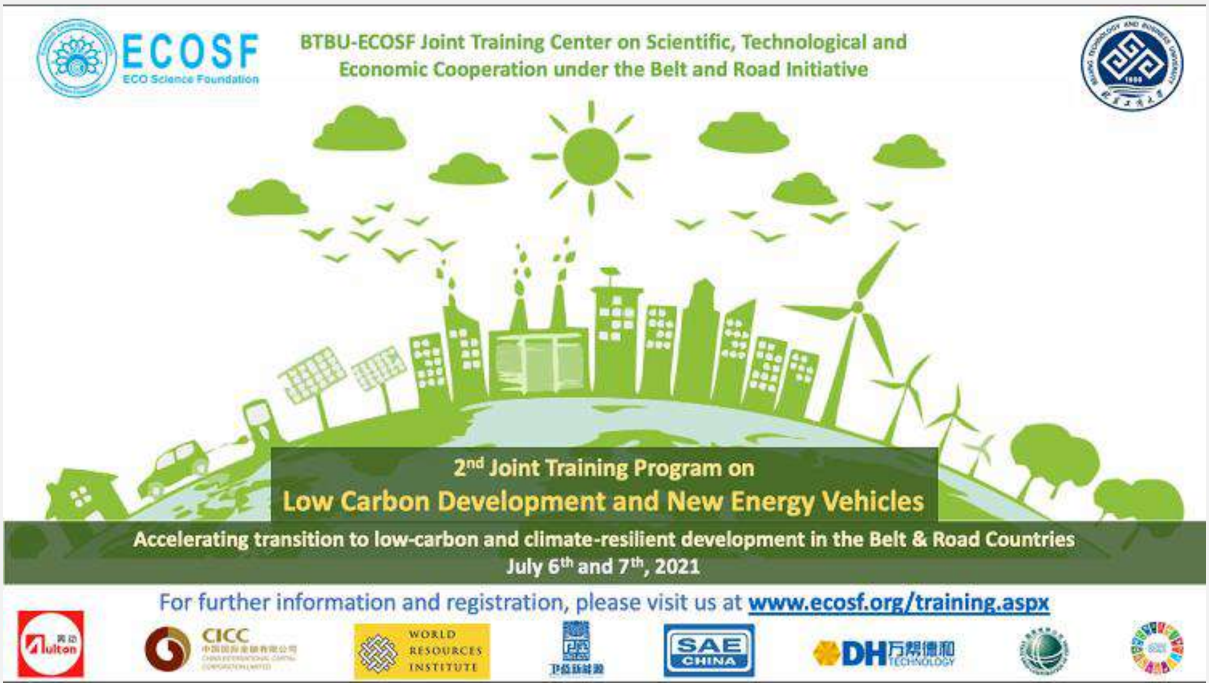
BTBU-ECOSF Joint Training Center on Scientific, Technological and Economic Cooperation under Belt and Road Initiative (BRI)

2nd Training Program

Low Carbon Development and New Energy Vehicles

Accelerating transition to low-carbon and climate-resilient development in the Belt & Road Countries



北京工商大学——经济合作组织会科学基金会

“一带一路”科技与经济合作联合培训中心

中国科协“一带一路”国际科技组织合作平台建设项目

China Association for Science and Technology (CAST) Program of International Collaboration Platform for Science and Technology Organizations in Belt and Road Countries

July 6th and 7th, 2021

ABOUT: BTBU-ECOSF Joint Training Center on Scientific, Technological and Economic Cooperation under Belt and Road Initiative (BRI)

The Belt and Road Initiative (BRI) is a massive global initiative aimed at connecting international trading partners in the east and the west. The BRI offers a tremendous potential to spur a new era of trade, economic and industrial growth for the countries in the Asia and beyond. In order to maximize the benefits of BRI, the participating countries require to develop adequate technological workforce and engage in an alliance for promotion of cross-border cooperation in the Science, Technology and Innovation (STI) sectors.

Appreciating the need for skill development and capacity building in key economic sectors, the Beijing Technology and Business University (BTBU) and Economic Cooperation Organization - Science Foundation (ECOSF) launched a **BTBU-ECOSF Joint Training Center on Scientific, Technological and Economic Cooperation under Belt and Road Initiative** in September 2020. The Center has won the financial support of China Association for Science and Technology (CAST) Program of International Collaboration Platform for Science and Technology Organizations in Belt and Road Countries.

BTBU is renowned as a one of the leading high-level research universities in Beijing. Having long been committed to promoting substantive exchanges and exchanges with overseas first-class universities and academic institutions, BTBU has achieved meaningful results in international exchanges and cooperation, personnel training, academic research, etc.

ECOSF is the specialized agency of the Economic Cooperation Organization (ECO) an intergovernmental organization for scientific and technological cooperation, with its 10-member states (Afghanistan, Azerbaijan, Iran, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkey, Turkmenistan, Uzbekistan). ECOSF has an extensive exchange and cooperation network with international scientific and technological organizations in Africa, Asia, Europe and other regions, as well as other international organizations.

BTBU-ECOSF Joint Training Center aims to promote the sustainable economic and social development of BRI countries through training in the fields of technology application, industrial economics, S&T standards and science communication. The Center would serve as a strategic training platform, which is deemed to be critical for infrastructure development and socio-economic growth for B&R countries, including Pakistan.

The Joint Training Center organized its 1^{st} training program on **Development and Management of Economic Zones** in December 2020. While this report contains the proceedings of the 2^{nd} training program on **Low Carbon Development and New Energy Vehicles,** which was held on July 6^{th} and 7^{th}, 2021.

2nd Joint Training Program

Low Carbon Development and New Energy Vehicles

Accelerating transition to low-carbon and climate-resilient development in the Belt & Road Countries

BTBU-ECOSF Joint Training Center with support of China Association for Science and Technology (CAST) organized the 2nd joint Training Program on Low Carbon Development and New Energy Vehicles on July 6th and 7th, 2021. This training was hybrid event where participants in Beijing joined the workshop at onsite at BTBU campus, while rest of the participants joined virtually through Zoom. The training attracted participation of over 200 participants from about 20 countries, particularly from the ECO Member Countries. This training workshop was moderated by Dr. Di Yuna, head of the BTBU-ECOSF Joint Training Center and Engr. Khalil Raza Scientific Officer – ECOSF.

Prof. Dr. Zheng Wenhong, Vice President, Beijing Technological and Business University (BTBU) opened the training program. Prof. Wenhong in his message highlighted that Chinese government has incorporated the “Dual Carbon Target” into the outline of China’s 14th five-year Plan this year. China is actively acting in various fields and has been actively working with other countries in the world to address the challenges of climate change. He further shared that China adheres to the principle of “joint consultation, co-building and sharing”, adheres to the concept of “openness, green and integrity”, and cooperates with relevant countries to promote the construction of a green Belt and Road Initiative (BRI).

At the same time, countries around the world are also facing the crisis and challenges brought about by climate change, actively promote low-carbon development, and hope to learn from China's development experience in related fields. Prof. Wenhong was confident that this program could promote exchanges and cooperation among countries, facilitate the building of a community with a shared future for mankind, and achieve global sustainable development.

Prof. Dr. Manzoor Hussain Soomro, President ECOSF in his welcome remarks emphasized that Science, Engineering, Technology and Innovation (SETI) play a critical role in providing policy instruments that are essential to develop strong base of countries in addressing the climate change impacts and boosting socio-economic growth and sustainable development. Prof. Soomro underscored that BRI of China commits to foster the industrial development with strong technical cooperation in many fields, including sustainable energy, infrastructure development, emerging technologies, and smart cities or transport etc. To achieve these massive goals, it requires a robust commitment to support science and engineering, including the capacity building and human resource development, Prof. Soomro remarked.

Prof. Soomro further elucidated that BRI offers a tremendous potential to spur a new era of trade, economic and industrial growth for countries in Asia and beyond. In order to maximize the benefits of BRI, the participating countries require to develop adequate technological workforce and engage in an alliance for promotion of cross-border cooperation in the Science, Technology and Innovation (STI) sectors." Prof. Soomro highlighted.

The training workshop addressed three focused areas of low carbon development

(a) Renewable and clean energy development
(b) Smart and resilient power transmission and distribution grid infrastructure and
(c) Latest electric mobility practices in the emerging markets, including China

Renowned experts and market leaders in low carbon development technologies participated as resource persons. The intended outcome of this training was to support policy development facilitating south-south cooperation, creating relevant knowledge and building capacities in the BRI countries.

Since climate change and its adverse effects are the serious threat to human civilization and one of the greatest global challenges of the 21st century, therefore it needs to be addressed through international cooperation in the context of sustainable development. Several countries have pledged to reach net-zero emissions by mid-century.

China has emerged as global climate leader with its announcement in 2020 that it would aim to achieve "carbon neutrality" before 2060. In so doing it joins the European Union, the UK and dozens of other countries in adopting mid-century climate targets, as called for by the Paris agreement.

China already leads the world in the clean technologies, and it is by far the largest investor, producer and consumer of renewable energy. One out of every three solar panels and wind turbines in the world are in China. It is also home to nearly half the world's electric passenger vehicles, 98% of its electric buses and 99% of its electric two-wheelers.[1] The country leads in the production of batteries to power electric vehicles and store renewable energy on power grids. By 2025, its battery facilities will be almost double the capacity of the rest of the world combined.

Hence, it was important to understand and share best practices and experiences amongst the countries towards promoting low carbon development initiatives. This training workshop provided an opportunity for transdisciplinary approach to facilitate knowledge exchange and dissemination to support policies and programmes through collaborative research and engagement. Hence, it is imperative for China to bring its extensive expertise and best practices in renewables and energy efficiency to Belt and Road Initiative (BRI) countries.

Experts underlined that promoting low-carbon development in BRI countries would require collaborative efforts from both within China—by leveraging finance and overseas investments in green projects—and participating countries—by promoting

[1] Barbara Finamore, What China's plan for net-zero emissions by 2060 means for the climate, the Guardian (2020) https://www.theguardian.com/commentisfree/2020/oct/05/china-plan-net-zero-emissions-2060-clean-technology

stronger clean energy and environmental policies that provide favorable market environments for China and other countries to make green investments in clean energy and sustainable transportation infrastructure.[2]

Resource Persons for the Training on Low Carbon Development

Zhang Xuming,
Deputy Secretary General, Society of Automotive Engineers (SAE) -China

Xiang Jin,
Deputy General Manager, Beijing WeiLion New Energy Technology CO., LTD

Zheng Junyi,
Vice President - Wanbang New Energy Investment Group CO., LTD.,
Expert of the National Standard Committee on Electric Vehicle Charging Facilities in the Energy Industry

Li Yanze,
General Manager, Global Business, INFRAMOBILITY-Dianba GmbH, JV of Aulton NEV Technology Corporation Limited

Xiong Wanpeng,
Chief Executive Officer, China Overseas Holding Group

Qin Yuyi,
Deputy Generald Manager, State Grid Sichuan Integrated Energy Service, CO., LTD.

Liu Wei,
Deputy General Manager & Chief Technology Officer -
State Grid Oman Company, State Grid International Development CO., LTD.

Liu Daizong
Program Director/ Communication
World Resources Institute (WRI) China Sustainable Cities, WRI China.

Zeng Tao
Chief Analyst in New energy, Executive General Manager, Research Department,
China International Capital Corporation Limited (CICC).

Note: The presentations made by the experts are annexed at the end of this report.

[2] Fuqiang Yang, China Has Every Reason to Promote a Green and Low-Carbon BRI, NRDC (2018), https://www.nrdc.org/experts/fuqiang-yang/china-has-every-reason-promote-green-and-low-carbon-bri

Key takeaways of the workshop

Policy and regulatory support are the key to scale up the electric mobility

- The role of policy makers is central to the evolution of electric vehicles. China has taken a massive lead over the rest of the world in EV adoption, with strong backing from its New Electric Vehicle Policy.
- China's vigorous promotion of new energy vehicle is an important measure for the low-carbon development of the automotive industry.
- Policy makers around the world are trying to support the electric mobility with the primary objective of combating climate change. The policies are largely focused on financial support to make EV economics favorable for adoption by customers.
- EVs are being encouraged with favourable policies like capital expenditure assistance, tax and permit exemptions, protection for domestic manufacturers.
- Lack of economic parity is a major hurdle in adoption of EVs today. Policy makers are trying to bridge this gap through subsidies to encourage EV adoption. Policy makers need to simultaneously adopt other levers also to encourage EV adoption further.
- China's New Energy Vehicle policy has taken several positive steps and aggressively pushing and promoting EV adoption, and NEV policy is a significant leap among those.
- Mandated adoption targets, localization of key components, clear guidelines on regulations and standards and EV adoption in public transport are some of the key levers that policy makers in developing countries need to leverage.

China has established a robust manufacturing base for New Energy Vehicles

- China is both the largest manufacturer and buyer of electric vehicles in the world, accounting for more than half of all electric cars made and sold in the world in 2020.
- From 2011 to 2015, China began to promote new energy urban buses, hybrid cars and small electric vehicles.
- From 2016 to 2020, further popularization was carried out for new energy vehicles, multi-energy hybrid vehicles, plug-in electric cars, hydrogen fuel-cell cars, etc.
- In 2021, new industry players in cross-industry cooperation in car making have emerged one after another, and pure electric vehicles have gradually become the mainstream.
- Among the three core technologies of electric vehicles, namely battery, motor and electronic control, the most disputed difficulty which is also most difficult to break through lies on battery safety, battery cost and battery driving range.
- On supply side, China continues to improve and produce technology, provide high-quality green building materials, reduce material consumption from the source, and reduce carbon emissions.
- The rise of electric vehicles has caused upheaval in the Lithium-ion battery industry. As of 2020, the global Li-ion battery manufacturing capacity was about 500 GWh per annum. A large part of this capacity is currently concentrated in China.
- China currently dominates the world in production of all four major components of Lithium-ion Batteries (LIB): Cathode, Anode, Electrolyte, and Separators. After 2015, the market share of all four major components has continued to increase, and the supply share of Chinese LIB material in each component category has exceeded 60% in 2020.

Grid Expansion and Charging Infrastructure placement is critical to uptake of electric vehicles

- Charging infrastructure is the key enabler towards accelerated adoption of electric vehicles.
- The EV adoption and charging infrastructure is fundamentally a chicken and egg problem. On one hand, without good infrastructure, owning and operating an EV is not convenient for users, hence, they would want to wait till such infrastructure is available. On the other hand, low adoption of EVs drastically impacts the economic viability of any public charging infrastructure project.
- This requires robust policy support from the government to put up charging infrastructure. China has put up massive charging infrastructure that is denser than all major (EV adopted) countries.
- There is need for integrated development of grid, load and storage. Power load, transmission, and distribution network would have to planned synchronously to meet charging infrastructure needs.
- Currently, the driving range of electric vehicles has not reached the same level as that of gasoline and diesel vehicles, which is also the core problem hindering the rapid development of new energy vehicle industry. With shorter range of current battery technologies require more charging infrastructure to be put in place to reduce the range anxiety. In future, the large capacity batteries can eliminate the pain point of low driving range.

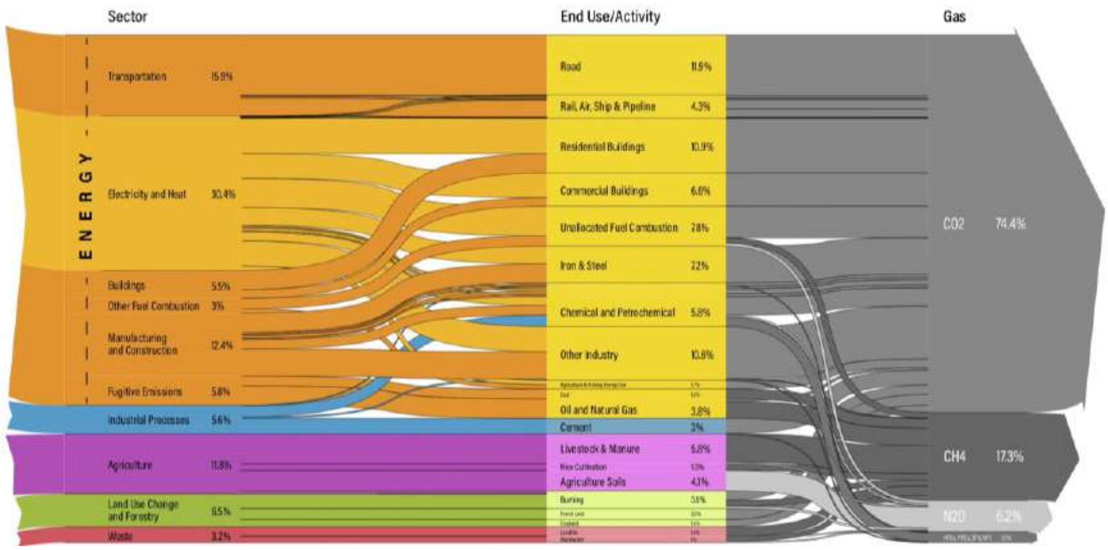
Conclusion

The "Chinese experience in new energy vehicles and low carbon development" can certainly help the energy and transport industry in the ECO Member Countries to develop towards integration, to strengthen the connectivity between upstream and downstream, and to drive the development of infrastructure development and related industries during project implementation. The strategic proximity of ECO Member Countries with China and with emerging initiatives such as ongoing development of Special Economic Zones in Pakistan, Iran and Kazakhstan provide tremendous opportunities for the Member Countries and China to develop manufacturing base for electric vehicles.

Presentations by the Resource Persons **ANNEX**

CLIMATEWATCH

能源部门仍是GHG排放的最大贡献者，占2016年全球排放量的73％



Source: Climate Watch Key Visualizations Last updated: May 10, 2021

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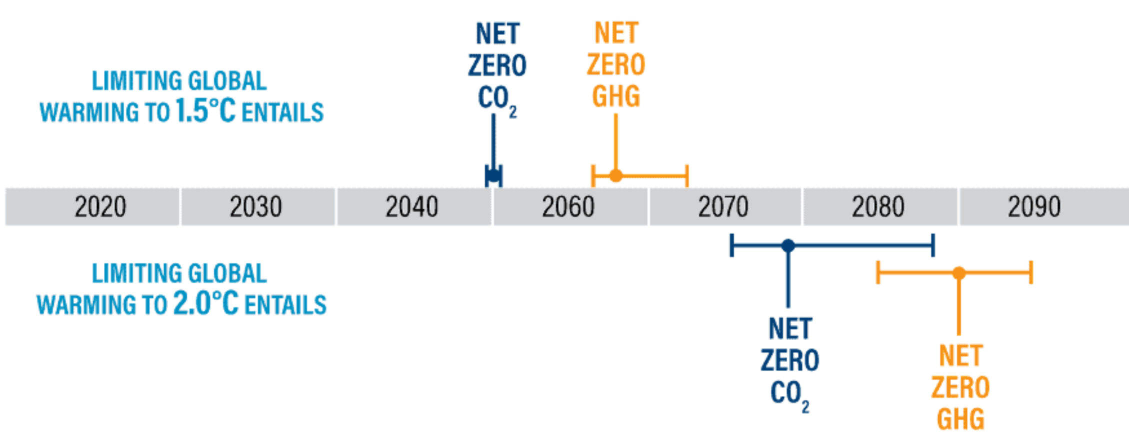
LIMITING GLOBAL WARMING ACTIONS



Source： IPCC Special Report on Global Warming of 1.5℃

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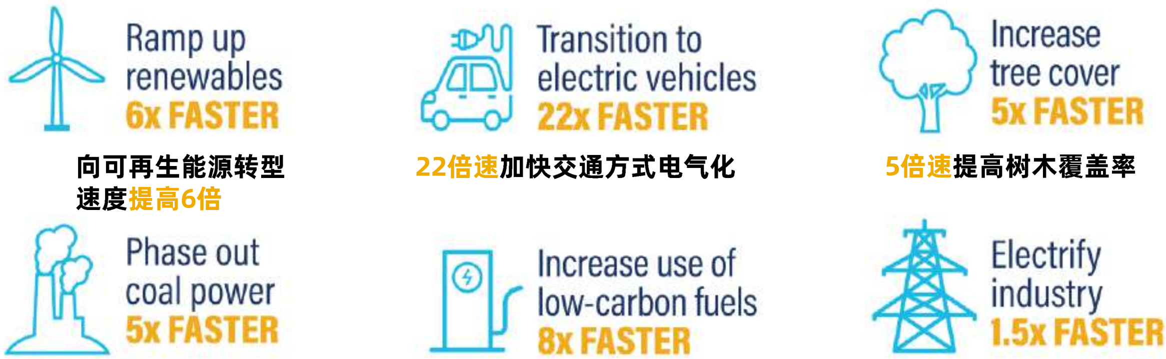
WRI: LIMITING GLOBAL WARMING TO 1.5 DEGREE ACTIONS



向可再生能源转型速度提高6倍

22倍速加快交通方式电气化

5倍速提高树木覆盖率

煤电以5倍速退出市场

8倍速增加低碳燃料使用

1.5倍速加快产业电气化

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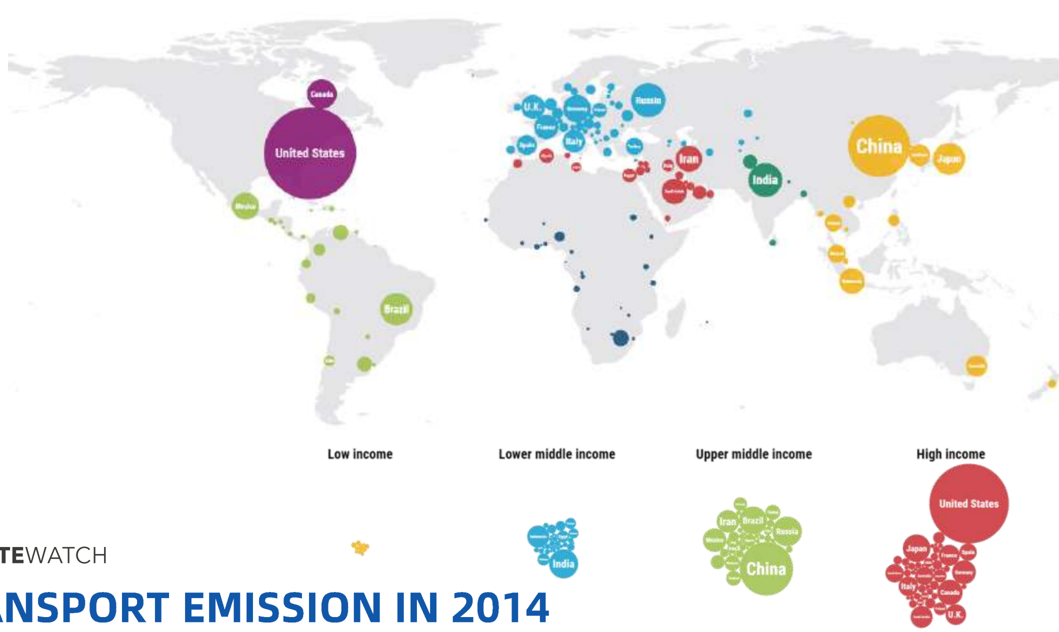

CLIMATEWATCH

TRANSPORT EMISSION IN 2014

Source: Climate Watch; World Resources Institute

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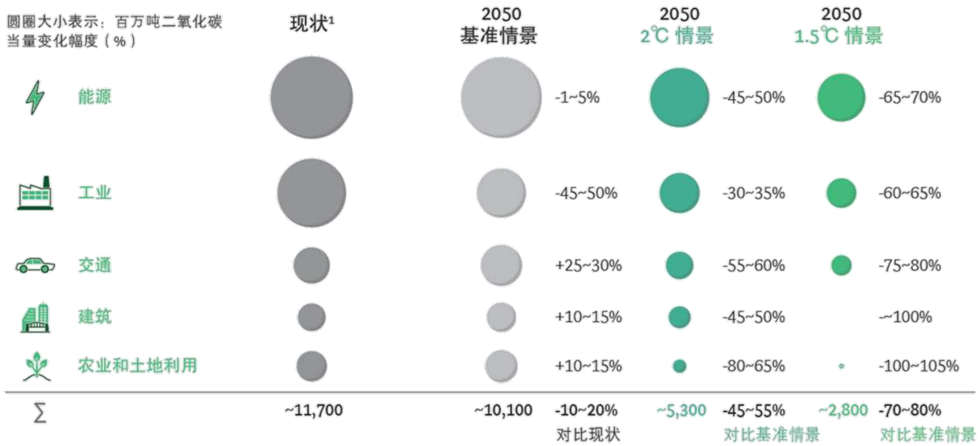
CHINA CARBON EMISSIONS



Source: 波士顿咨询集团模型测算，空心圆为负排放

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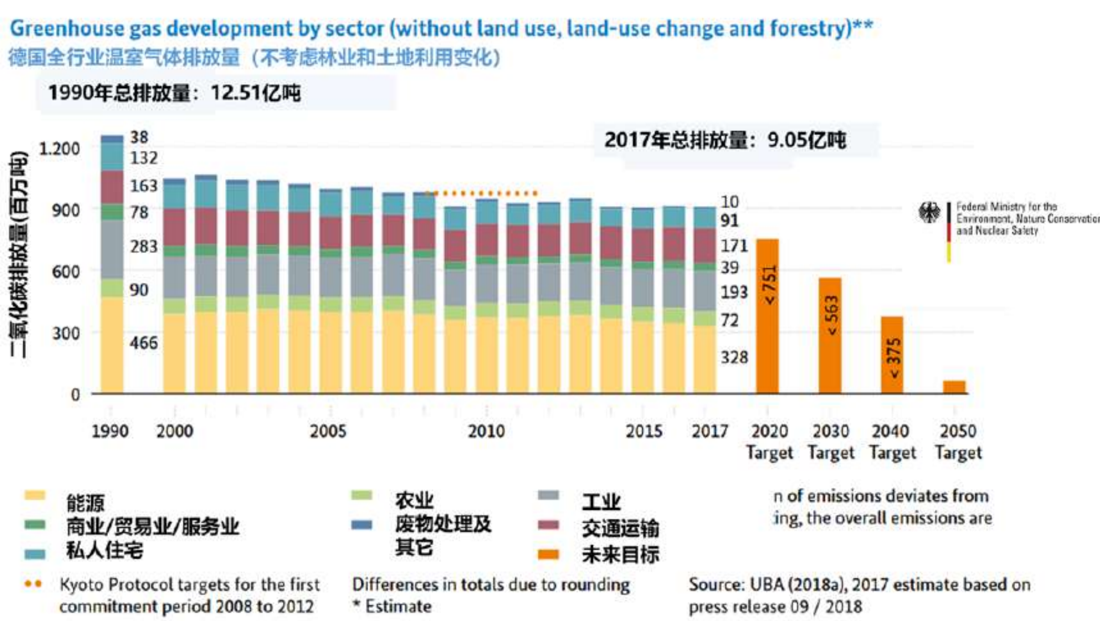

Source: 德国环境、自然保护与核安全部2017年年报

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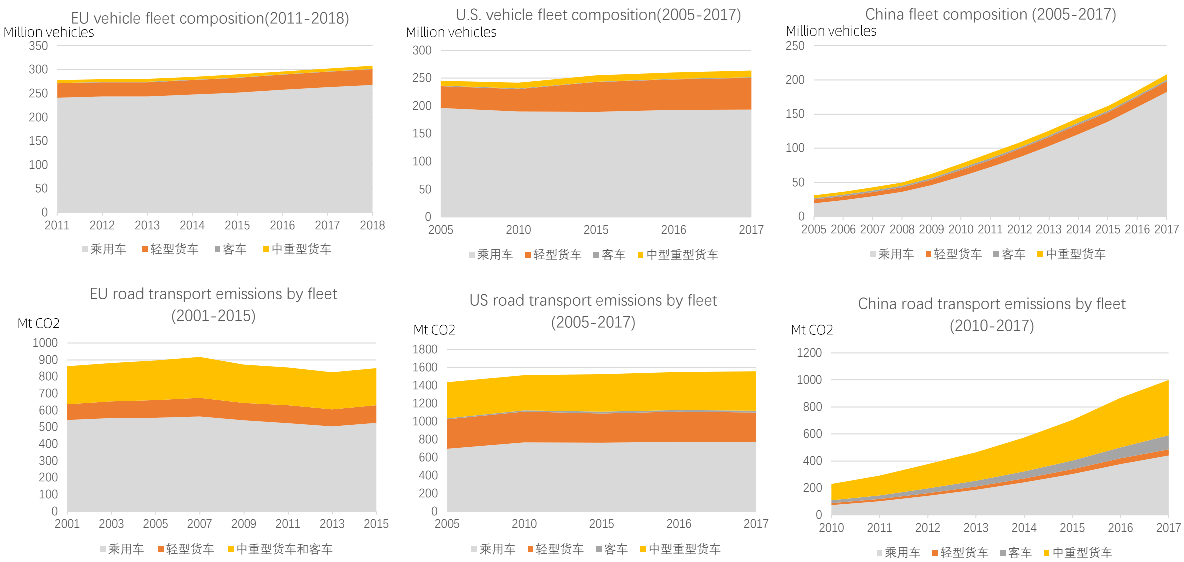
CHINA-US-EU TRANSPORT SECTOR COMPARISON



Sources: EPA, BTS, ACEA, European Transport & Environment 2018, China Statistical Bureau, WRI 2019, ERI 2017

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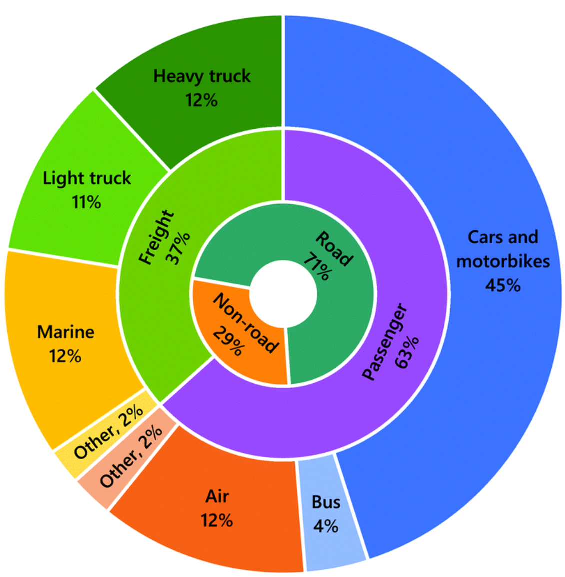
DECARBONIZING THE ROAD TRANSPORT SECTOR



Breakdown of energy usage in the transport sector globally in 2015

Source: Energy Information Administration, *International Energy Outlook*, 2017.

