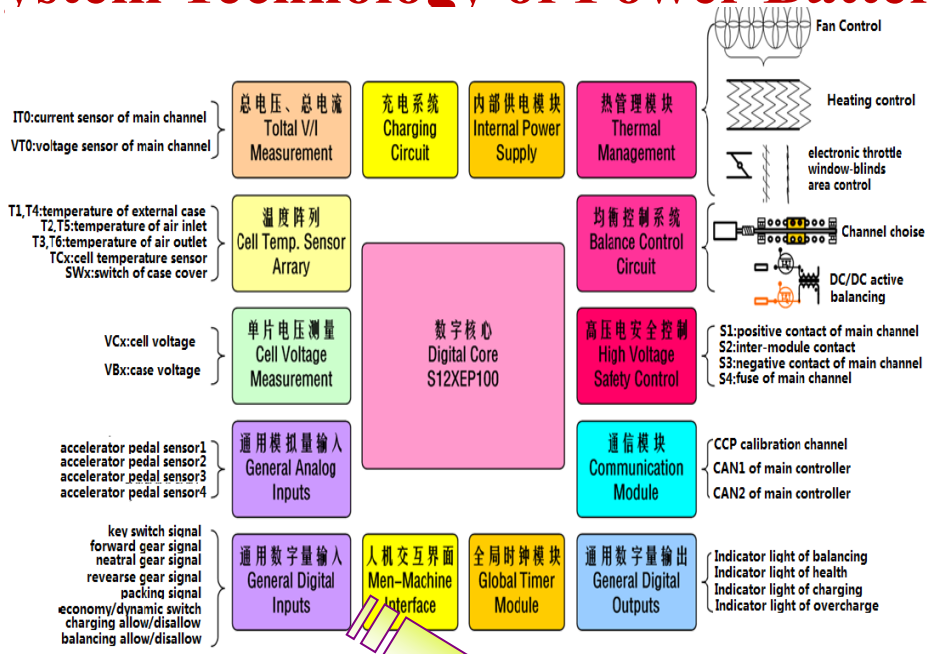
Nail

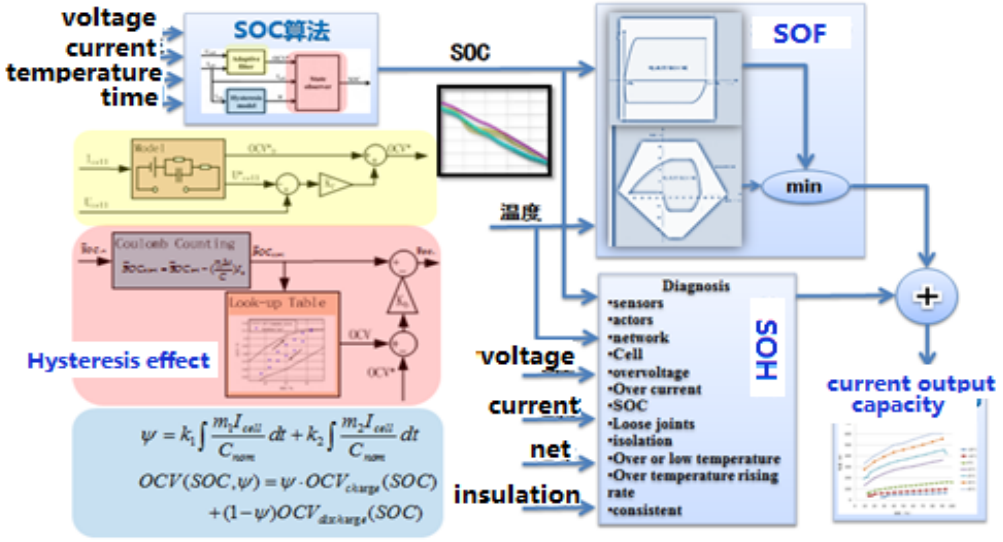


Crush

The Technical Progress of Power Battery

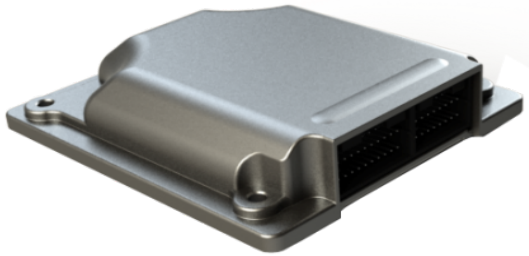
System Technology of Power Battery: advanced BMS





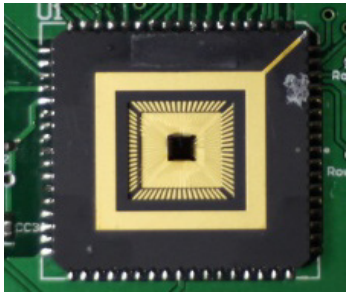
Material object of BMS

Main controller



Sub-controller

Intelligent chip



The Technical Progress of Power Battery

Technology of Power Battery System: Performance Optimization of Power Battery System

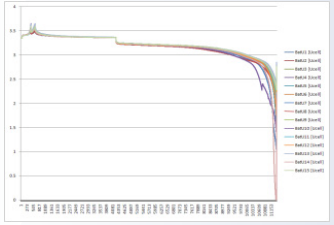
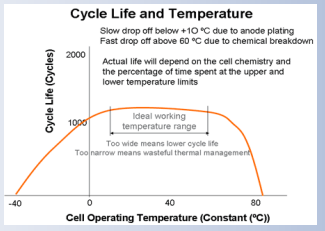
Safety

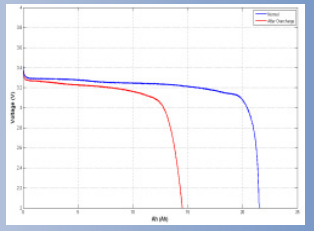
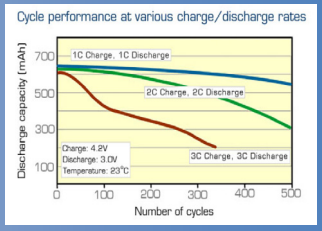
Over-temperature burning | Bloating-leakage | Loose-contact | Abuse




Durability

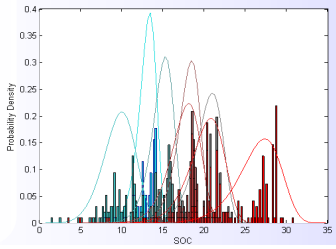
High-low temperature | Overcharge and overdischarge | Charge and discharge with large current | Other factors

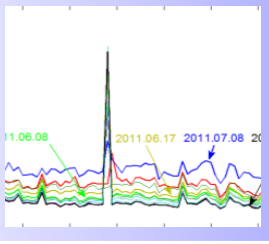



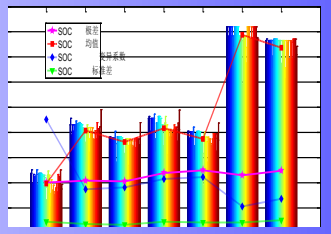
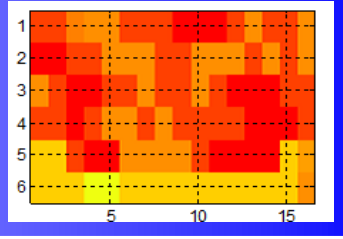



Uniformity

Capacity | Resistance | Self-discharge rate | Heat distribution | Other



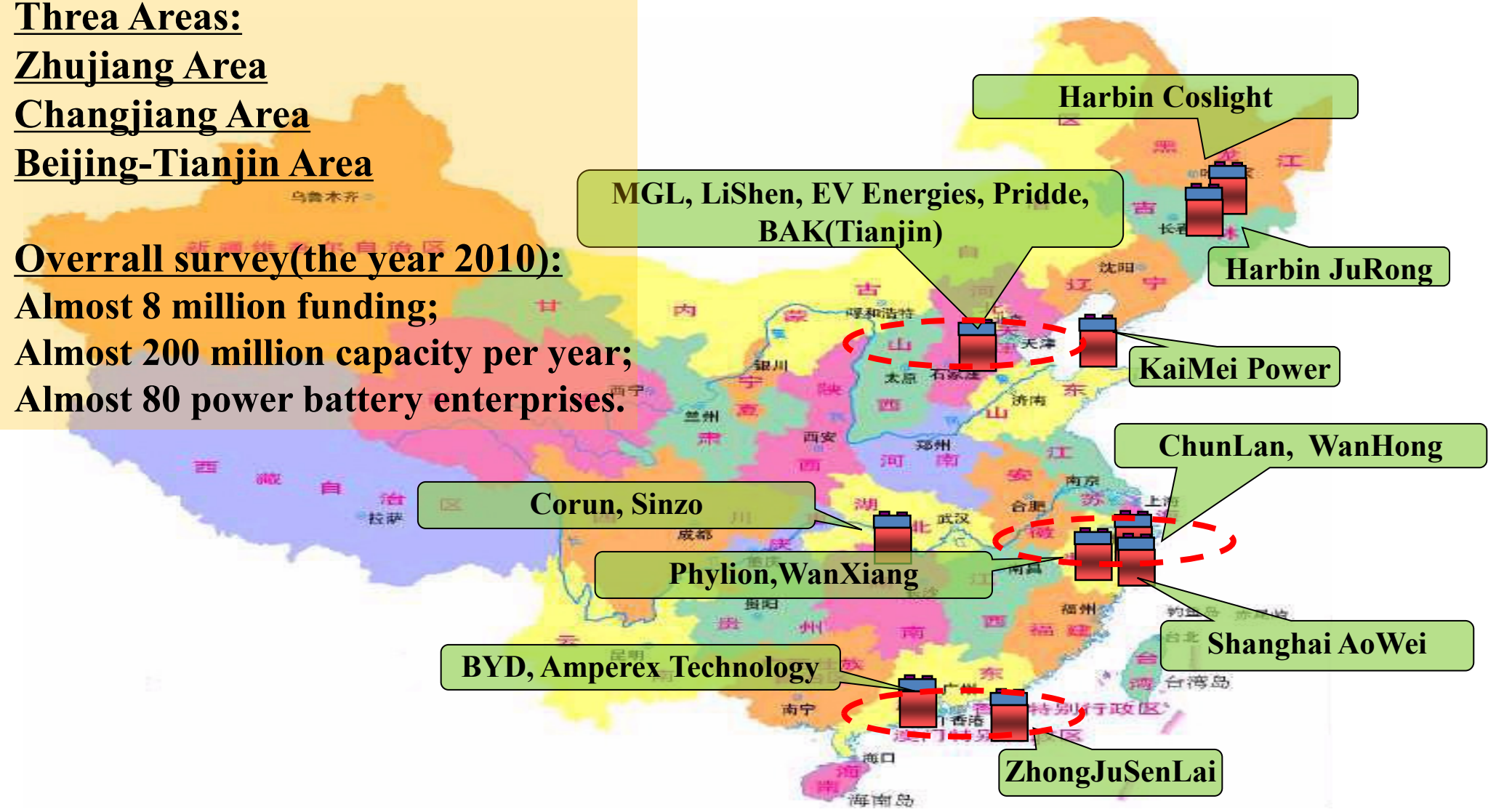


Development of Power Battery Industrialization

Threa Areas:
Zhujiang Area
Changjiang Area
Beijing-Tianjin Area

Overrall survey(the year 2010):
Almost 8 million funding;
Almost 200 million capacity per year;
Almost 80 power battery enterprises.

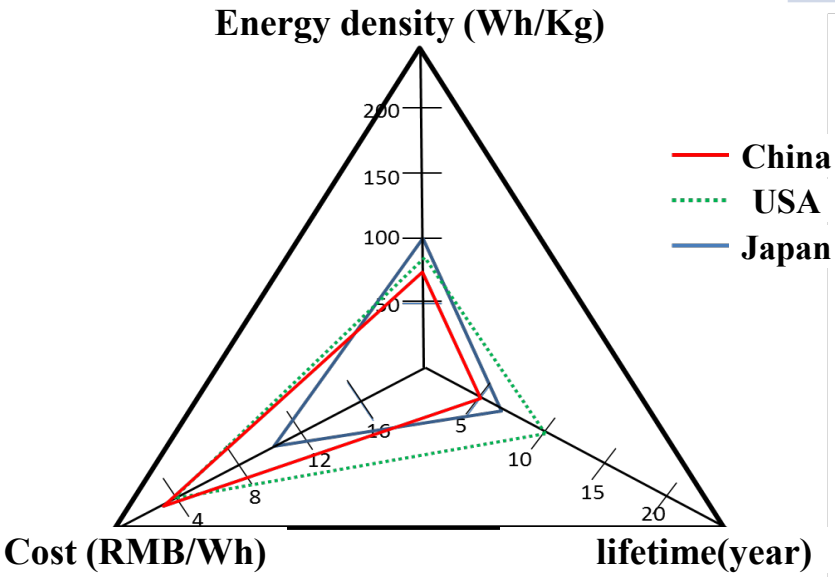


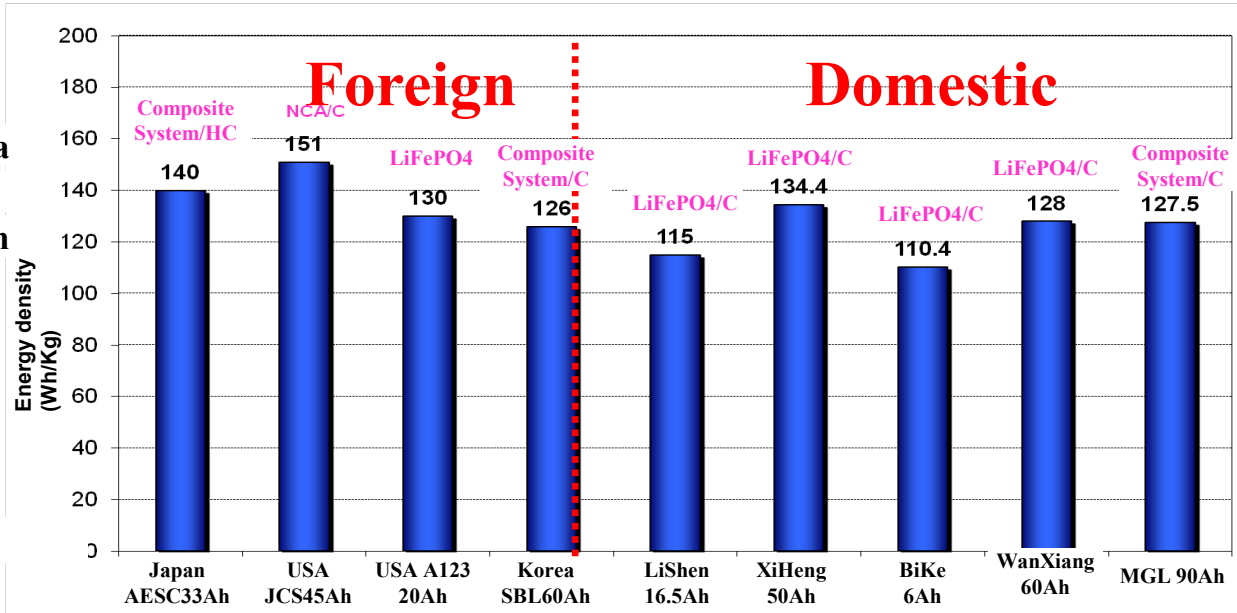
Technical Progress of Power Li-ion Battery

Comparison of lithium battery technology of different countries

- in percentage

Country	China	USA	Korea	Japan	Germany
Technological innovation	60	90	80	100	50
Manufacture	80	50	90	100	50
Material, etc	80	70	60	100	60

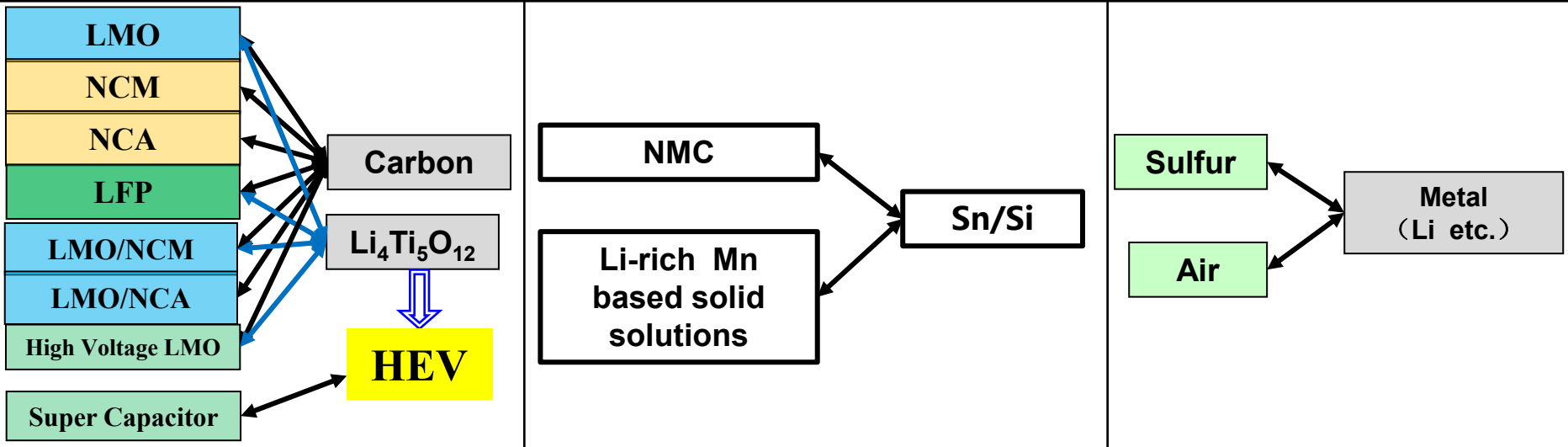




Basically, technical skills of developing the lithium ion battery monomer in China is at the same level as overseas. However, China falls behind relatively in the terms of group technology and system integration technique.