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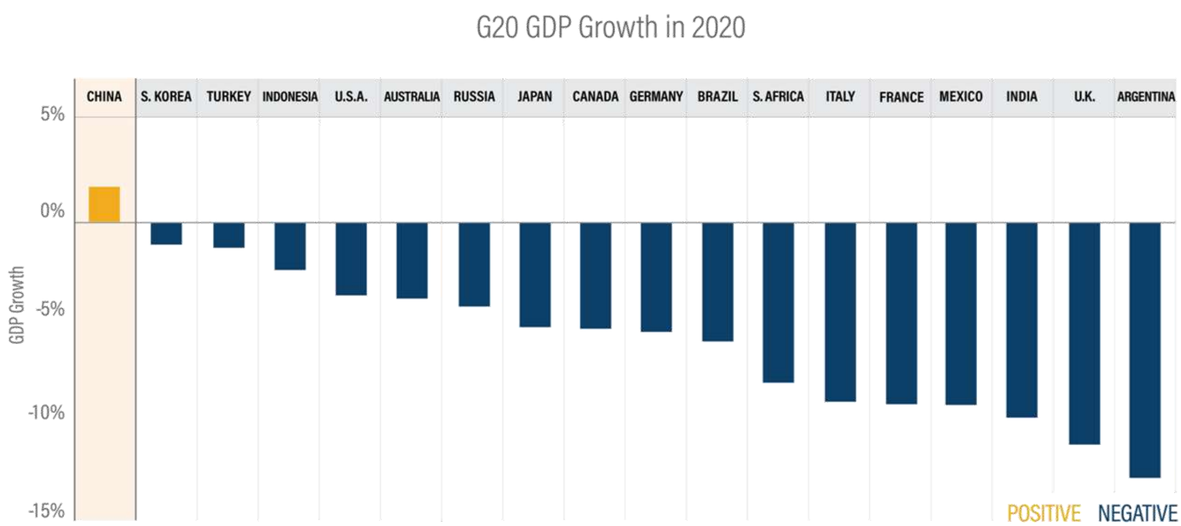
CHINA: FROM COVID RELIEF TO POST-COVID RECOVERY



Source: WRI & OECD

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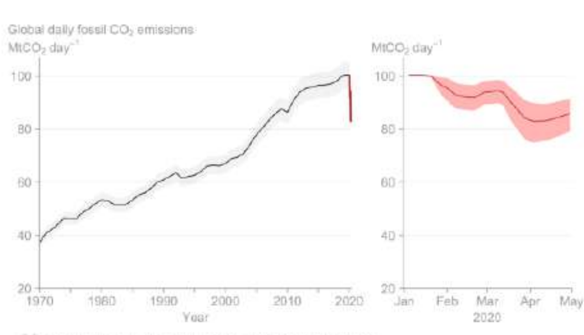
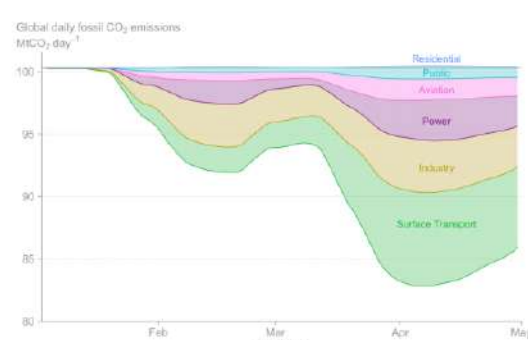
SURFACE TRANSPORT ACCOUNTS FOR HALF OF THE CO2 EMISSIONS REDUCTION SINCE COVID-19

Emissions from surface transport accounted for almost half (43%) of the decrease, industry & power together accounted for 43%, and aviation 12%. But this drop in CO2 emissions are still very small and temporary.





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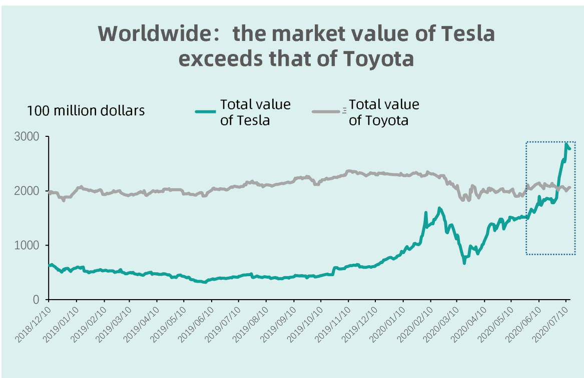
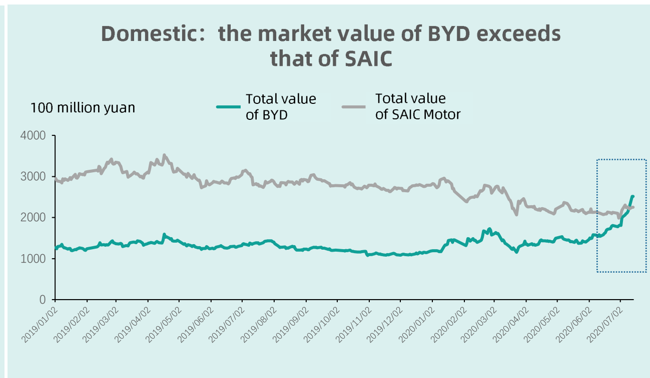
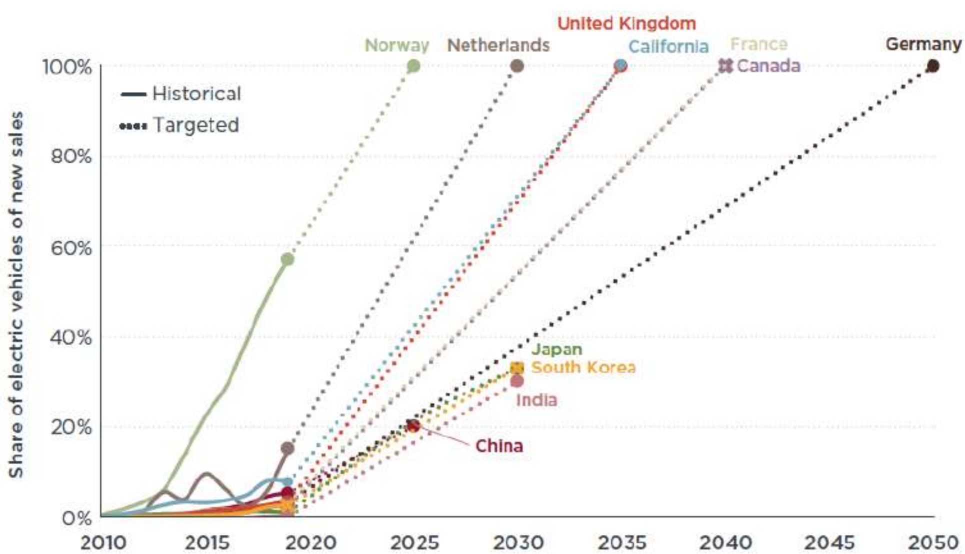
COVID-19 IMPACTS ON MARKET VALUE OF AUTO MANUFACTURER





TARGET SHARE OF NEV NEW SALES

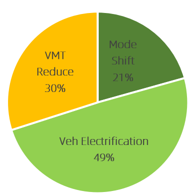


Source: ICCT publication:驱动绿色未来: 中国电动汽车发展回顾及未来展望

DECARBONIZING THE ROAD TRANSPORT SECTOR

- Recent technology advances and policy efforts by Chinese governments can fast track the road transport sector to attain the peak before 2035. When China submitted the NDC goal in 2015: road transport sector was expected to peak between 2035 and 2040, assuming a low penetration of EVs.
- However, after the emission peak, road transport's emissions in China will experience only a discernable decline, if no further proactive measures are taken.

From BAU to stated policy scenario



From stated policy to 1.5 degree scenario

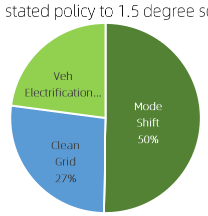
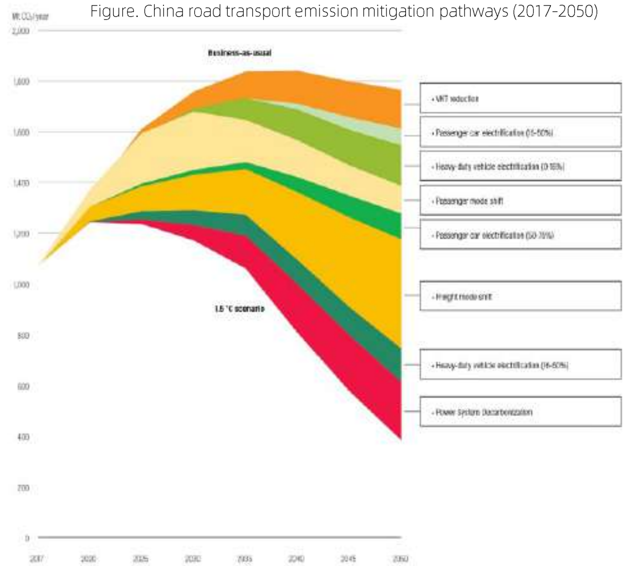


Figure. China road transport emission mitigation pathways (2017-2050)



Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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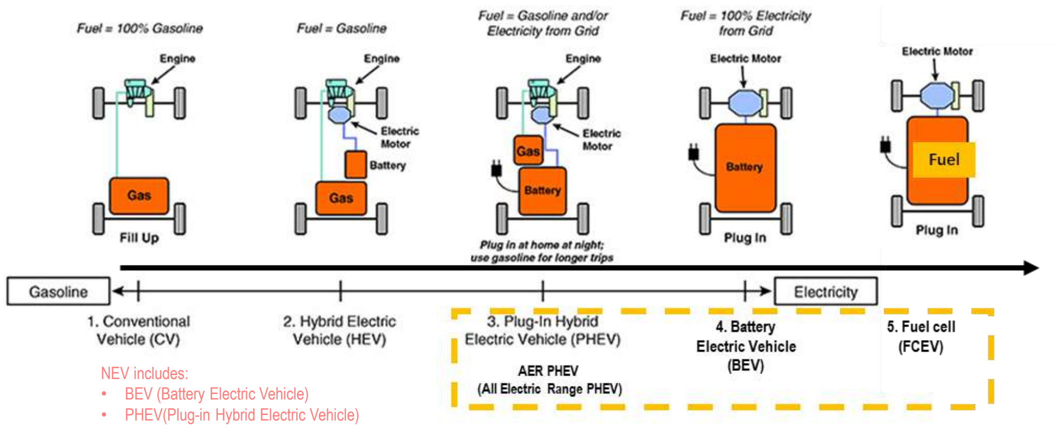
Accelerate vehicle electrification & charging network expansion

Defining New Energy Vehicles



NEV includes:

- BEV (Battery Electric Vehicle)
- PHEV(Plug-in Hybrid Electric Vehicle)
- AER PHEV (All Electric Range PHEV)
- FCEV(Fuel Cell Electric Vehicle)

Other types named as Energy Saving Vehicle (HEV CNG LNG…).

Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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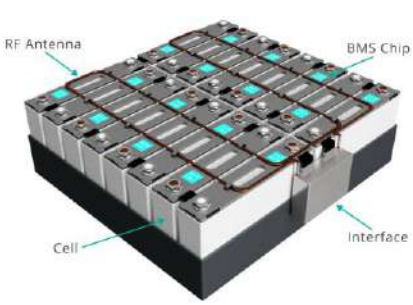
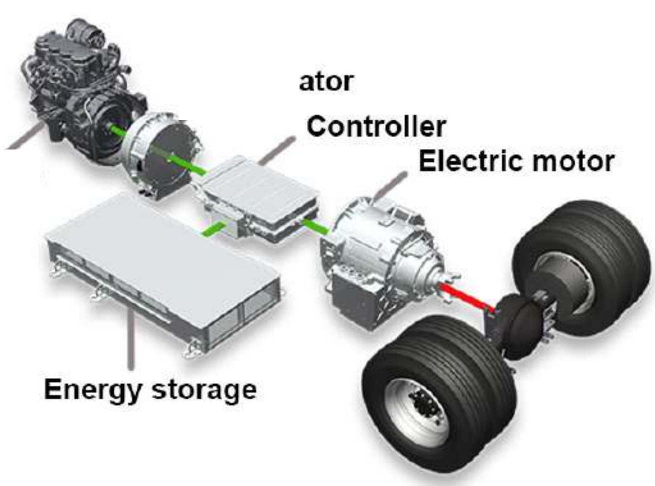
Accelerate vehicle electrification & charging network expansion

Key Components for EV

Battery Management System (BMS)





Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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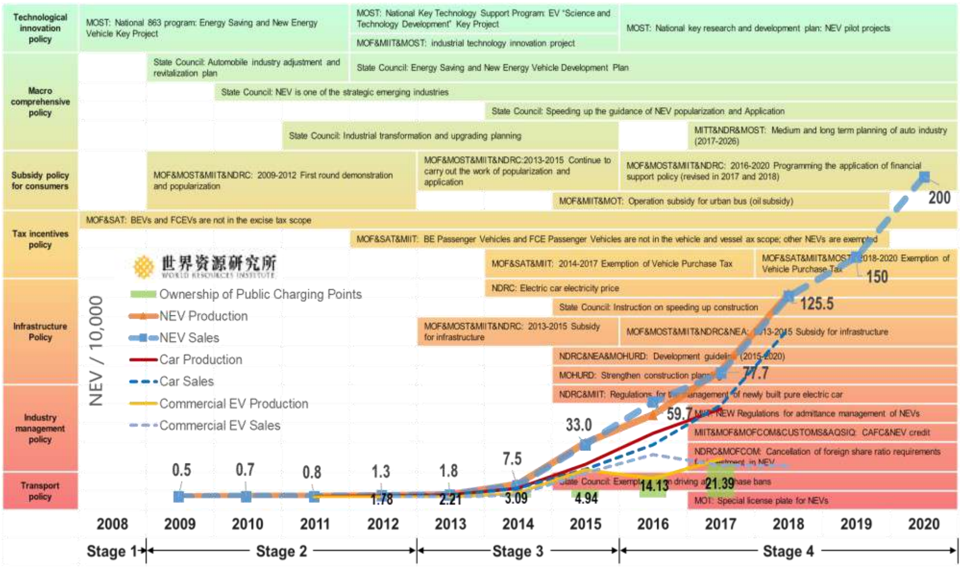

Systematic Policies Tools In China to promote EVs

Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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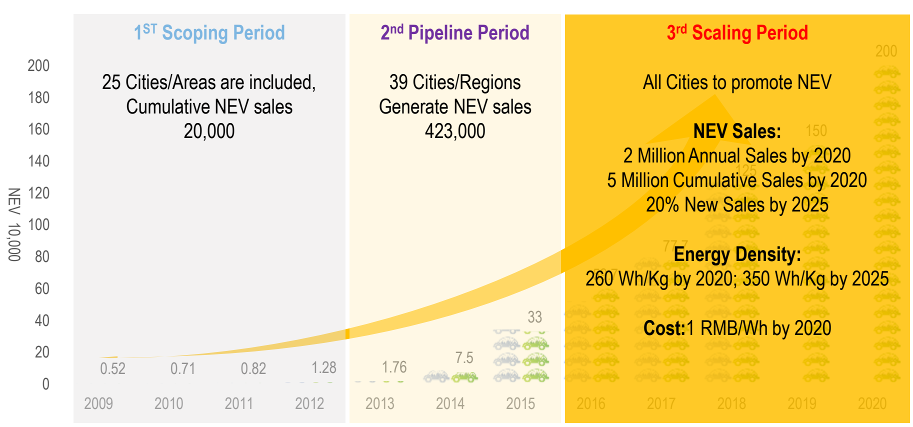
Accelerate vehicle electrification & charging network expansion



Systematic Policies Tools In China to promote EVs

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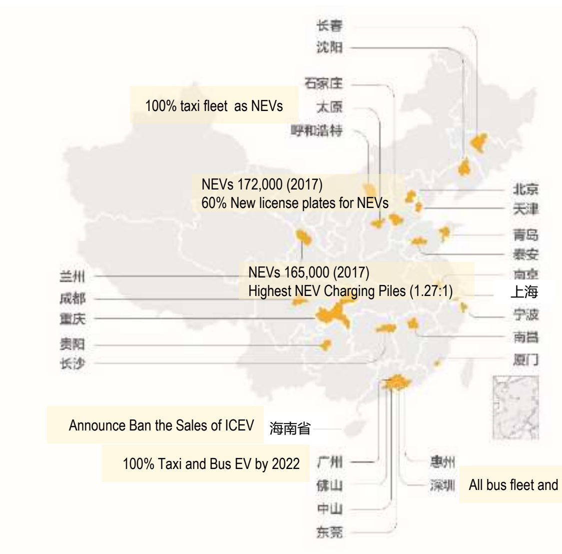
Accelerate vehicle electrification & charging network expansion



SECTOR	SUBSECTOR	TARGETS							
		2019		2020		2025		2030	
		New sales	Stock	New sales	Stock	New sales	Stock	New sales	Stock
Government		100%		100%		100%	100%	100%	100%
Bus		100%		100%	80%	100%		100%	
Taxi	Conventional	100%			100%	100%	100%	100%	100%
	Ride-hauling	80%		100%		100%	90%	100%	
Urban freight		100%		100%		100%	60%	100%	
Sanitation		50%		50%		50%	60%	100%	
Rental	Car-sharing	100%		100%		100%	80%	100%	
	Conventional	20%		40%		100%	60%	100%	
Tour coach				20%		100%	50%	100%	
Inter-city coach				20%		100%	45%	100%	
Private		10%		40%		80%		100%	

Electric Vehicles / Clean Energy Vehicles

Hainan's near-to-long term targets on clean energy vehicle deployment by sector

(Hainan provincial government. (2019). Clean Energy Vehicle Development Plan of Hainan Province.)

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Accelerate vehicle electrification & charging network expansion

- By 2050, in the stated policy scenario: 1. *CAFC&NEV credits, 2 tax exemption, 3 subsidy by 2026*
- Electric passenger vehicles: 55.4% of the total passenger vehicle fleet-480 million
- Light- and heavy-duty freight trucks: 30.3% of the total light- and heavy- duty trucks-27 million

	Sequences
Heavy-duty trucks	5
Long-distance coaches	5
Private cars	4
Logistic vehicles(LDVs)	3
Ride-hailing cars	2
Public service vehicles	2
Government cars	1
Taxis	1
Buses	1

Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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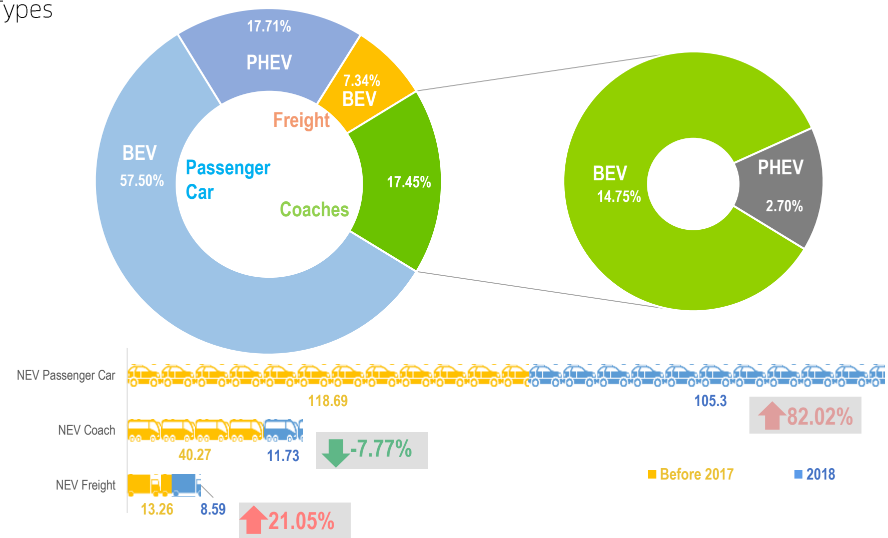
Accelerate vehicle electrification & charging network expansion

Sales by Types

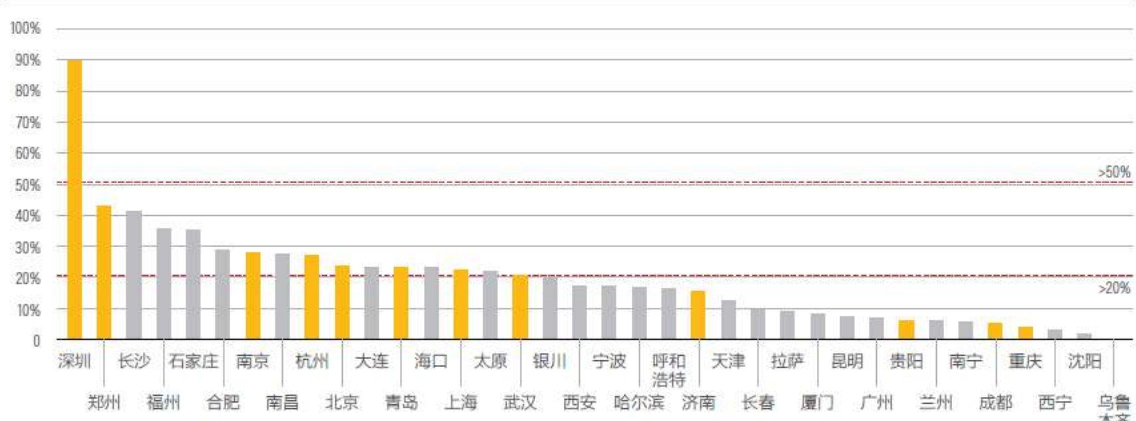


Source: China Association of Automobile Manufacturers 2018

E-BUS OUTLOOK IN CHINA

Penetration rate of BEV-buses for Chinese Cities, and differences because of:
1) Climate; 2) Local Financial Capability;3) Gas and Electricity Price Difference; 4) Local E-bus Industry

图 5 | 2017年36个中心城市纯电动公交车普及率（%）及研究样本城市

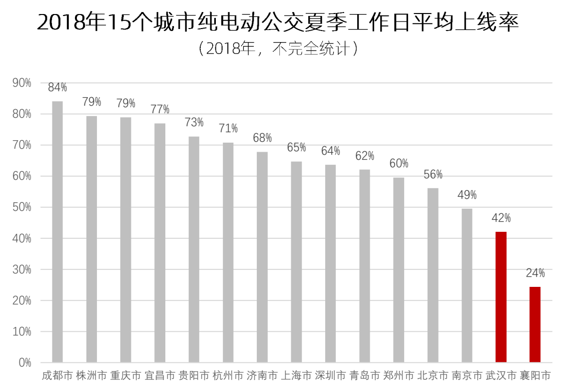


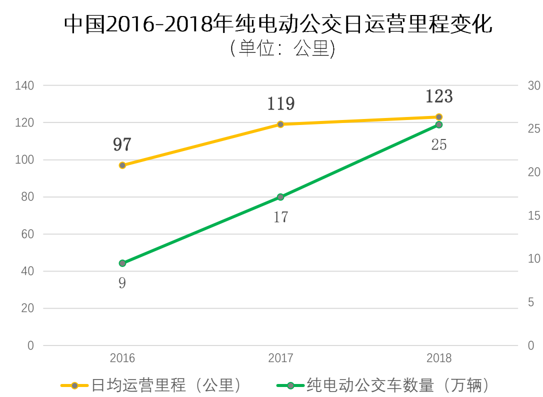
说明：图中标黄色的城市为本文选择的一部分研究城市；除这部分城市外，研究城市还包括少数非中心城市。
来源：交通运输部科学研究院《2017 中国新能源公交车推广应用研究报告》

Source: WRI 2018

E-BUS OUTLOOK IN CHINA

Penetration rate of BEV-buses for Chinese Cities, and differences because of:
1) Climate; 2) Local Financial Capability;3) Gas and Electricity Price Difference; 4) Local E-bus Industry





来源：交通部科学研究院2018年度中国新能源公交车推广应用研究报告， 世界资源研究所 2019

Source: WRI 2019

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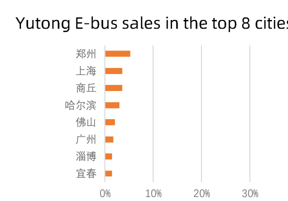
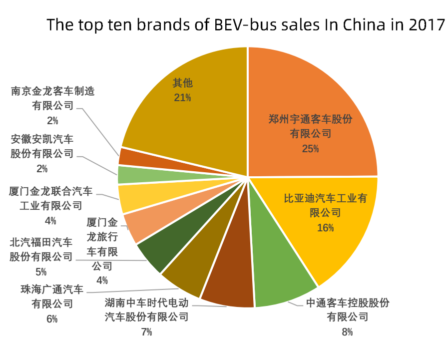
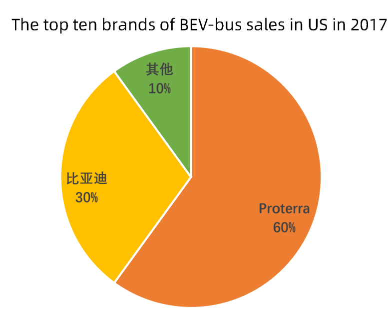
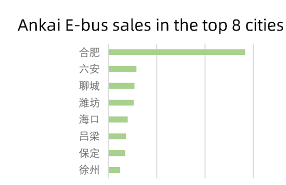
E-BUS OUTLOOK IN CHINA

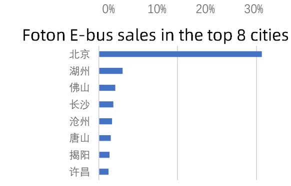
E-bus: Quality and specification of vehicles vary greatly











Source: WRI 2018

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E-BUS OUTLOOK IN CHINA

E-bus: Quality and specification of vehicles vary greatly

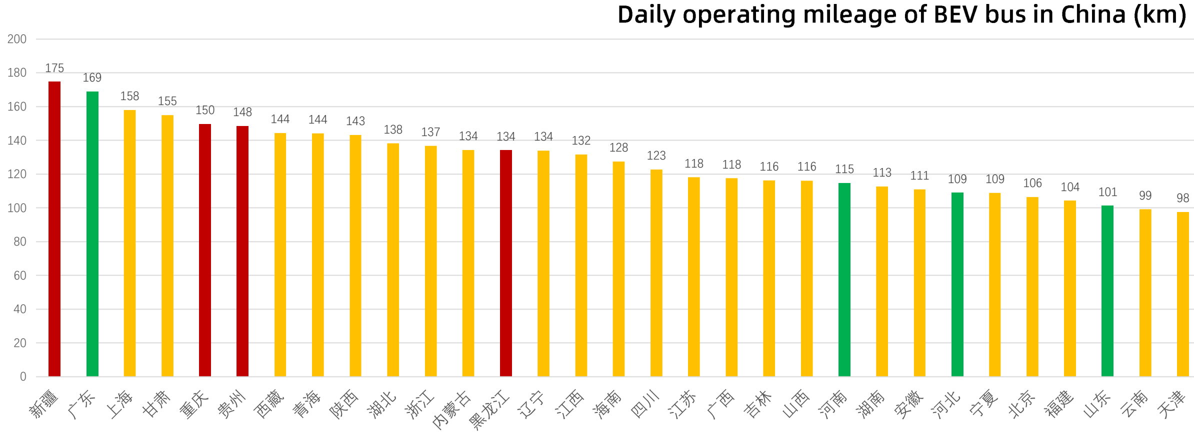
	BYD K9 (12m)	Yutong E12	Hengtong CKZ6127HBEV	Foton BJ6123EVCA-3	Kaiwo
Charging method	Slow	Slow	Fast	Fast	Slow
Battery capacity (kWh)	324	324	140	64.4	221.1
Battery range (km)	230-250	250	150	65	180
Max charging power (kW)	80	150	400	400	150
Energy consumption per 100km	1.0	1.0	0.8	0.4	1.2
Charging speed (kWh/min)	0.86	0.82	4	3.6	1.8

Source: WRI 2018

E-BUS OUTLOOK IN CHINA

How to improve operating efficiency of BEV-bus.

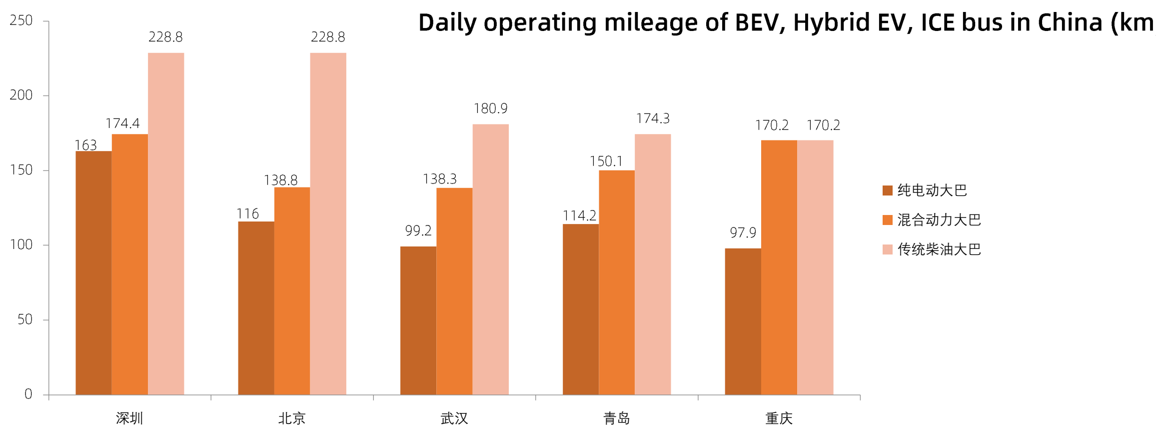
Daily operating mileage of BEV bus in China (km)



Source: WRI 2018

E-BUS OUTLOOK IN CHINA

How to improve operating efficiency of BEV-bus.



Source: WRI 2018

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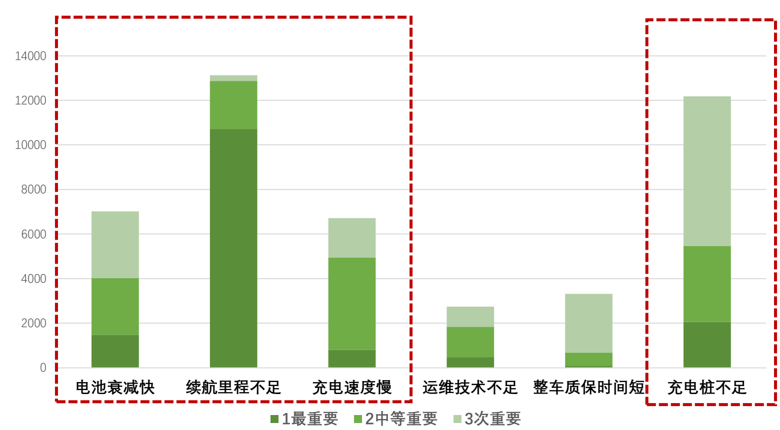
E-BUS OUTLOOK IN CHINA

How to improve operating efficiency of BEV-bus.

The importance of each influencing factor (unit: sample size after bootstrap sampling)



Source: WRI 2018

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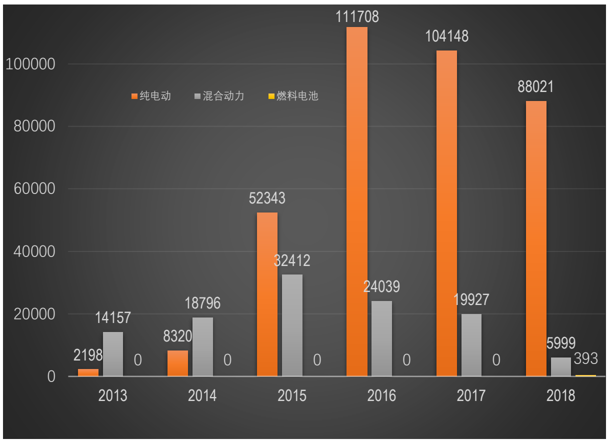
E-BUS OUTLOOK IN CHINA

Trend1: BEV is taking over PHEV becoming the mainstreamed model.