Development Tendency of Power Battery
（Combination of Different Material System）

Existing Electrochemical System	New Electrochemical System with High-performance	Next-generation Electrochemical System
~100Wh/kg or less （HEV/PHEV/EV）	~200Wh/kg (PHEV/EV)	~300Wh/kg (EV)

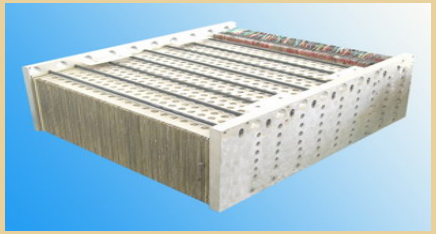
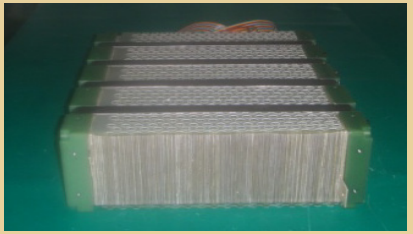
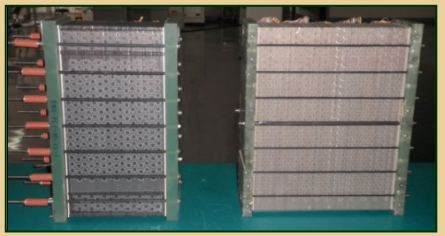


Seperater： PP, PE, PVDF, PI, composition or modification
Electrolyte： High voltage, Flame retardant, solid electrolyte
Type： Cylinder, prismatic & soft pack

Note: The energy density is calculated by statistics

The Technical Progress of Fuel Cell

Sustainable development of technical progress of fuel cell piles

	2008	2009	2010
Electric Pile	 STK08，20L，30kg 0.8kW/L(THU 863acceptance) Average 0.65V@0.7Acm^{-2}	 STK09，20L，30kg 1.4kW/L(New Pile development) Average 0.65V@1Acm^{-2}	 STK10，13L，20kg 1.6kW/L(pile with thin metal plate) Average 0.58@1Acm^{-2}
Electrode	MEA07c-GDE04ab 1.2mgPt/cm^{-2} Import Pt/C catalyst Nafion 212 Import Toray carbon paper 0.46W/cm^{-2}@0.65V	MEA08b-GDE04db 1.0mgPt/cm^{-2} Import Pt/C catalyst Nafion 211 Import Toray carbon paper 0.65W/cm^{-2}@0.65V	MEA10a-CCM10 0.8mgPt/cm^{-2} PtPd/C metal catalyst(made in china) Composite membrane(made in china) Carbon paper (made in china) 0.65W/cm^{-2}@0.65V
Bipolar Plate	**Metal graphite** Plt-C-05 Thickness: 2.0mm Concurrent flow field 270cm^2	**Metal graphite** Plt-C-06 Thickness: 2.0mm Flow field optimization 310cm^2	Thin metal stamping Plt-M-01 Thickness: 1.3mm First generation of metal flow field 310cm^2

Technical Progress of Fuel Cell

Fuel cell life improves significationtly:

Development and Application

Demonstration Validation

System control optimization, strengthen hydrothermal management of electric pile

New MEA and new water management technique of battery

Hour

5k

3k

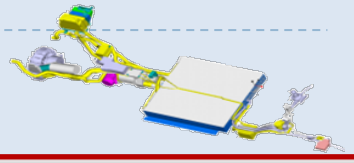
2k

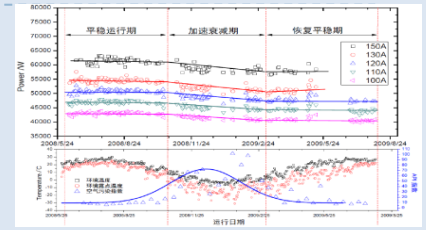
1k

0.5k

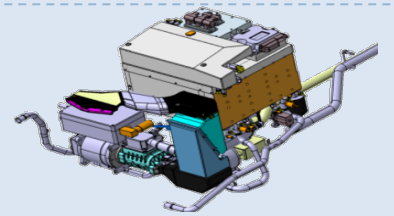
0.1k

~500hrs@20%degredation
Real way running (863 car)

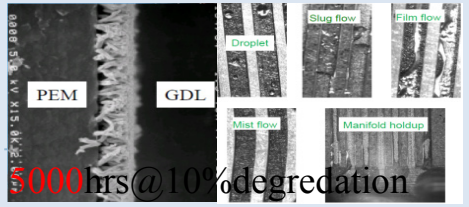




1500hrs@7%degredation
Real way running (863 bus)



3000hrs@10%degredation
Real way running



5000hrs@10%degredation
Real way running

2008

2009

2011

2015 Target

Technical Progress of Fuel Cell

The cost of fuel cell reduces significantly

Guiding the development of key materials made in china so as to lay the technical foundation of application

Applying the application of domestic materials

Double the power density, diminish the material usage and pt amount drops

Forming supply chain of key materials for fuel cell made in china

10 thousand RMB/kW

1

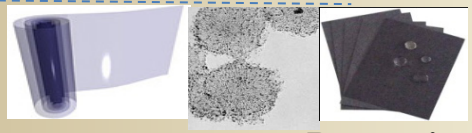
0.8

0.6

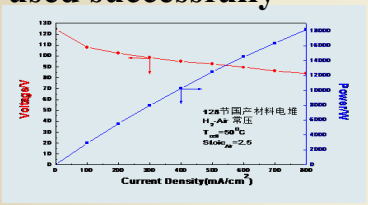
0.4

0.2

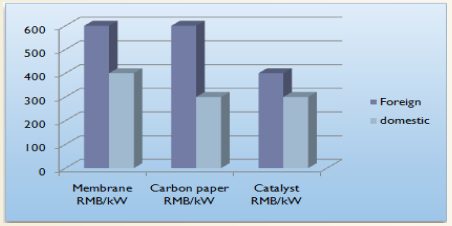
the import of membrane, carbon paper and some other key materials.



Domestic materials are used successfully



The application of domestic materials (100 unit) reduces the cost up to 30%.



The reduction of material dosage & The application of domestic materials

~1000RMB/KW @ 1000 FCE

2009

2010

2012

2015 Target

Technical Progress of Motor

Specification Comparison

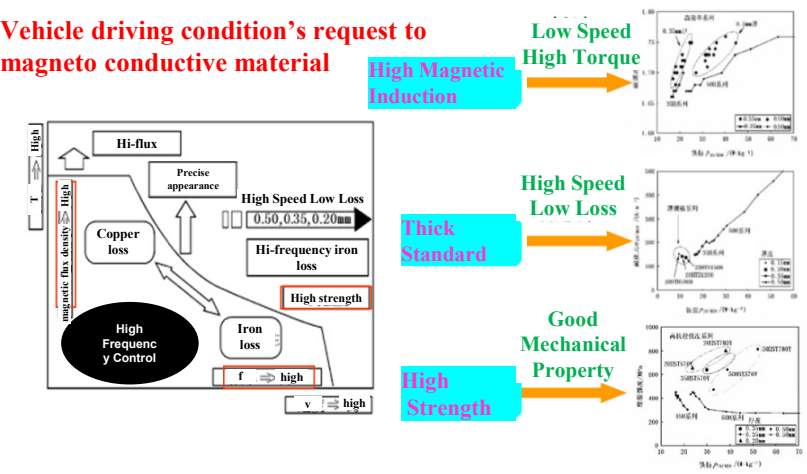
Key Technical Index	Chinese typical PMSM274YZ-XI 02 	Chinese typical PM motor 274YZ-XI TYC-168-260 	American typical company 	Japanese typical company 
Peak Power(kW)	92	90	90	60
Peak Torque(Nm)	210	240	239	207
Maximum Speed(r/min)	11500	6000	10000	13500
Efficiency/Efficient Area	94%/70%	91.2%/70%	90%/50%	94%/75%
Motor/MCU Total Height(kg)	65/28	99/30	65/35	37.7/17.9
Motor/MCU Power Density （kW/kg）	1.42/3.29	0.91/3.00	1.39/2.57	1.59/3.35

Data sources：Oak·Ridge National Laboratory Annual Progress Report for the Power Electronics and Electric Machinery Program；

The Technical Progress of Motor

The key technology of the breakthrough part: basic Components

The basic generality technology of the product chain for the vehicle driving motor has been broken through and applied widely. For example, magnetic silicon steel, rare-earth permanent magnetic material, insulating material, position sensor etc.



High-performance magnetic conductive material

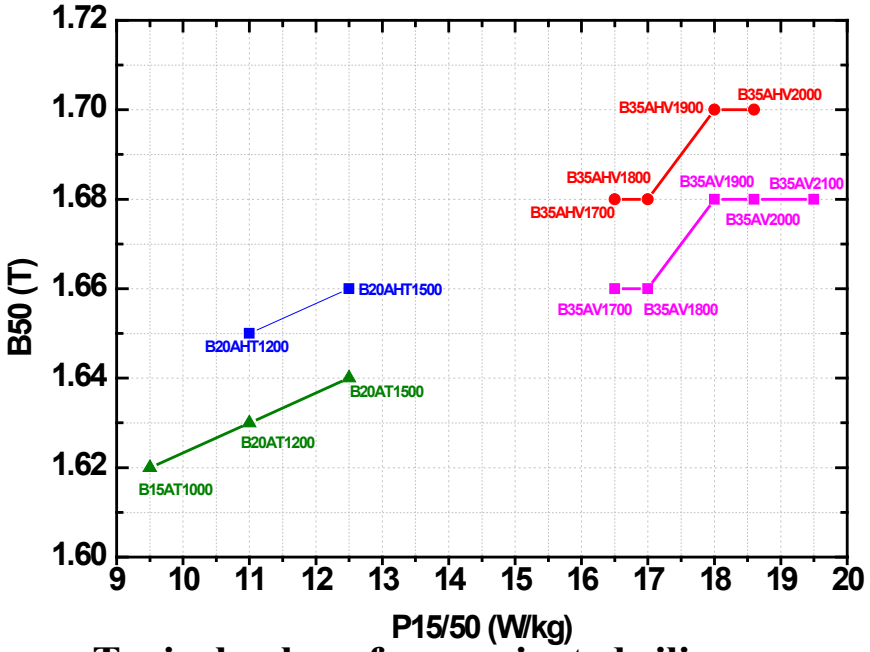
High-performance rare-earth permanent magnetic material

High reliability velocity and position sensor

The Technical Progress of Motor

The key technology of the breakthrough part: electric steel

The electric steel studied by Baosteel has developed into AV and AHV series. The AV series contains 3 trademarks and the AHV series contains 7 trademarks. Both series are used in the vehicle motor.

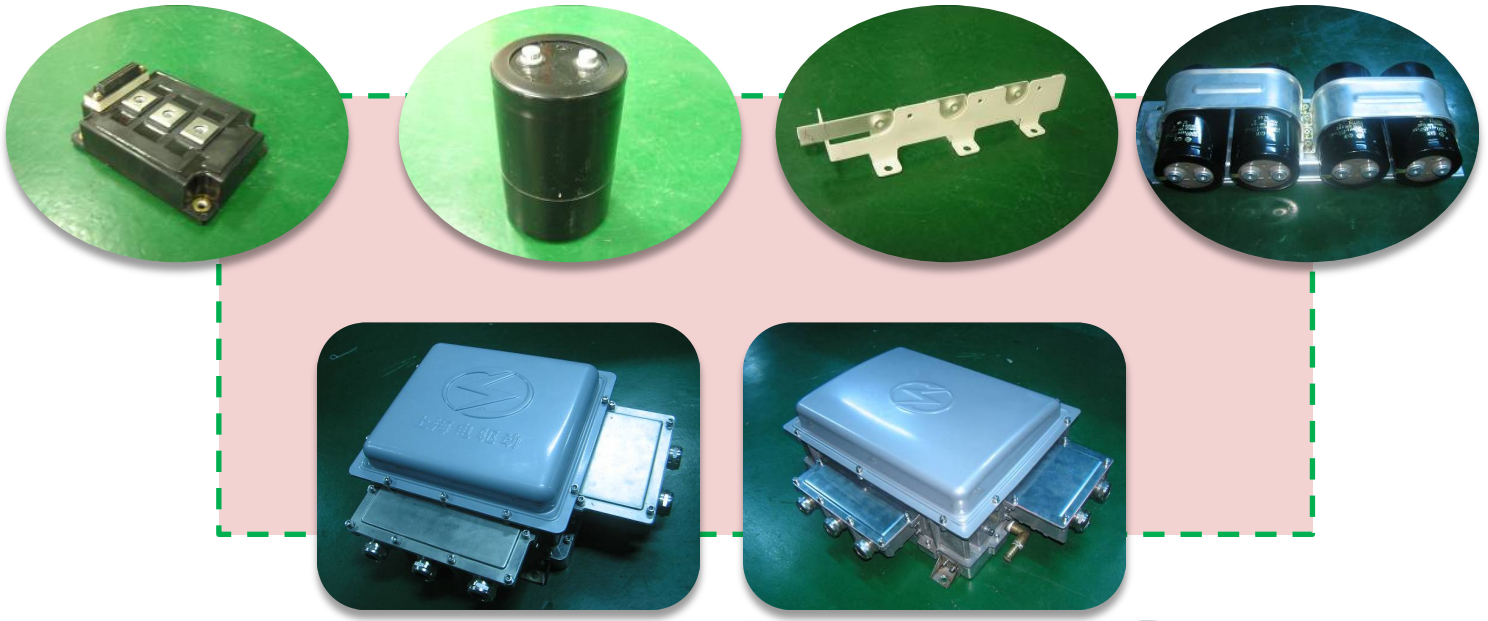


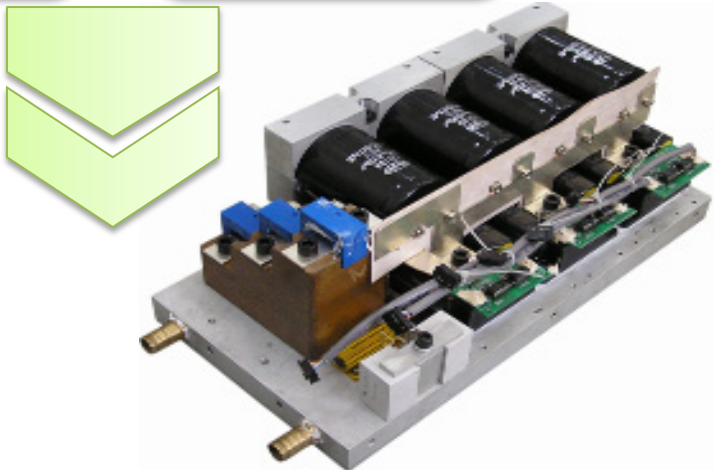
Typical value of non-oriented silicon steel for the vehicle driving motor

The Technical Progress of Motor

The key technology of the breakthrough part:

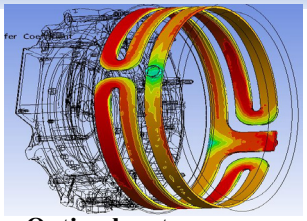
the power component modularization of motor control unit



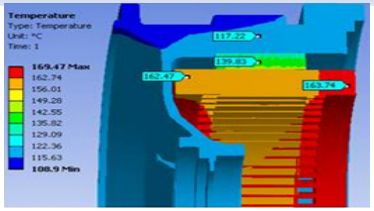


The Technical Progress of Motor

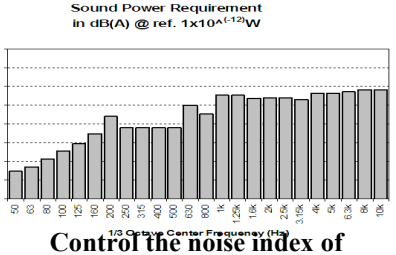
- Apply advanced design principle and method to develop motor with high efficiency, good cooling systems and low vibration noise.
- System integration and Optimization technology
- The testing technology for safety, reliability, durability and environmental adaptability



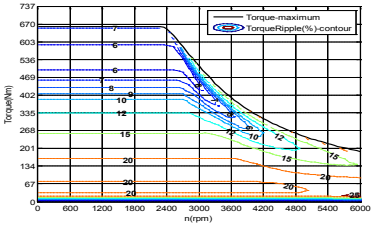
Optimal water passage design（Patent of JingJin Electric）



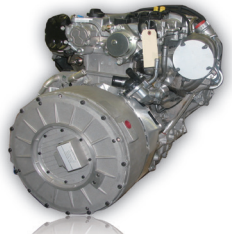
Increase efficiency, increase heating, effective thermal radiation



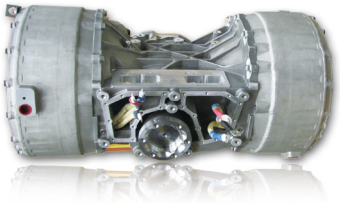
Control the noise index of frequency doubling point



Minimize the torque ripple of the motor



Generator -engine assembly



Driving motor-main reducer assembly

Installed capacity 2.4 MW durability test bench

The running state test for performance, reliability, durability

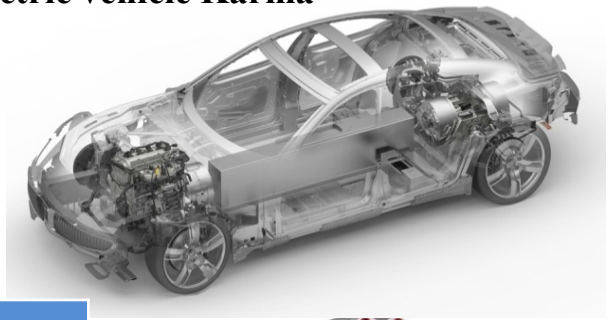
The Technical Progress of Motor

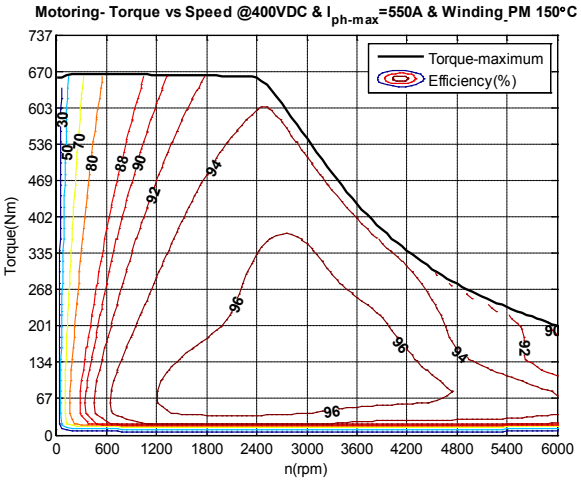
China exports batches of EV drive motor

In 2011, Jing-Jin Electric began to export batches of motors that supporting the high-end extended-range electric vehicle – Fisker Automotive's extended-range electric vehicle Karma

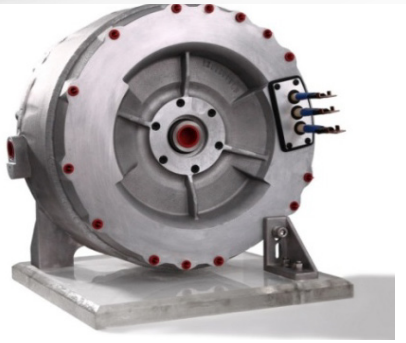
- High power and high torque permanent magnet synchronous drive motor of 150kW / 665Nm
- The 175kW permanent magnet synchronous generator has achieved the best match of performance and high efficiency area of motor and engine
- Power density (effective weight) of 3.2kW/kg, which is the highest power and highest power density production permanent magnet synchronous motor internationally at present
- The dynamic and NVH of the motor has been highly acclaimed in various authoritative tests

The US. Fisker Automotive's extended-range electric vehicle Karma





Power density (kW/kg)	3.2
Torque density (Nm/kg)	13.2
Peak power/ Continuous power (kW)	150/110
Peak torque/ Continuous torque (Nm)	650/450
Maximum speed (rpm)	6000
Maximum efficiency	97%
High efficiency area (>80%)	75%
Degree of protection	>IP65



Jing-Jin Electric's 150kW drive motor

The Technical Progress of Motor

Breaking through in key technologies of industrialization , and achieving large-scale production

Jing-Jin Electric's Shanghai Jiading factory (Annual production is 10 million)

- The annual capacity is more than 100 thousand sets (150 kW motor)
- Breaking through low-cost technology, leaping from batch production to continuous production
- Innovation of production technology and equipment, and building the world's leading high-performance vehicle drive motor production line

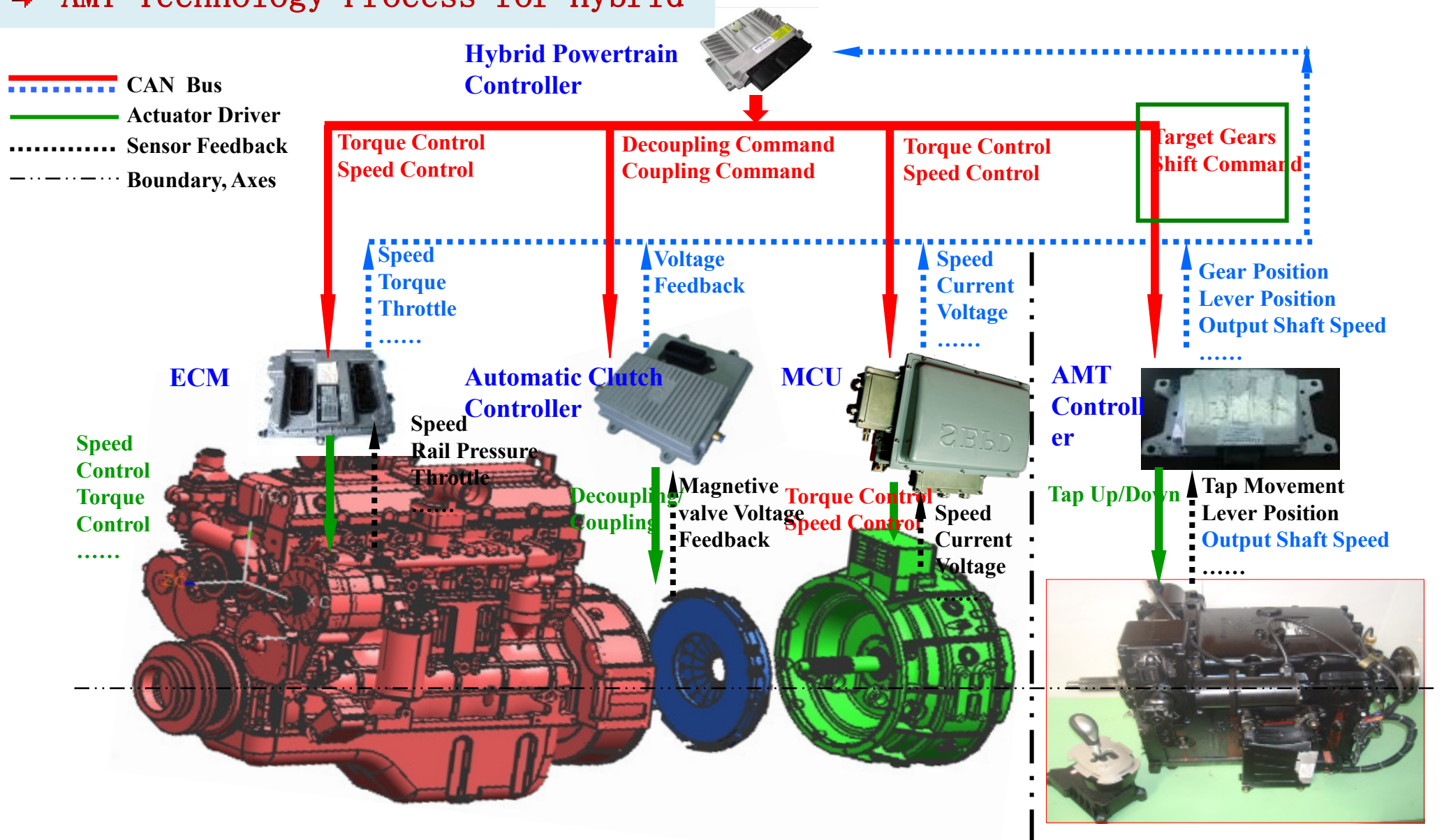
Jing-Jin Electric's Motor assembly line

Ultrasonic three-phase terminal welding and motor final inspection test bed

Contents

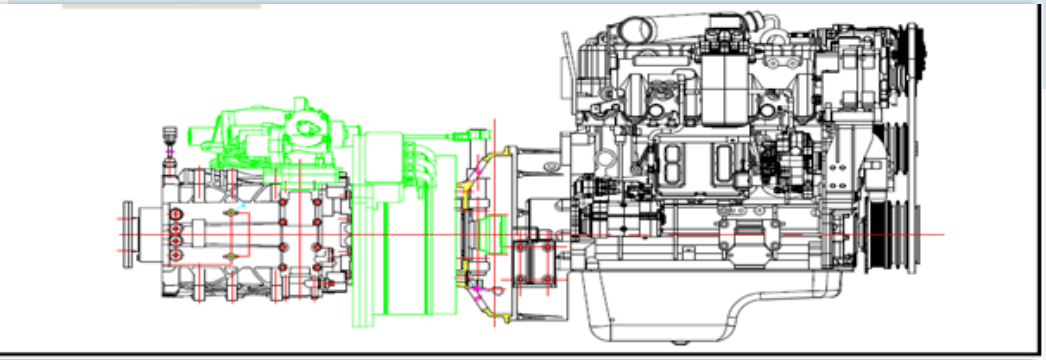
Technology Process of Hybrid Vehicle（City Bus）

AMT Technology Process for Hybrid

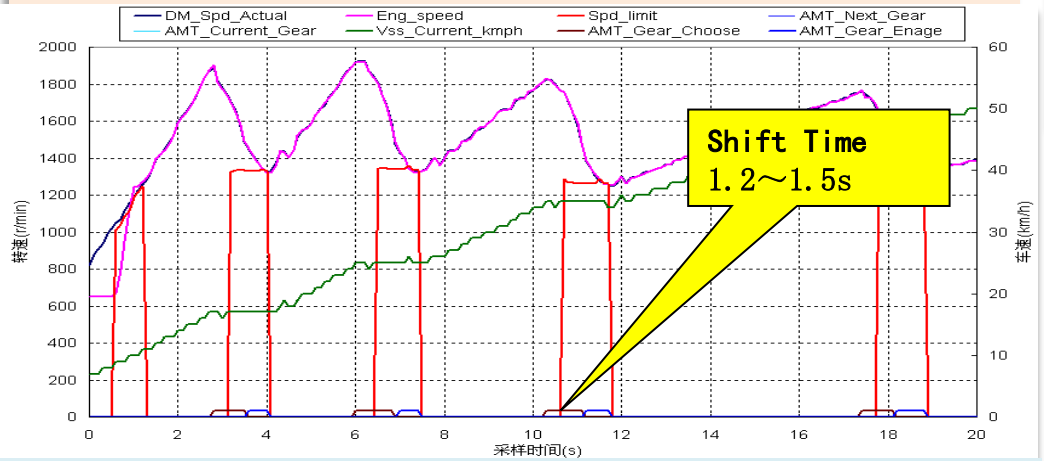


Technology Process of Hybrid Vehicle（City Bus）

AMT Technology Process for



- Rising “dynamic shifting regular based on driver command” and “AMT Control Strategy based on Torque”



Verification of AMT Shifting

- **Common Axle Parallel Hybrid system is developed , breaking the monopoly of foreign companies， realizing the industrialization**

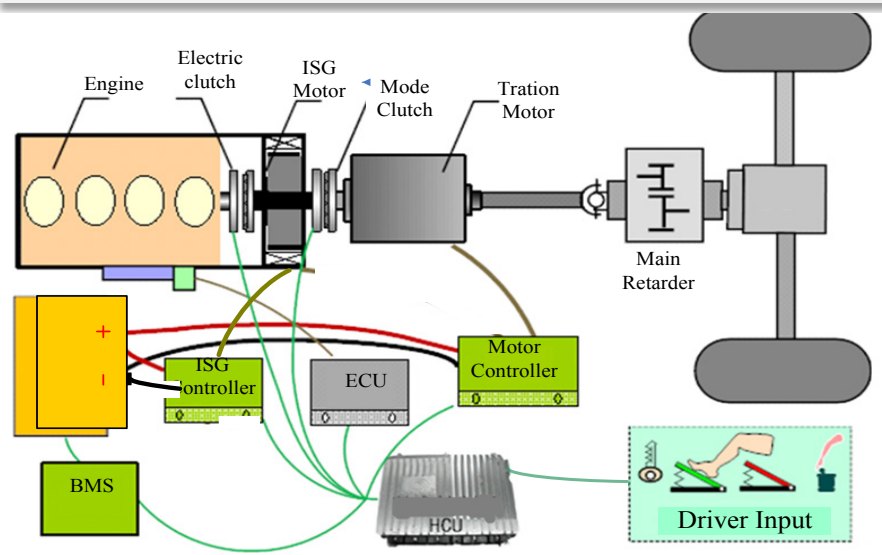
  Demonstration line in 8 cities including Tianjin, Chongqing, Shenzhen, and Tai’an with an increase in fuel economy of 30%

- **AMT products for car, bus, and track**
  - Accomplish all the tests of China, the performance index meet the international standard
  - Some AMT systems is going to production

Technology Process of Hybrid Vehicle（City Bus）

Break Through in Hybrid Technology without AMT

Dedicated Engine +Automatic Clutch + ISG Motor + Mode Clutch + Traction Motor Coaxial Hybrid Configuration

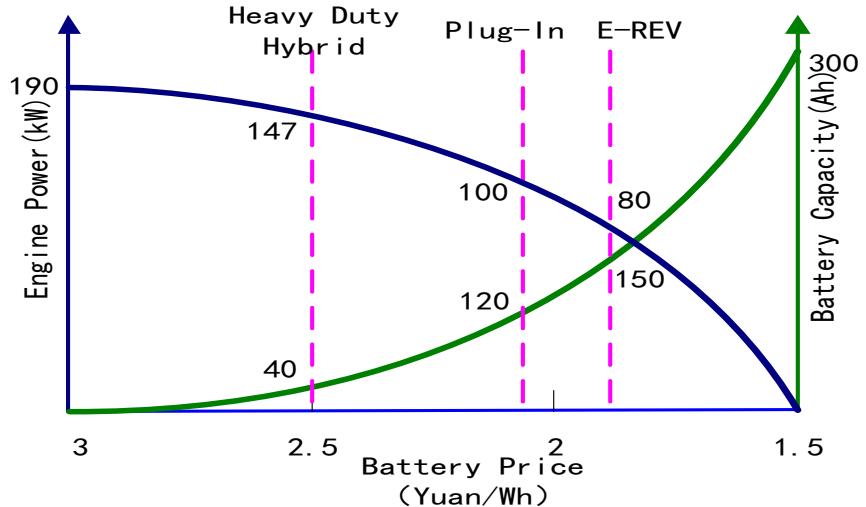


Velocity	Clutch	Operation mode	Fuel economy algorithm	advantage
≤20km	Decoupling	serial	Engine is decoupled from retarder, so engine will work in area of high efficiency	Better than parallel
＞20km	coupling	Parallel	Engine drives the wheel directly, which could reduce the energy loss of transmission	better than serial

System has the following advantages:

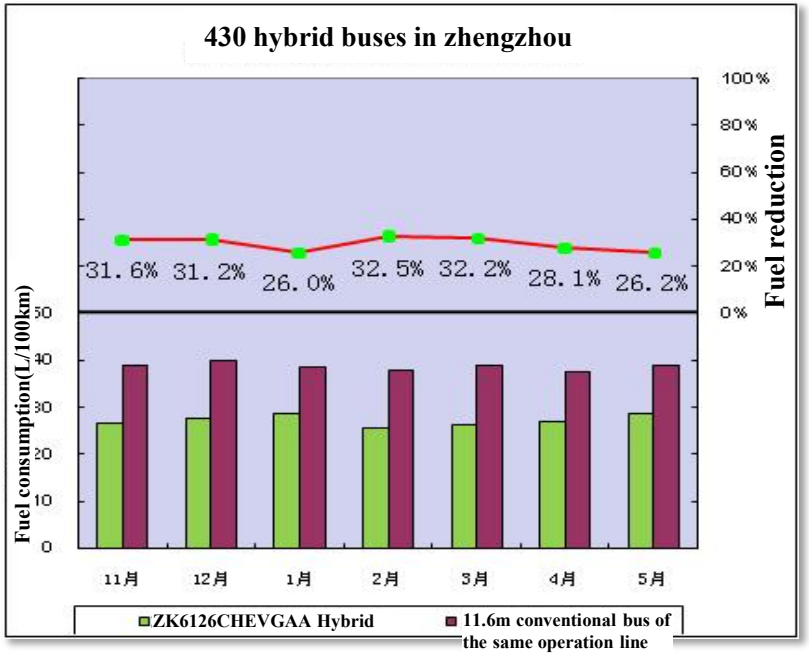
①Simple structure without transmission, no shifting during operation, good harshness

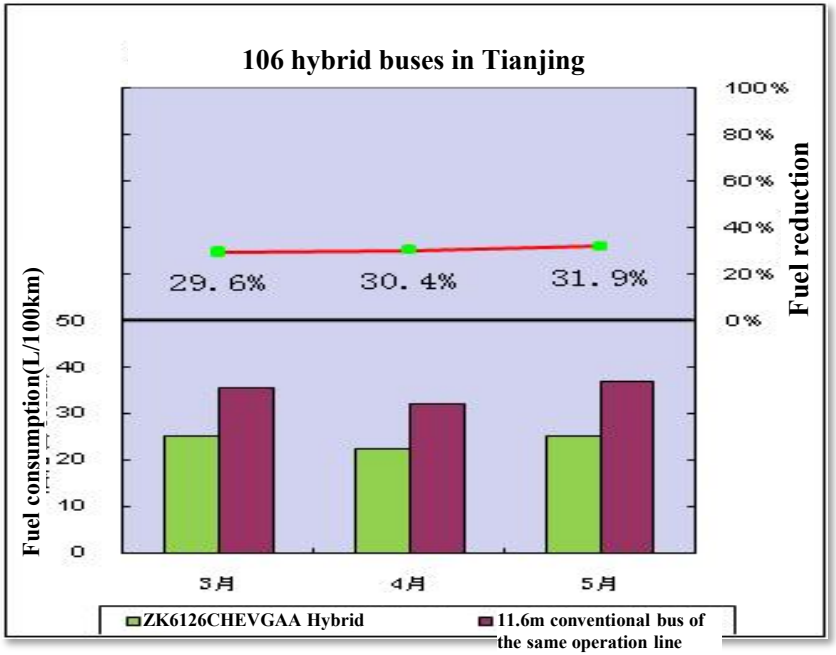
②With platform and series, it could be extended easily. heavy duty hybrid →plug in →EREV" could be implemented in one platform, which could realize the transition from hybrid to electric steady



Technology Process of Hybrid Vehicle（City Bus）

Fuel economy verification from massive commercial road operation





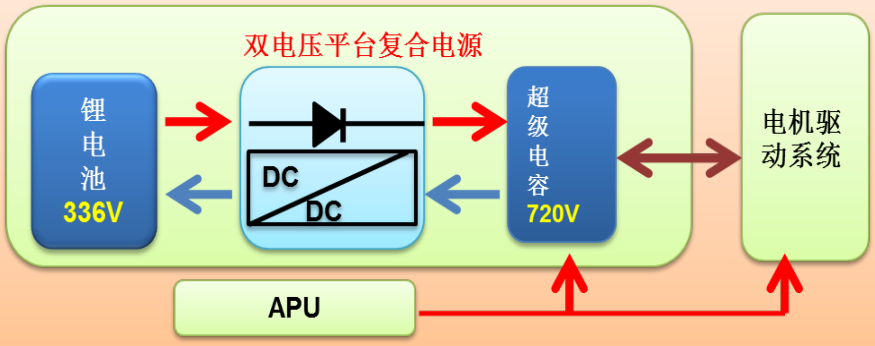
Technical Progress of Electric Vehicle（City Bus）