Annual sales of new energy buses in China



China-specific context:

- Single city-owned bus companies vs. multiple privately-owned bus companies
- Heavy public subsidies vs. shortage of fiscal supports
- Mature industrial ecosystem vs. lack of manufacture base

Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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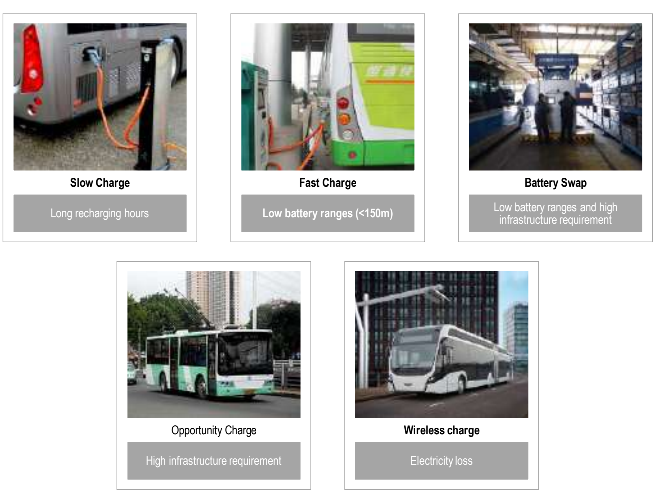
E-BUS OUTLOOK IN CHINA

Trend2: Charging technologies converge to slow & fast charging



- *Slow charge*: overnight charge + less than 1 recharge at day time
  Examples: Shenzhen (battery range 250km)
- *Fast charge*: overnight charge + every recharge per 1-3 cycle Example: Beijing (battery range 60-150km)
- *Battery swap*: swap every 1-3 cycle
- *Opportunity charge*:
- *Wireless charge*: costly technology and safety concerns

Source: WRI 2019. Toward net-zero road transport in China (in Chinese).

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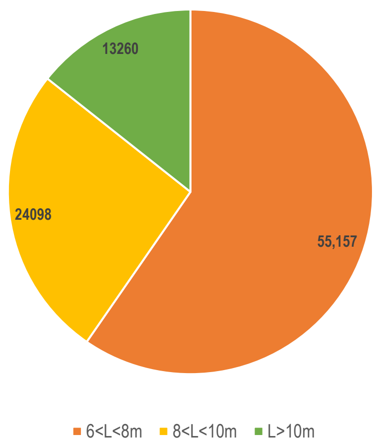
E-BUS OUTLOOK IN CHINA

Trend3: Small-sized buses are the main target for electrification (differing from Latin American countries).

Annual sales of e-buses in China by vehicle lengths (2015)



	Average electricity consumption per 100km travelled (kWh)
6<L<8m	41
8<L<10m	60
10<L<12m	82
L>12m	100-120

Source: WRI & NEVL 2019

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Thoughts on the Integrated Development of "Vehicle-pile-network" under the Goal of "Peak Carbon Dioxide Emissions & Carbon Neutrality"

YIYU QIN

CONTENTS

01

China's program on "Dual Carbon"

China's program on "Dual Carbon"

According to the information released by the World Meteorological Organization, the warming trend of global climate system continues further. From 1951 to 2018, the annual average temperature in China rose by 0.24 ℃ every 10 years, and the temperature rise rate of China was higher than that of the global average in the same period

Given the grim situation, on September 22, 2020,

Chinese President Xi Jinping made a solemn promise

in the GENERAL Debate Of the 75th Session of UN General Assembly that China would implement "Dual Carbon": China will strive to reach the peak carbon dioxide emissions in 2030, and go out for achieving carbon neutrality in 2060.

02

Energy technology path for realizing the "Dual Carbon"

Building a new power system with clean energy as the main body

the power generation pattern of power system will be changed.

It is expected that by 2060, wind power and photovoltaic in China will replace the original thermal power as the main power source. Through the access of friendly power grid, the power generation pattern of power system will be changed.

90%

The proportion of clean energy generation will reach 90%

70%

and the proportion of energy consumption at power terminal will reach 70%

80%

the proportion of non-fossil energy consumption will reach 80%

Promote the integrated development of "Source, grid, load and storage".

By integrating the resources of source, grid and load, and taking the "big data, cloud computing, Internet of things, mobile Internet, artificial intelligence and blockchain" as support

and basing on the target of giving priority to the exploitation and utilization of renewable energy, power load and transmission and distribution network are planned synchronously.

Meanwhile, auxiliary regulation system such as electrochemical energy storage is provided to enhance the emergency support and risk defense capability.

The integrated development mode of "source, grid, load and storage" is helpful to quickly realize the cross-regional allocation of power generation resources and increase the proportion of clean energy in power consumption.

03

Comprehensive energy service solution of State Grid

Comprehensive energy service solution of State Grid

Under the "Dual Carbon" goal, the industrial orientation of State Grid for comprehensive energy services will be

Committed to providing electricity-based comprehensive energy service solutions and formulating industry standards, endeavoring to become a leader that directs the orientation of industry development, as electricity will become a basic energy form, not only being a converted form of primary energy such as wind energy, solar energy and water energy, but also the main form of energy consumption of users.

Committed to tackling key technical problems and innovating business models related to comprehensive energy in a bid to accelerate the upgrading of upstream and downstream industries and become the promoters of industrial innovation. Through comprehensive energy services, it helps to get through the industrial chain from power generation to power consumption, and constantly improve the cooperation relationship and accelerate the iteration of the industry.

Committed to strengthening the online service platform and offline industry alliance, integrating high-quality resources of the industry and becoming the builder of industrial ecology. Through comprehensive energy projects, we integrate technology, capital and talent resources to find customers' needs in a broader perspective, promote the implementation of projects, and constantly innovate replicable business models.

The core business of comprehensive energy of State Grid involves six aspects

01 Energy efficiency management

focus on the fast-growing groups of industrial enterprises, public buildings and parks with great energy-saving potential, and serve the customers with energy efficiency improvement combined with the key energy use equipment and systems of customers. Including energy-saving improvements for independent systems (e.g. lighting), and combined energy optimization for multiple systems (e.g. overall energy-saving for air conditioning systems and hot water supply)

02 Multi-energy coordination

focus on large-scale buildings, such as industrial parks, universities, hotels, hospitals and other customers, and build a service system with electric power as the center, collaborative supply of cold source, heat source, natural gas source, pressure source and so on by using heat pump, solar-thermal power generation, electric boiler steam making, cold and heat storage and other technologies.

03 Clean energy

basing on the local energy resources, selecting the rich areas of wind, light and biomass resources, utilizing the complementary and cascade utilization of energy, building distributed photovoltaic, decentralized wind power, biomass power station and other projects, and expanding the utilization of renewable energy.

04 Emerging energy consumption

in the field of industrial Internet and Internet of things, focus on 5G base station, data center, electric vehicle charging network, electrochemical energy storage, electric hydrogen generation and other new power consumption scenarios, and deeply explore the characteristics of this type of power consumption (rapid industrial development, large single power consumption, flexible adjustment of power consumption period, etc.), which can not only coordinate with intermittent clean energy, but also rapidly increase the proportion of electric energy in terminal energy consumption. The integrated development of "vehicle-pile-network" to be addressed in following pages is an important part of this part.

05 Smart energy

establishing a comprehensive energy service platform for power grid, relying on artificial intelligence and mobile internet technology; carrying out monitoring and analysis on target customers, providing remote services such as energy consumption monitoring, multi-energy coordination, optimal control, intelligent operation and maintenance, and building smart power generation and utilization projects with self-perceiving, self-learning, self- optimizing and self-healing.

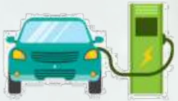
06 Energy trading

By relying on the comprehensive energy service platform of power grid, we will carry out the electricity trading agency service to earn the price difference in the initial stage, and then to participate in auxiliary services and the demand side response system in the medium term, and launch carbon trading in the long term.

04

New energy vehicle service: integration of "vehicle-pile-network"

Basic precondition



Integration of "vehicle-pile-network" highly adapts to the new power system with clean energy as the main body, and falls in line with the development idea of "source, grid, load and storage" integration.

car

he "vehicle" mainly refers to electric rechargeable vehicle, focusing on the consumption of renewable energy

pile

"pile" refers to charging equipment specially serving the vehicle in the integration project

grid

"network" refers to both the exclusive power supply grid and the Internet-based management platform.

The integration of "vehicle-pile-network" is based on unified planning, simultaneous construction and one-time forming in the mode of "Internet Plus". This construction model will break through the difficulties in the development of the electric vehicle charging industry, so that the new energy vehicle charging project can be centrally managed and efficiently operated in a closed-loop platform.

Important ideas

The service object of "vehicle-pile-network" integration is pure electric vehicles with advanced technology, and the service concept is to meet the needs of customers with the best charging experience.

speed

efficient

convenient

At present, charging facilities are in the initial stage of development and it is difficult to meet the ultimate pursuit of users for fast charging. Therefore, we will also take the combination of fast and slow charging facilities as a compromise during the transition period. But it can be predicted that in the future, with the progress of technical advancement, the experience of charging speed will eventually surpass refueling. Taking fast charging as the ultimate goal is the belief of the integrated development of "vehicle-pile-network".

Key technologies

Large capacity battery, fast charging and swapping technology	Pure electric vehicle and intelligent driving technology	Interaction between strong power grid and electric vehicle

problem

Among the three core technologies of electric vehicles, namely battery, motor and electronic control, the most disputed difficulty which is also most difficult to break through lies on battery safety, battery cost and battery driving range.

idea

The driving range of electric vehicles has not reached the same level as that of gasoline, diesel and CNG vehicles, which is also the core problem hindering the rapid development of new energy vehicle industry. As mentioned above, large capacity batteries can eliminate the pain point of low driving range (large capacity batteries are also required for battery swapping station); the charging facilities matching with large capacity batteries must be high-power DC charging piles, and the charging speed is the most intuitive charging experience of users.

Key technologies

Large capacity battery, fast charging and swapping technology	Pure electric vehicle and intelligent driving technology	Interaction between strong power grid and electric vehicle

1 **2011-2015**

From 2011 to 2015, China began to promote new energy urban buses, hybrid cars and small electric vehicles.

2 **2016-2020**

From 2016 to 2020, further popularization was carried out for new energy vehicles, multi-energy hybrid vehicles, plug-in electric cars, hydrogen fuel-cell cars, etc.

3 **2021**

In 2021, new industry players n cross-industry cooperation in car making have emerged one after another, and pure electric vehicles have gradually become the mainstream.

Because pure electric vehicle is easier to achieve intelligence than traditional fuel vehicle, the new energy vehicle industry in the future must take the development path combining pure electric vehicle and intelligent driving technology. Now, as more and more Internet industries join the research on key technologies of electric vehicles, intelligent driving technology has achieved a leap-forward development.

Key technologies

Large capacity battery, fast charging and swapping technology	Pure electric vehicle and intelligent driving technology	Interaction between strong power grid and electric vehicle

Driven by energy transformation and scientific and technological progress, high-proportion renewable energy and high-proportion electric and electronic equipment are becoming an important trend and key feature of power system development, namely "double high" power system. The renewable energy dominated by wind and solar power is fluctuating and intermittent, and the load of demand side electric vehicles is also at random. The energy power system will evolve from the traditional demand side' s unilateral random system to the bilateral random system. With the continuous improvement of the driving range of electric vehicles, the grid will be subject to stronger and more random load impact after fast charging technology is adopted. If there is no strong power grid as a support, the superposition of "double high" and "double random" will make it impossible to achieve integrated development of "vehicle-pile-network". Therefore, a strong power grid is a fundamental guarantee for the integrated development of "vehicle-pile-network" under the "Dual Carbon" goal.

Electric vehicle V2G technology refers to the technology of electric vehicle reverse power transmission to the grid, and its core is to use a large number of idle energy storage of electric vehicles as the supplement of the grid and the buffer of renewable energy.

Implementation path

There are three typical development models for "vehicle-pile-network" integration

priority to vehicles

make public transport vehicles such as urban buses, taxi cabs, ride-hailing cars which will take the lead in adopting electric vehicles. Such kind of A-to-B scenario, with stable passenger flow scenario and a considerable scale of electric vehicles so invested in the initial stage, will make the running much easily profitable. This model is recommended for government-led projects.

priority to charging pile

swapping model in mines, factories and industrial parks in which the internal environment can be controlled and the site management of short-distance transportation is relatively simple. It is easy to realize the optimal scale matching between charging equipment and charging vehicles, and quickly supplement and expand the capacity of charging equipment along with the increase of transport capacity at any time. This model is recommended for private car scenario.

priority to network

the construction of comprehensive energy station, including water, electricity, gas, oil or comprehensive energy stations. As the miscellaneous incomes are possible to reduce the cost pressure of charging business in the beginning period, it is most conducive to rapid expansion and construction of exclusive charging network, and quickly form network by using multi-point synchronous development, so as to attract increased volume of vehicle flow to reach a proper economic scale rapidly. This model is suitable for overall deployment based on power grid.

Taking advantages of resources and make development according to local conditions

determine an integrated development model according to local conditions.

We shall analyze the advantages of resources available in different regions and determine an integrated development model according to local conditions. Before the development of electric vehicles in cities, unified planning is needed to analyze different application scenarios according to the needs of customers.

For example, a city in Sichuan Province, China has abundant hydraulic resources,

For example, a city in Sichuan Province, China has abundant hydraulic resources, with installed capacity up to 12.72 million kilowatts. By virtue of sufficient and low-cost hydropower generation, the government made great efforts in introducing electric buses and taxi cabs. The off-peak charging feature tallies with the cheapest power

this area is mainly mountainous in landform and rich in mineral resources, and there are many mine owners who may go for new energy vehicles; the power grid has the planning of complex comprehensive energy projects in different areas of the city.

development models

In this case, three development models can be introduced simultaneously. Through integration and cooperation, the city is expected to achieve extraordinary development in "vehicle-pile-network" integration.

Cross-industry capital cooperation

Compared with the traditional fuel vehicles, new energy vehicles are overlapped with new characteristics such as self-driving, and their development will drive more related industrial chains, such as lithium mining, power battery enterprises, charging pile enterprises, IT enterprises, etc.

The inherent advantages of electric vehicles in intelligent and scientific and technological aspects have brought the Internet industry into automobile industry.

For the integrated construction of "vehicle-pile-network", more cross-industry cooperation will be attracted. Meanwhile, the effective combination of the heavy assets of operating vehicles and the light assets of management platform will jointly form a huge industrial chain of new energy vehicles relying on their respective advantages.

05

New energy vehicle ecosystem and international cooperation prospect

The status of China new energy vehicle industry chain

New energy vehicle is a new industrial pattern jointly formed by vehicle manufacturing and parts vendors, which is composed of upstream material end, midstream parts and downstream vehicle.

Upstream

Key raw materials are mainly such two major mineral raw materials as cobalt and lithium. The raw materials are mostly owned by some large and monopolistic mining companies, which have certain pricing rights.

Midstream

The number of parts for new energy vehicles is only 20% of the traditional vehicles, while the battery accounts for a large proportion of the cost of new energy vehicles, which is a business field China is good at or relatively leading at present time.

Downstream

Charging equipment is the most important supporting equipment of electric vehicles, which will be a fast-growing industry in a long time. Professional back-end service market includes charging service, derivative service (travel service, Internet of vehicles service, etc.), second-hand vehicle transaction, battery recycling and other businesses.

New industrial structure

Leading enterprises in Chinese new energy vehicle industry chain: (details to be skipped)

Equipment manufacturers: pile enterprises (XJ, NARI, TGOOD, Star, Potevio, Wanma), battery manufacturers (CATL, BYD, Gotion High-tech), etc.

Automobile enterprises: BAIC New Energy, BYD, NIO, LI, Xpeng, Tesla (technology of battery, motor and electronic control), etc.

Power grid enterprises: State Grid, Southern Power Grid, etc.

Investors: State Grid, TGOOD, Star Charge, etc.

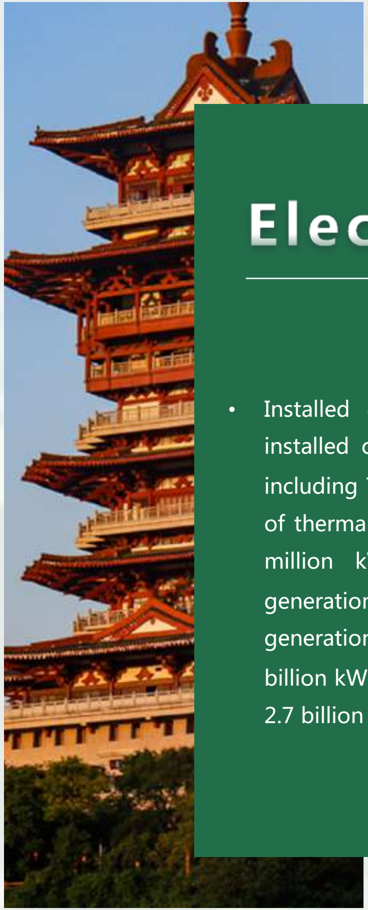
Operators: State Grid, Southern Power Grid, TGOOD, Star Charge,

Platform R&D enterprises: State Grid, Southern Power Grid, TGOOD, Star Charge

International cooperation in energy

Advancing the green Belt and Road Initiative is conducive to turning the rich resource advantages accumulated in China into experience. The "China experience" will help the energy industry in Central Asia to develop towards integration, to strengthen the connectivity between upstream and downstream, and to drive the development of infrastructure construction and related industries in the course of project implementation.

Development experience of Sichuan Province



Electricity situation

- Installed capacity: By the end of December 2020, the installed capacity of the province was 101.05 million kW, including 78.92 million kW of hydropower, 15.96 million kW of thermal power, 4.26 million kW of wind power and 1.91 million kW of photovoltaic power. The total power generation is 416.73 billion kW·h, of which, hydropower generation is 354.14 billion kW·h, thermal power is 51.27 billion kW·h, wind power 8.62 billion kW·h, and photovoltaic 2.7 billion kW·h.

Sichuan experience

- With the construction of large-scale hydropower bases as the focus, efforts are made to develop emerging industries including new energy vehicle;
- To widely promote the use of new energy vehicles with CNG and LNG as fuel in the fields of public transport and environmental sanitation etc.;
- To actively make deployment of wind power, solar power generation and biomass energy;
- To vigorously promote the projects of "coal-to-electricity" and "coal-to-gas";
- To accelerate the construction of new inter-provincial power transmission channels, and promote Sichuan’ s clean energy to play a part in the national energy balancing arrangement.

Cooperation outlook

new energy vehicles with the integrated development of "vehicle-pile-network".

In conclusion, under the guidance of China's "Dual Carbon" goal, the comprehensive energy service of State Grid will devote itself to making full play of its advantages to promote a sound development of new energy vehicles with the integrated development of "vehicle-pile-network". Sichuan has a wide area, rich resources and excellent performance in power grid operation and management. We hope to help the development of energy industry in the Central Asian countries with our "Sichuan experience"!

THANK YOU

Thoughts on the Integrated Development of "Vehicle-pile-network" under the Goal of "Peak Carbon Dioxide Emissions & Carbon Neutrality"

Interpreting the development of new energy vehicles from the perspective of global value chain

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Jun. 24, 2021

Chapter 1

Review of the global LIB chain: Supply of LIB change from Japanese monopoly to triad of China, Japan and South Korea, and concentrated to China in the past five years

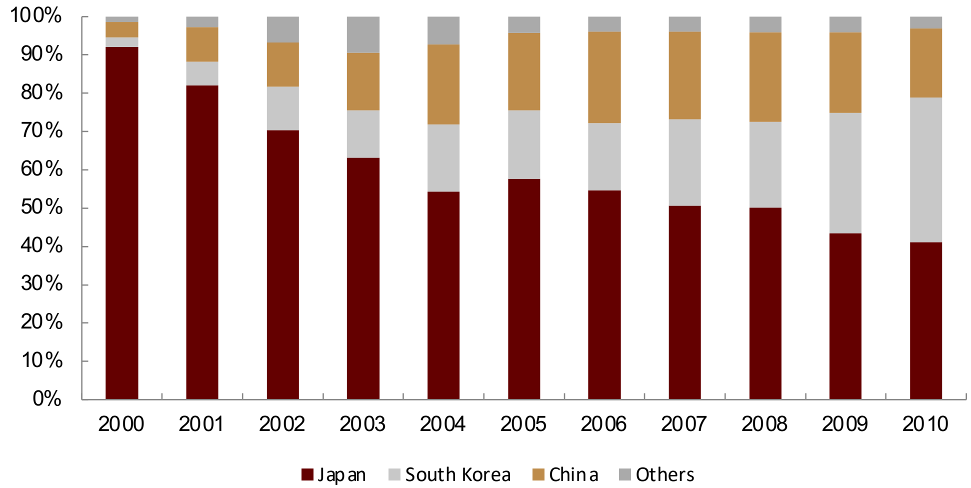
Supply of LIB change from Japanese monopoly to triad of China, Japan & South Korea

Before 2010, 90%+ LIBs were used in the consumer sector, and the market went from a monopoly in Japan to a triad of China, Japan, and South Korea:

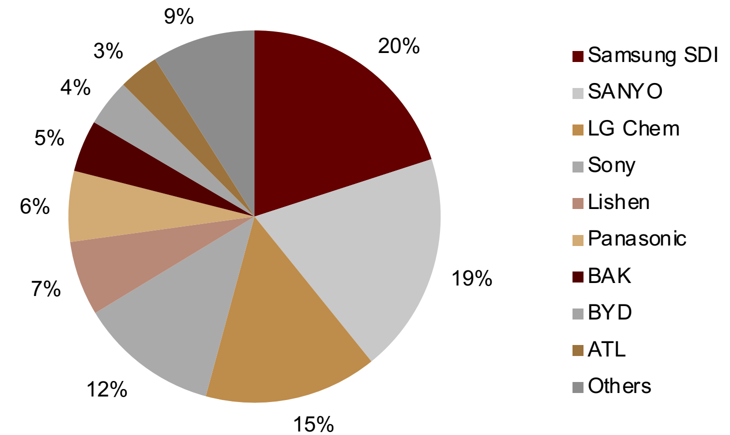
- Before 2000: Japan monopolized, South Korea entered, and China developed. Japan monopolized the global market (90%+). South Korea introduced advanced technology from Japan. In 1998, LG Chem launched LIB business; in 1999, SDI developed 1800 mAh cylindrical LIB. In China, Coslight, BYD, and ATL established.
- 2001-2010: China, Japan, and Korea were in harmony, and localization helped China rise. After 2001, China became the center of consumer electronics manufacturing, driving the development of LIBs in China. Prices of 4 materials dropped down, and China's LIB share expanded from 11% in 2002 to nearly 20% in 2010.

LIB battery mainly supplied by companies from Japan, South Korea and China before 2010

Global LIB battery market share (2000-2010)



Global shipment market share of LIB battery (2010)



Source: GGII, CICC research

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Supply of LIB change from Japanese monopoly to triad of China, Japan & South Korea

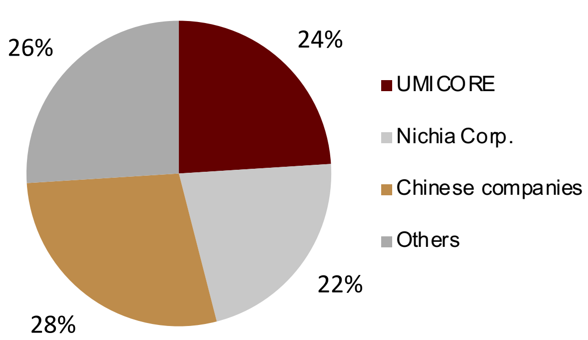
Four major materials of LIB achieved a certain degree of localization.

In 2010, 4 major materials:

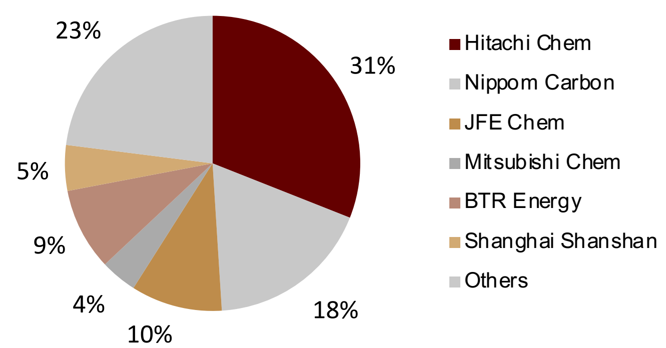
- The localization rate of positive electrode > 25%
- The localization rate of electrolyte > 25%
- The localization rate of diaphragm link was low, and market was occupied by Japan and Korea
- The localization rate of negative electrode > 10%

Global market share of four LIB materials (2010)

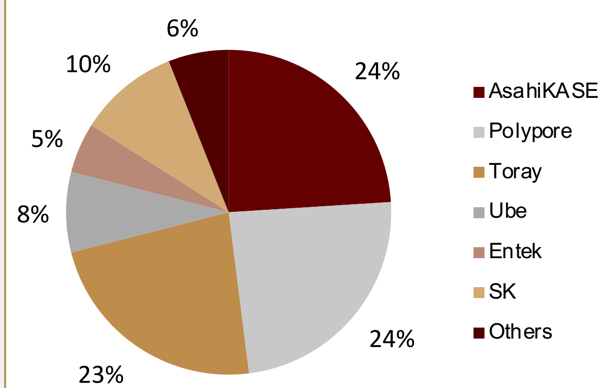
Cathode materials



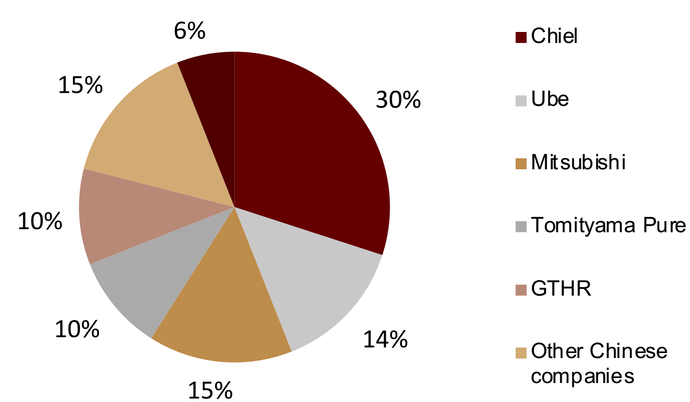
Anode



Seperator



Electrolyte



Source: CIAPS, CICC research

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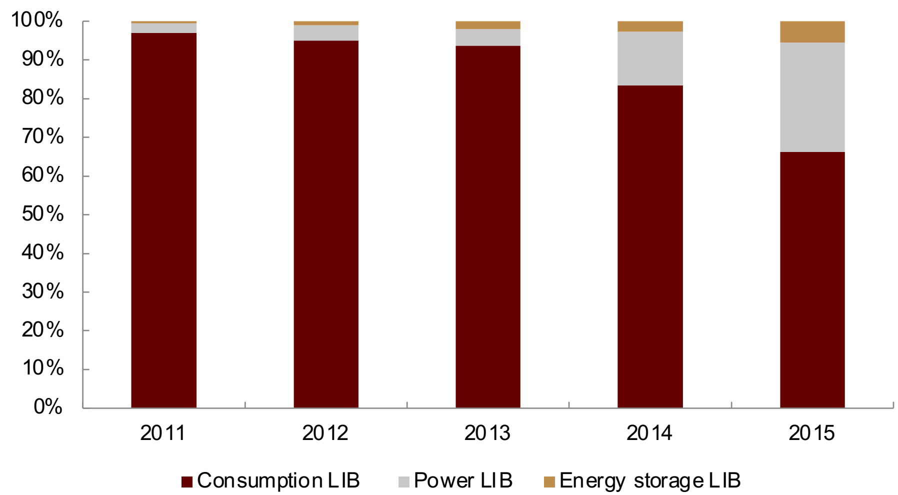
Power LIB and four major materials' share concentrated in China

Power LIB rose from 2010 to 2015, and the global supply share of China increased

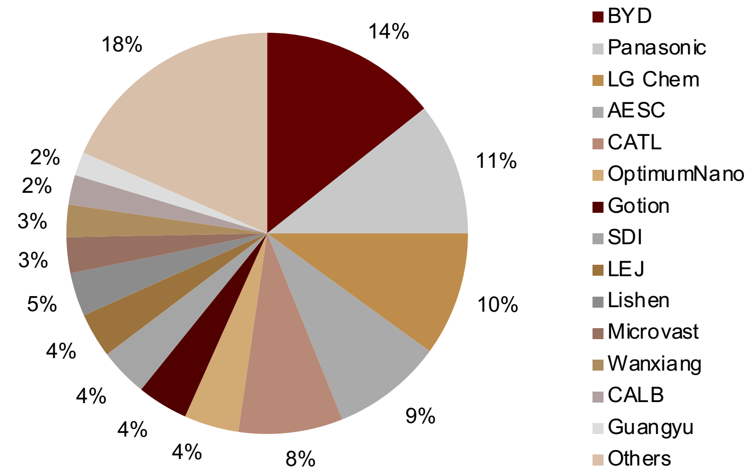
- After 2010, power LIB grew rapidly, and accounted for 28% in LIB in 2015
- By 2015, domestic manufactures such as BYD, CATL, Watermark, and Guoxuan Hi-Tech increased their market share in power LIB market. In 2015, the domestic share exceeded 30%.