Different modes of electric buses

Battery Swapping

Recharging

Quick-Recharging



Extended Range

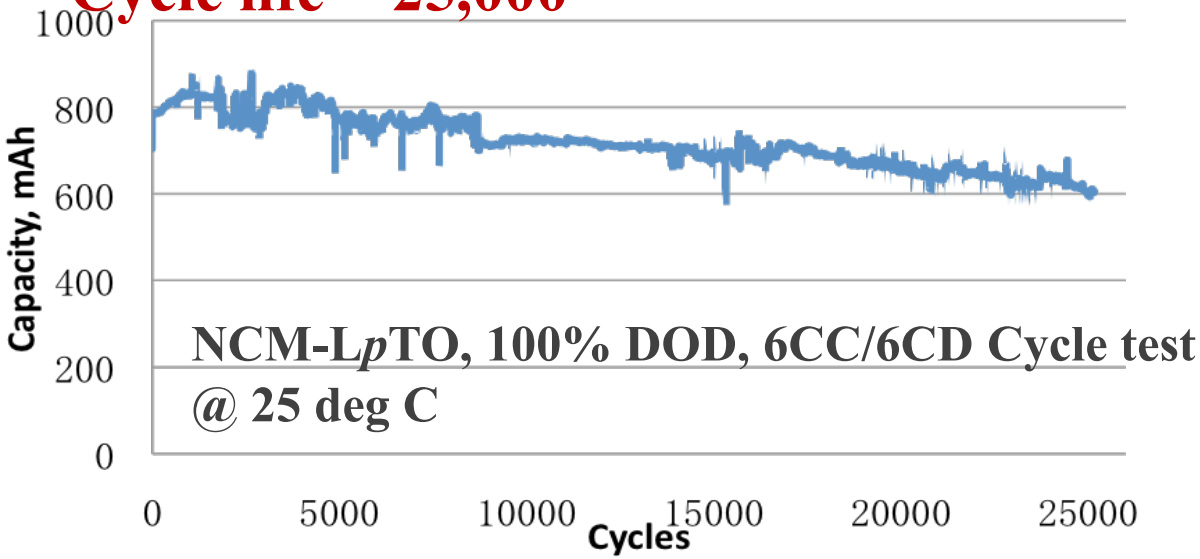
Technical Progress of Electric Vehicle（City Bus）

Electric buses with LTO

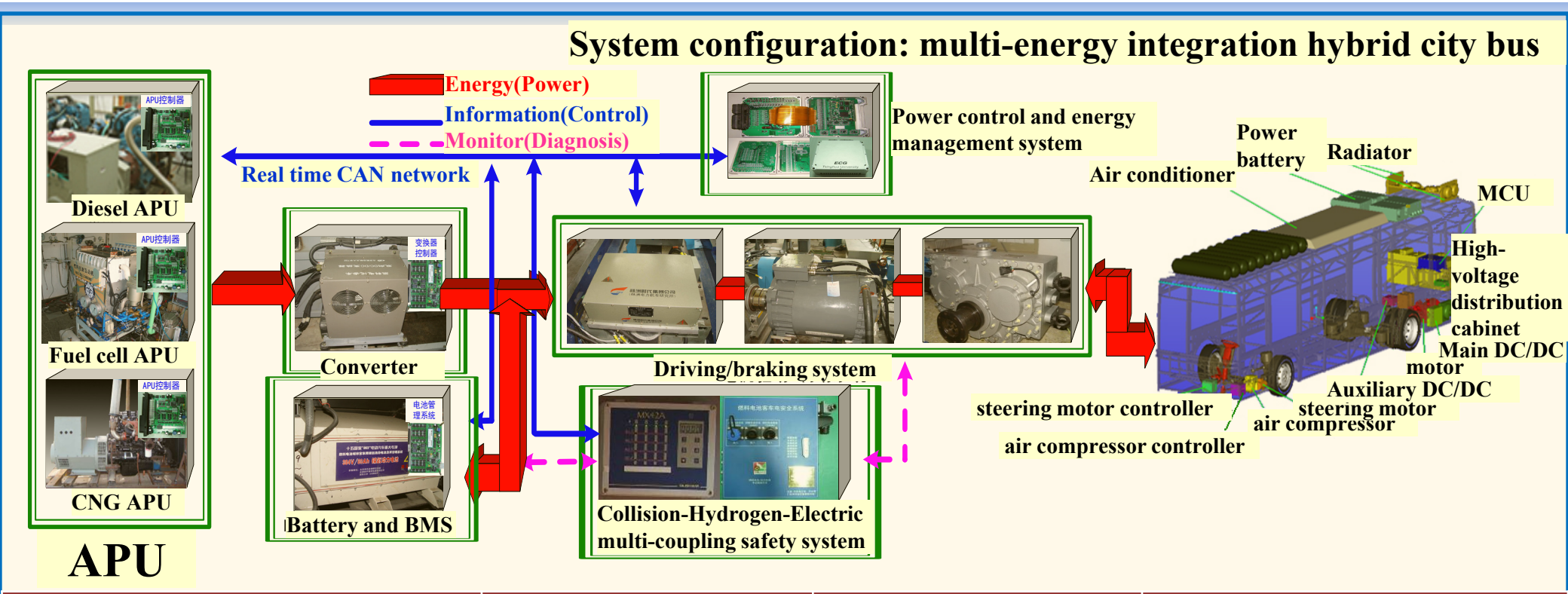
More than 400 city buses demonstrated in Chongqing City by Heng tong Company

The longest time vehicle exceeds 500 days

Cycle life = 25,000



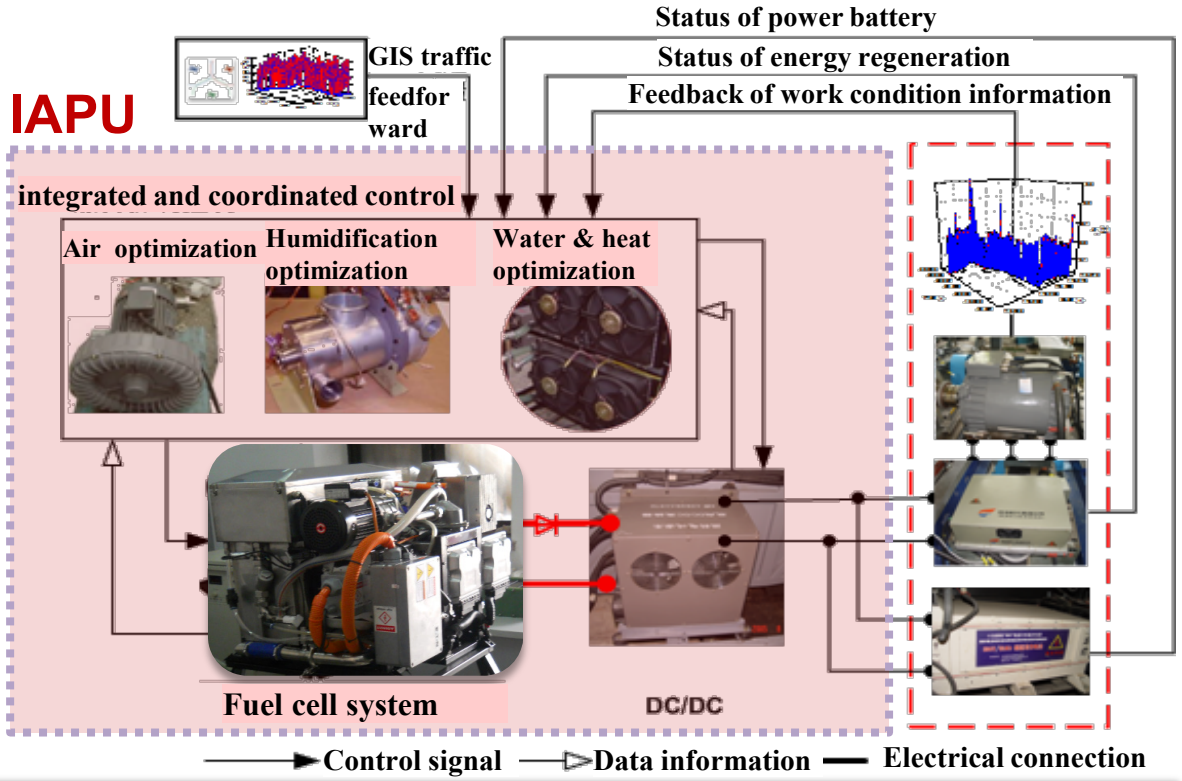
Powertrain platform of Fuel cell（City Bus）

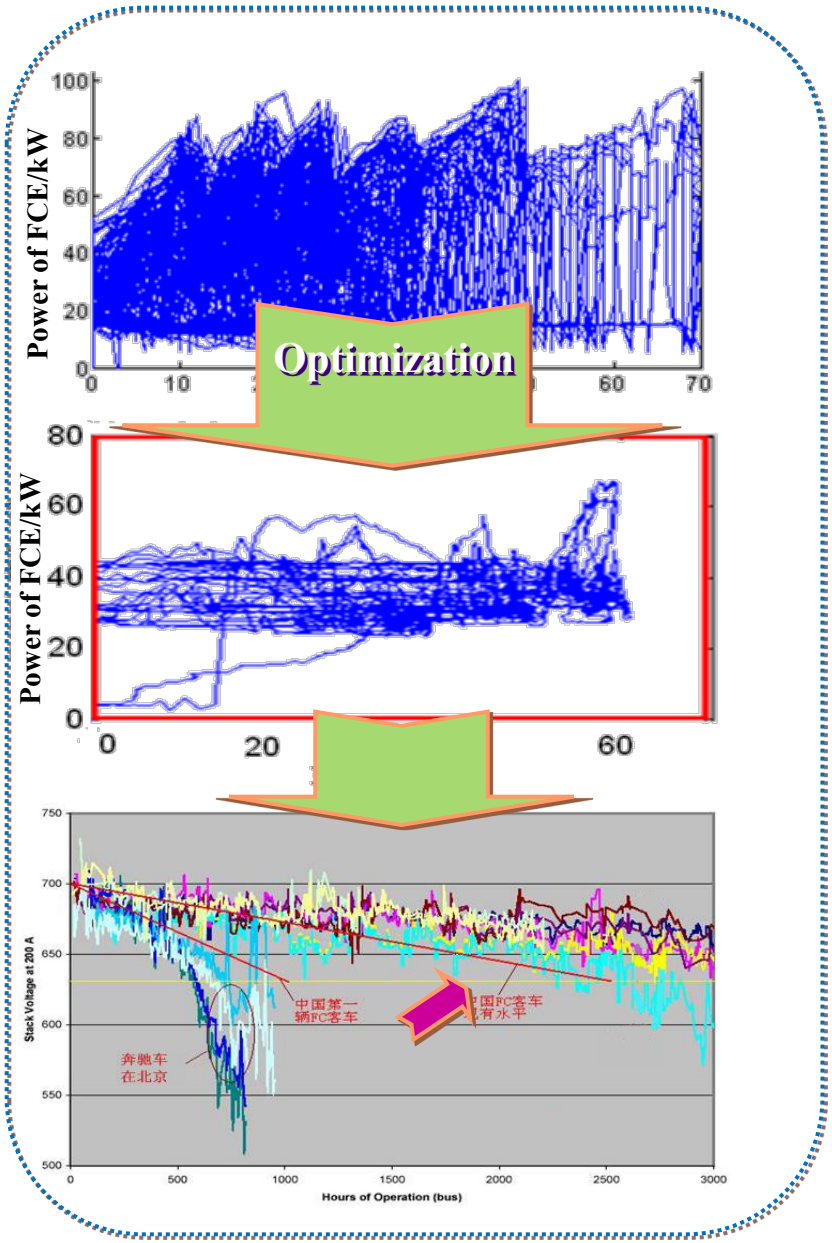


System Configuration		1st Generation	2nd Generation	3rd Generation
Parameter matching	Power of APU	100kW	80kW	50kW equal to the power of an economic car's engine
	Battery Capacity	80A.h/288V	80A.h/384V	130A.h/384V
		1/5 to 1/10 of the electric buses		

Powertrain platform of Fuel cell（City Bus）

APU of Fuel Cell





Develop IAPU based on Multi-sensor information fusion, which could filter the vehicle transient load, centralize the work condition, make the operation smooth, and extend the life by over 1.3 times.

Powertrain platform of Fuel cell（City Bus）

Demonstration of Summer Olympic Games in Beijing, 2008

Demonstration of UNDP in Beijing, 2009

Demonstration of World Youth Championship in Singapore, 2010

Demonstration of World Expo in Shanghai, 2010

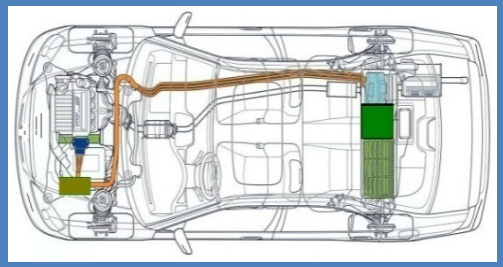
Demonstration-scale :	3 buses	6 buses	1 bus	6 buses
Demonstration time :	1 month	12 months	1 month	6 months
Demonstration achievement :	20000km,1500hrs	60000km	1800km,120hrs	5000km,370hrs

Technical Progress of Electric Vehicle
（Passenger Car）

Break through in Mild Hybrid Technology to realize the popularize and application of hybrid cars

Technology Platform	Demonstration Production	Massive production

ISG Platform (2005-2008)



ISG Platform

- Mature ISG platform for Chery
- ISG will become base configuration of Chery

Demonstration operation (2008-2010)

A5 ISG

M11 ISG

- Demonstration operation of Beijing Olympic, over 2 million kilometers
- Demonstration operation of “Davos Forum”
- Demonstration operation in government systems including Wuhu, Dalian, Peiking

Massive Sale (2010~)

A5 ISG

A5 BSG

- Massive Sale of BSG in 2009
- Massive Sale of ISG in 2010

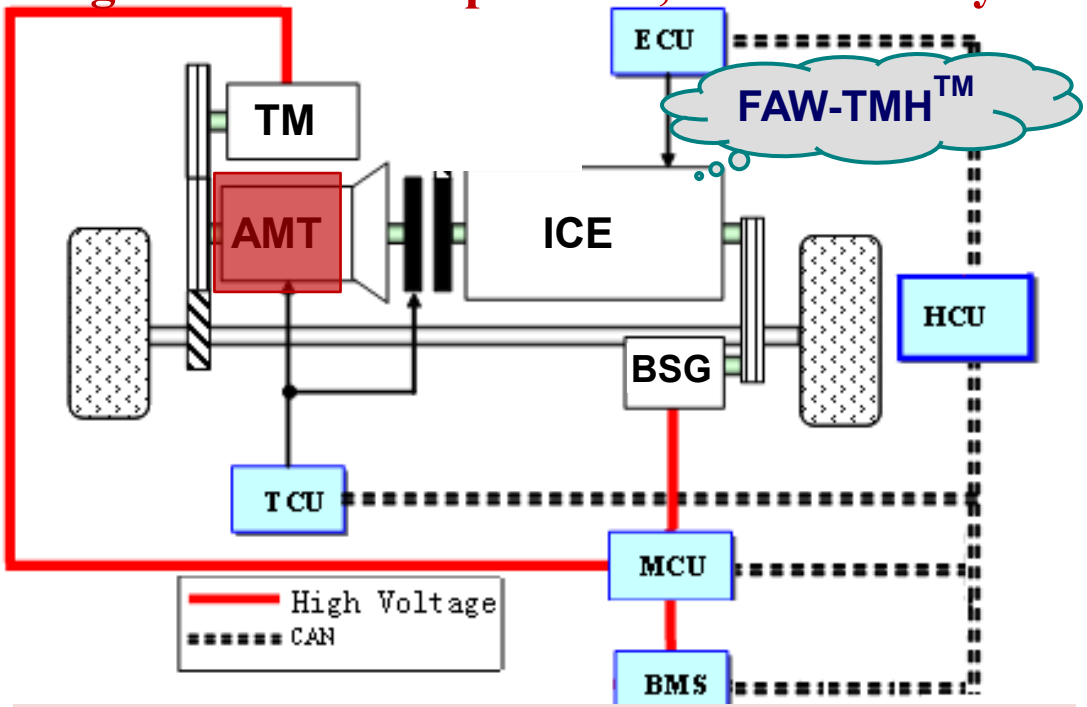
Technical Progress of Electric Vehicle

（Passenger Car）

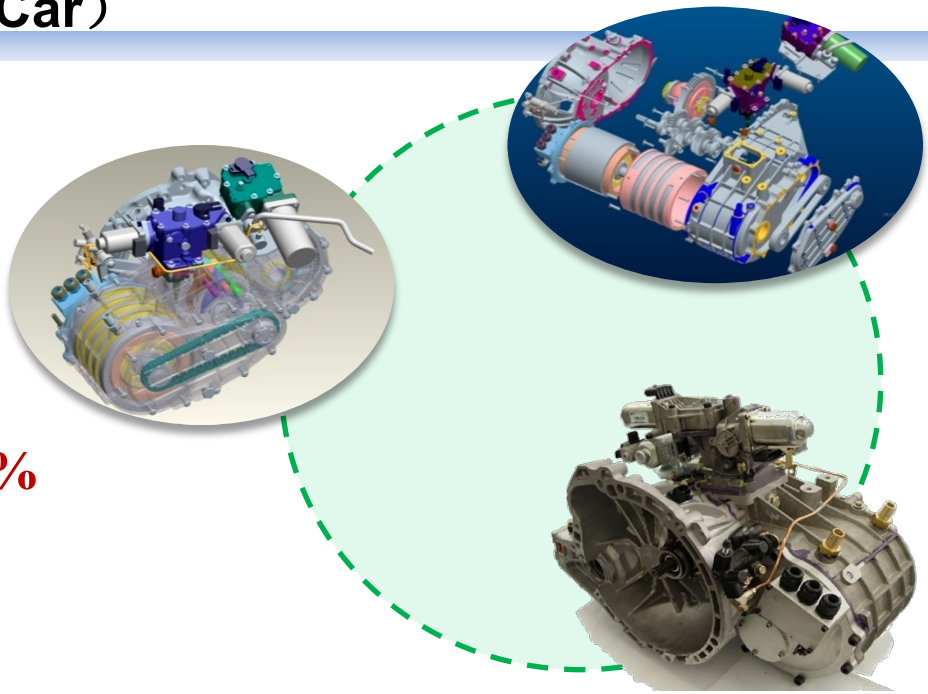
Breakthrough of heavy duty hybrid

The coupling method of engine and motor from PSHEV is solved
The integration design of motor shell and transmission shell is realized

Single car 20k km operation, Fuel economy of 35%



FAW Double Motor Configuration registered: FAW-TMH™



development of AMT system dedicated to hybrid

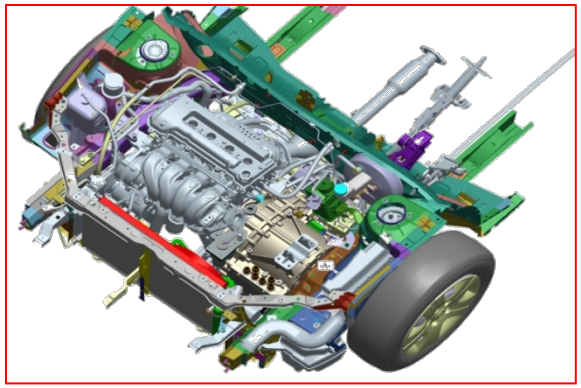
Engine	TA1(CA4GA1)	1.34L 4-cylinder in line Euro-3 63kW@6000rpm,120Nm@4000rpm
AMT	5T136	5 Gears AMT 3.273/2.859/1.241/0.919/0.756 R3.124;Diff4.333
BSG Motor	Starter	PMSE, Forced Water-Cooling,288V Power:5Kw/10kW@2000-120000rpm Torque:25Nm/50Nm@0-2000rpm
PM Motor	Traction Motor	PMSE, Forced Water-Cooling,288V Power:20Kw/30kW@2000-80000rpm Torque:100Nm/150Nm@0-2000rpm
Battery		Ni-H Cell, Forced Air-Cooling 288V-6.5Ah
Chassis	ABS,EPS, DC-DC	
Body	Electric Air Condition, Gauge Display	

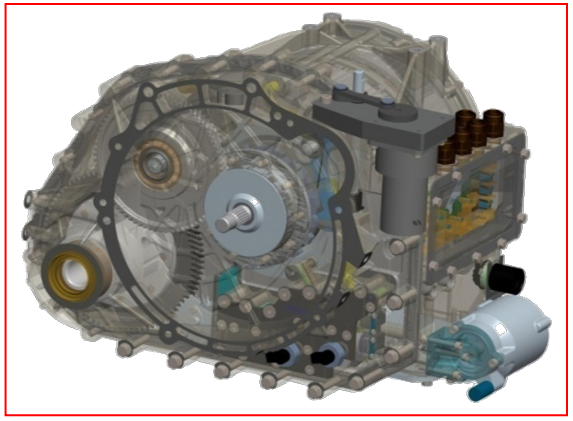
Technical Progress of Electric Vehicle

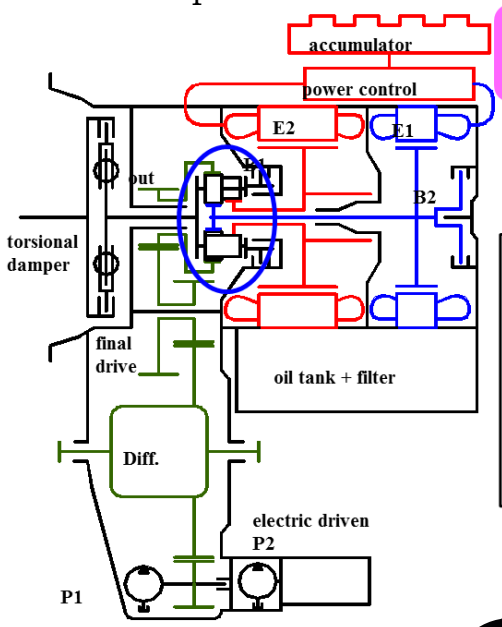
（Passenger Car）

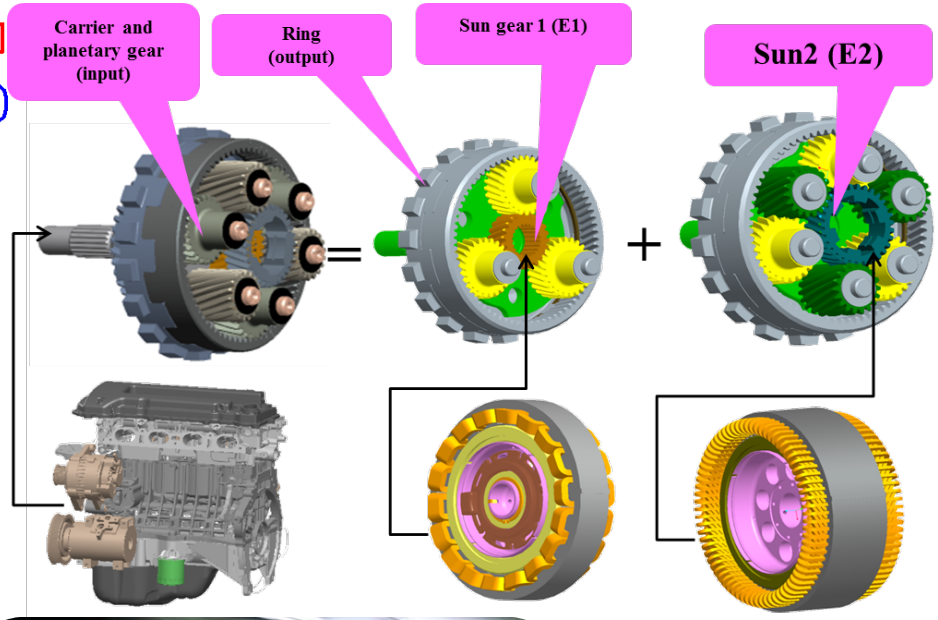
Break through in heavy duty hybrid: GL-ESD “ESD” —Energy Split Device

- Implement power split like PSD from Prius
- Could be used as electric platform of EV





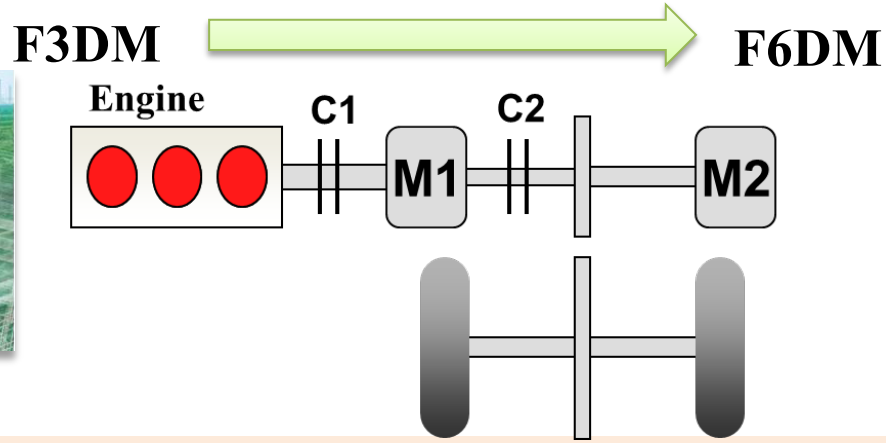




Fuel consumption is 5 L/100km. (with a conventional prototype of 7.8L/100km)

Technical Progress of Electric Vehicle
（Passenger Car）

Plug-in technology is being improved, and the platform is being upgraded.



F6DM： driving range 430km if fully charged（electric mode 100km+hybrid mode 330km），maximum speed 160 km/h.

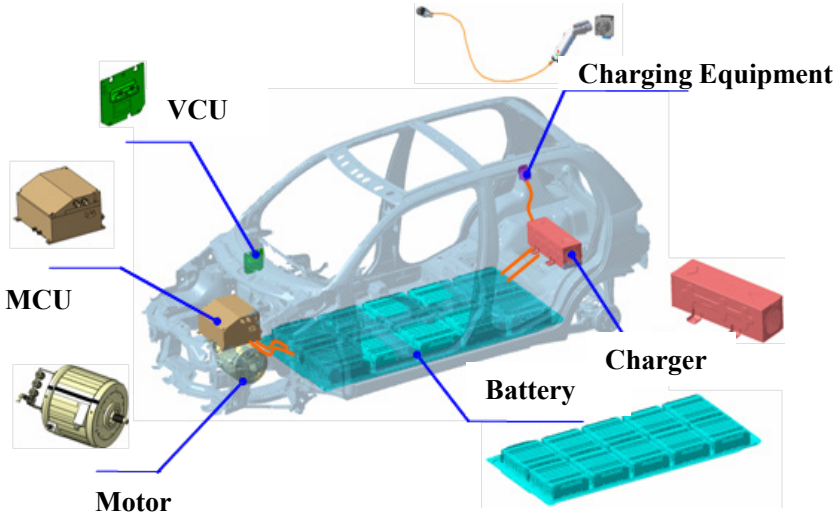
Model	F3DM	F6DM-II
Cell Mass	2.2kg	0.63kg
Energy Density	82.9Wh/kg	101.59Wh/kg
Power Density	409.09 W/kg	952.38W/kg

F6DM –II has battery cooling system, keeping battery performance in the best status even in harsh environments.

Technical Progress of Electric Vehicle
（Passenger Car）

Great progresses have been made in small electric cars.
Series products and models have entered industrial stage.

Maximum speed	＞120km/h
0~50km/h Acceleration time	5.5s
Battery type	LFP Li-ion
Energy	18kWh
Peek power	52kW
Driving range	150km
Normal-charging time	6~8h
Quick-charging time	30min



EV of SAIC motor

EV of Chery

EV of Geely

EV of FHC-Mazda

EV of CHANGAN

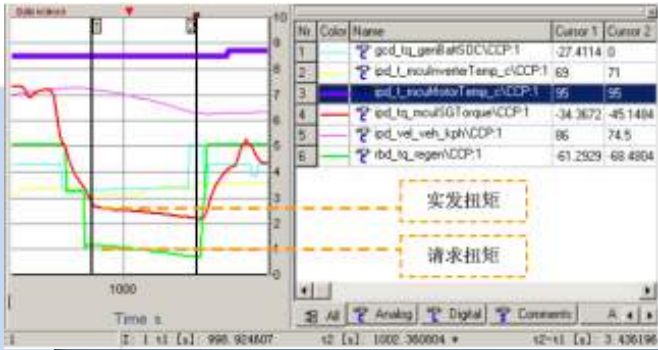
EV of JAC

Technical Progress of Electric Vehicle

（Passenger Car）

Technology progress of the electric vehicle matching and calibration:

Environment adaptive calibration of the vehicle



- ✓Experimental verification of the motor cooling system
- ✓Calibration of the battery cooling system
- ✓SOC balance calibration
- ✓Driving test and calibration
- ✓Restriction calibration of the brake vacuum pressure on power generation torque
- ✓Impact validation of the brake vacuum pressure on the idle stop and restart
- ✓Test of starting overshoot in the high-temperature, high altitude environment
- ✓Air-conditioning performance verification in high temperature
- ✓Experimental verification of the system protection

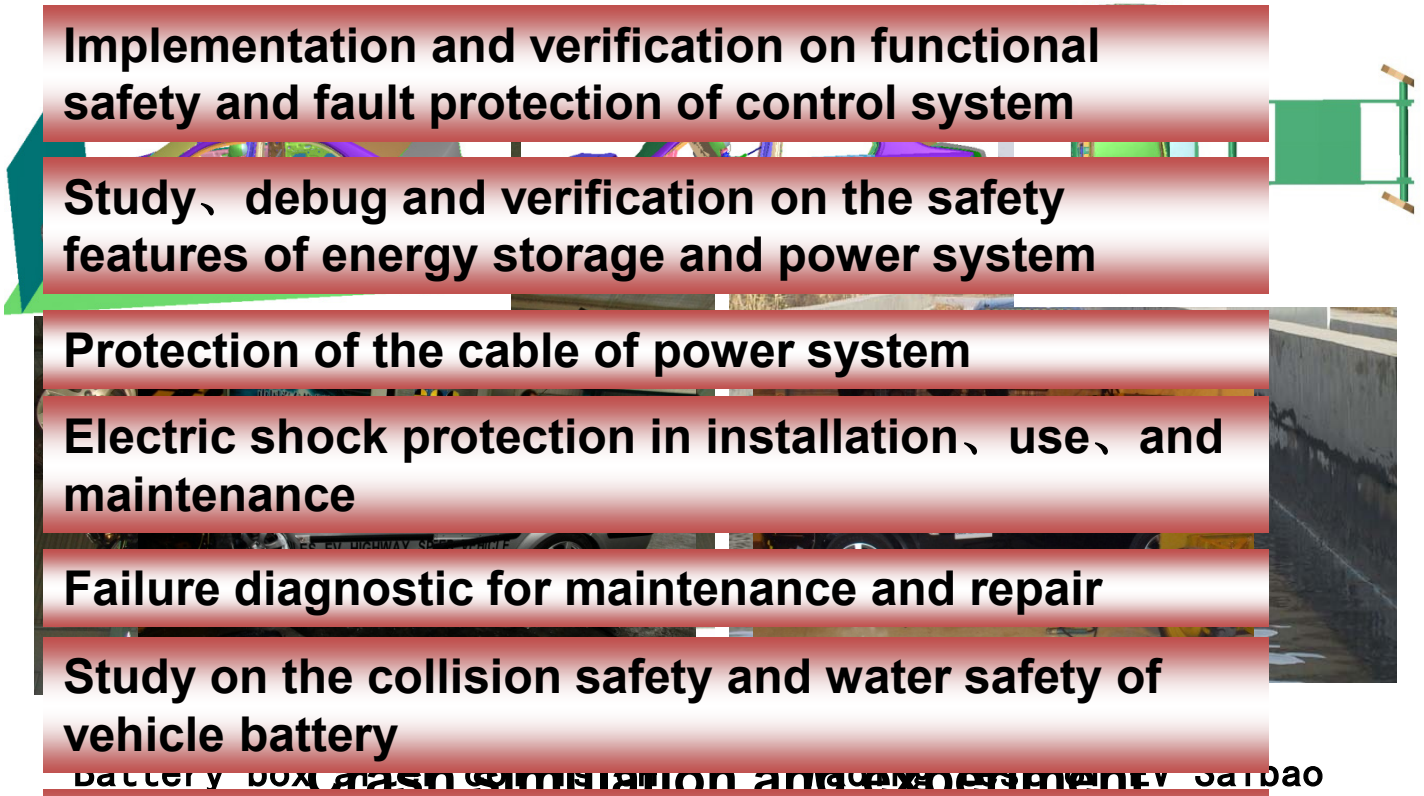
	restarts	1	2	3	4	5	6	7	8	average
High Temperature Test	Site	Turpan								
	n_max (rpm)	1109	1051	1074	1141	1098	/	/	/	1094
	Start Time(s)	1.26	0.92	0.98	0.98	1.05	/	/	/	1.0
	Temper ℃	41.8	36.4	38.2	43.6	43.7	/	/	/	40.7
High Altitude Test	Site	Kunlun Mountain(4767m)			Xidatan(4200m)					/
	n_max (rpm)	1080	943	948	1030	1050	1039	1047	1038	1021
	Start Time(s)	1.87	1.05	0.84	1.19	1.33	1.12	1.26	1.12	1.22

Technical Progress of Electric Vehicle
（Passenger Car）

Safety design technology for electric cars:
Research of safety technology for vehicle and key powertrain assembly

Research of safety technology

- Implementation and verification on functional safety and fault protection of control system
- Study、debug and verification on the safety features of energy storage and power system
- Protection of the cable of power system
- Electric shock protection in installation、use、and maintenance
- Failure diagnostic for maintenance and repair
- Study on the collision safety and water safety of vehicle battery
- Experimental study on collision safety and passenger protection



Technical Progress of Electric Vehicle

（Passenger Car）

Breakthrough in key technology of small-scale electric car， and realize demonstration and extension, the technology of small-scale electric car is keeping improved by demonstration and testing.

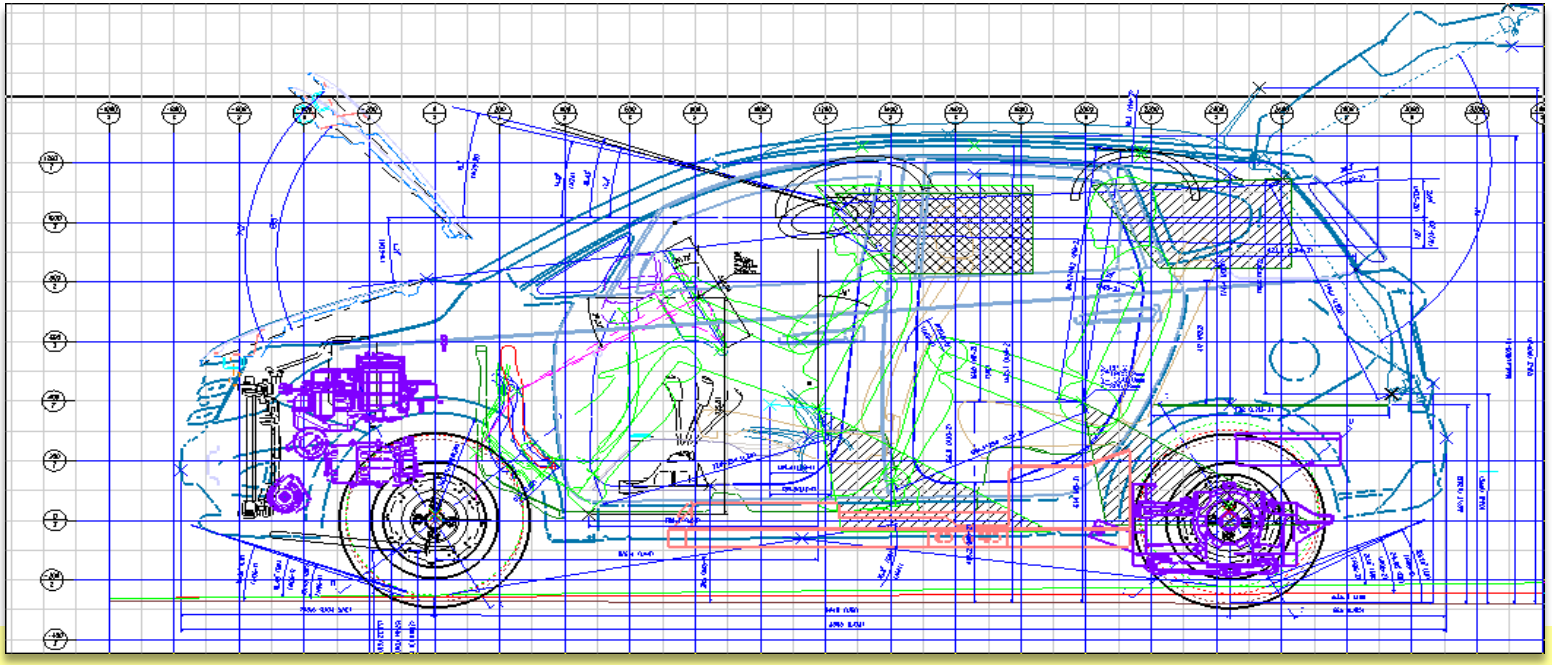
Project		1st 、2nd generation	3rd generation
Parameter	Curb weight（kg）	1240	1240
Dynamics	Maximum speed（km/h）	100	100
	0-50km/h acceleration time（s）	6	6
Economics	Driving range in ECE	100	≥ 130
Battery	Type	$LiFeCOPO_4$	$LiFeCOPO_4$
	Capacity（Ah）	50	60
	Energy（kWh）	15	18
Motor	Type	BLDC or PMSM	PMSM
	Rated/peak power（kW）	11/27 or 18/42	18/42

- Short-distance urban commuting, suburban traveling；
- More than 1500-car demonstration for a single model；
- Totally 10,000,000km driving，maximum 35,000km driving for a single car.