Power LIB demand rising from 2010 to 2015, and global market share of Chinese LIB companies increased

Global LIB battery applications



Global installed market share for LIB battery (2015)



Source: GGII, CICC research

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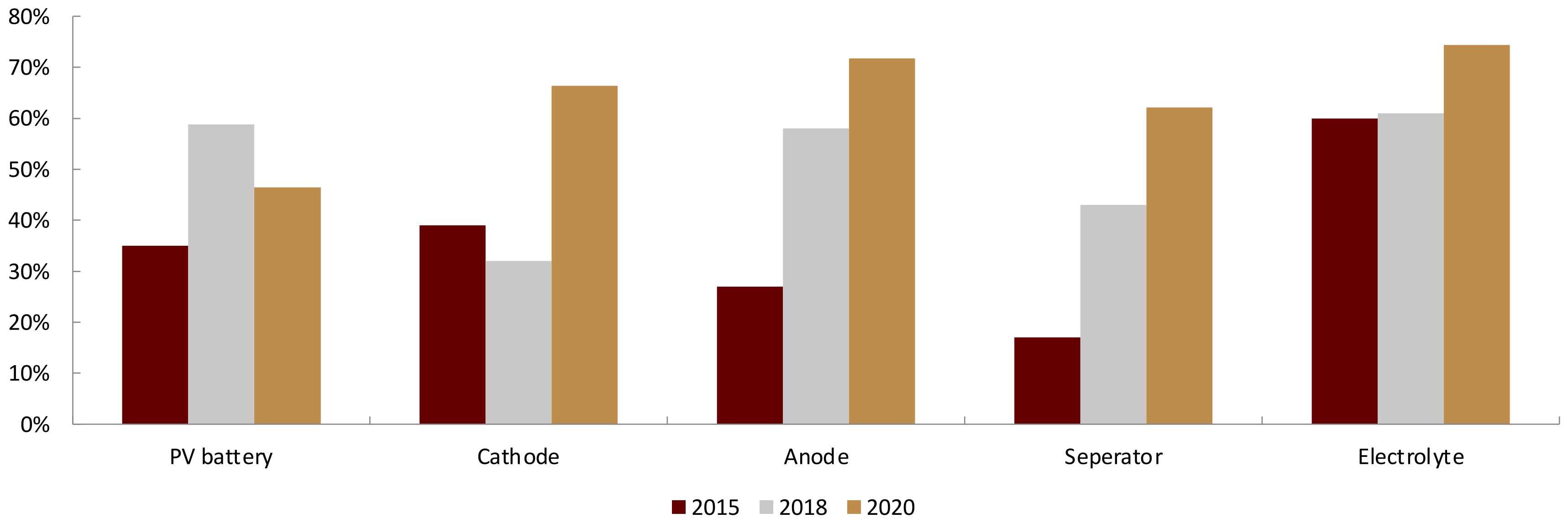
Power LIB and four major materials' share concentrated in China

After 2015, the share of LIB and the four materials continued to concentrate in China:

- LIB: From 2015 to 2018, China's new energy vehicle sales drove the share of domestic power LIBs to grow; after 2019, the European new energy vehicle market rose, and the share of Chinese LIBs declined slightly
- Four major materials: After 2015, the market share of the four major materials continued to increase, and the supply share of Chinese LIB material Companies in each sectors has exceeded 60% in 2020.

Domestic production rate of lithium battery and four major materials



Source: GGII, CIAPS, CICC research

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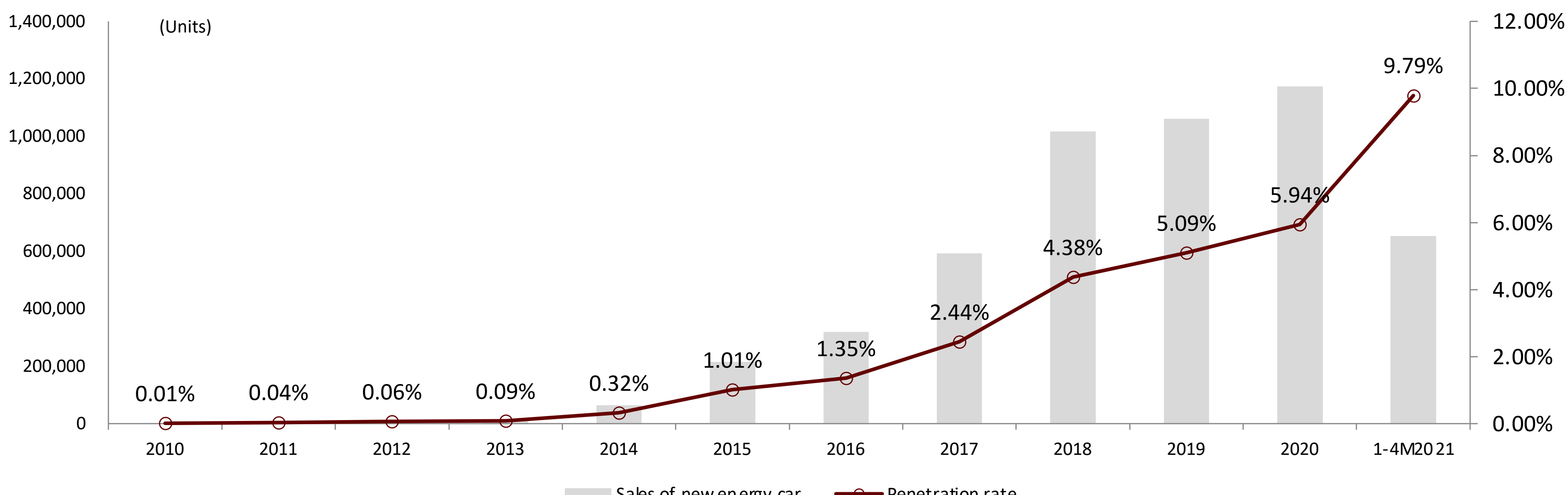
Chapter 2

Chinese market: Policies from demand and supply side promote the development of LIB supply chain

EVs stimulated by fiscal subsidies, tax exemptions and right-of-way policies

Since 2010, China has driven the rapid penetration of new energy vehicles from 2010 to 2020 through a series of policies such as purchase subsidies, tax reductions, and rights-of-way preferential treatment:

- **Financial subsidies :** In June 2010, *Pilot Subsidies for Private Purchase of New Energy Vehicles* launched, which gave 13 pilot cities to purchase PHEVs and EVs with national subsidies: 3000 RMB/kWh, PHEV up to 50,000 RMB, EV up to 60,000 RMB; local governments also supported subsidies; since 2016, subsidies would be implemented nationwide; in 2020, subsidies was extended to 2022 and would retreat to 10%/20%/30% in 2020-2022.
- **Tax reduction:** *Opinions on Accelerating the Promotion of New Energy Vehicles* issued, which indicated EVs and PHEVs purchased from 2014/9/1 to 2017/12/31 were exempted from vehicle purchase tax (10%); in 2020, the exemption policy was extended to 2022.
- **Right-of-way policy:** license-restricted cities would issue special licenses for new EVs; new EVs were not restricted or unable to be purchased.



Source: CPCA, CICC Research

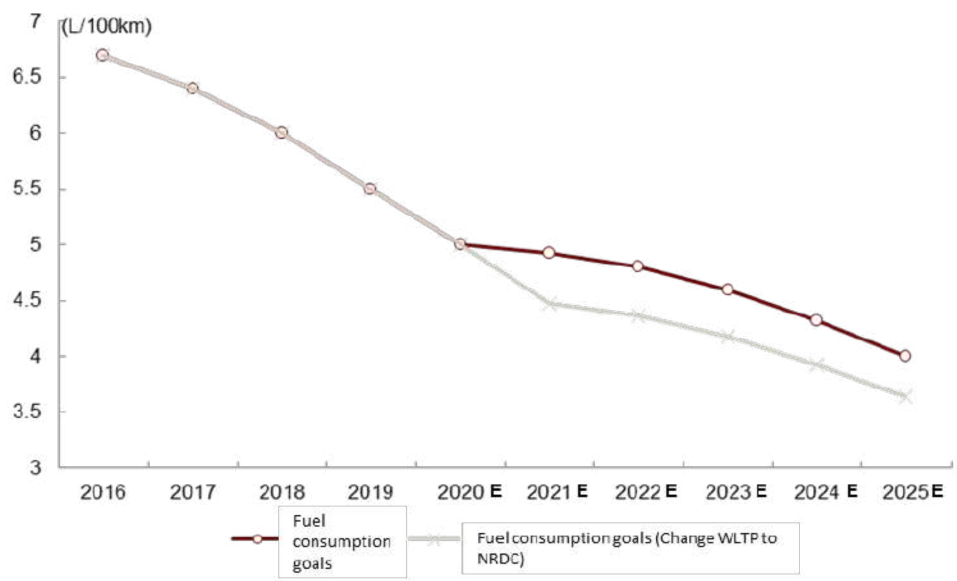
Dual-point policy will be the most important policy for EVs

After the subsidy completely declined, we believe that new energy passenger vehicles are promoted mostly by the dual-point policy, and new energy commercial vehicles are mainly promoted through policies such as local bus subsidies and charging subsidies.

The dual-point policy is committed to achieving 2 goals: 1) to guide the increase in the penetration rate of EVs, 2) to realize the subsidy of fuel vehicles to new energy vehicles through point-trading. We believe that the dual-point policy will significantly tightened after 2020, and the price of points will rise.

- Evidence of the tightening of dual-point policy: CAFC uses WLTP operating conditions for fuel consumption, and the average fuel consumption increased by more than 10%, and the 2025 target has been reduced to 4 L/100 km.

Requirements on fuel consumption from CAFC draft



Source: MIIT, CICC research

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Roadmap instructs the development of EVs in medium and long term

Energy-saving and New Energy Automobile Industry Development Plan and Roadmap instructed：

- **2016-2017 edition:** In 2020/2025/2030, the penetration of EVs will reach 7/15/40% of vehicle sales; the specific energy of the power battery cell will reach 300 Wh/kg, and the specific energy of system strives to reach 260 Wh/kg, and the cost will be less than 1 RMB/Wh. By 2025, EVs will account for more than 20% of vehicles, and the specific energy of the power battery system will reach 350 Wh/kg.
- **2020 edition:** In 2025/2030/2035, the penetration of EVs will reach 20%/40%/50%, of which the proportion of pure EVs is far more than 90%; the energy density of popular batteries will be more than 200 Wh/kg in 2025, and the cost will be less than 0.35 RMB/Wh; by 2030, the density will reach 350 Wh/kg, and the cost will be less than 0.30 RMB/Wh.

Guidance of Roadmap	2025	2030	2035
Penetration rate of AFVs	New energy vehicles accounted for 20% the total sales, and more than 90% are BEV	New energy vehicles accounted for 40% the total sales, and more than 93% are BEV	New energy vehicles accounted for 40% the total sales, and more than 95% are BEV
Cell energy density	- Ordinary type: 200Wh/kg - Commercial type: 200Wh/kg -High-end type: 350Wh/kg	- Ordinary type: 250Wh/kg - Commercial type: 225Wh/kg -High-end type: 400Wh/kg	- Ordinary type: 300Wh/kg - Commercial type: 250Wh/kg -High-end type: 500Wh/kg
Cost	- Ordinary type: <Rmb0.35/Wh - Commercial type: <Rmb0.45/Wh -High-end type: <Rmb0.5/Wh	- Ordinary type: <Rmb0.32/Wh - Commercial type: <Rmb0.4/Wh -High-end type: <Rmb0.45/Wh	- Ordinary type: <Rmb0.3/Wh - Commercial type: <Rmb0.35/Wh -High-end type: <Rmb0.4/Wh

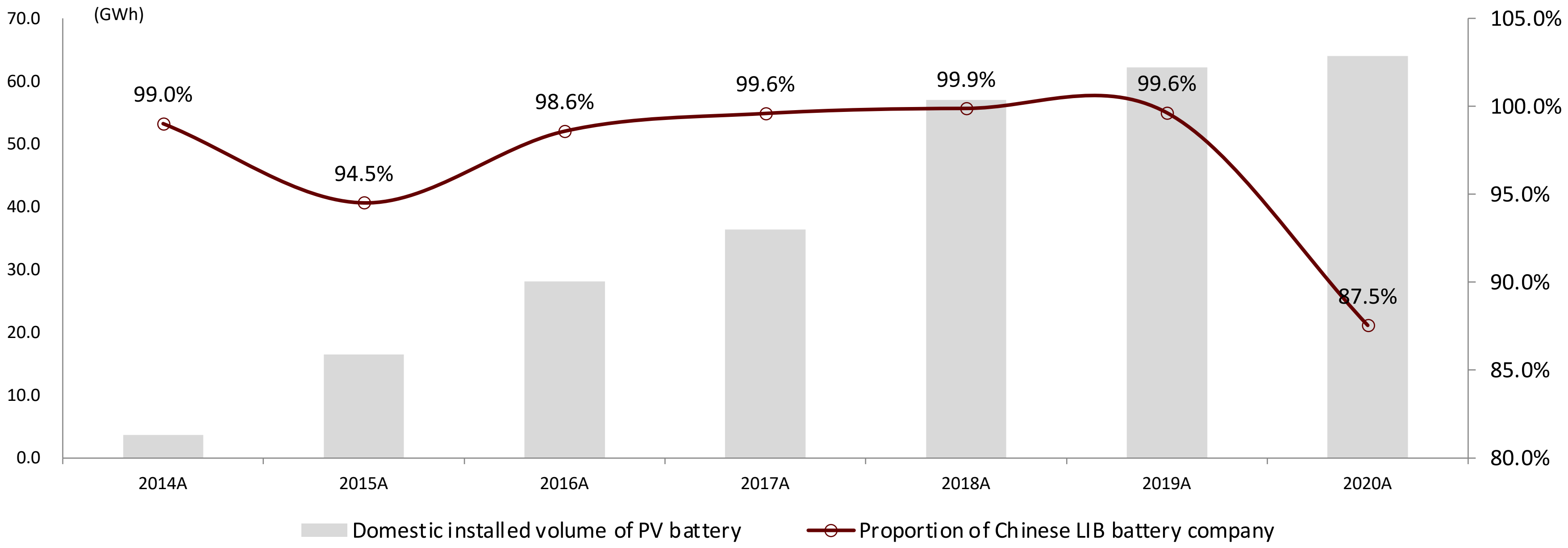
Source: State Council, MIIT, CAAM, CICC research

‘Whitelist of battery’ defenses for domestic power batteries

- In March 2015, *Regulations for Automotive Power Batteries Industry* issued, and stipulated that only EVs equipped with batteries that entered the whitelist could enjoy subsidies. From November 2015 to July 2016, 4 batches of whitelist of 57 battery companies, all of which were domestic power battery companies, and no foreign power battery manufacturers were shortlisted.
- On 2019/6/21,*Regulations for Automotive Power Batteries Industry* was officially abolished.

The whitelist strives for a period for the development of the domestic lithium battery industry chain. Since 2014, the domestic power battery demand has basically achieved self-sufficiency.

Percentage of domestic installed volume of PV battery by Chinese LIB companies



Source: GGII, CICC research

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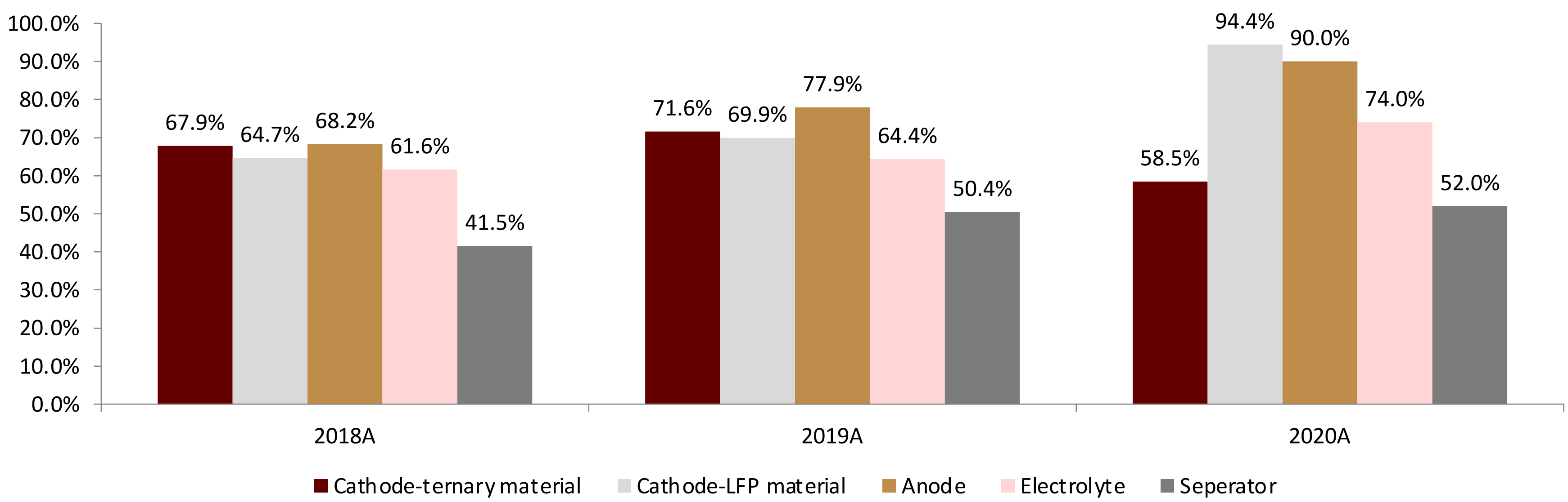
The rise of domestic power battery drives the development of LIB

The rise of domestic power companies promoted the development of local LIB chain; In 2013, 60-80% of the core materials of batteries need to be imported, and now they are fully self-sufficient and cut into the global supporting facilities:

- 2018-2020: the global supply of China's 4 major materials for LIB is rising. In 2020, more than half of the world's 4 major materials came from China.

Percentage of total shipments by Chinese companies for four LIB materials increased year by year



Source: CIAPS, GGII, CICC research

European and American demand for localized supply chains driven the globalization of Chinese LIB capacity

The global EV industry chain concentrated in East Asia in the past 10 years, and concentrated in China in the past 5 years. The division of labor has led to the faults in emerging industrial chains such as EVs. Demand for localization of chains is strengthened: Europe and US strive to cultivate localized companies; short-term S&D gap pushes them to introduce external companies, and exchange technology with the market; as for the supply chain security, European and American OEMs hope that the supply chain distance will be shortened and decentralized, which all provide an opportunity for Chinese companies.

We observed that Chinese LIB suppliers are planning overseas capacities; we believe that Chinese LIB suppliers will enter Europe and US by virtue of its manufacturing and cost advantages.

		Region	Investment amount	Capacity plan	Expected completion date
PV battery					
	CATL	Germany	Rmb14.1bn	28GWh	2023
	Farasis	Germany	Rmb4.6bn	10GWh	2022
	SVOLT	Germany	Rmb16.5bn	24GWh	2023
Electrolyte					
	TINCI	Czech	Rmb275mn	100,000 tonnes	1Q22
	CAPCHEM	Poland	Rmb360mn	40,000 tonnes	2Q21
	GUOTAIHUARONG	Poland	Rmb300mn	50,000 tonnes	
Diaphragm					
	Yunnan Energy	Europe	EUR183mn	400mn square meters	2022
	SENIOR	Europe	Rmb130mn	90mn square meters	2023

Source: Corporate filings (CATL, Farasis, TINCI, etc.), CICC research

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Chapter 3

European market: carbon emission policy and strong subsidies catalyze market demand, government emphasizes the construction of local lithium industry chain

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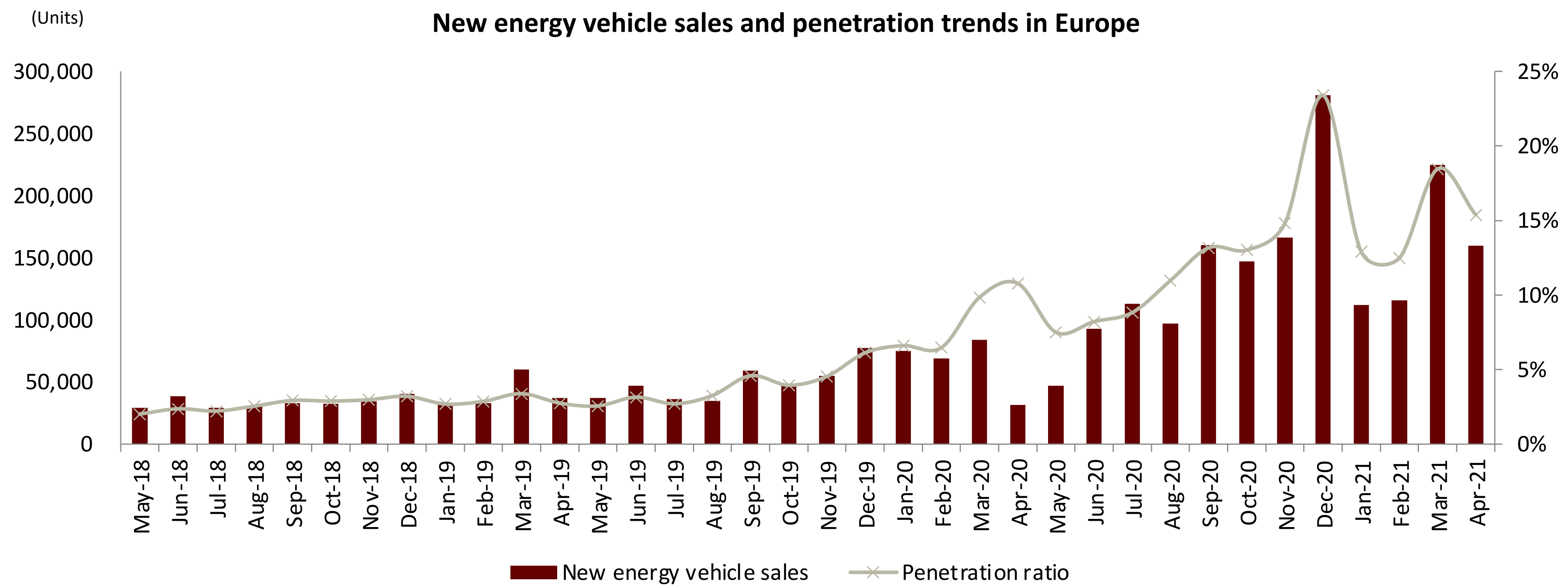
European EV penetration rate is increasing rapidly driven by policies

Europe has formed a "sandwich" structure policy based on the plan under the 2050 carbon neutral target. Under this structural policy, there are strong subsidies and mandatory targets, which promotes the acceleration of the supply-side electrification transformation and the increase of electric vehicle supply.

At the same time, the demand side is driven by strong subsidies, resulting in a high growth of new energy vehicle sales. Since 4Q20, the penetration rate has climbed to more than 15%.

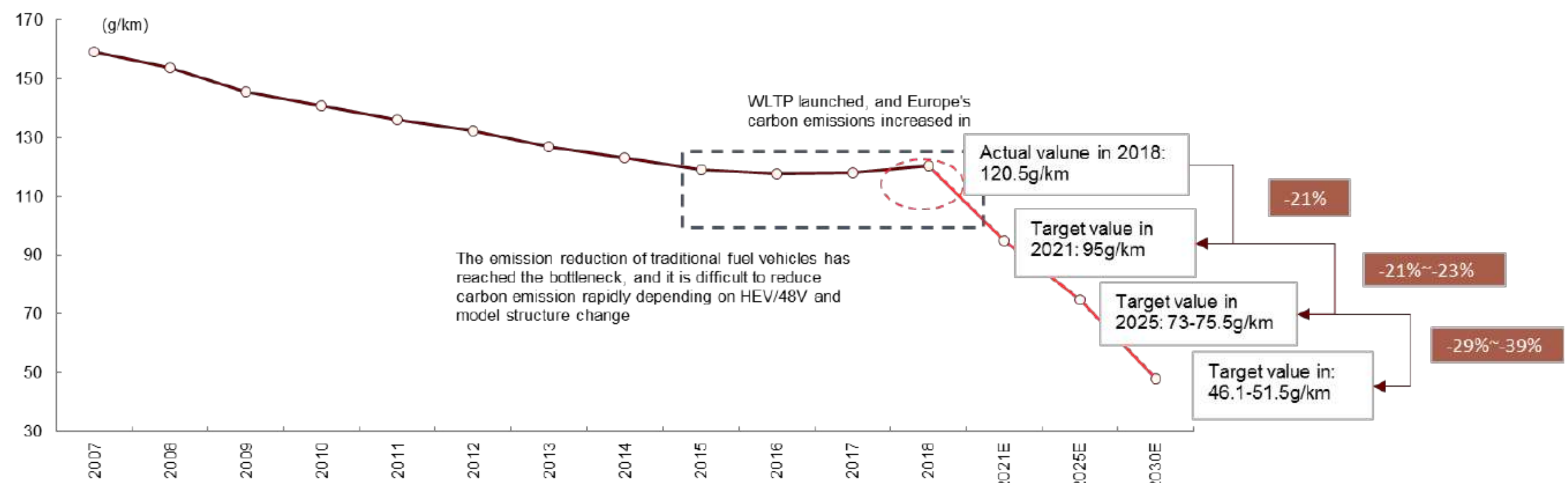


Source: EV-sales, CICC research

European carbon emission policy is the core driving force of EV growth

Carbon emission planning is the core driving force of the EV growth in Europe. The EU's carbon emission target in 2021 is 95g / km. **Based on the latest EU 2030 emission reduction target (55% lower than 1990), the target in 2025 will continue to decrease by 21-23% compared with 2021, and the target in 2030 will further decrease by 29-39% compared with 2025.** However, the average carbon emission of passenger cars in Europe was 118.5g/km in 2017, which basically remained unchanged from 2015 to 2017. In 2018, the average carbon emission of European car companies even increased to 120.5g/km affected by the conversion of NEDC to WLTP.

- Car companies will face fines for exceeding carbon emissions. If calculated according to the carbon emission levels in 2017, Volkswagen will face a maximum fine of 9.2 billion euros in 2021.
- The emission reduction of fuel vehicles has reached the bottleneck, with no decline from 2016 to 2017. In 2018, the emission reduction of fuel vehicles has even increased affected by the change of standards. The pressure to achieve the carbon emission target forces car companies to accelerate the electrification.
- The change of German car companies' path will also affect their global sales structure and accelerate the pace of global electrification.



Source: EUROPA, CICC research

European countries have diversified incentives for EV, with penalties and subsidies existing at the same time

Incentive policies for EV and punitive policies for fuel vehicles are implemented at the same time.

- **The comprehensive cost of fuel vehicles continues to increase:** 1) the purchase and ownership tax is directly related to carbon emissions in many European countries, and these taxes continue to increase for high emission vehicles. 2) Some countries impose punitive taxes on the purchase of high emission fuel vehicles.
- **Direct purchase/conversion subsidy and large tax deduction stimulate the purchase of EV:** European countries with great passenger car sales and high EV penetration have introduced direct purchase subsidy (UK/France/Germany/Italy/Spain), replacement subsidy (France/Italy) or large tax deduction (Norway) for EV.
- **Reduction of ownership tax and private use of company car tax to reduce life cycle cost:** the ownership tax (vehicle turnover tax paid regularly) for new energy vehicles is reduced according to carbon emissions in major European countries. Meanwhile, private use of company car is a common corporate welfare in Europe, so the reduction of private use of company car tax also forms a significant incentive for new energy vehicles.

	China	UK	France	Germany	Italy	Spain	Norway	Netherlands
Purchase subsidy	★	★	★	★	★	★		
Replacement compensation			★		★			
Purchase tax or registration fee reduction	★		★			★	★	★
Ownership tax relief		★		★	★	★		★
VAT relief				★			★	
Tax relief for private use of corporate vehicles		★	★	★			★	★
ICE purchase penalty			★		★			
Purchase subsidy deadline	2022	2023	2022	2025	2021	2020	-	2025
Maxinum purchase subsidy (2019, Rmb1,000/vehicle)	2.5	3.1	4.6	3.1	3.9	4.3		
Maxinum purchase subsidy (2020, Rmb1,000/vehicle)	**2.3**	**2.6**	**5.6**	**7.2**	**3.9**	**4.3**		**3.2**
Road concessions (free parking, free tolls, etc)		★		★		★	★	

Source: ACEA, wallbox.com, CICC research

European direct purchase subsidies are currently higher than China and most of them are extended to 2022

Major European countries have sustained purchase subsidies or large tax reduction. Since the outbreak of the COVID-19, subsidies have been on the rise, and most of them have been extended to 2023. Countries in Europe with continuous subsidies for EV purchase include France, UK, Germany, etc., and their national subsidies are even earlier than those of China. Some Eastern European countries with low EV penetration (such as Poland, Romania, etc.) have greatly increased the purchase subsidies after 2H19, while Norway has directly stimulated the consumption of EV by reducing the 25% value-added tax.

Pure electric vehicle purchase subsidy			2019	2020	2021	2022	2023	Expiry date
Europe								
France	EUR		6000	6000-7000	6000	5000	4000	2023
		YOY			-14%	-17%	-20%	
Germany	EUR		4000	6000	9000			2025
		YOY			50%			
Irish	EUR		5000	5000	5000			2021
		YOY			0			
Italy	EUR		4000	4000	6000			2021
		YOY			50%			
Romania	EUR		10000					
		YOY						
Slovenia	EUR		7500	8000				
		YOY						
Spain	EUR		5500	5500	5500			2023
		YOY			0			
Swedish	EUR		5760					
		YOY						
Britain	EUR		4061	3481	2901			2025
		YOY			-17%			
Poland	EUR		8600	8600	8600			2020
		YOY			0			
Slovakia	EUR		8000	8000				2020
		YOY						
Austria	EUR		3000	3000	5000			
		YOY			67%			
Netherlands	EUR			4000	4000	3700	3350	2025
		YOY			0	-8%	-9%	
Asia								
South Korea	EUR			5948	5948			
		YOY			0			
Japan	EUR			3168	6336			
		YOY			100%			
China	EUR		2329-3234	2058-2859	1652-2287	1156-1601		
		YOY		-10%	-20%	-30%		

Source: Electrive, CICC research

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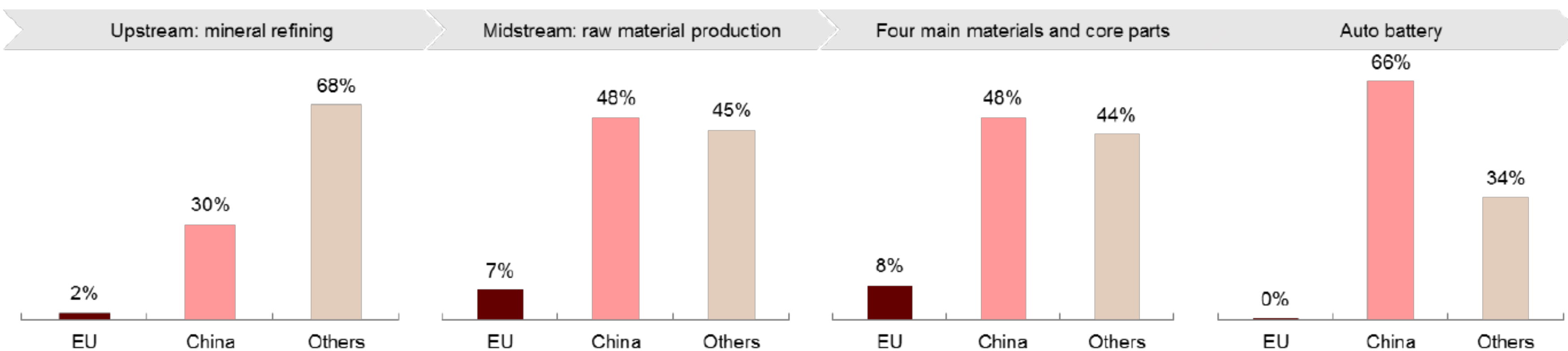
Europe emphasizes the construction of local lithium battery industry chain

The vice president of the European Battery Association (EBA) delivered a speech on May 19: the power battery is the core of the industrial recovery. In 2022, the total output value of the European battery ecosystem will reach 210 billion euro. EAB and related enterprises will strengthen the development of EV and the autonomy of EV production and lithium industry.

- EBA proposes that the European battery ecosystem will create 1 million jobs and 210 billion euro output value in 2022. At the same time, the European Investment Bank (EIB) stressed that batteries and related industrial chains would have high investment priorities.
- EBA will promote the localization of the European battery supply system to reduce its dependence on the supply chains of China and South Korea. Europe's power battery industry is expected to account for 14.7% of the global share in 2024, surpassing the United States and other Asian countries except China.
- EBA will work with EIB, member countries and related enterprises to promote: 1) large investment, 2) sustainable development and innovation of power batteries, and 3) building an independent material supply system in Europe.

No scaled power battery supply chain in Europe, and the localization rate less than 10% by 2018



Source: JRC, CICC research

Chapter 4

US market: Biden government's new energy stimulus policy is unprecedented, and local demand and industrial chain construction are expected to take a turn for the better

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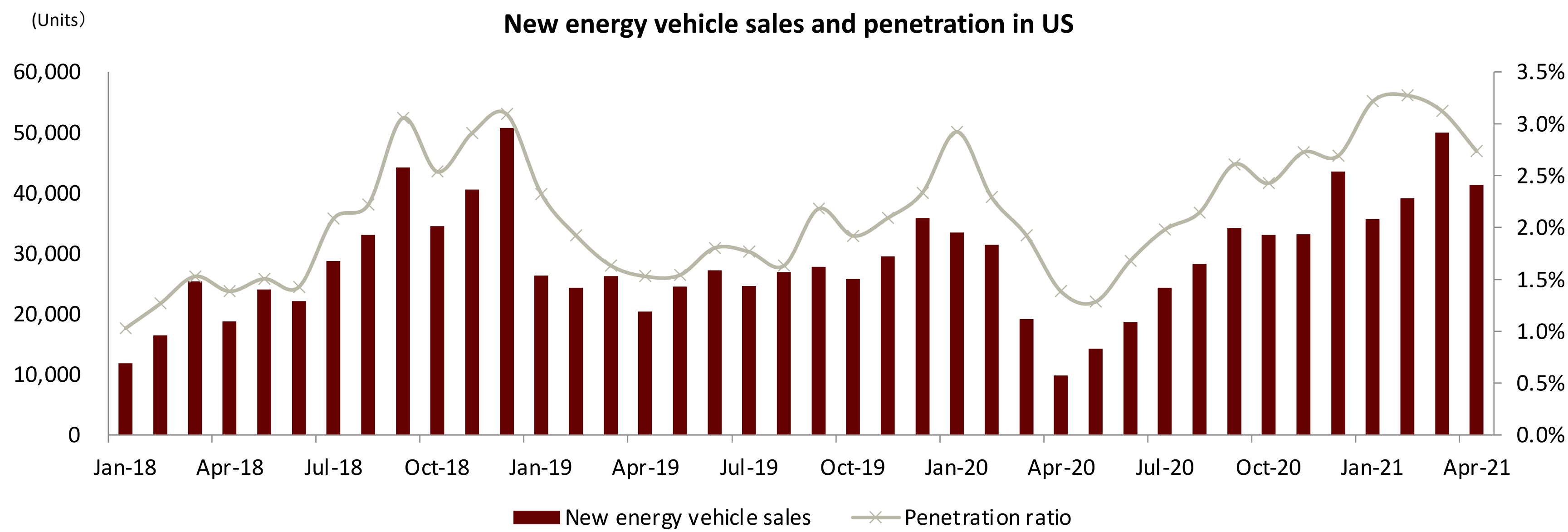
The current EV penetration rate is lower in US

The current US policy of new energy vehicles is limited, and there are few high-quality new energy vehicles (Tesla's penetration rate is already high), which leads to the slow development of new energy vehicle market in US. The penetration rate is at a low level of 2-3% since 2020.

The US national new energy policies include CAFE policy and EV tax credit policy, but: 1) the 2025 goal of CAFE value set by the Obama government was locked at a low level during Trump government, which did not promote the transformation of fuel vehicles; 2) the beneficiaries of EV tax credit are limited (only for the group with high tax amount), and there is a quota limit of 200,000 units. The quota of GM and Tesla has been used up.

As a whole, current U.S. policies have limited efforts to promote supply-side transformation and consumption of new energy vehicles.

New energy vehicle sales and penetration in US



Source: EV-sales, CICC research

US president Biden put forward a 174 billion new energy stimulus plan

Plan for a clean energy revolution and environmental justice: Biden directly put forward a $174 billion proposal to promote the development of electric vehicles.

- Invest $100 billion to provide subsidies for the purchase of electric vehicles;
- Invest $15 billion to build 500,000 electric vehicle charging stations;
- Invest $10 billion to support new tax credits for zero-emission medium and heavy vehicles;
- Invest $45 billion to convert at least 20% of yellow school buses into new energy vehicles;
- The remaining funds are used for the electrification of federal service vehicles such as the U.S. Postal Service.

The Biden plan for a clean energy revolution and environmental justice	Major content
Target	**Achieve a 100% clean energy economy and net-zero emissions no later than 2050 here at home.**
United States Federal level	Requiring aggressive methane pollution limits for new and existing oil and gas operations.
	Using the Federal government procurement system – which spends $500 billion every year – to drive towards 100% clean energy and zero-emissions vehicles.
	Reducing greenhouse gas emissions from transportation – the fastest growing source of U.S. climate pollution – by preserving and implementing the existing Clean Air Act, and **developing rigorous new fuel economy standards aimed at ensuring 100% of new sales for light- and medium-duty vehicles will be electrified and annual improvements for heavy duty vehicles.**
	Doubling down on the liquid fuels of the future, which make agriculture a key part of the solution to climate change. Advanced biofuels are now closer than ever as we begin to build the first plants for biofuels, creating jobs and new solutions to reduce emissions in planes, ocean-going vessels, and more.
	Establishing targeted programs to enhance reforestation and develop renewables on federal lands and waters **with the goal of doubling offshore wind by 2030.**
	The Biden plan will double down on this approach to create the industries of the future by investing $400 billion over ten years. Biden will establish ARPA-C, a new, cross-agency Advanced Research Projects Agency focused on climate. This initiative will target affordable, game-changing technologies to help America achieve our 100% clean energy target.
	Identify the future of nuclear energy. Supporting a research agenda through ARPA-C to look at issues, ranging from cost to safety to waste disposal systems, that remain an ongoing challenge with nuclear power today.
	Accelerating the deployment of electric vehicles. Biden will work with our nation's governors and mayors to support the deployment of more than 500,000 new public charging outlets by the end of 2030.In addition, Biden will restore the full electric vehicle tax credit to incentivize the purchase of these vehicles. He will ensure the tax credit is designed to targeted middle class consumers and, to the greatest extent possible, to prioritize the purchase of vehicles made in America.
State and city level	New Mexico Governor Michelle Lujan Grisham pledged to reduce statewide greenhouse gas emissions by 45% by 2030; New Mexico is currently the country's third-largest producer of oil.
	Colorado Governor Jared Polis committed his state to 100% clean electricity by 2040; he signed an executive order to move the state to zero-emission vehicle standards and increase adoption of electric vehicles.
	Oregon lawmakers have introduced a carbon cap and trade proposal that would set a 52 million metric ton cap on greenhouse gas emissions.
	Cities have taken the lead too: over 35 cities set a goal of 80% emissions reductions by 2050 and over 400 mayors honor the Paris Agreement.
Call on the rest of the world	**Re-enter the Paris Agreement on day one of the Biden Administration and lead a major diplomatic push to raise the ambitions of countries' climate targets.**
	Pursue strong new measures to stop other countries from cheating on their climate commitments.
	Stop China from subsidizing coal exports and outsourcing carbon pollution.
	Demand a worldwide ban on fossil fuel subsidies. Biden will build on the achievements of the Obama-Biden Administration to get G20 countries to phase out inefficient fossil fuel subsidies. He will lead by example, with the United States cutting fossil fuel subsidies at home in his first year and redirecting these resources to the historic investment in clean energy infrastructure.
	Create a Clean Energy Export and Climate Investment Initiative.

Source: White house website, CICC research

Clean Energy for America Act further increases subsidies for new energy vehicles

On May 26, 2021, the U.S. Senate Finance Committee passed the proposal of Clean Energy for America Act. The proposal's stimulus to new energy exceeded market expectations.

- **Trigger change for tax credit retrogression:** cancel 200,000 units restriction and change to retrogression in 3 years after the EV penetration rate reaches 50%, retrogression in the 1st/2nd/3rd year is 25%/50%/100%.
- **Tax credit ceiling raises:** single car credit limit raises from $7,500 to $12,500. **Manufacturer incentive:** provide 30% tax credit for manufacturers to help them restructure or build new factories for production, and encourage manufacturers to buy commercial electric vehicles.
- **TBC:** the bill still needs to be passed by the Senate and the house of Representatives.

Summary of proposed Clean Energy for America Act		
Clean Fuel Production		
	Current law	Incentives for a variety of alternative fuels and blends, including revenue incentives and excise tax credits (US$0.5-US$1.01 per gallon) for natural gas, propane, hydrogen, etc. These incentives expire at the end of 2017.
	Proposal	The act proposes technology-neutral incentives based on how much carbon is emitted over the life of the fuel. The current incentives would need to be at least 25% less than the current U.S. average, with zero and net negative emissions likely to receive a maximum reward of US$1 per gallon. Between now and 2030, the fuels that meet the incentives will need to get cleaner. The fuel needs to be transport-grade and can be used on road vehicles or aircraft.
Traffic electrification		
	Current law	Under existing rules, new qualified plug-in hybrid electric vehicles and pure electric vehicles purchased by US taxpayers can enjoy the subsidy in the form of tax return.The specific subsidy amount is: US$2,500 / vehicle for 5kwh of vehicle power battery capacity, US$417/ kWh for the part larger than 5kwh, and the upper limit is US$7,500 / vehicle (all pure electric vehicles can basically meet the upper limit subsidy requirements). However, when the cumulative sales volume of new energy vehicles of automobile enterprises exceeds 200,000 units, the subsidy retrogression mechanism will be triggered: after reaching 200,000 units, the subsidy will be halved in the following first and second quarters, and then halved in the third and fourth quarters, and no subsidy will be enjoyed after that. At present, GM and Tesla have reached the upper limit and no longer enjoy subsidies.
	Proposal	1. Total amount: about US$259.5 bn in clean energy tax credit scheme, of which US$31.6bn is for electric vehicle consumer tax credit; 2. The proposal provides more fair and powerful incentives for electric transportation. The proposal will increase the tax credit limit of US$7,500 per vehicle: for vehicles assembled in the United States, a US$2,500 credit will be added on top of US$7,500, and if the factory where the vehicle is assembled has a union representative, another US$2,500 credit can be added. But that only applies to electric cars worth US$80,000 or less. 3. Expand the 200,000 vehicle tax credit for automakers and provide US$100bn in cash back for consumers. The bill also includes a 30% tax credit for manufacturers to help them reorganize or build new plants to make advanced energy technologies, and incentives to buy commercial electric vehicles. 4. If EV penetration reaches 50%, the subsidy will be phased out over the next three years.
	Transition period	To provide a transition period for administrative coordination between Treasury, EPA, and the Department of Transportation, the act extends current and soon-to-expire clean energy provisions, including legislation on refueling and charging infrastructure.

Source: Finance.senate.gov/download/clean-energy-for-america-act-of-2019-one-pager, CICC research

US lacks the domestic lithium battery industry chain, and plans to strengthen the construction of the local industry chain

In June 2021, Biden government released the supply chain safety assessment results and action plan including results and plan of large capacity batteries.

Results: the construction of US local industry chain was slow and highly dependent on foreign countries: upstream core minerals production and refinement (lithium/nickel/cobalt/copper, etc.) mainly depended on imports, and the global market share of the midstream four major materials, cells and battery packs manufacture was less than 10%. There are high risks in supply chain security.

Plans: <u>1)increase the government investment in the upstream core minerals, and the government fiscal, tax and financial support for the construction of midstream lithium industry chain; 2)build circular industry, strengthen supply guarantee, and form a complete closed-loop industry chain; 3)give subsidies to cars with high localization rate to promote the use of local industry chain.</u>

Percentage of total manufacturing capacity by country for various component manufacturing (2021)

	Cell	Cathode	Anode	Electrolyte	Seperator
US	8%	0%	10%	2%	6%
China	76%	42%	65%	65%	43%
Japan	4%	33%	19%	12%	21%
South Korea	5%	15%	6%	4%	28%
Others	7%	10%	0%	17%	2%

Source: BloombergNEF, CICC research

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Chapter 5

Technical route: LFP and High nickel ternary develop simultaneously, LFP may start global supply in 2021

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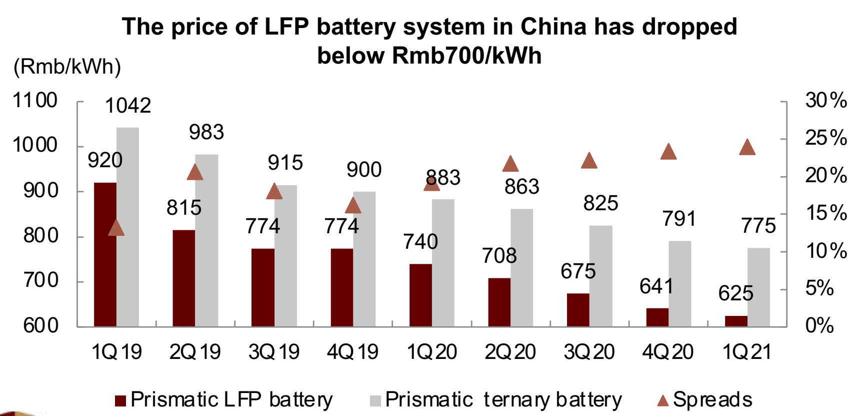
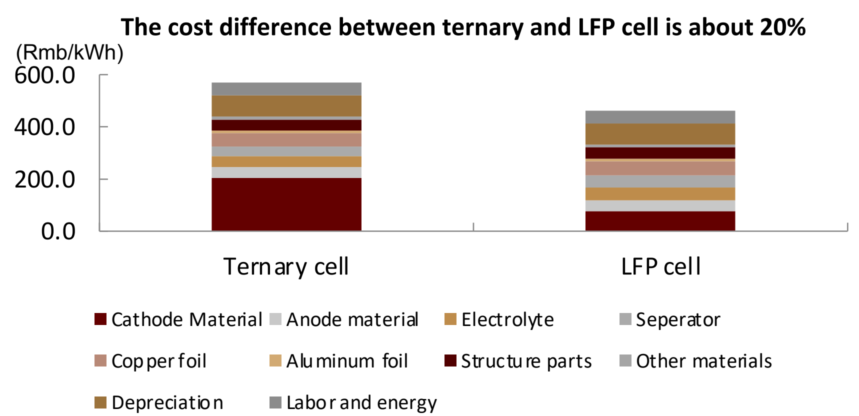
Demand for price parity with fuel vehicle, LFP is expected to penetrate rapidly in new energy vehicles

- **We believe that three major factors will drive the penetration rate of lithium-iron batteries to further increase , and it is expected to export to overseas.**
  - **High cost performance and high security.**
  - **The acceleration of the penetration rate of new energy vehicles brings forward the demand for price reduction.**
  - **Leading automobile companies such as Tesla and Daimler accepted the LFP.**
- **Cost performance: The current average price of LFP is about 625 ¥/kWh. We believe that combined with CTP, it can meet the maximum demand of about 500km for general A-level vehicles.**
  - The application limitation of lithium iron is mainly due to its low volume/mass energy density, which is suitable for the mileage below 500km of the general vehicle.
  - Considering further price reduction, we believe that the cost of LFP for 500km passenger cars can be 44/32/29 thousand yuan respectively in 2021/2025/2030, so that models for the public will have a better cost performance.
  - The current median price of 100 km for A00/A0/ A-class models is 27/38/41 thousand yuan. We believe that the optimization of energy consumption and the use of LFP are expected to achieve fuel-electricity parity soon for models for the public.

Average price of LFP has reached Rmb625 /kWh level



Costs difference between LFP and ternary cell (2020)

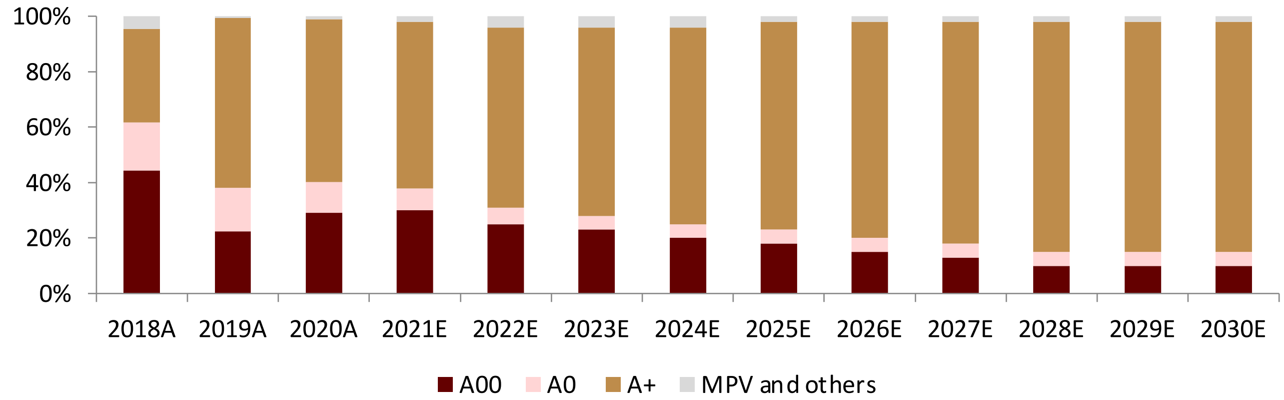


Source: GGII, CIAPS, CICC research

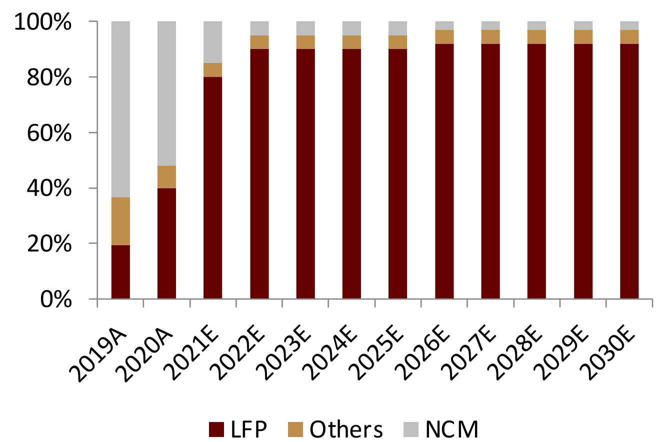
We expect that the installed proportion of lithium iron in China's A+ class models will increase rapidly and the A00 class will be fully lithium iron

- From the installed data of 2020YTM, among A00/A+ models, iron-lithium installed accounts for 40%/3%. The proportion of A00 models increased rapidly, and A+ models entered the start-up stage of LFP batch installation。
- We expect that the installation of LFP in the A00 model will accelerate.
- We expect the LFP share of China's A+ models to rise rapidly to 30% in 2021 (thanks to M3 and BYD's full replacement of iron-lithium) and continue to rise to peak in 2023. Considering the further improvement of overall mileage and the accelerated cost reduction of nickelic ternary, we expect that the overall share may fall slightly in 2024-2025.

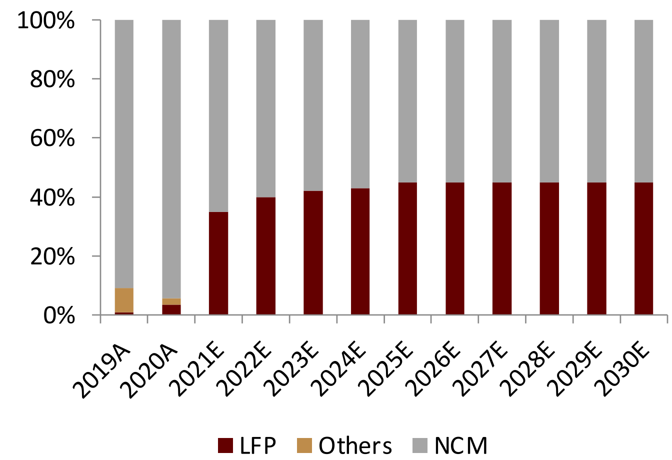
Output forecast of pure electric passenger vehicle in China



Installed structure forecast for A00 class pure electric car



Installed structure forecast for A+ class pure electric car



Source: CPCA, GGII, CICC research

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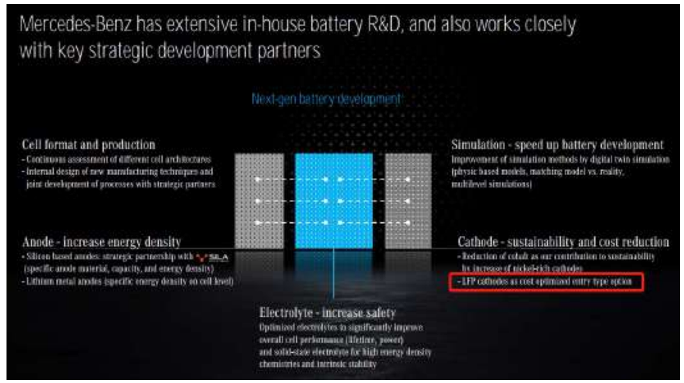
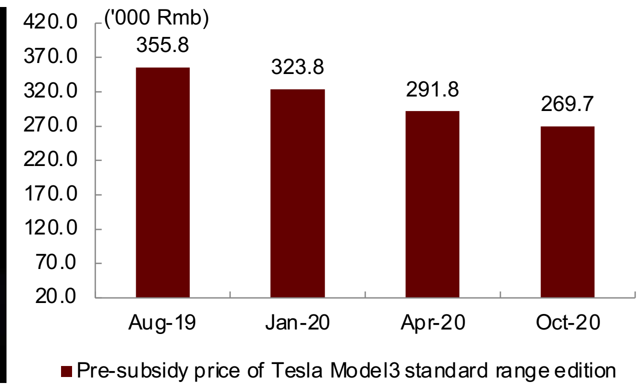
The acceptance of international automobile Co. will be improved, patent barriers will be eliminated, and LFP global supply may be started in 2021

- **The acceptance of LFP by international automobile Co. increase, and A00 in the Chinese market has positively reflected the structural change. Tesla may lead the trend further**
  - Tesla fully replace the standard version with LFP in China, bringing a new round of price reduction. Daimler also said it would introduce LFP in its entry-level models.
  - Since H2 in 2020, the installed proportion of LFP of A00 in the Chinese market has increased continuously
- **Core patent expired globally, and the export threshold is eliminated.**
  - The core is battery material basic patent WO9740541 and cathode coating patent CA2270771, and both have expired after 2020/10/30.

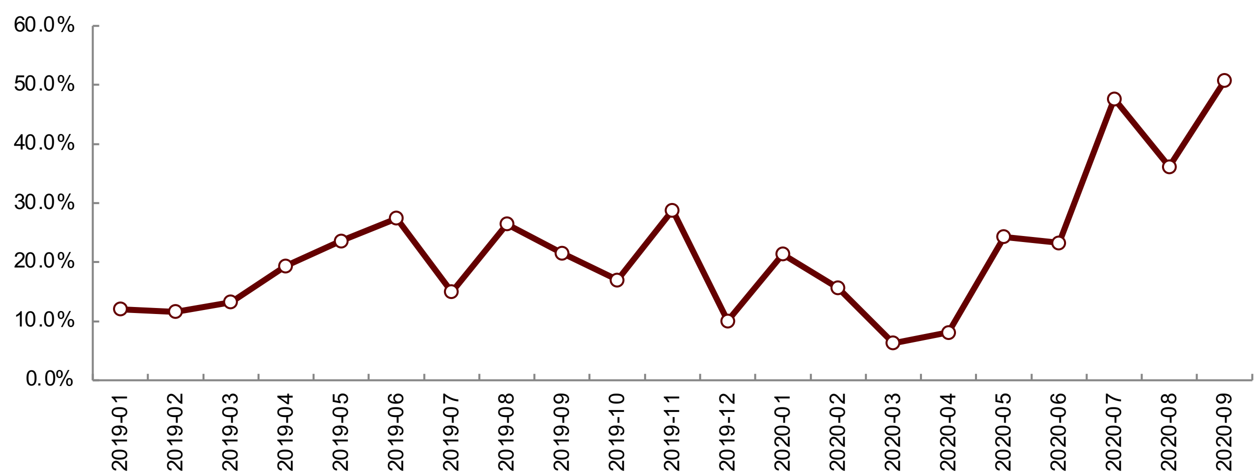
    Another patent is synthetic patents, which domestic companies can bypass through other processes.

LFP penetration rate in vehicles below 450km range could exceed our expectations





Installed proportion of LFP battery in A00-level passenger car



Source: Tesla official website, GGII, CICC research

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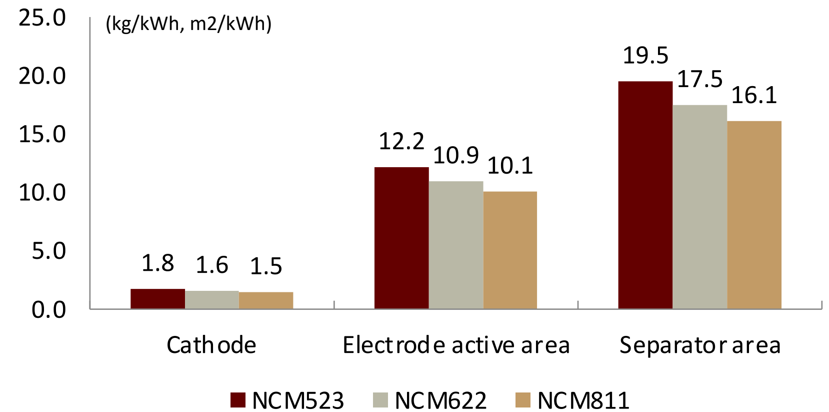
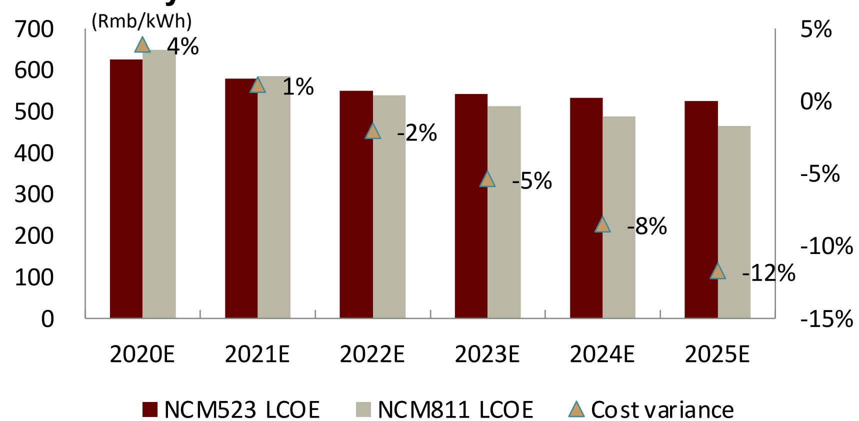
High nickel is the only way to improve the quality and reduce the cost of ternary

- **High nickel: a medium- and long-term deterministic path to improve quality and reduce cost**
- **High nickel route has dual significance of performance improvement and further cost reduction.** We estimate that the nickelic lithium battery can save about 15-17% in the use of cathode/electrode plate/diaphragm materials compared with NCM523. Considering the consistent product yield and unit price, the cost can be reduced by about 10%.
- **The manufacturing of nickelic lithium batteries is more difficult from raw materials to cells, and the leading manufacturing capacity promotes large-scale mass production.**
- **Supply chains limit current costs and process accumulation creates advantage. We believe that under the promotion of the leading, the process and supply chain will continue to improve.**
  - The overall small size of the industry and the limited number of eligible suppliers limit the rate of short-term cost reduction
  - The mid- and long-term head duopoly trend of lithium batteries is determined. Leading companies lead technological iteration and consolidate technological advantages. Supply scale will open up the supply chain space, promoting the next stage of cost reduction.