Technical Progress of Electric Vehicle

（Passenger Car）

The progress of the next generation small-scale electric driving platform



- By May 2012, all vehicle companies and platform departments have finished the general arrangement of vehicles, the design of key parts and the matching/simulation of assemblies.
- Most companies have completed the selection of parts.
- Some companies are trial-producing and debugging the first prototypes.

Technical Progress of Electric Vehicle
（Passenger Car）

range-extender technology of small-scale electric car

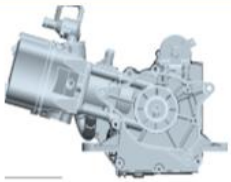
First Generation E-REV		Second Generation E-REV	Advantage
Clam Curve Engine as range-extended	→	Wankel Engine as range-extended	Smaller、quieter、lighter
PMSM、 Li-ion Battery		PMSM、 Li-ion Battery	Platform and Universal
Electric accessory system		Electric accessory system	Platform and Universal

Clam Curve Engine

Wankel Engine

range-extender

1st generation



2nd generation

3rd generation

Technical Progress of Electric Vehicle

（Passenger Car）

Electric air conditioning technology for electric car

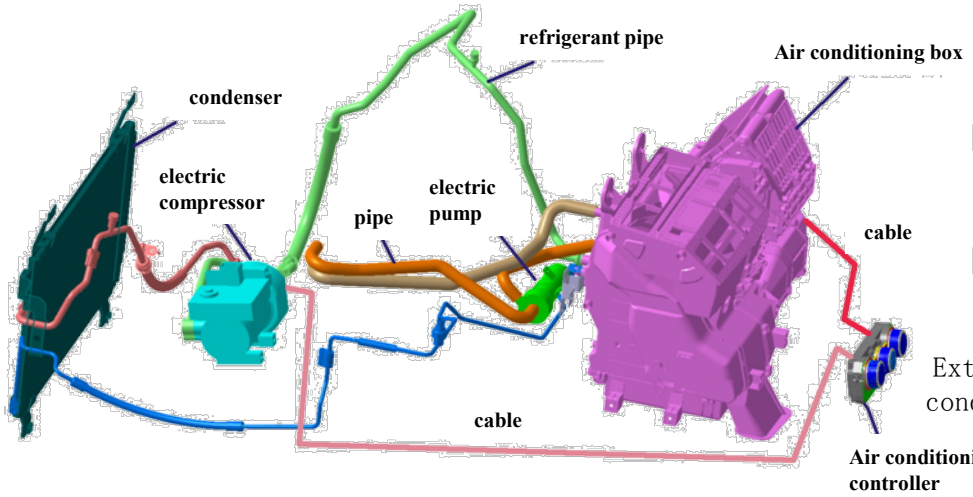
Electric compressors

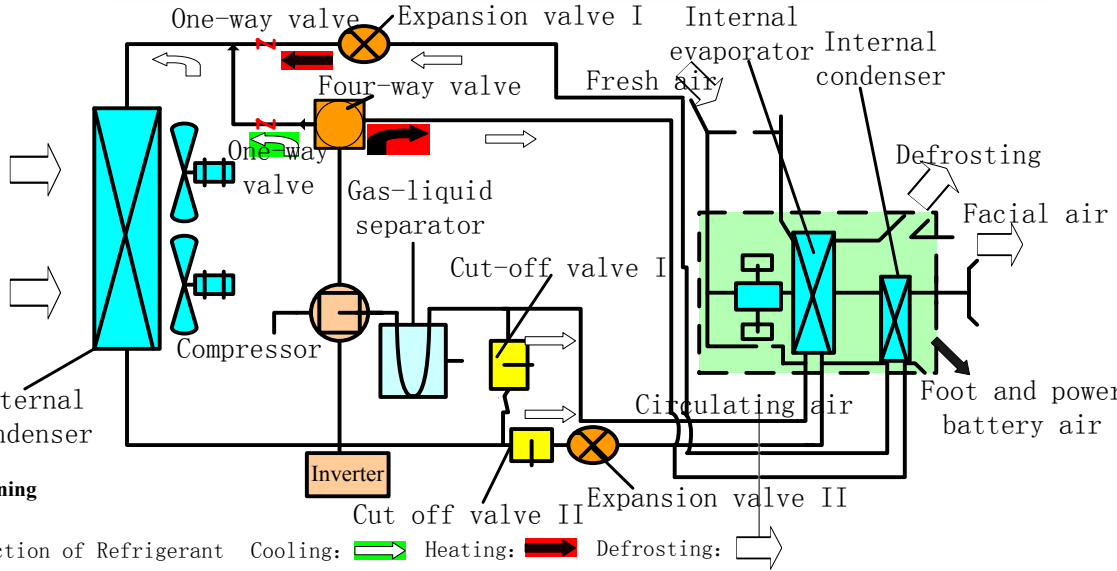
Replace traditional compressors with electric compressors. Adjust compressor speed based on cooling demand, realize the function of inverter air conditioner, and achieve the target of environment protection and comfort.

Heat pump air conditioning

(1) Realize the reversing of refrigerant in different conditions with four-way valve. Heating in winter and refrigerating in summer. There are independent heat exchangers for heating and refrigeration modes.

(2) Energy efficiency ratio more than 2.5。Solve the problem of high energy consumption, low Energy efficiency ratio（0.7～0.8），low security and bad comfort，improve the dynamics and economics.

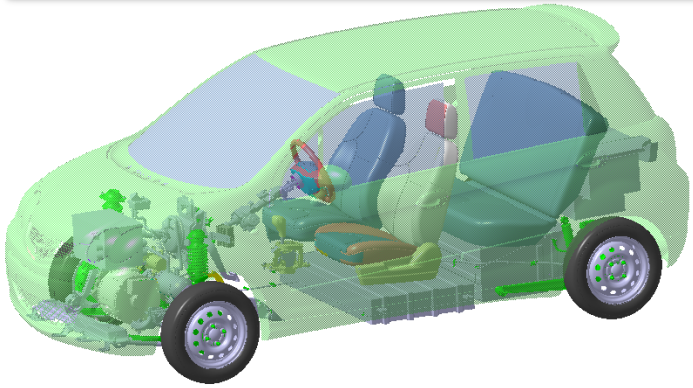


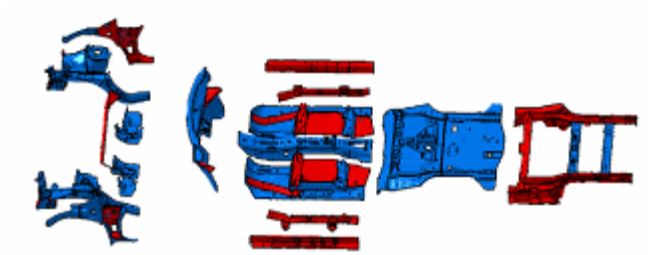


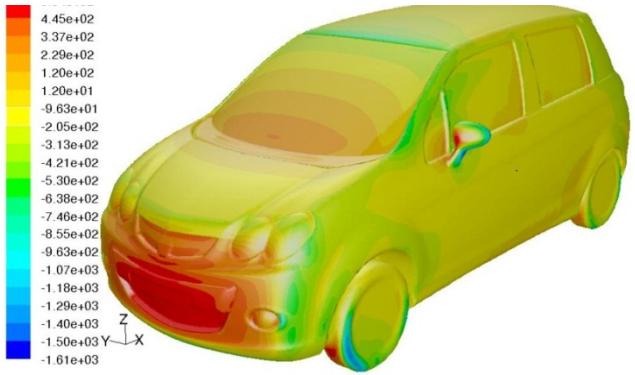
Technical Progress of Electric Vehicle
（Passenger Car）

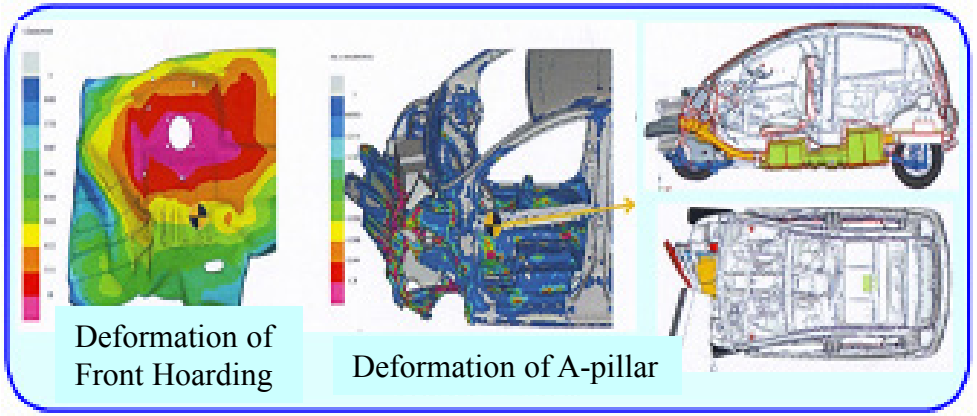
Light-weighting technology of small-scale electric vehicles

- Development of high-strength light material： high-strength Steel plate、 Panels of carbon fiber composites 、 some parts of light material like Aluminum-magnesium alloy
- Production progress of light-weighting： Stringer with splice welding、 B-pillar with hot molding of strengthen plate.







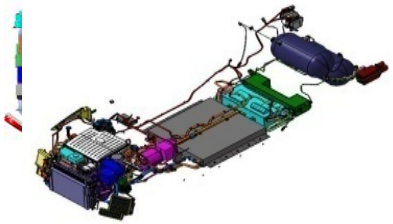


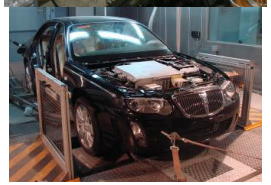
Powertrain platform of Fuel cell vehicle
（Passenger Car）

Development and application of new generation powertrain platform for fuel cell cars

2006 → 2007 → 2008 → 2009 → 2010

Powertrain platform and prototype of New generation fuel cell car





3 prototype models based on new generation powertrain platform

22 fuel cell cars demonstration in 2008 Beijing Olympic Games

Fuel cell cars can obtain road license by Notice and Review.

70 fuel cell cars demonstration in 2010 Shanghai World Expo

5 models obtain new energy vehicle production license, launching World Expo demonstration of 6 months.

Powertrain platform of Fuel cell vehicle

（Passenger Car）

Development and application of new generation powertrain platform for fuel cell cars

2004

“Exceed II” joint Challenge Bibendum

2006

“Exceed III” joint Challenge Bibendum

2007

Three types of new generation fuel cell car joint Challenge Bibendum

2008

Demonstration in Beijing Olympic Games

2009

Demonstration in California, U.S.

2010

Demonstration in Shanghai World Expo

2011

Challenge Bibendum

Powertrain platform of Fuel cell vehicle

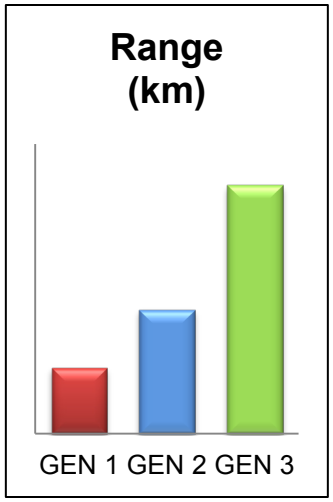
（Passenger Car）

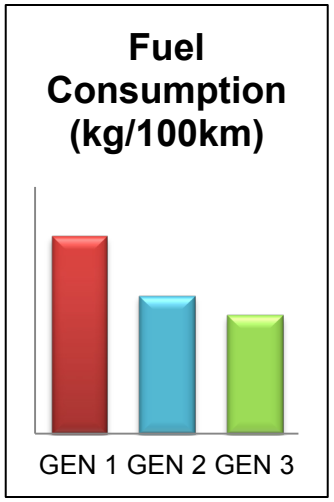
Development and application of new generation powertrain platform for fuel cell cars

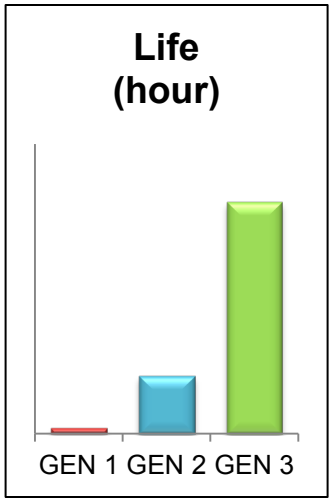
GEN 1

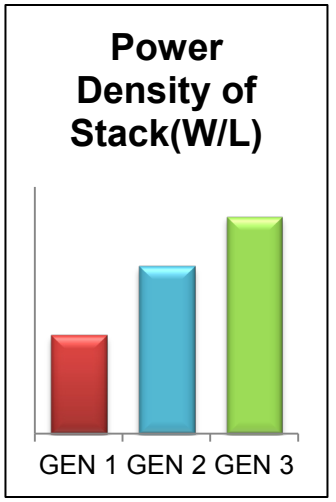
GEN 2

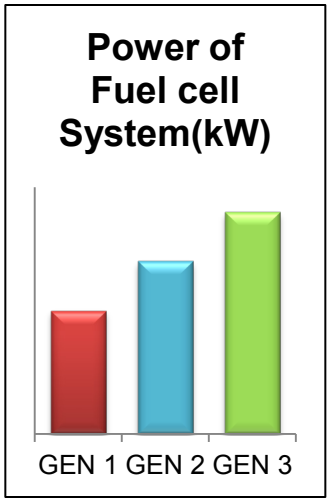
GEN 3











Contents

Technology development of public support platform

The establishment of the testing platform of electric vehicle

We have established testing sites for electric vehicle represented by China Automotive Technology & Research Center and China Automotive Engineering Research Institute, testing sites for performance of power battery pack represented by Beijing 201 institute and Tianjin 18 institute, testing sites for driving motor used in the vehicle represented by Beijing Institute of Technology, testing sites for fuel cell stack & fuel cell engine represented by Tongji University and Tsinghua University, Material detection base represented by Dalian Institute of chemical physics. A lot of senior professionals in testing and experimenting to make sure that the technique of experiment and verification can be improved at the same time.

- testing sites for electric vehicle
- testing sites for power battery pack
- testing sites for vehicle used driving motor
- testing sites for fuel cell engine

Technology development of public support platform

Testing Institutes for power battery (Accredited by Ministry of Industry and Information Technology)

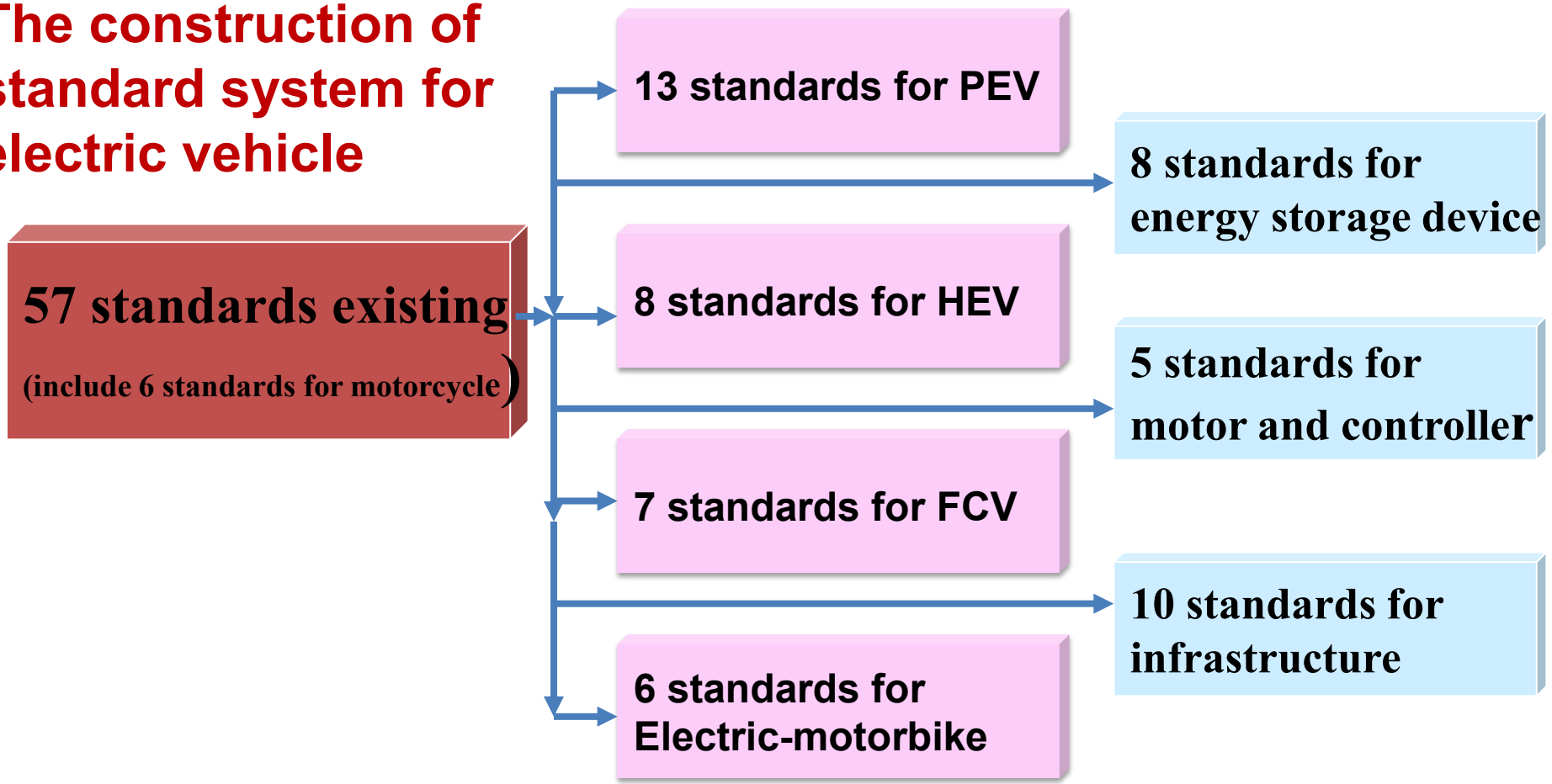
include:

The National Automobile Quality Supervision and Inspection Center (Changchun)
The National Automobile Quality Supervision and Inspection Center (Xiangfan)
China Automotive Technology & Research Center(Tianjin)
China Automotive Engineering Research Institute(Chongqing)
National Quality Control＆Inspection Center for Buses (Chongqing)
National Center Of Supervision And Inspection On Motor Vehicle Products Quality(Shanghai)
Beijing 201 Institute
Tianjin 18 Institute

Independent testing institutes for power battery have been established, which can test and evaluate the integrated performance of the battery.