We estimate that high nickel applications will directly reduce the amount of material used in each process to drive down costs



Ideally, the high-nickel technology is expected to deliver a 12% reduction in the cost compared with NCM523 by 2025



Source: GGII, Push EVs, CICC research

Leading battery enterprises continue to promote high nickel ternary battery line

- Shanghai Auto Show released a number of models equipped with nickelic ternary battery, which is expected to build a new generation of popular models, driving nickelic ternary further volume.
- According to CIAPS data, NCM811 shipments accounted for 11%/ 24%/32% respectively in 19/20/3M21, with a significant increase in penetration rate.
- "Roadmap 2.0" plans that the specific energy of power battery will reach more than 300Wh/kg in 2035, and the nickelic ternary is in line with the direction of technical upgrading.
- CATL, LGC, SKI and Panasonic are firmly on the nickelic line

Model	Range (km)	Battery capacity（kWh）	Time to market	Price（Rmb '000）	Battery supplier	Cathode material supplier
Mercedes-Benz EQS	700	108	Released		CATL、LGC	Ronbay, B&M、MSDS, Easpring, Huayou
Mercedes-Benz EQC	500	80	Released	499.8	CATL、LGC	Ronbay, B&M、MSDS, Easpring, Huayou
Mercedes-Benz EQB	500	80	Released		CATL、LGC	Ronbay, B&M、MSDS, Easpring, Huayou
Mercedes-Benz EQA	486	66.5	Released		CATL、LGC	Ronbay, B&M、MSDS, Easpring, Huayou
BMW iX3	500	74	Released	399.9	CATL	Ronbay , B&M, MSDS
BMW iX	600	100	Released		CATL	Ronbay , B&M, MSDS
Zeekr 001	526-712	86/100	Released	281.9	CATL	Ronbay , B&M, MSDS
LEAPMOTOR C11	480	76.6	Released	159.8	CATL	Ronbay , B&M, MSDS
SAIC Audi Q4 e-tron	500	82	Released	347.2	CATL	Ronbay , B&M, MSDS
SAIC Volkswagen ID.4X	520	83.4	Released	199.9	CATL	Ronbay , B&M, MSDS
ARCFOX S	700	93.6	Released	251.9	CATL	Ronbay , B&M, MSDS
NIO ES6	430/510/620	70-100	Released	358	CATL	Ronbay , B&M, MSDS
SAIC IM L7	655/800	93/118	Released	408.8	CATL	Ronbay , B&M, MSDS
NETA U Pro	610	82	Released	99.8	CATL	Ronbay , B&M, MSDS
XPENG P7	562-700	70.78/80.87	Released	229.9	CATL	Ronbay , B&M, MSDS
ORA ES11	400	59.1	Released	103.9	SVOLT	Ronbay
Polestar 2	562	64/78	Released	252.8	CATL	Ronbay , B&M, MSDS
Peugeot e2008	360	45.24	Released	166	CATL	Ronbay , B&M, MSDS
FAW HONGQI EHS9	510	99	Released	509.8	CATL	Ronbay , B&M, MSDS
KIA EV6	600	77.4	Released	-	SK	Easpring, Ronbay, BTR
SAIC Volkswagen ID.6X	565	91	3Q21	-	CATL	Ronbay , B&M, MSDS
NIO ET7	1000	150	2022	-	Welion	
Audi RS e-tron GT	472	93	4Q21	-	LGC	Ronbay, B&M, MSDS
SAIC IM LS7	-	-	2022	-	CATL	Ronbay, B&M, MSDS
Honda SUVe concept	-	-	2022	-	CATL	Ronbay, B&M, MSDS
NETA S	800	-	2022	-	CATL	Ronbay, B&M, MSDS
Cadillac LYRIQ	500	-	2022	-	LGC	Easpring, B&M, Huayou
ORA ES11	-	-	4Q21	-	SVOLT	Ronbay
HyundaiIONIQ5	600	-	3Q21	-	-	-
Dongfeng Nissan ARYIA	600	-	Coming soon	-	-	-
Mercedes-Benz VISION AVTR	700	-	Concept cars	-	-	-
NIO EVE	-	-	Concept cars	-	-	-
Toyota BZ 4X	-	-	Concept cars	-	-	-
Lexus LF-Z	600	-	Concept cars	-	-	-
SAIC Cyberster	800	-	Concept cars	-	-	-

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Source: Ronbay Technology, autohome, corporate filings, CICC Research

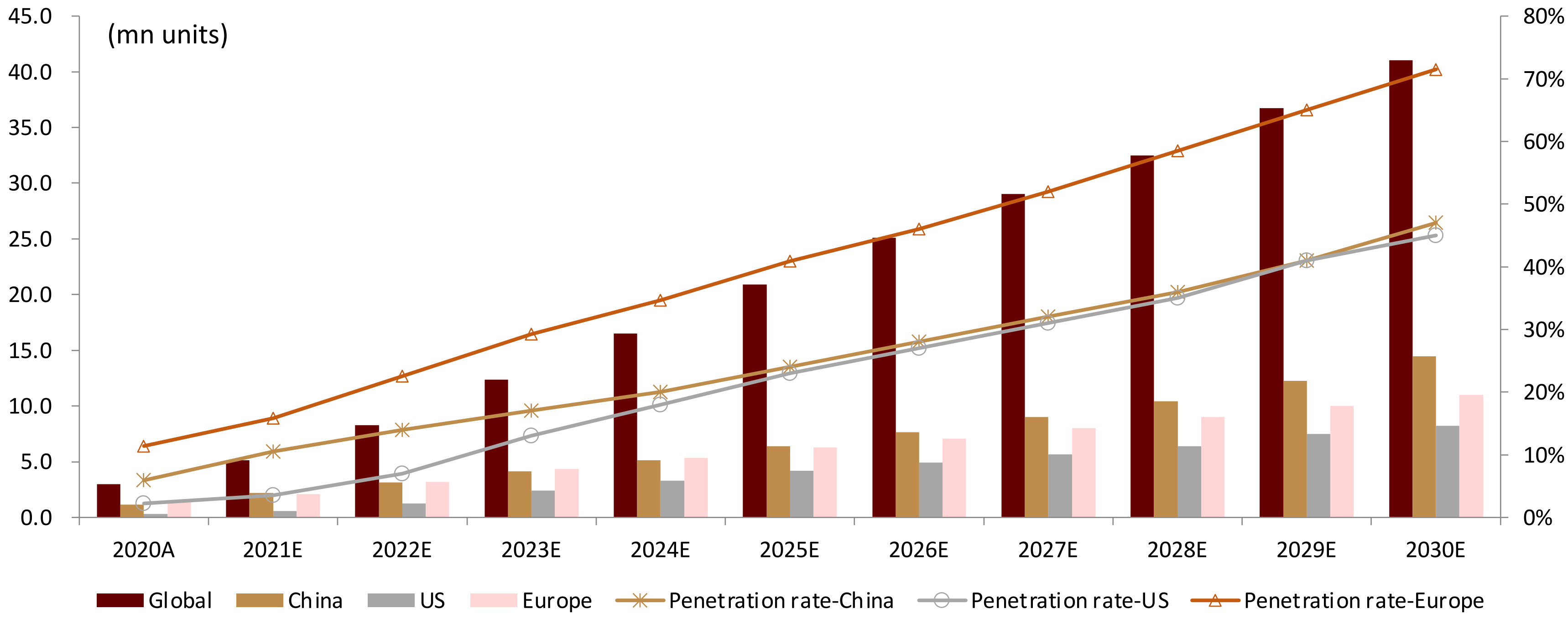
Chapter 6

Global market outlook: lithium power supply toward the era of capacity globalization and integration

Global carbon neutral: China, US and Europe will fully shift to electric

As the global consensus on "carbon neutrality" has been reached and China, US and Europe have set carbon-neutral targets for 2050-2060, we believe that the global trend of electrification is certain. We estimate that the global sales volume of new energy passenger cars will reach 20.90/41.04 million in 2025/2030, with a corresponding penetration rate of 35/64%. By region:

- China: 2025/2030e The sales volume of new energy passenger vehicles will reach 6.38/14.47 million , with a corresponding penetration rate of 24%/47% ;
- Europe: 2025/2030e The sales volume of new energy passenger vehicles will reach 6.29/10.99 million , with a corresponding penetration rate of 41%/71% ;
- US: 2025/2030e The sales volume of new energy passenger vehicles will reach 4.21/8.25 million , with a corresponding penetration rate of 23%/45% ;



Source: CAAM, EV-sales, CICC research

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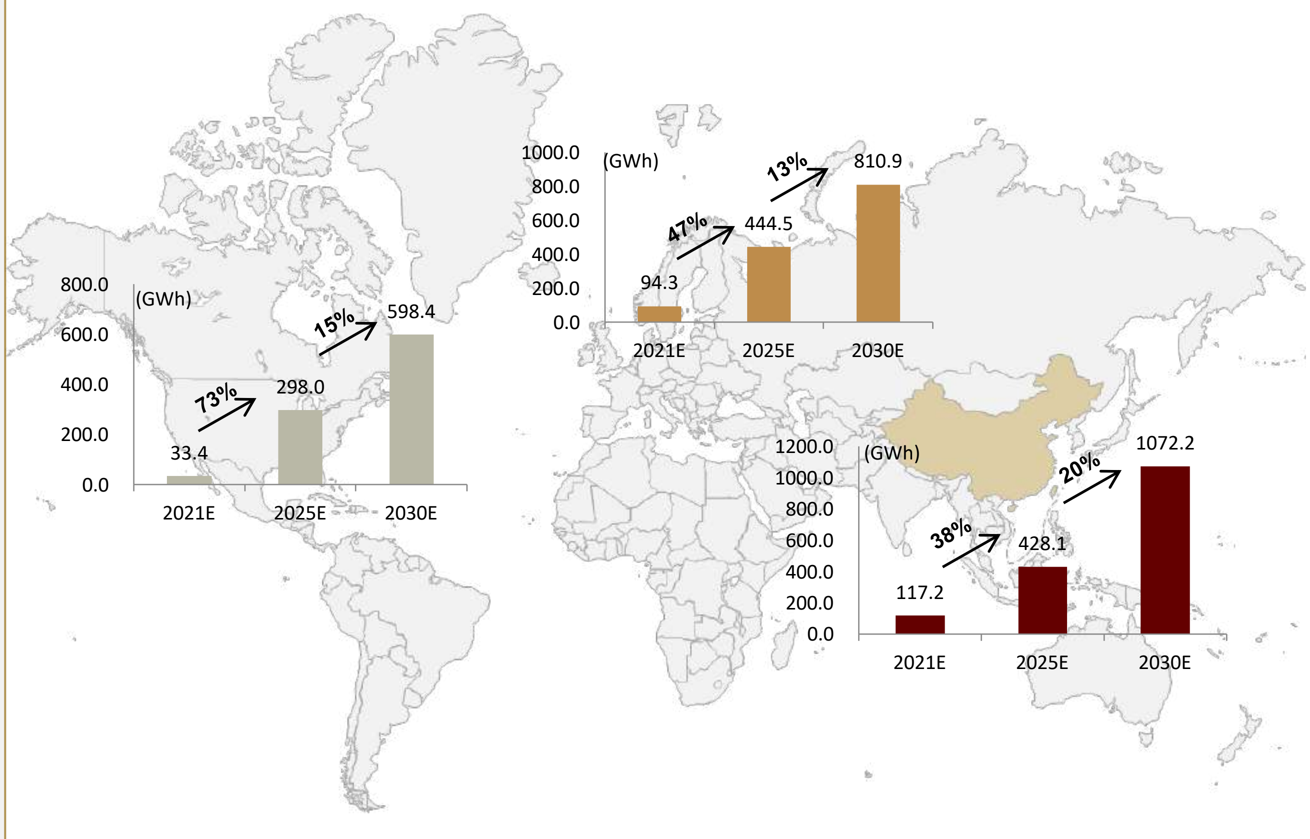
The growth of overseas demand and the strengthening of localized demand in Europe and US drive the LIB chain toward the globalization

We believe that the future lithium industry chain will shift from the current focus on East Asia to the global production layout：

- We expect that 2025/2030E overseas market power installed capacity accounts for 70%/64%; 2021-2030E China/overseas installed capacity compound growth rate of 28%/34%; It will provide momentum for the lithium industry to set up production capacity in Europe and US；
- Europe and US do not have large-scale production capacity at present, so they have a strong demand for localization of the industrial chain. OEM also hope that the lithium battery industry can support nearby facilities and reduce supply risks. Considering that domestic lithium enterprises are difficult to form in the short term, it brings historical opportunities for external lithium enterprises to enter into local supporting facilities.

Power battery installed demand forecast in different areas



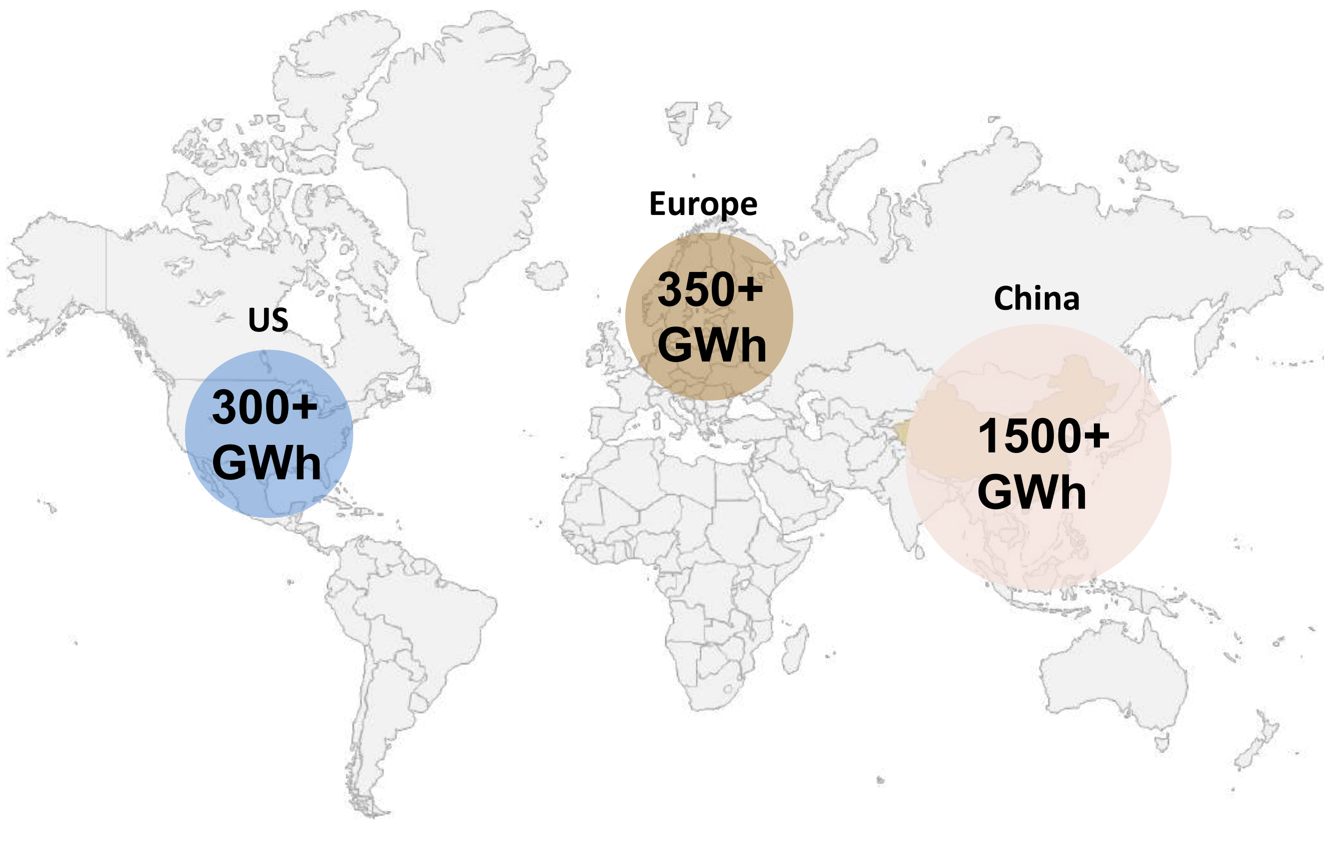
Source: ACCA, EV-sales, GGII, CICC research

LIB capacity construction in Europe and US accelerate, and enterprises in China, Japan and South Korea continue to increase capacity layout

We have observed that China, Japan and South Korea as well as domestic lithium enterprises in Europe and US have accelerated capacity layout in the European and American markets.

PV battery capacity till 2025 in China, Europe and US is planned to 1500+GWh, 350+GWh and 300+GWh, respectively.

PV battery capacity plan in 2025e in different area



Source: Corporation files, CICC research

LIB capacity construction in Europe and US accelerate, and enterprises in China, Japan and South Korea continue to increase capacity layout

PV battery capacity planned in Europe and US

Battery companies		Location	Investment amount (Rmb bn)	Target capacity (GWh)	Expected date to reach target capacity
CATL	Europe	Turing, Germany	14.1	28 (Estimated)	2023
LG Chem	Europe	Wroclaw, Poland	16.2	70	2021
	US	Ohio(Joint venture with GM)	/	35	2023
	US	Tennessee, USA (joint venture with GM)	17	35	2023
	US	Michigan	14	5	2017
	US	T.B.D.	/	70	2025
SKI	US	Georgia	13	22	2023
	US	T.B.D. (Joint venture with Ford)	17.1	60	2025
	Europe	Hungary	/	23	2023
Samsung SDI	Europe	Hungary	8.6	20	2021
Panasonic	US	Nevada	34	38	2021
Farasis	Europe	Saxony-Anhalt, Germany	4.6	10	2022
SVOLT	Europe	Saarland, Germany	16.5	24	2023
AESC	Europe	Sunderland, England	/	1.9	In production
Volkswagen	Europe	Sweden (Joint venture with Northvolt)	/	40	2023
	Europe	Salzgitter	/	40	2025
Tesla	US	Fremont, California	/	10	2022
InoBat	Europe	Slovakia	/	10	2025
Verkor	Europe	France	13.1	16	2025
FREYR	Europe	Norway	/	32	2023
Tesvolt	Europe	Germany	/	1	2021
PSA-Saft	Europe	France	39	24	2023

Source: Corporate filings, CICC research

PV battery enterprises build factories in Europe and US, which drives the nearby supporting demand of LIB materials enterprises

The construction capacity of LIB battery enterprises in Europe and US also drives the demand for supporting LIB materials enterprises. China, Japan and South Korea as well as European and American domestic LIB materials enterprises have increased capacity construction; We observed that some of the domestic LIB material enterprises have taken the lead in the overseas market in the separator link with higher barriers and the electrolyte link with integrated competitive advantages.

LIB materials capacity planned in Europe and US

		Region	Investment amount	Capacity plan	Expected completion date
Cathode					
	BASF	Germany			2022
	BASF-Precursor	Finland			
Anode					
	Mitsubishi Chemi	UK			
Electrolyte					
	TINCI	Czech	Rmb275mn	100,000 tonnes	1Q22
	CAPCHEM	Poland	Rmb360mn	40,000 tonnes	2Q21
	GUOTAIHUARONG	Poland	Rmb300mn	50,000 tonnes	
	Soulbrain	Hungary			2021
	Panax	Hungary			2022
	Enchem	Poland			
Diaphragm					
	Toray	Hungary	EUR397mn		2023
	Yunnan Energy	Europe	EUR183mn	400mn square meters	2022
	SENIOR	Europe	Rmb130mn	90mn square meters	2023

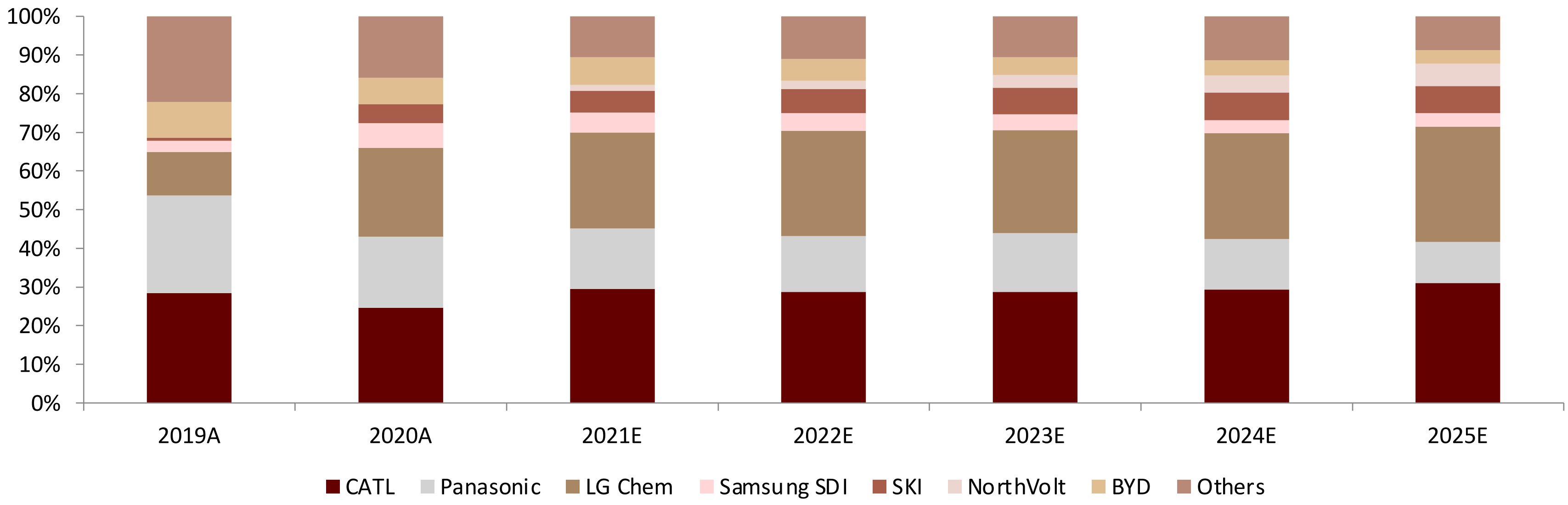
Source: Corporate filings, CICC research

Following the globalization of the industry chain, the share of the leading companies in LIB chain is expected to further increase

We believe that under the trend of the PV battery demand shifting to overseas and localization of the LIB chain in Europe and US, the leading LIB companies in the sector which go abroad smoothly are expected to fully benefit, and are expected to drive the global supporting share up in the medium and long term:

- **For PV batteries, we raise global market share estimates for LG Chem and CATL 2025E to 30-35% (from 25-30% previously).**
- **For the four material sectors, we believe that the separator and electrolyte sector are certain to go abroad. We are optimistic about SEMCORP and TINCI's long-term global market share of 45-50% and 30-35%.**

Global installed market share forecast of PV battery



Source: GGII, EV-sales, CICC research

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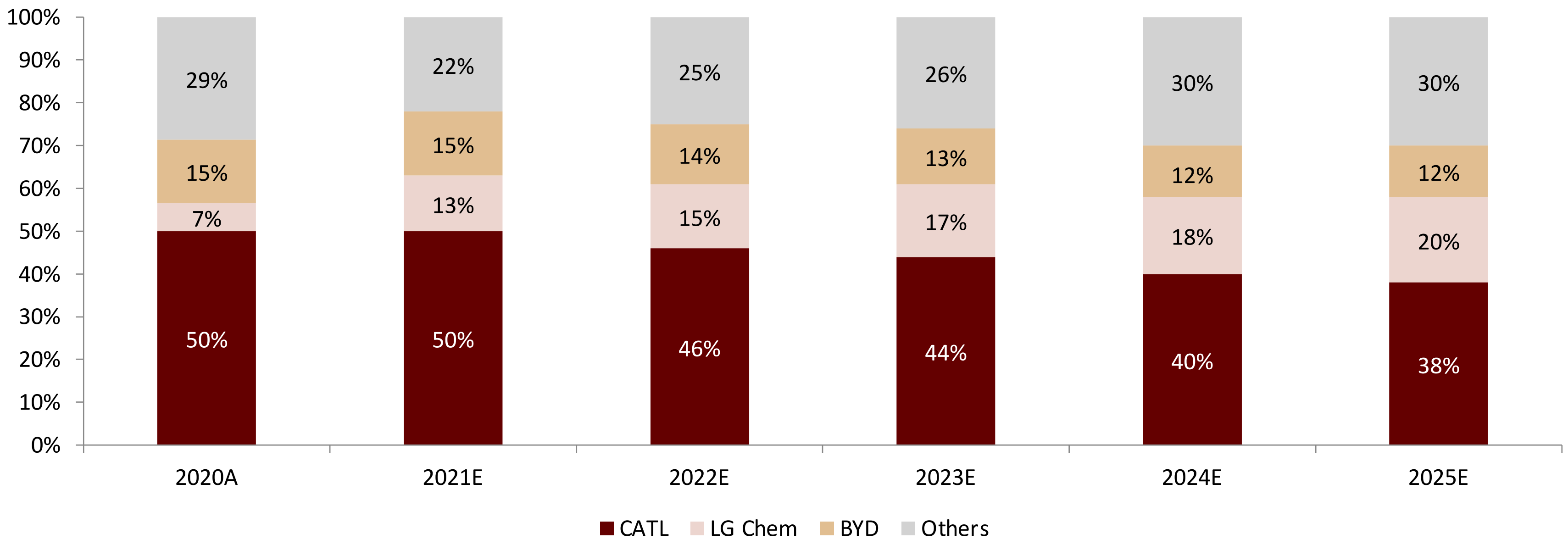
China's PV battery market is expected to be decentralized, bringing opportunities for 2nd-tier power enterprises to break out

We believe that with the rise of independent brands and new automobile manufacturers, the shares of the second-line and first-line enterprises in the industry chain are gradually shrinking in the domestic market. We believe that in the next three years, independent brands and new automobile manufacturers, including some joint ventures, will make more use of the products of 2nd-tier enterprises or supply themselves to cope with supply chain security and cost control. With the increase of 2nd-tier batteries in independent and joint ventures, the domestic pattern is expected to be decentralized, forming a pattern of one superpower and many powers. We estimate that the leading share will not exceed 40%, and the 2nd-tier battery companies will account for 30-35% of the total share.

Domestic installed market share forecast of PV battery



Source: GGII,CAAM, CICC research

Vertical and horizontal integration of LIB supply chain is expected to become the future trend

- Under the background of limited production capacity of high-quality lithium material manufacturers, capable battery manufacturers will seek to deeply bind with material manufacturers to ensure the supply.
- A key condition to ensure high quality delivery is a stable supply of raw materials, and battery and material manufacturers are also seeking partnerships with mining companies.
- Both CATL and LGC have a strong control over the cathode industry chain. On the one hand, they produce cathode materials by themselves, and on the other hand, they lock the supply of lithium, cobalt, nickel and other key resources by buying shares in upstream resource enterprises or signing long orders with resource enterprises.

Resource	Battery	Cathode	Anode	Separator	Electrolyte
		Dynanonic (LFP)	KAIJIN	Yunnan Energy (Wet)	Tinci
Shareholder: Tian Yi Lithium		Hu Nan Yu Neng (LFP)	PUTAILAI	SENIOR (Wet)	Capchem
Shareholder: Teng Yuan Cobalt		Pulead (LFP)	Shan Shan	JGP Energy (Wet)	JSGT
Shareholder: North American Lithium		RONBAY Technology (NCM)	BTR	Hunan Chinaly (Wet)	
Shareholder: Pilbara (Lithium)		MSDS (NCM)	ZHONG KE	Hubei Yi Teng (Dry)	
Shareholder: North American Nickel	CATL	ZEC (NCM)		CANGZHOU MINGZHU (Dry)	
Shareholder: QMB (Nickel)		B&M (NCM)		ZIMT (Dry)	
		XTC (NCM)			
		GEM (NCM precursor)			
		Brunp Recycling (NCM precursor)			
		CNGR (NCM precursor)			
Shareholder: Kemco (Nickel)		LGC (NCM)	PUTAILAI	TORAY	UBE
Nemaska (Lithium)		Umicore (NCM)	Shan Shan	Yunnan Energy	Mitsubishi Chemical
Kidman (Lithium)		HUAYOU Cobalt (NCM)	XIANG FENG HUA	SENIOR	Capchem
Pilbara (Lithium)		Easpring (NCM)	Mitsubishi Chemical	Asahi Kasei	JSGT
SQM (Lithium)	LGC	B&M Science and Technology (NCM)	Hitachi	JGP Energy	Tinci
		L&F (NCM)	BTR		
		POSCO (NCM)			
		CNGR (Precursor)			
		GEM (Precursor)			
		Sumitomo (NCM)	BTR	Yunnan Energy	Capchem
		BTR (NCM)	Hitachi	Asahi Kasei	JSGT
	Panasonic	FANGYUAN (Precursor)	PUTAILAI	UBE	Mitsubishi Chemical
		Umicore (NCM)	Novonix		UBE
		XTC (NCM)	Mitsubishi Chemical		
		Umicore (NCM)	BTR	Asahi Kasei	Mitsubishi Chemical
		Ecopro (NCM)	Hitachi	TORAY	Capchem
	Samsung SDI	L&F (NCM)	PUTAILAI	TEIJIN	JSGT
		Easpring (NCM)	Shan Shan	Yunnan Energy	UKSEUNG
		POSCO (NCM)	Mitsubishi Chemical	JGP Energy	Soulbrain

Source: Corporate filings, CICC research

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Thank You

Development of NEV and Charging Infrastructure

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Deputy Secretary General of China Society of Automotive Engineers (China SAE)
Vice President of CSAE Automotive Innovation and Strategy Institute (AISI)

July 6th, 2021

About China SAE

World NEV Congress

Academic Exchange

Annual Conference & Exhibition

Think Tank

Technology Roadmap

Individual members：**61798**

Corporate members **1756**

Staff **150+**

Public Awareness

Student Competition

⁎ AISI: Automotive Innovation & Strategy Institute

contents

NEV Plays Key Role Facing Climate Change Challenges

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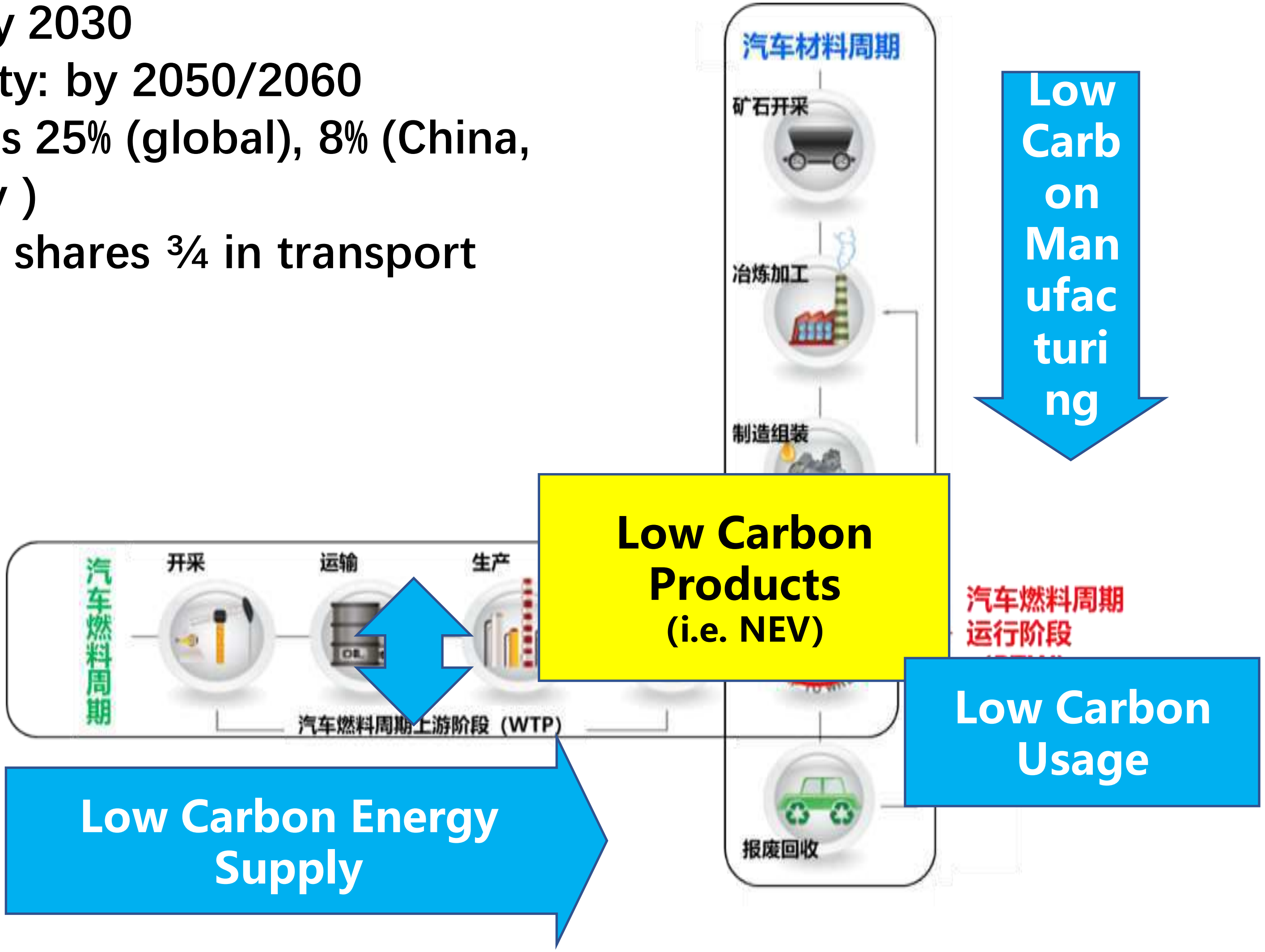
- Carbon peak: by 2030
- Carbon neutrality: by 2050/2060
- Transport shares 25% (global), 8% (China, growing quickly)
- Road transport shares ¾ in transport



Global NEV Sales Jumped, Driven by “Market + Policy"

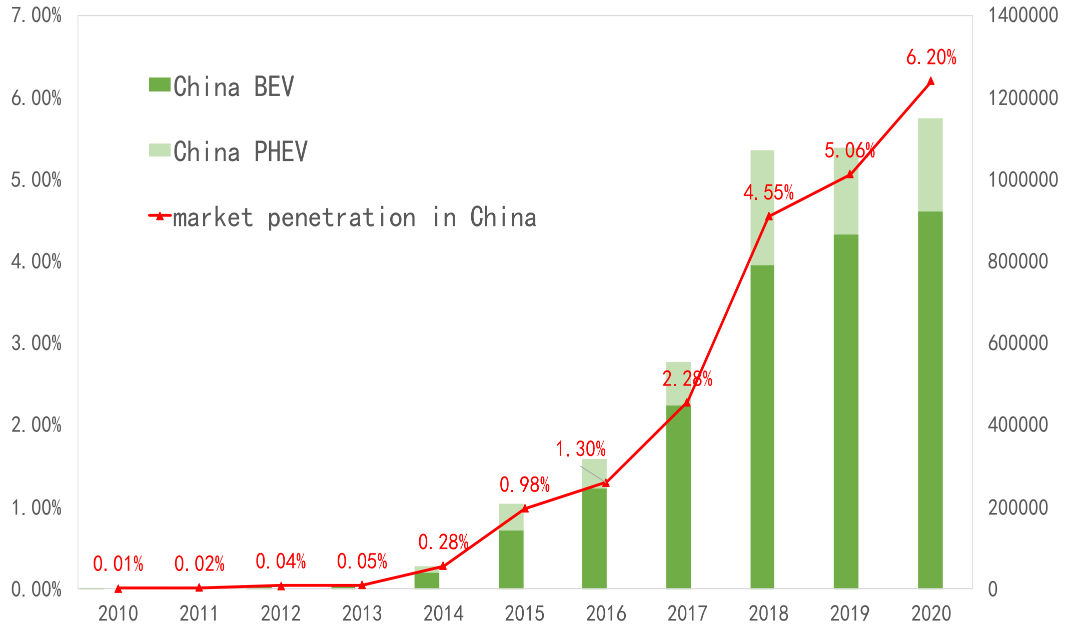
- **Globally, In 2020, global NEV sales: 3 million, 41.49% more than 2019**
- **China: in 2020, NEV sales: 1140k, YOY growth 24.8%, market penetration 5.8%**

Note: The data of Growth rate and market penetration are from January to April 2021.