Technology development of public support platform

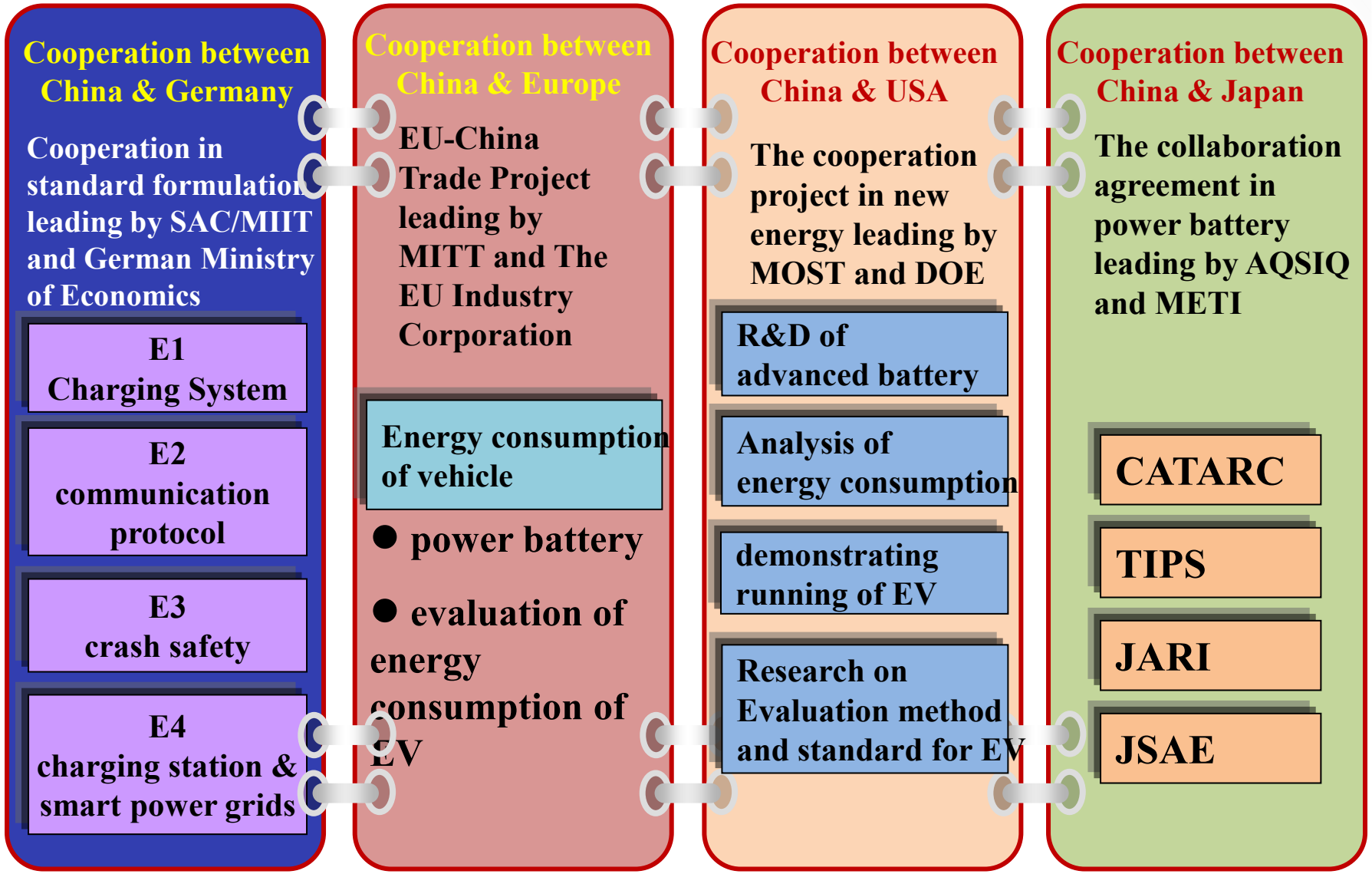
The construction of standard system for electric vehicle



There are 11 standards which have been revised and to be ratified, 14 standards being made or revised, and no standards to be re made. But 45 items of standards are needed in the industry, and the standard system for electric vehicle is the largest in both aspects of coverage and quantity around the world.

Technology development of public support platform

International cooperation of standard formulation



Technology development of public support platform

Take part in formulation of international standards for electric vehicle

① **The proposal of 9 core DC charging interface proposed by China has become one of the 3 DC charging interfaces in IEC62196-3** (the other two are CHAdeMo DC charging interface proposed by Japan and COMBO DC charging interface proposed by USA & Europe.)

② **The proposal of Charging control guidance proposed by China has become one of the 3 DC charging interfaces in IEC62196-23**(the other two are the Joint Proposal proposed by Japan & USA and the Proposal proposed by Europe)

③ **The proposal of communication protocol of DC charging using CAN proposed by China has become one of the 3 communication protocols of DC charging in IEC62196-24** (the other two are the communication protocol of DC charging using CAN proposed by Japan and the communication protocol of DC charging using PLC proposed by USA &Europe)

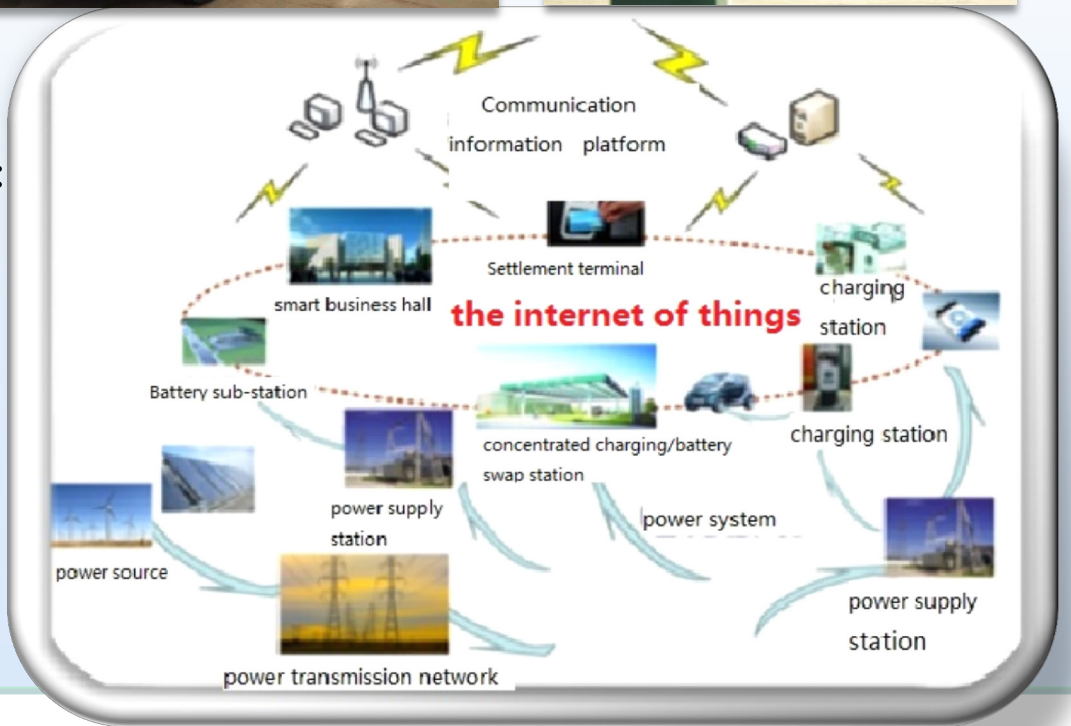
④ **The proposal of the specification & dimension of lithium battery proposed by China has become part of the ISO/IEC PAS 16989** (19 of the 80 specification series of lithium battery are proposed by China, which has laid a good foundation for lithium battery products in China into the world's market.)

Technology development of public support platform

Smart power grid for electric vehicle

China has become the country which has the most equipments for charging/battery swap. 243 standard stations for charging/battery swap and 13283 AC charge spots has been established and put into use by State Grid.

The develop mode for intelligent service network of charging/battery swap : Use the united technology of smart power grid, the Internet of things and the network of communication lines to make the management networked, informatization and automatic, in order to provide the service with the same network, quality and price across the region.

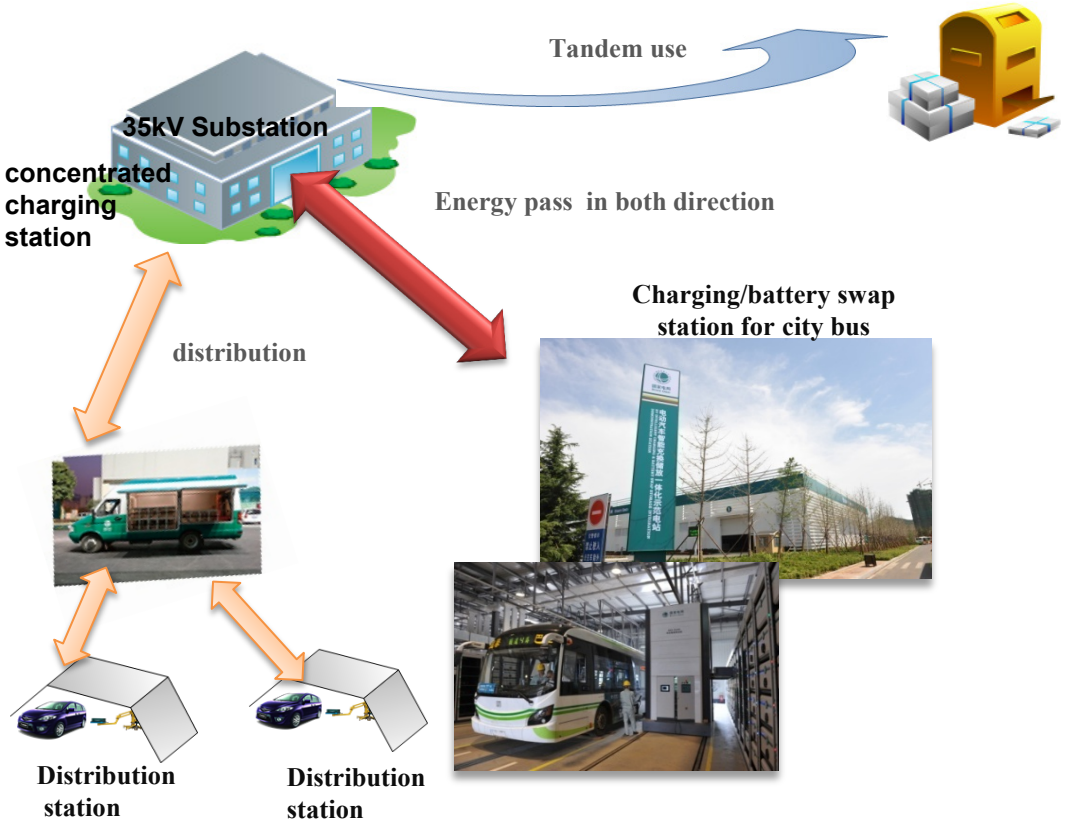


Technology development of public support platform

Power supply technology and construction of network for EV

Charging/battery swap storage integration station in Qingdao

In July 11th,2011, State Grid built a EV charging/battery swap station integrated by battery swap of city bus, battery charging of passenger car and energy storage in Xuejiadao in Qingdao City. The station can provide service of charging and battery swap for at most 280 electric buses, and provide service of charging and battery delivery for electric passenger cars in Huangdao District.



Technology development of public support platform

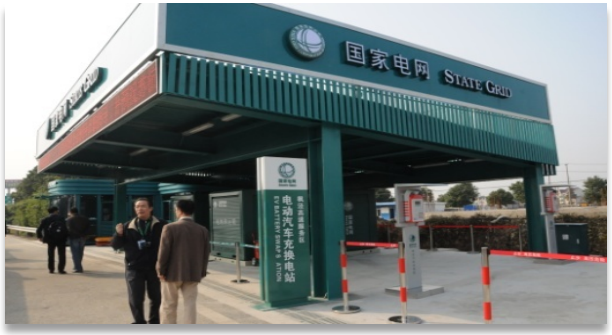
Power supply technology and construction of network for EV

Interconnection project between Suzhou, Shanghai and Hangzhou

- 9 charging/battery swap stations in 5 service areas in 3 high ways are involved in the preliminary stage of the project, and the operational system are built at the same time.
- The service of charging/battery swap between Suzhou, Shanghai and Hangzhou in different provinces.

charging/battery swap station in Baiyanghu Service area

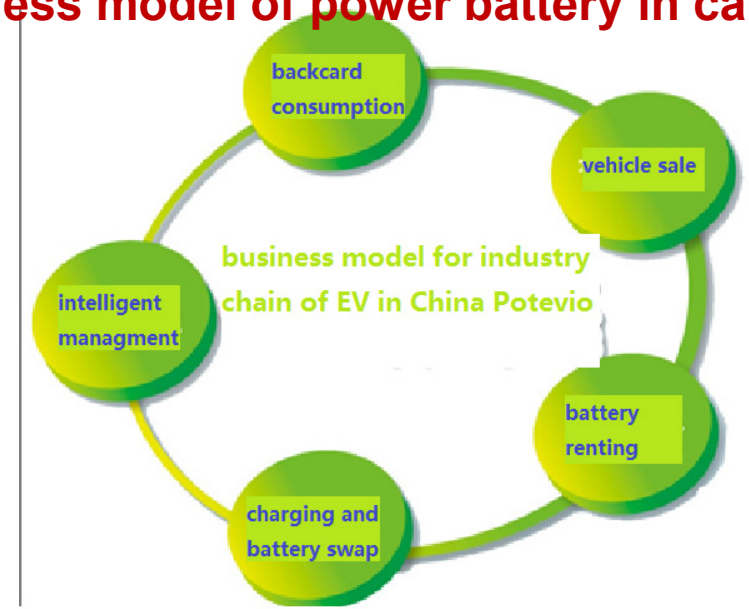
charging/battery swap station in Fengjing Service area

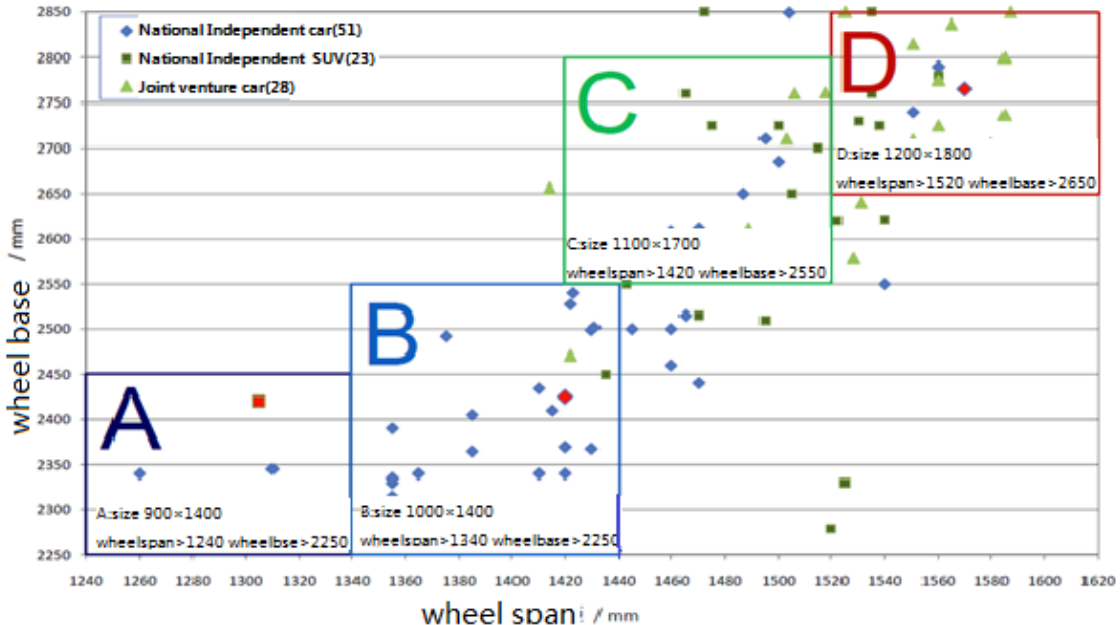


charging/battery swap station in Jiaxing Service area

Technology development of public support platform

The automatic replacement system and a new business model of power battery in car





Technology development of public support platform

➢More than 500 vehicles have been put into operation, and the whole mileage has reached 15 million kilometers.

R&D and Experiment confirm

2006～2007

➢The mileage of 595 energy saving vehicles or new energy vehicles has reached 3.714 million kilometers, and the number of the passengers is more than 4.417millon.

Beijing Olympics

2008

➢1147 new energy vehicles which carried more than 125 million passengers have been operating safely for 29.216 million kilometers.

Shanghai World Expo, Guangzhou Asian Games and Shenzhen Universiade

2009～2012

2011Shenzhen Universiade

➢6 million people carried by 2011 electric vehicles.