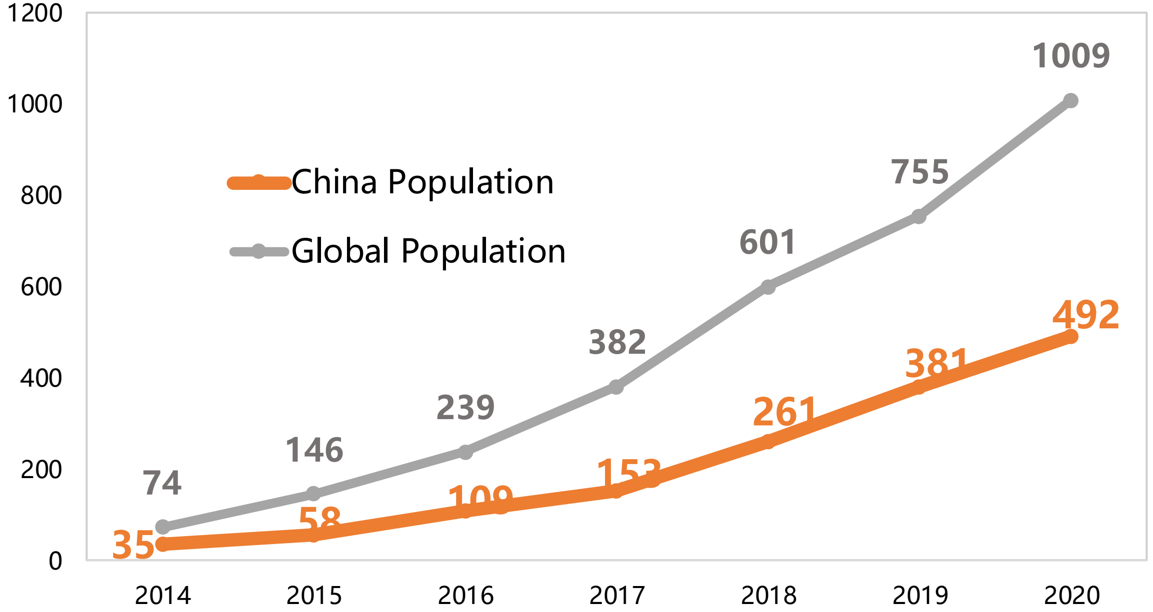
Data sources: marklines, China Automobile Industry Association

China Leads Global NEV Market

- >1M/y NEV Sales in recent 3 years and over 5% market share in 2019 and 2020 ; 75%BEV+25%PHEV ;
- Cumulatively, 5M NEVs on the road in China, accounting 48% of the global population



NEV Sales And Market Penetration

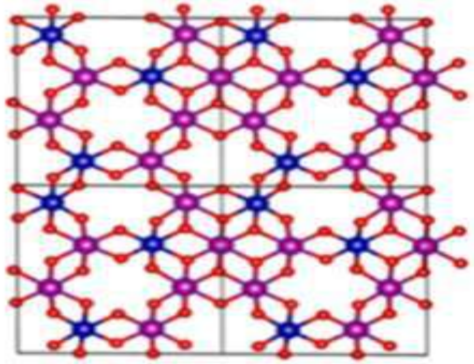


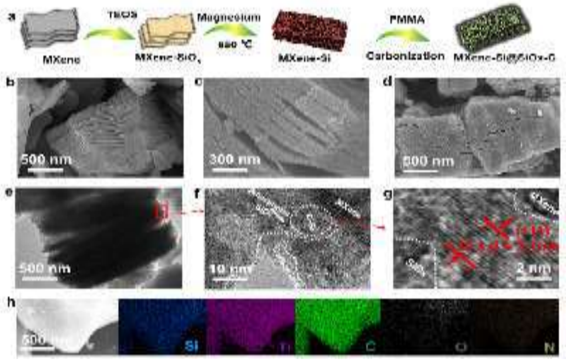
NEV Population

Sci-tech Innovation Improve NEV Competitiveness

Specialized all-aluminum lightweight and **electrical platform**

Cell system integration technologies: **blade battery, CTP (cell-to-pack)**





Energy density of the next-generation battery is over **400Wh/g**; developed the next-generation of rich lithium manganese base new anode materials reached **400mAh/g** and Si/C negative electrode materials reached **1600mAh/g**.

Power density of the drive motor exceeds **5kW/kg**

Efficiency of the **"three-in-one" drive** reaches 97%, noise in full operation less than 80dB

Power density of the galvanic pile with the bipolar metal plate reaches **4.2kW/L**

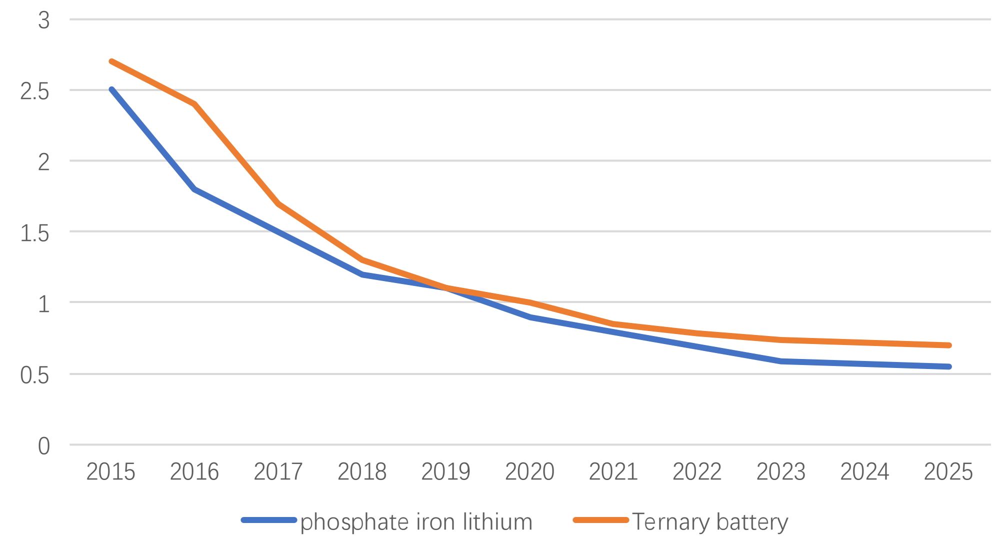
Power density of the galvanic pile with the graphite bipolar plate amounts to **2.2 kW/L**

Data source: Technology Innovation Alliance of electric vehicle industry

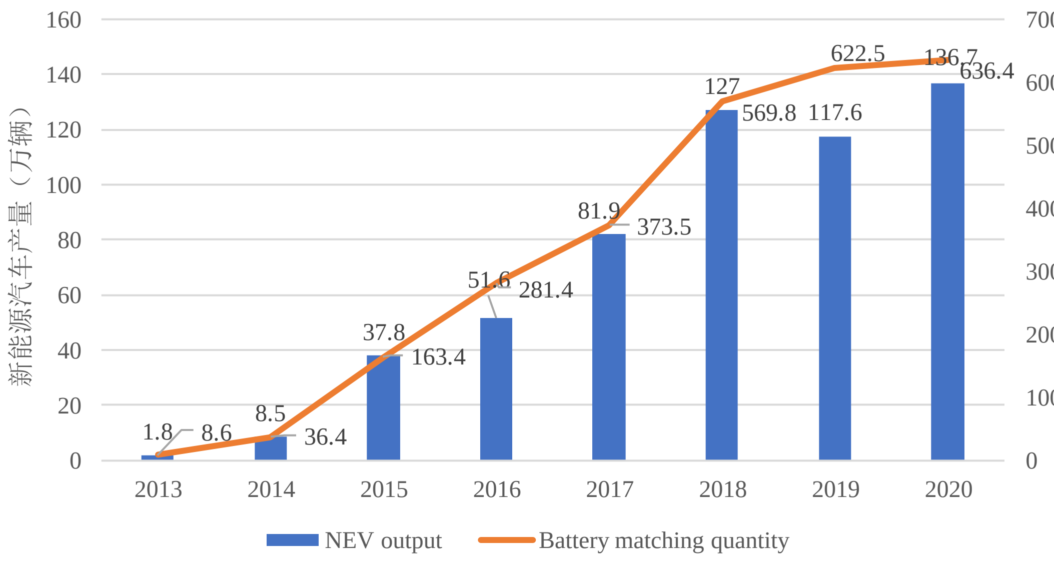
Technology Progress Drives Power Battery Cost Decreasing

- **The cost of battery is decreasing by more than 20% annually. The cost of battery accounts for 30% - 50% of the total cost of BEV. The reduction of battery cost will significantly reduce the cost of vehicles.**
- **The total cost of ownership of electric vehicles is expected to be lower than that of ICE vehicles around 2025 。**

Current situation and forecast of unit cost of power battery system[unit， yuan/kWh]



NEV output and Battery matching quantity[unit，Gigawatt hours]

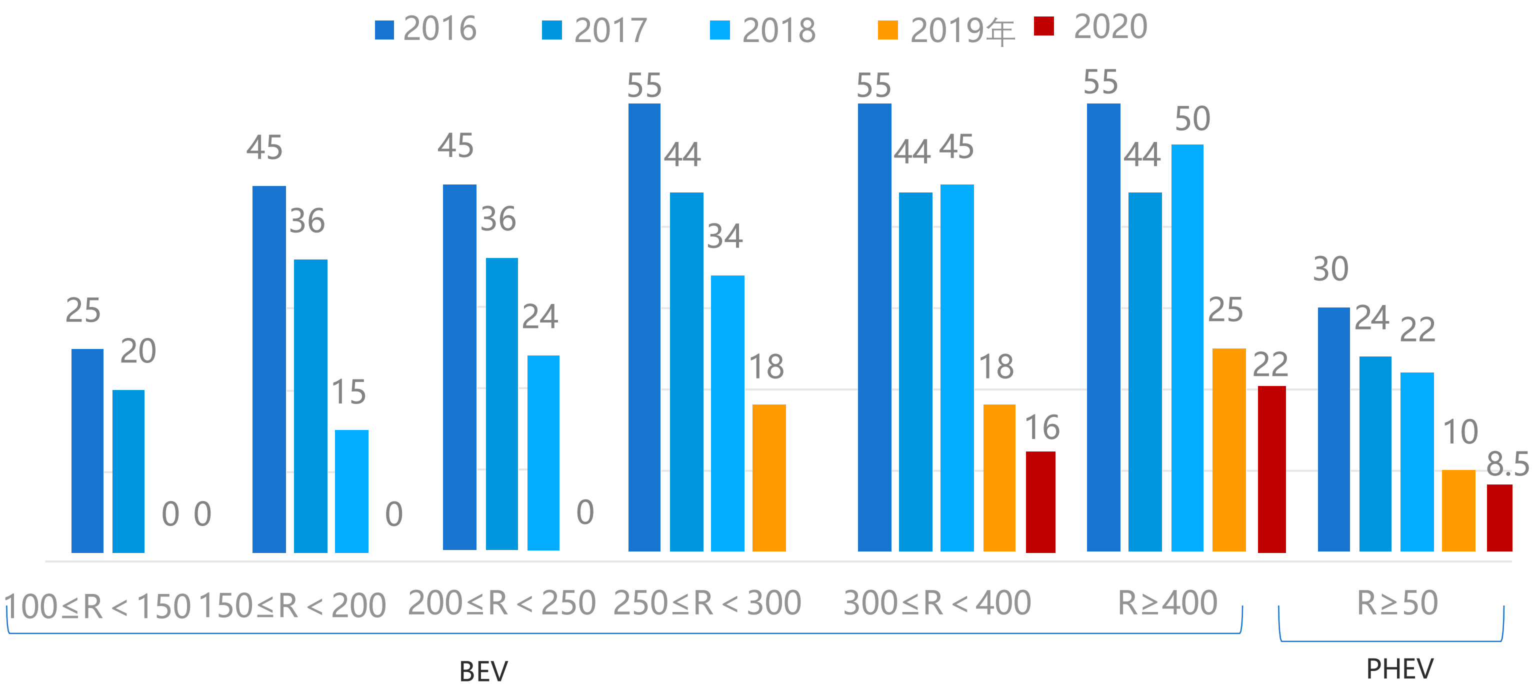


Data source: Technology Innovation Alliance of electric vehicle industry

Subsidies to Fade Out, Less Incentives for NEV

- **National and local NEV subsidies have declined sharply:** in April 2020, MOF and other four ministries jointly issued the notice on improving the financial subsidy policy for the promotion and application of NEV. In principle, the subsidy standards for 2020-2022 will decline by 10%, 20% and 30% respectively on the basis of the previous year, and the technical threshold will not be greatly adjusted, Support the development of new business models such as "separation of Vehicle and Battery“.
- **Tax incentives are expected to continue, and the dual credits policy will continue to promote NEV marketization :** it is expected that from 2023, subsidies for other types of NEV, except hydrogen vehicles, will be completely withdrawn, but the exemption policies for purchase tax and vehicle and vessel tax are expected to continue until 2025. The double integral policy and the exemption of consumption tax on BEV will promote the electrification of the automobile market from the production side.

Changes of subsidy standards for NEV over the years [unit,k]



Double integral policy

- The enterprise's average fuel consumption and NEV shall be subject to integral management. Enterprises need to clear the negative points of fuel consumption, and the integral of NEV should meet the annual proportion requirements. The annual integral proportion requirements of NEV are: 2019, 2020, 2021, 2022 and 2023 are 10%, 12%, 14%, 16% and 18% respectively.

	ICE	BEV & fuel cell	PHEV	Collection times	Relation
Purchase tax	10%	0	0	one	Price
Vehicle and vessel tax	150-4500 yuan/unit	0	0	annually	Engine displacement
Consumption tax	1%-40%	0	1%-40%	one	Engine displacement, production costs

Data source： MOF,MOST,MIIT,NDRC

Non-Fiscal Policy Proved Effective

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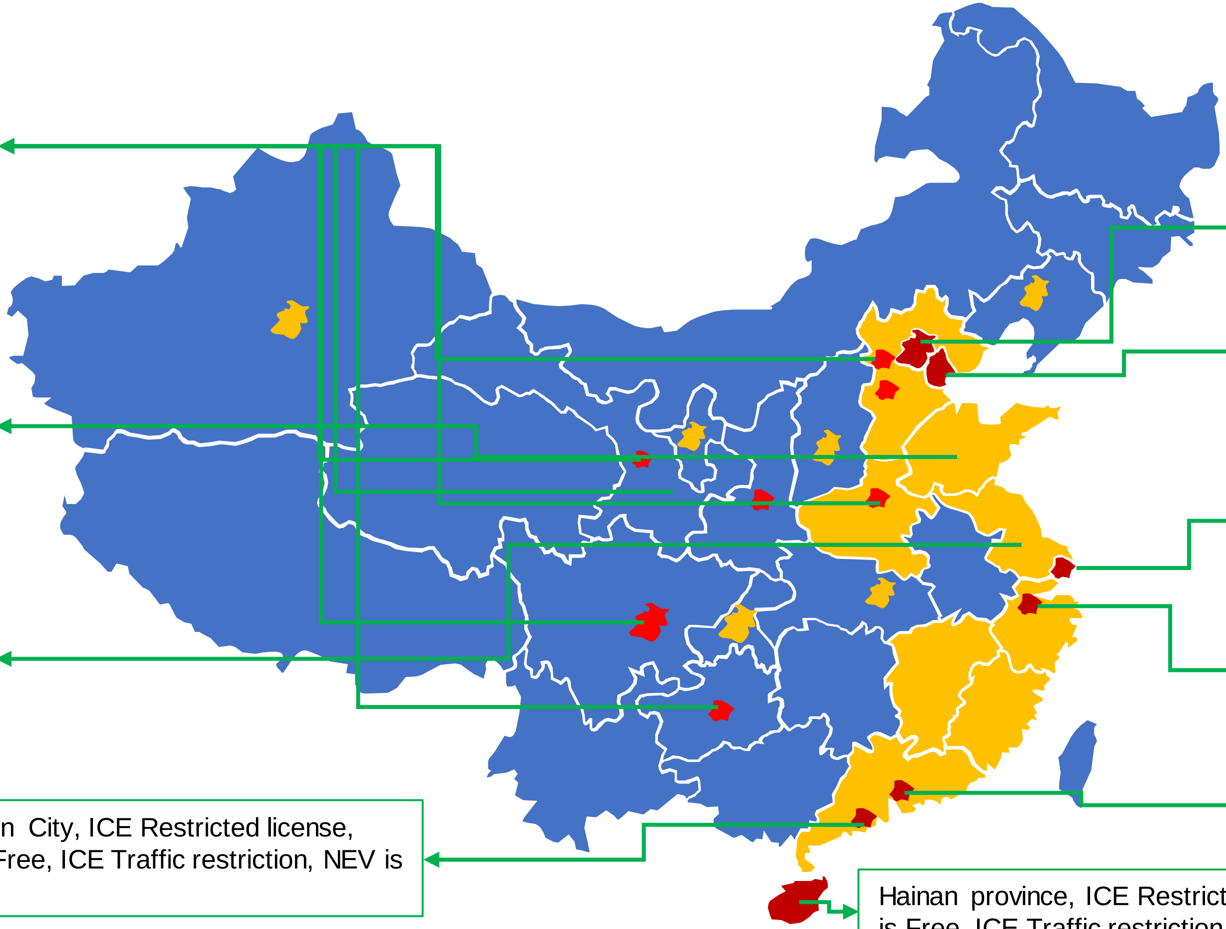
- **In recent years, the state and local cities have issued strong support policies in the fields of license plate restriction, traffic restriction, public vehicles and online car Hailing to support the development of NEV.**

Chengdu,Xi'an,Zhengzhou,Shijiazhuang city,Guiyang,Lanzhou, Baoding,Langfang,Qinhuangdao,Cangzhou,Luoyang, Xinxiang, Anyang, Hebi and so on, **ICE Traffic restriction, NEV is free**

Since 2021, Beijing Tianjin Hebei, Yangtze River Delta, Pearl River Delta, Shandong, Chengdu, Chongqing and most of the provincial capital cities require new or updated public vehicles**, 80% of which are NEV**

As of May 2021, there are 3 first tier cities, 10 second tier cities and 15 third tier cities that require new or updated online car Hailing to be NEV, and 4 of them require BEV.



Beijing City, ICE Restricted license, Only BEV(60k-70k), ICE Traffic restriction, BEV is free

Tianjin City, ICE Restricted license, NEV is Free, ICE Traffic restriction, NEV is free

Shanghai City, ICE Restricted license, NEV Free, ICE Traffic restriction, NEV is free

Hangzhou City, ICE Restricted license, NEV is Free, ICE Traffic restriction, NEV is free

Guangzhou City, ICE Restricted license, NEV is Free, ICE Traffic restriction, NEV is free

Shenzhen City, ICE Restricted license, NEV is Free, ICE Traffic restriction, NEV is free

Hainan province, ICE Restricted licence, NEV is Free, ICE Traffic restriction, NEV is free

NEV Development Strategy (2021-2035)

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2025

- NEV accounts for about **20%** of new car sales.
- The average power consumption of new battery electric passenger cars drops to **12.0**kWh/100km.
- Realization of commercial applications of highly autonomous vehicles in limited areas and specific scenarios.

2035

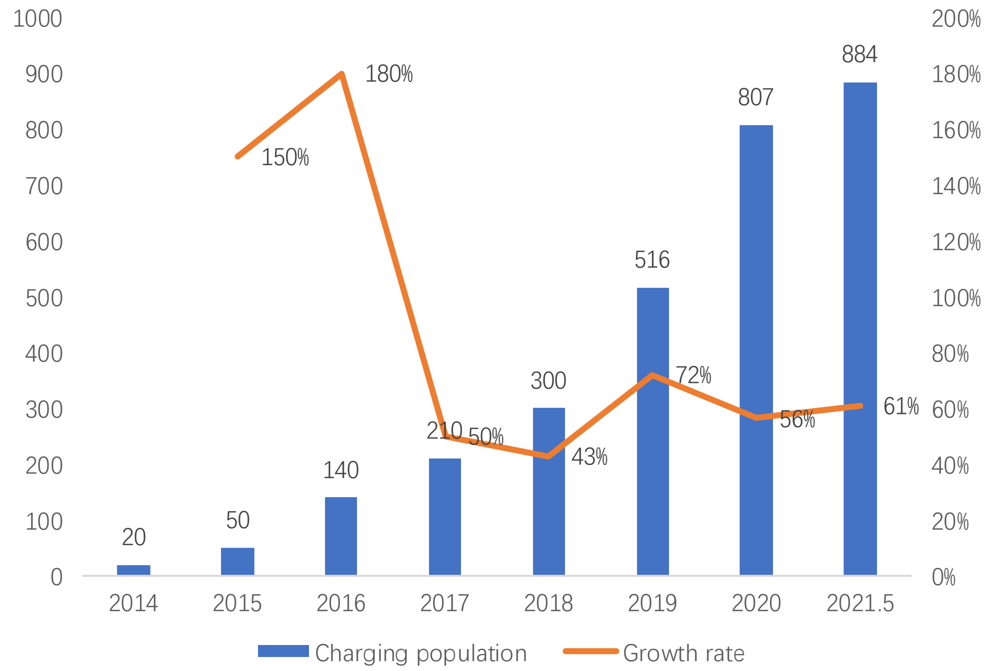
- BEV becomes the **mainstream** of new car sales.
- Fully electrified vehicles in public sectors.
- Commercialized application of fuel cell vehicles.
- Realization of highly autonomous vehicles in large-scale application.

contents

Charging Infrastructure Critical to NEV Development

- China's public charging piles have increased significantly, optimizing the use cost and experience of electric vehicles: in May 2021, China's public charging piles have increased to 884k units. China has established a high-speed fast charging network covering 19 provinces.

Number of public charging piles in China (unit,k)



Source: charging facilities Alliance

China's fast charging network

"Four horizontal and four vertical" fast charging network

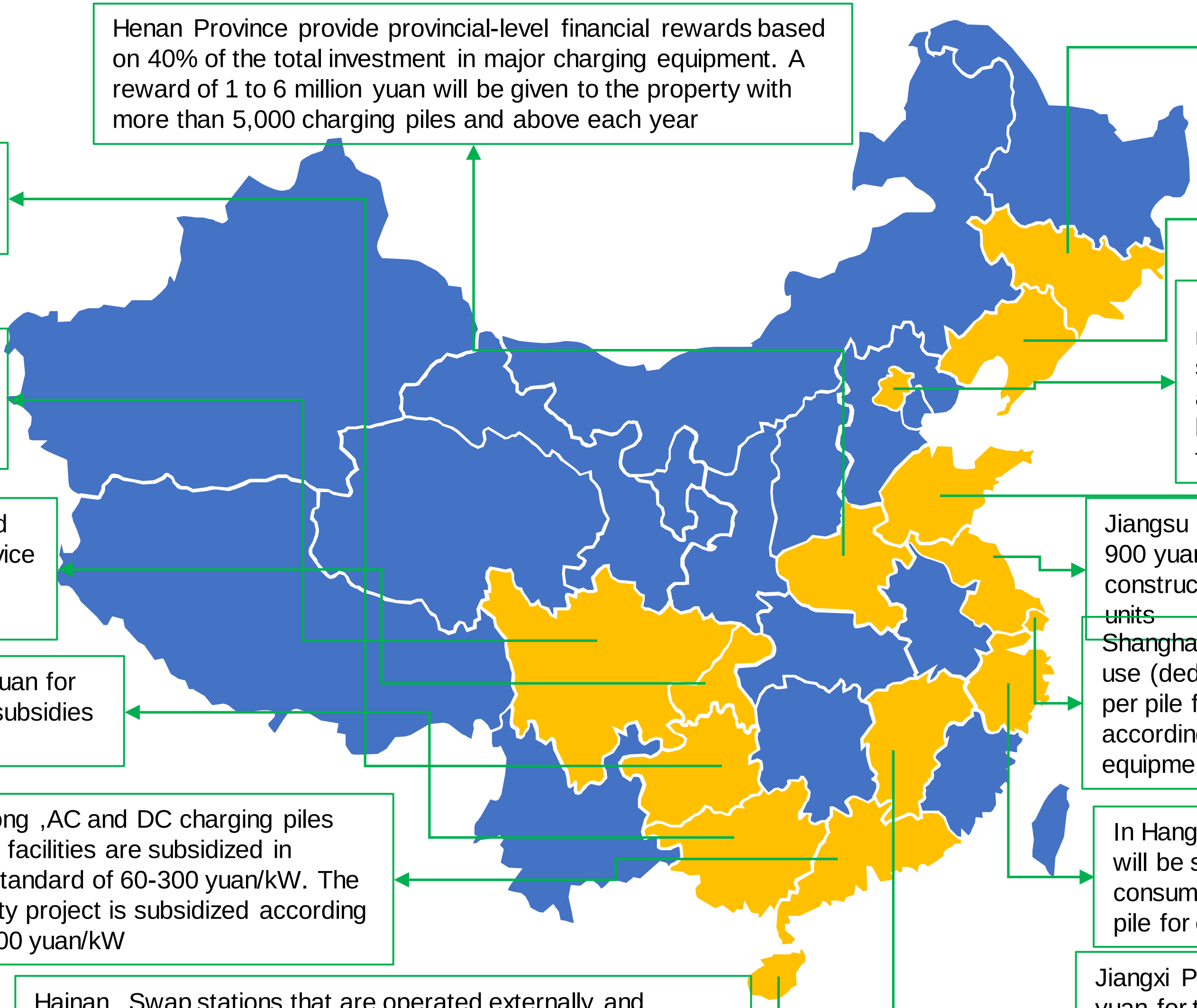
"Nine vertical and nine horizontal double ring" urban fast charging network

Source: electric vehicle charging infrastructure development guide (2015-2020), State Grid Corporation

National Policies for Charging Infrastructure

- 2013.1 — *Energy Development Twelfth Five-Year Plan*
- 2015.11 — *Guidelines for the Development of Electric Vehicle Charging Infrastructure (2015-2020)*
- 2016.8 — *Notice on Speeding up the Construction of Electric Vehicle Charging Infrastructure in Residential Areas*
- 2016.12 — *Notice on Coordinating and Accelerating the Integrated Construction of Parking Lots and Charging Infrastructure*
- 2017 .1 — *Speed up the construction of electric vehicle charging infrastructure within the unit*
- 2018 .11 — *Action Plan to Improve the Charging Guarantee Capability of New Energy Vehicles*
- 2020.1 — *Action Plan to Improve the Charging Guarantee Capability of NEV*
- 2021.4 — *Notice on organizing and launching the pilot work of NEV battery swap mode application*

Local Incentives for Charging Infrastructure Construction



Henan Province provide provincial-level financial rewards based on 40% of the total investment in major charging equipment. A reward of 1 to 6 million yuan will be given to the property with more than 5,000 charging piles and above each year

Jilin Province ,a one-time construction subsidy of 300-600 yuan/kW will be provided. 300,000 yuan for each replacement station

Guizhou Province, subsidies 100-200 yuan for the construction of charging piles, and 0.1-0.2 yuan/kWh for operation

Dalian City, Liaoning Province, grants a 30% financial subsidy for the investment in charging facilities

According to the installed power, subsidies of 100-400 yuan/kW will be given to the investment entity, and 200000-5000000 yuan will be subsidized for charging and replacement power stations

Beijing City, The daily reward standard for charging stations is 0.1 yuan/kWh, and the upper limit is 1500 kWh/kW·year. Unit charging facility 0.4-0.5yuan /kWh

Shandong Province, subsidies for the construction of charging piles are 300-400 yuan/kWh

Chongqing,Dedicated DC charging infrastructure and public DC charging infrastructure in expressway service areas will be given a construction subsidy of 100-400yuan/kW.