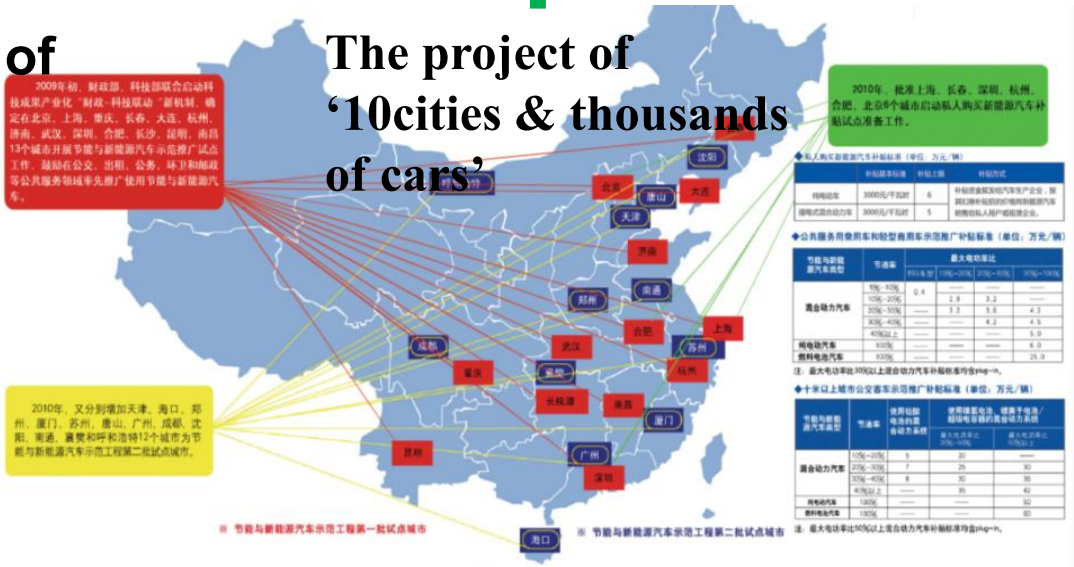
➢58 charging/hydrogen stations and more personal charge spots

◆In 2011, more than 10 thousands of vehicles have been put into demonstration operation.

◆In 2010, 4402 vehicles have been put into demonstration operation.

◆In 2009, 2566 vehicles have been put into demonstration operation.

The project of ‘10cities & thousands of cars’



Technology development of public support platform

The technology of HEV and PEV is progressing, forming the industry scale of Independent intellectual property

In recent years, thousands of energy saving vehicles and new energy vehicles have been put into demonstration operation and product technology assessment, promoting the R&D in the industry, enhancing the ability of innovation. The technical level of vehicle and power battery has progressed a lot compared with the level before demonstration.

Fuel consumption and pollution comparison between private cars, taxis, and buses

- Taxi:300-400km/day 30-40L/day
- Private car:40-50km/day 3-4L/day
- bus:220-280km/day 90-120L/day

1 taxi ≈10 private cars

1 bus ≈30 private cars

The number of EV/HEV Bus till the end of 2011

HEV	9418
EV	1537
total	10955

◆The technology of medium and deep hybrid with independent intellectual property rights used in hybrid electric city bus has formed. For example, a certain kind of HEV, whose fuel saving rate has reached 30% in typical urban conditions in China ,and 15% in actual driving route in Zhuzhou, has been widely accepted by bus companies there.

◆The technology of pure electric city bus is progressing. The power consumption of a certain kind of PEV is 0.84kWh/km at the condition of constant driving (with air-conditioner closed)in Beijing, 1.25kWh/km around the year(with air-conditioner open in summer & winter), and is decreased by 25% compared with that in 2009.

Technology development of public support platform

Electric passenger vehicles begin to take shape, power consumption is obviously decreasing, some of which has reached 15kWh/100km

500 private E150EV in Beijing

300 BYD E6 electric taxis in Shenzhen

280 ZOTYE-HAIMA private cars and taxis with mode of charging or battery swap

1585 JAC-Tongyue private PEVs in Hefei

Vehicle quantity	585 Tongyue PEVs of the first generation	1000 Tongyue PEVs of the second generation
consumers	Consumers of designated terminal, include controlled customers such as JAC, HFUT, bus company, Power Supply Corporation	Consumers of designated terminal, customers in Hefei who has cooperation with the company
running	21 months till now	9 months till now

◆Loading battery of 15.2kwh; maximum speed is 100km/h ;
◆Driving range is 100km in Hefei actual condition, consuming 15kWh of electricity

◆Most of the customers use the EV for daily commute or for business. charging is usually finished at home or workplace(slow charge).

◆Driving distance<50km/day:73.1% ;
◆50km/day<Driving distance<80km/day:22.5%
◆Driving distance>80km:4.39% ;

Technology development of public support platform

19159 EVs have been put into demonstration operation until the end of 2011 in China, and are widely welcomed as green transport.

Public service	Hybrid electric city bus	9148
	Hybrid electric passenger cars	3492
	pure electric city bus（include FCV and Plug-in）	1537
	pure electric special vehicle and official vehicle（include FCV and Plug-in）	2657
	subtotal	16834
Personal consumption	pure electric and plug-in electric passenger cars	2325
total		19159

Contents

Development&chanllange

The R&D of EV in China hasn't started late or developed slowly, but there is still distance compared with developed countries reflected in unstable foundation and imperfect system, so that the pressure of competition at high-level technology is becoming larger. It's important to make a change of the automotive industry from investment-driven to innovation-driven, or there will be a flow of importing of new technology.

FCV

- The technology of basic material of fuel cell is far behind that in developed countries, reflecting in the life of the battery.
- There is a big distance of the integration technology in engineering of FCV between China and other advanced countries

PEV

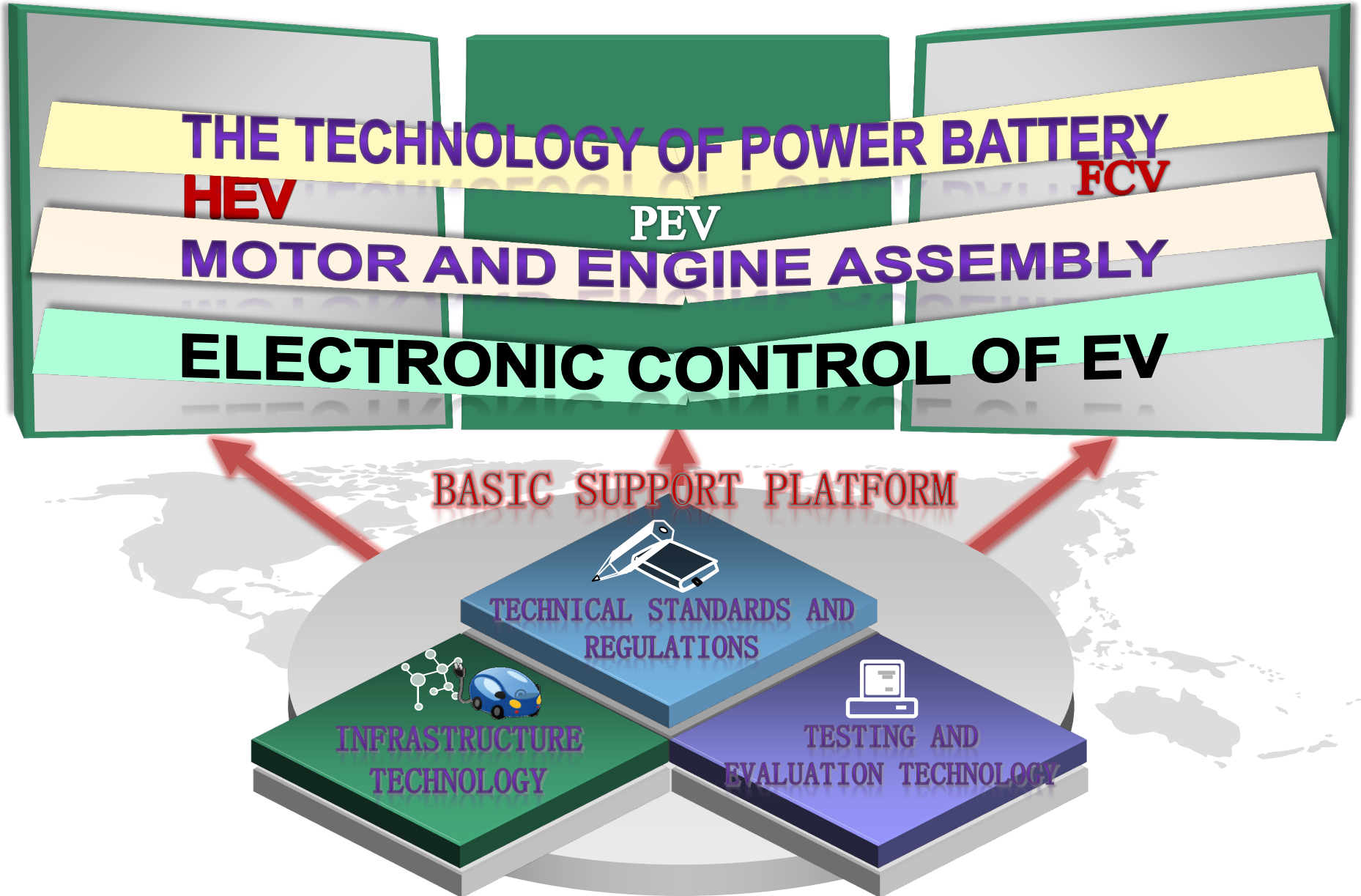
- The technology of the system of group of battery and thermal management is far behind advanced products in the world.
- Key chips of motor controller and the technology of encapsulation are mostly depending on import
- Reliability and the ability of engineering of high-performance PEV is far behind

HEV

- The foundation of the technology of engine and AT falls behind, and dedicated technology for HEV such as electromechanical coupling system are developed slowly.
- The technology of deep Hybrid electric vehicle hasn't been known well.

The self-dependent innovation of EV of the 12th 5-year plan is the important period for the development of the automotive industry in China.

The strategic mission during the 12th Five-Year Plan : 3 platforms at vertical and horizontal directions



The main technical specifications for industrialization of HEV

technical indexes			Passenger vehicle	commercial vehicle
Power battery	NI-MH battery	Energy density	monomer≥43Wh/kg system≥30Wh/kg	monomer≥50Wh/kg system≥40Wh/kg
		Power density	monomer≥1280W/kg system≥900W/kg	monomer≥870W/kg system≥700W/kg
		lifetime	200,000km/10years	200,000km/8years
		Target cost	≤￥3/Wh	
	High-power Li-ion battery	Energy density	≥70Wh/kg / ≥50 Wh/kg	
		Power density	≥2280W/kg / ≥1600 W/kg	
		lifetime	200,000km/10 years	
		Target cost	≤￥3/Wh	
	Super capacitor	Power density	≥4000 W/kg	
		Energy density	≥5Wh/kg	
		cycle life	≥50000 times	
		System cost	≤￥60/Wh	
Motor		cost	￥200/kW	￥300/kW
		Power density	>2.7 kW/kg	
		Torque density	>55Nm/L	
		Highest efficiency	>94%	
		lifetime	≥300,000km	
Electronic control			● Key technology of electronic control for engines of HEV which have satisfied State IV&V emission regulations. ● The development of controller of high performance with 16bits/32bits facing the demand of powertrain technology using many kinds of energy.	
Vehicle platform		fuel saving rate	≥25%(medium hybrid) ≥40%（deep hybrid）	≥40%
		Additional cost	≤￥15000	≤￥150000

The main technical specifications for industrialization of EV

technical indexes		PEV				Plug-in	
		Small pure electric passenger vehicle			Commercial vehicle for public service	Passenger vehicle	Commercial vehicle
		New structural design	promotion	EREV			
Power battery	Energy density	monomer≥150Wh/kg module≥120Wh/kg				monomer≥120Wh/kg system≥100Wh/kg	
	Cycle life	≥2000 times（100%DOD）				3000 times	
	lifetime	≥10years				200,000km/10years	
	Target cost	module≤￥1.5/Wh				system≤￥2/Wh	
Motor	cost	￥200/kW			￥300/kW	￥200/kW	￥300/kW
	Power density	≥2.7kW/kg					
	Torque density	≥55Nm/L					
	Peak efficiency	≥94%					
	lifetime	≥300,000km					
Electronic control		● Control system of electric assembly of PEV ● Advanced distributed control system for PEV ● vehicle-mounted information, intelligent charging and remote control system of PEV					
Vehicle platform	Maximum speed	≥75km/h (micro) ≥100km/h(≤980kg) ≥100km/h(≤1100kg)	≥100km/h	≥75km/h≤1100kg） ≥100km/h(≤1300kg)	≥80-110 km/h	The same as traditional vehicle	The same as traditional vehicle
	pure electric driving range	≥100km	≥100km	≥100km	≥160-≥200km	≥30km	≥50km
	Additional cost	the same as fuel vehicle or basic model(energy system not included)				≤50,000	≤200,000
Support platform	infrastructure	More than 400,000 AC charge spots and 2000 concentrated charging/battery swap station					
	Demonstration scale	200,000-300,000			100,000	≥10,000	
	Demonstration city	≥25					

The main technical specifications for next generation EV

technical indexes			Next generation of platform for the system of PEV		The platform for the system of FCV	
			Passenger car	Commercial car	saloon car	Passenger car
Power battery	Energy density of battery cell of energy type	New type	250Wh/kg			
		New system	400Wh/kg			
	Power density of battery cell of power type		5000W/kg			
fuel cell	Power density of fuel cell stack		———		1000W/kg(L)(facing demonstration evaluation) 1500W/kg(L)(facing the technical breakthrough)	
	Power density of the system				300W/kg(facing demonstration evaluation) 450W/kg(facing the technical breakthrough)	
	Storage and start at low temperature				-10℃(facing demonstration evaluation) -20℃(facing the technical breakthrough)	
	lifetime				≥5000h	
motor	Power density		3.0kW/kg			
	Torque density		75Nm/L			
	Peak efficiency		95%			
	Next generation of motor technology: new technology of new type of motor assembly such as Electric wheel hub, polyphase motor, EVT, hybrid excitation motor, Axial magnetic circuit motor, Advocate complementary traction motor					
Electronic control			• Control technology for Chassis dynamic of integrative driver of new type of motor • Key technology of EV control system of the next generation • The ITS of PEV and the technology of V2G/V2H			
Vehicle platform	Maximum speed		≥180km/h	≥80km/h	≥160km/h	≥80km/h
	pure electric driving range		≥250km	≥200km	≥350km	≥350km
	Energy consumption		≤140Wh/km	≤0.05kWh/km.t	≤1.0kg/100km	≤8.0kg/100km

The union of *3 vertical directions and 3 chains* technical innovation has been implemented

The union of technical innovation of the EV industry has been built, in order to make a breakthrough on the key technology of EV.

EV technology and industry alliance

- EV union of central enterprises
- union of the Top10 New energy vehicles
- The union for improving the industry technical innovation of EV
- The union of fuel cell vehicle
- The union of EV between China and Germany
- The union of clean energy vehicle between China and USA
- ……

Development strategy and forecast

The strategy of the development of the vehicle on both ends

The development pattern of *both ends*, which can activate the market of scale.

Electric city bus of large and medium size

Energy saving vehicle

HEV

Electric Intermediate car or Limousine car

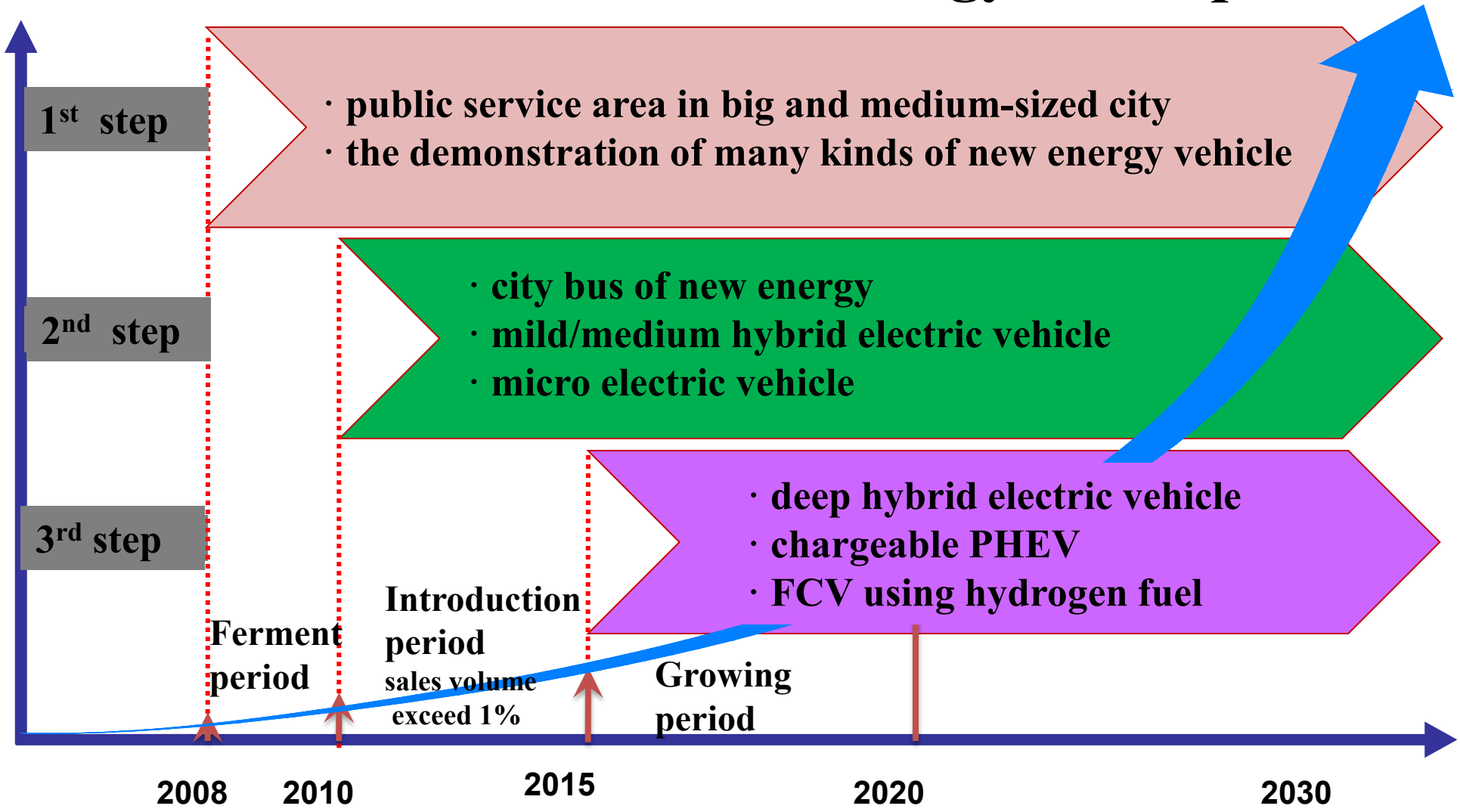
Micro EV

Rolling development of different kinds of vehicle make it possible to have the access to the market of Intermediate car or Limousine car

Break through on both ends and rush out in the middle

Development strategy and forecast

The industrialization strategy of *3 steps*




ACME ELECTRONICS
THANKS !