Jiangsu Province rewards 600-900 yuan/kW for charging pile construction and operation units

Guangxi Province, subsidies 200-400 yuan for the construction of charging piles, and subsidies for operating units at 20% of the cost

Shanghai city,Support the sharing and transformation of self-use (dedicated) charging piles, with a subsidy of 500 yuan per pile for properties, and subsidies for charging equipment according to the standard of 50% of the amount of charging equipment

Guangzhou, Guangdong ,AC and DC charging piles and wireless charging facilities are subsidized in accordance with the standard of 60-300 yuan/kW. The power exchange facility project is subsidized according to the standard of 2,000 yuan/kW

In Hangzhou, Zhejiang, the construction of charging piles will be subsidized at 30% of the actual investment; individual consumers will be given a one-time subsidy of 600 yuan per pile for charging piles for their own use

Hainan ,Swap stations that are operated externally and connected to the provincial platform will be given construction subsidies of 100-200 yuan per kilowatt. One-time grant of 10% -15% capital subsidy of project equipment investment

Jiangxi Province, subsidies 200-400 yuan for the construction of charging piles, and 0.15-0.25 yuan/kWh for operating units

Charging Infrastructure Standards In Place

The charging facility standard system is basically completed

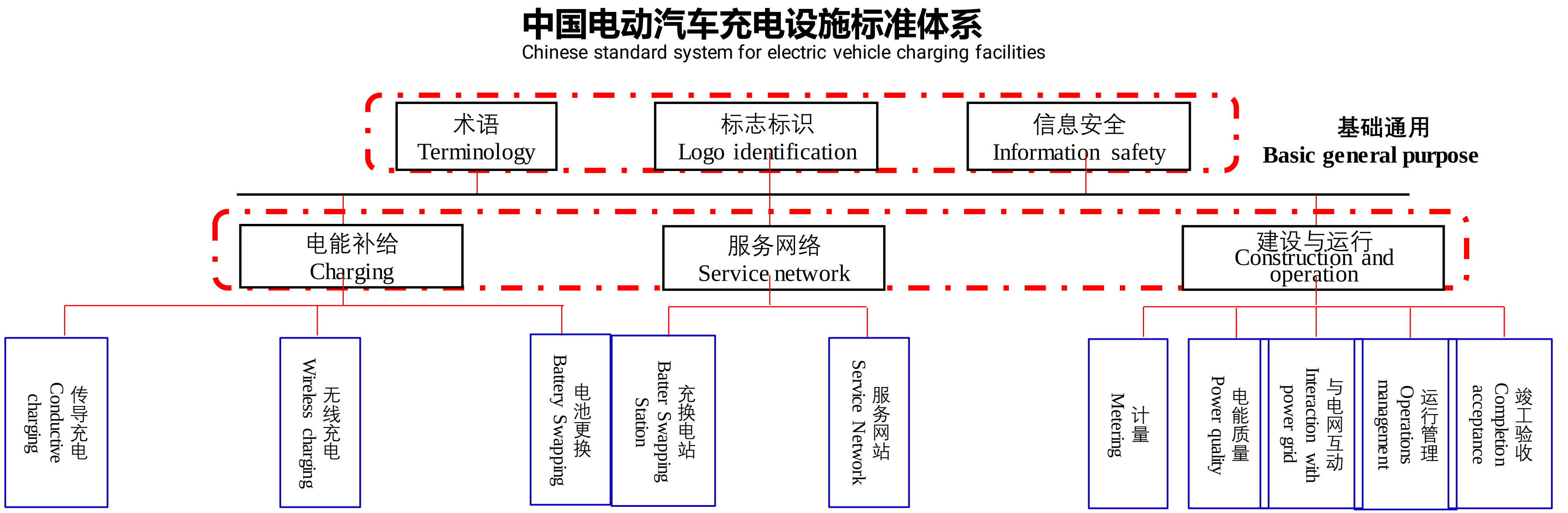
- A total of 153 standards are planned for the charging facility standard system, of which 58 are planned national standards, 59 are industry standards, and 36 are standards of CEC(China Electricity Council).
- Up to now, there are 72 effective charging facilities standards, and 58 projects are under planning
- Promote the internationalization of China's charging technology standards, and have made breakthroughs in the fields of DC charging, charging roaming, and battery swap. The Chinese voice has become an important party in the international standard.

		Currently valid	Editing standards
Divided by standard category	National standard	31	16
	Industry Standard	26	21
	CEC standard	15	21
Divided by technical route	Conduction charging	23	19
	Battery replacement	14	7
	Wireless charging	5	8

Source: China Electricity Council

Charging Infrastructure Standards In Place

- The standard system is divided into four parts: basic standards, electrical energy supply standards construction and operation standards, and service network standards. It mainly includes 3 charging technology routes such as conductive charging, wireless charging, and battery replacement, involving 21 professional field standards such as terminology, conductive charging system and equipment standards, wireless charging system and equipment standards, power battery box standards, metering, and service networks.



contents

Challenges for Charging Infrastructure

Safety

Charging safety needs to be further improved.

Maintenance

Charging facilities performance needs to be improved.

V2G

The car network interaction system has not yet been formed.

Home Charging

It is difficult to build charging pile in residential area.

Public Charging

Imperfect planning of public charging facilities.

Three Charging Technology

Conductive Charge

- DC charging
- AC charging

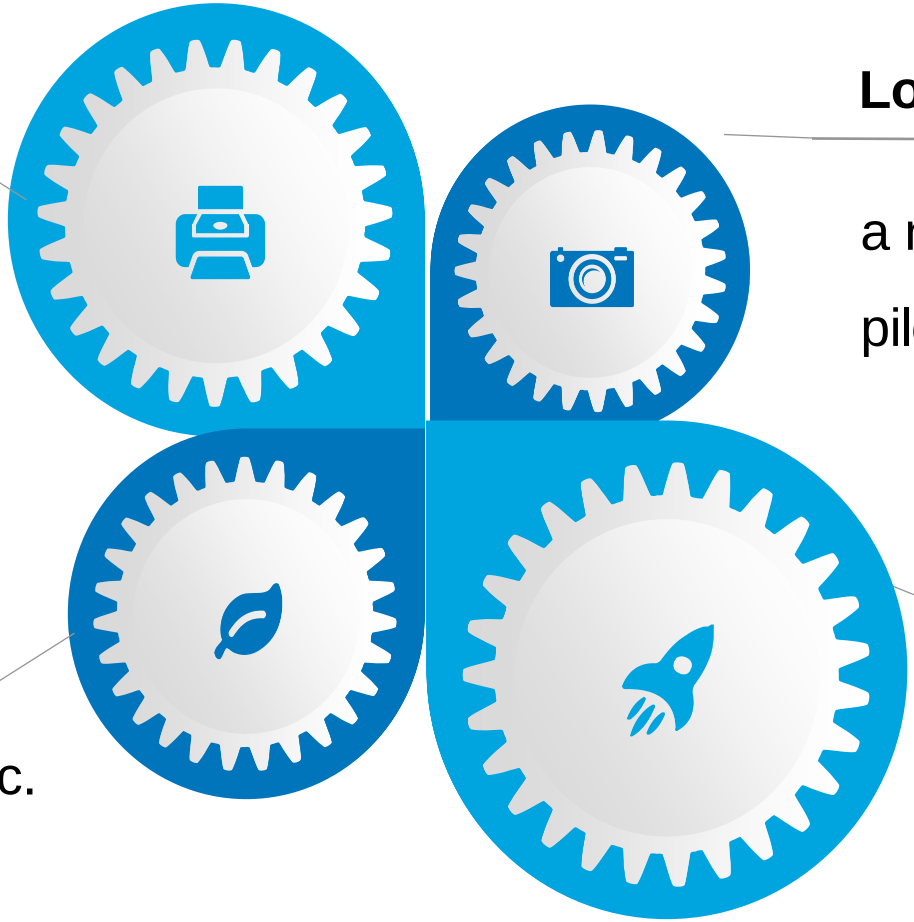
Battery Swap

Wireless Charging

Conductive Charging Technology

Ultra Fast DC charging

- Fast charging
- Improve user experience
- Demonstration and application stage



Low Cost DC charging

a new choice to replace AC pile.

V2X

V2G, V2V, V2H, V2L, etc.

Fast AC charging

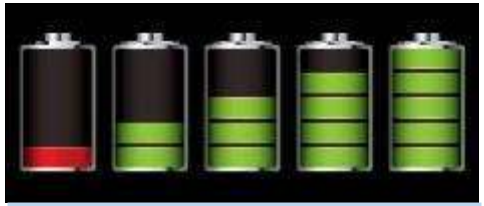
Meet the charging needs of different users in different scenarios.

Ultra Fast DC Charging Technology

Problems solved by high power ultra fast charging technology

Long charging time

Range and waiting anxiety



Short battery life

High power ultra fast charging

- ➢ Conductive high power charging technology
- ✓ High power charging technology for passenger cars
- ✓ High power charging technology of bus
- ➢ Wireless charging high power charging technology

Technical specs of conductive high power charging

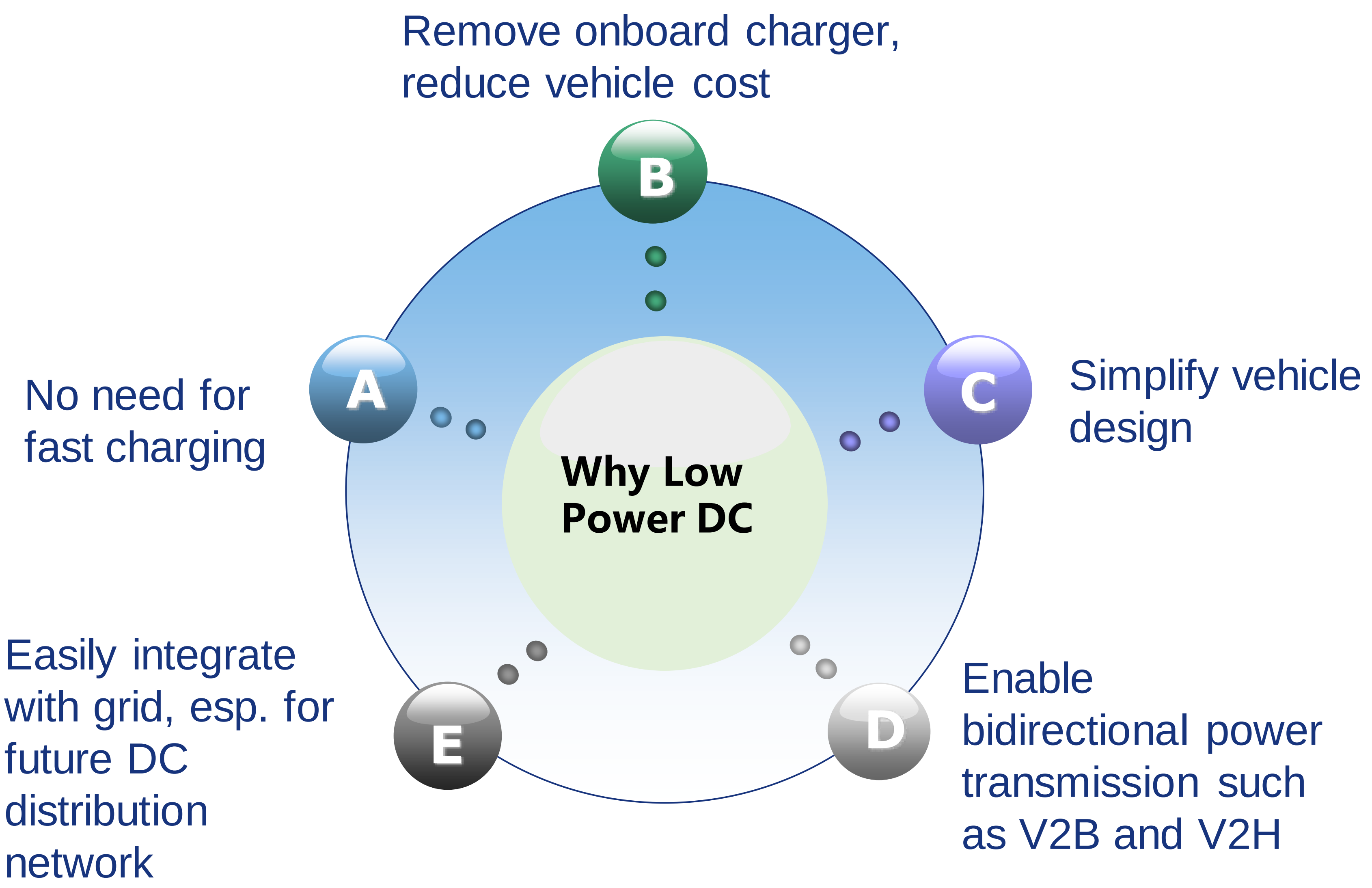
- ➢ Charging power: ***≥ 350kW***
- ➢ Charging time: ***10-15 m***
- ➢ Mileage : ***300 km***

➡ **Chaoji international WG**

Application scenarios:

Long range vehicle; Rental, logistics, online car booking; bus; Heavy duty vehicle; Public charging in megacities; Highway charging.

Low Cost DC Charging



Low cost DC charging specs:

Input voltage:
480V AC / 600 V DC
Maximum output voltage:
450 / 700 / 950 (1500) V
Maximum output current:
32A
Maximum output power:
7kW (single phase) /
20kW (three phase)

Low Cost DC Charging Products

four main types of low-power DC charging products

- 3.5kW portable DC charger, instead of AC mode 2 charging box;
- 2kW portable DC charger, instead of AC mode 2 charging box;
- 7kW wall mounted DC charger, instead of OBC 6.6kW + 7kW AC pile;
- 20kW wall mounted DC charger is an optional export for high-end models.

Comparison to conventional charging

similarities

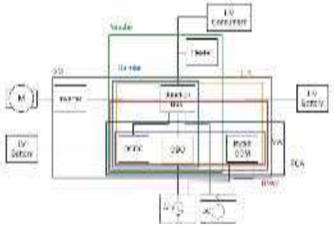
- Control guidance
- communication protocol
- Power input range
- Voltage output range
- Input power quality
- Output ripple and voltage stabilization
- Working environment requirements
- Safety requirements of mode 4

differences

- Thermal management requirements are slightly lower
- The requirement of Y capacitance is slightly lower
- Add DC mode 2 electric shock protection requirements
- Human machine interface can be simplified
- PE conductor selection, etc

High Power Fast AC Charging

High power OBC



Deep integration of OBC with other power electronic components.

Compliance to oversea market demand

Meet the charging needs of different users.

Advantages Of Fast AC Charging

Increase charging speed

Charging is much faster than two-phase AC.

Flexible charging scene

Enrich charging scenarios and improve charging network.

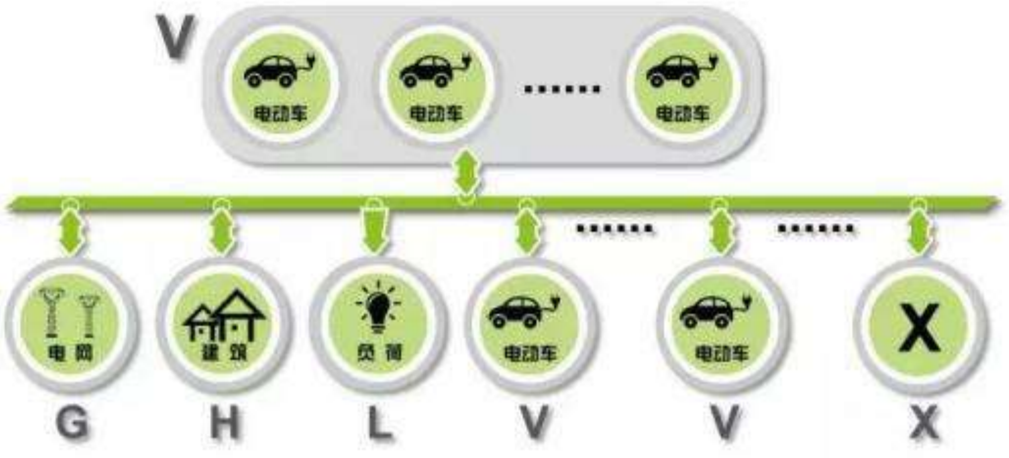
Rich charging types

Enrich the charging type to meet the needs of different users for charging.

Low investment cost

The investment cost is small and the payback period is short.

V2X Technology



V2X application scenarios

- Family (residence): V2H、V2B
- Load: V2L
- Energy Internet: V2E

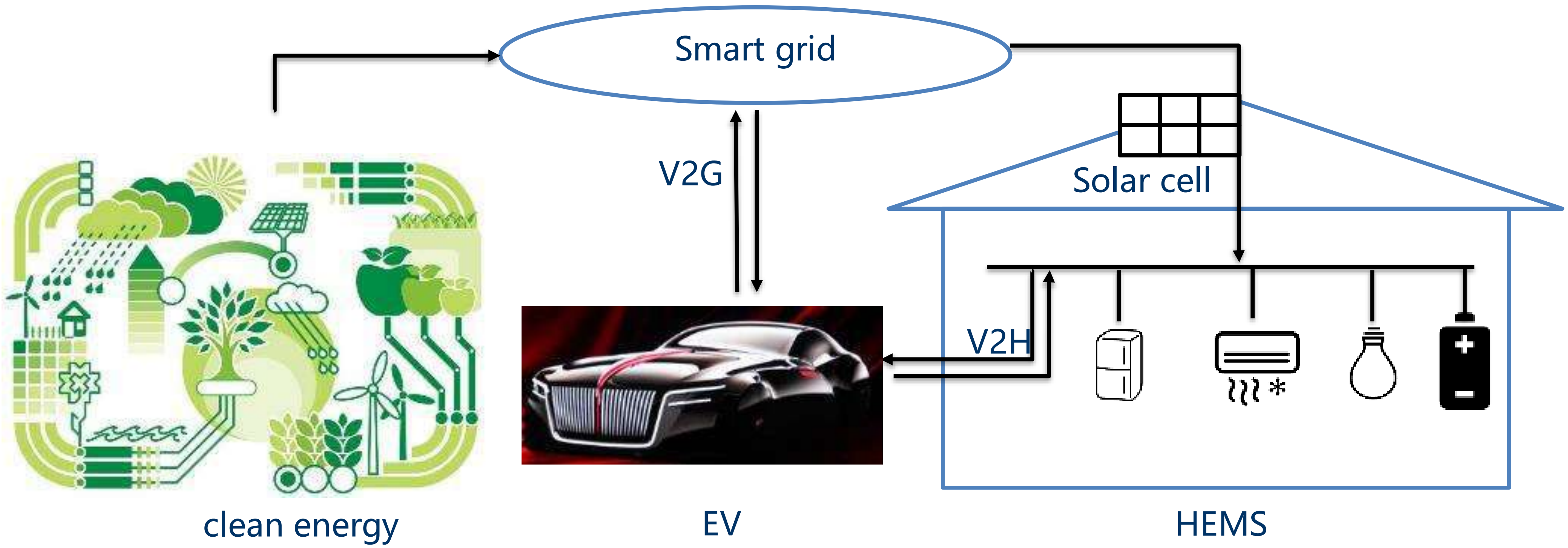
V2G

- Orderly charging
- Power demand side management
- Microgrid
- Virtual power plant

- State Grid Corporation of China, telecall and Putian new energy have carried out V2G related technology research and pilot application.
- BAIC, BYD, Chang'an Automobile and other automobile enterprises have carried out relevant technical research on electric vehicle V2X, and achieved V2V and V2L.

V2G Technical Specs

- **Two way interaction:** Vehicle and power grid interaction;
- **Efficient coordination:** V2G fast peak shaving;
- **Mutual benefit and win-win:** Win-win for customers, automobiles and power grid.



Battery Swapping Technology

Israel better place chassis power exchange

BAIC new energy chassis power exchange

Power exchange of Weilai automobile chassis

Power exchange in the trunk of State Grid

Box type power exchange of Lifan automobile

Space time electric side exchange

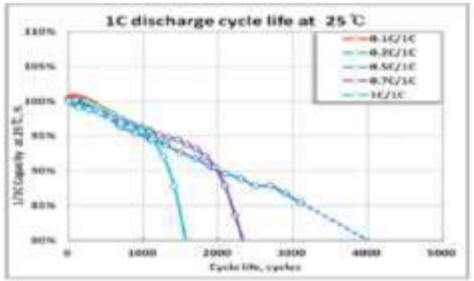
Advantages of Battery Swap Technology

1.You can buy a car without piles

2.Change the power for 3 minutes

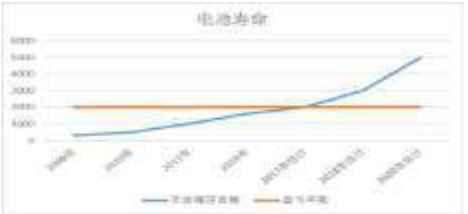
3.High safety performance

4. Long battery life



5.Small impact on Power Grid

6.Sustainable development of business operation mode



7. Saving and efficient use of land resources

8. It is conducive to the echelon utilization of batteries

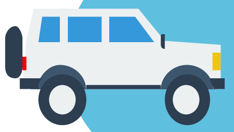
Battery Swapping Business

- Rely on the odometer, charge by mileage difference
- Applicable to operating vehicles

Mileage charging

- Derivatives of mileage charging
- Applicable to official vehicles

Pay per view



- Relying on AC watt hour meter, charging by watt hour
- For private cars

Electricity metering

Wireless Charging

No need to plug charging g **Convenient** r experience

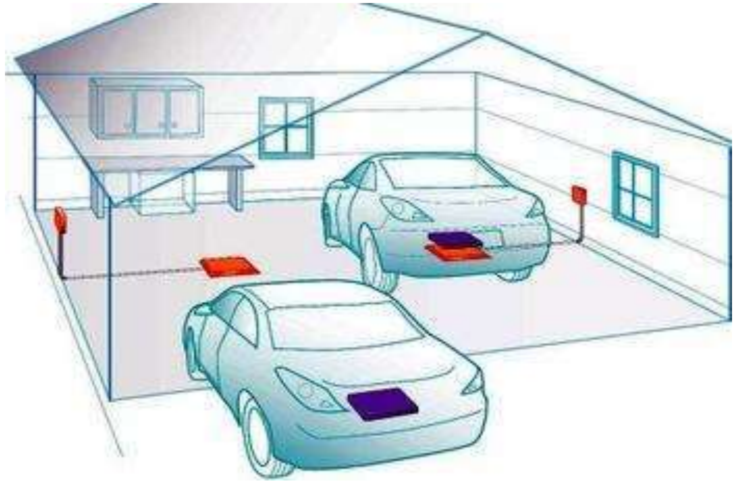
Reduce the risk of electric s **Safe** gher safety

It can adapt to humid and **Reliable** nvironment

No mechanical contact, no **Durable** ng

Small area, can be combin **Small** ereo garage

It is conducive to the reali **Better for AD** driving



- **Power:** 3.3kW and 6.6kW → 11kW;
- **Efficiency:** The efficiency of the equipment is more than 90% and the output is more than 85%;
- **Safety:** foreign object detection, electromagnetic radiation, electromagnetic compatibility.

Wireless Charging Rolling Out Plan

2018
Starting stage

Pilot mode, no industry standard and commercial application.

2019-2021
Introduction period

Small scale promotion, standard formulation and business model exploration.

2022-2024
Promotion period

It is popular in first tier cities with mature business model and high degree of automation.

2025
Mass production period

Large scale application.

Charing Technology Trend

Source: NEV Technology Roadmap 2.0, 2020

NEV Population

>120M

>80M

>20M

>2M

Fully integrated with intelligence

Charing Service Always On-line

公共桩联网在线率优于95%

车、桩、APP、平台在线化的互联互通，带来即插即充优良体验，充电体系日趋完善。

Automatic Charging

实现充电漫游、
自动泊车结合
自动充电

车网协同智能充电带来充电方式的颠覆性转变。

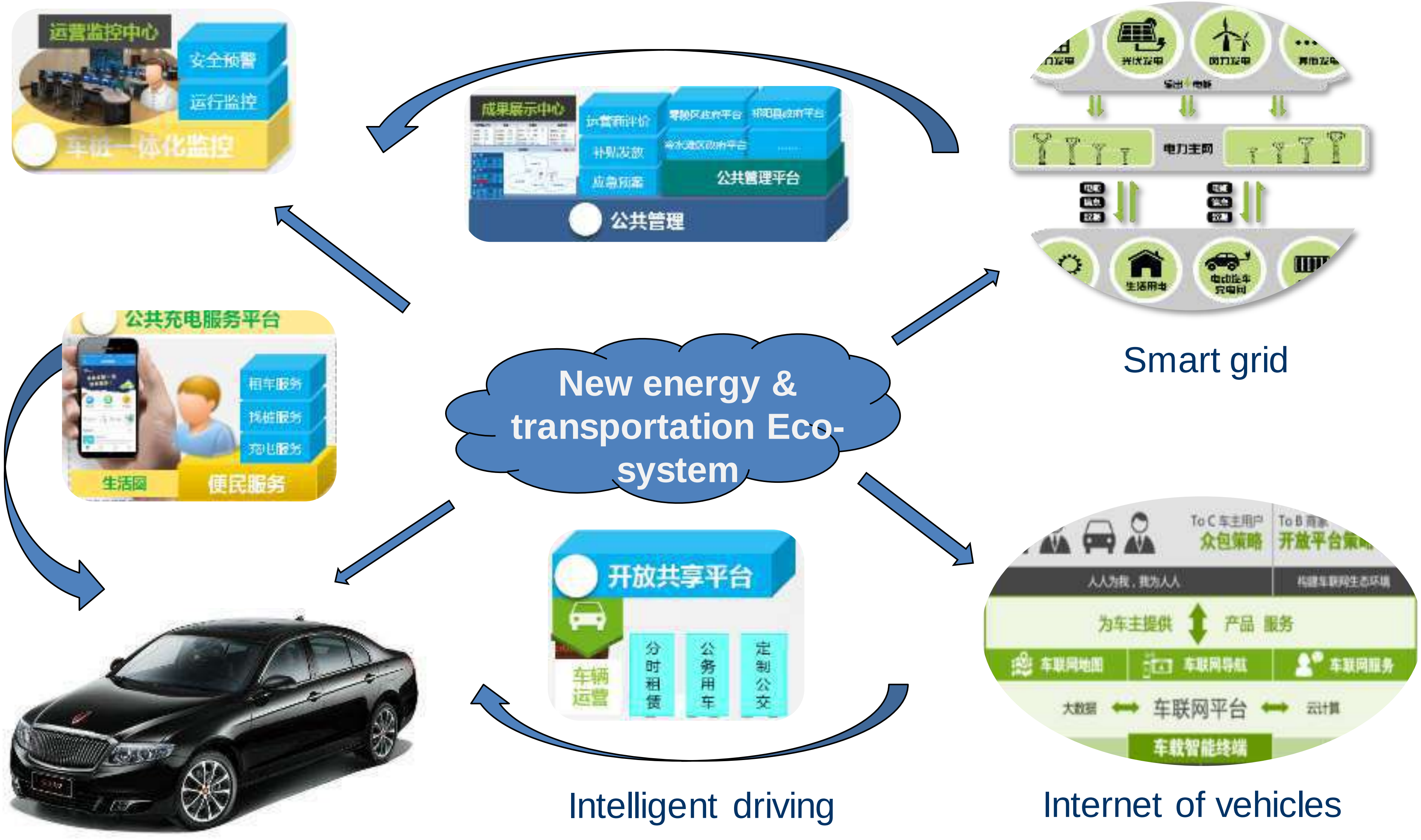
Interactive with Grid

车网协同
能源互联
智慧决策

1、动力系统变革推动能源生产方式转变、可再生能源使用大幅提升，交通、能源、信息技术大融合构成智慧型技术设施。
2、参与者和运营模式呈多样性，灵活多变场景定制与软件技术结合高效自适应，充电服务融合智慧城市孕育巨大潜力。

2025 2030 2035

New Energy & Transport Eco-system



Thanks for Your Attention！

国汽战略院
CSAE-AISI

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国家电网国际发展有限公司
STATE GRID INTERNATIONAL DEVELOPMENT LIMITED

The role of grid planning in promoting development of new energy vehicles under carbon emmision commitment

LIU WEI

CTO of Oman Electrical Transmission Company
Professor-level Senior Engineer
Chartered Engineer(IET)

2021.07.06

About Liu Wei:

The current Chief Technology Officer of Oman Electrical Transmission Company.(OETC , State Grid holds 49%) , responsible for planning, design, construction and asset management. Professor-level senior engineer, DBA from the University of Montpellier, France, a member of the National Grid Planning and Operation Standards Committee, an engineering member of the Chinese Association of Science and Technology Engineers, and a chartered engineer of the Institute of Engineering Technology (IET). Engaged in power system planning, construction, operation and maintenance and other related work. Worked for one year in Cambodia's BOT project and six years in State Grid Brazil Holding Company.

Grid Planning promote the development of new energy vehicles

Contents

EI --Energy Internet   BM-business model   RE--renewable energy

01

Part One

Severe Global Warming Situation Gave Birth to the EI

1 Severe Global Warming Situation Gave Birth to the EI

Taking the average temperature of the 100 years from 1901 to 2000 as a benchmark, The global temperaturethe in 21st century has increased by nearly 1 degree, and the climate warming trend has basically been established.The United Nations Environment Programme (UNEP) predicts that if the current carbon emission policy continues, the global average temperature in 2100 will rise by 3.4°C to 3.7°C relative to the pre-industrial level, and continue to rise.

The continuous rise in temperature will bring higher precipitation, more frequent extreme weather and irreversible damage to the ecological balance.The problem of climate warming has caused a variety of natural disasters, which will be irreversible after reaching a critical point. Natural disasters caused by global warming have become more frequent and severe.

1 Severe Global Warming Situation Gave Birth to the EI

Nine critical points of climate change identified globally, currently taking place:

A. Amazon tropical rain forest is often dry;

B. The Arctic sea ice area has decreased;

C. The Atlantic circulation has slowed since 1950;

D. Northern forest fires and pests in North America;

E. Mass death of coral reefs worldwide;

F. Accelerated melting and loss of ice in the Greenland ice sheet;

G. Thawing of permafrost;

H. The ice sheet in the western part of Antarctica is rapidly melting and losing ice;

I. Eastern Antarctica is rapidly melting.

1 Severe Global Warming Situation Gave Birth to the EI

The UN has repeatedly held climate change conferences. Since 1995, the UN Climate Change Conference has been held in rotation in different regions of the world every year. In the **2015**, **Paris Agreement** was made for the global response to climate change after 2020, and the goal of controlling the temperature rise to 2°C or even 1.5°C was setted. Nearly 200 parties signed the agreement. The next , 26th United Nations Climate Change Conference is scheduled to be held in Glasgow, UK from November 1-12, 2021.

时间	地点	会议	主要成果
1992	里约	地球首脑会议	通过《气候变化框架公约》，世界上第一个应对全球气候变暖的国际公约
1995	柏林	第1次缔约方会议	通过《柏林授权书》
1997	京都	第3次缔约方会议	通过《京都议定书》，规划05-20年人类减排总体陆续。05-12年为第一承诺期，12-20年是第二承诺期。是人类社会第一次正面做出减排承诺
2001	马拉喀什	第7次缔约方会议	通过《马拉喀什协定》
2005	巴厘岛	第13次缔约方会议	通过《巴厘岛路线图》
2009	哥本哈根	第15次缔约方会议	达成无法律约束力的《哥本哈根协议》，明确了各国京都议定书第二承诺期的减排责任
2011	德班	第17次缔约方会议	与会方同意延长5年《京都议定书》的法律效力（原议定书于2012年失效）
2012	多哈	第18次缔约方会议	通过了对《京都议定书》的《多哈修正》
2015	巴黎	第21次缔约方会议	近200个缔约方一致同意通过《巴黎协定》，为2020年后全球应对气候变化行动作出安排
2021	格拉斯哥	第26次缔约方会议	

1 Severe Global Warming Situation Gave Birth to the EI

According to estimates by the international scientific community, the carbon budget should be around one trillion tons. (1000PgC) based on the global temperature rise is more likely to be controlled within 2°C compared to the pre-industrial era.World Resources Institute,Global Carbon Budget Report 2015.

1860-2014

Since the Industrial Revolution (1861-1880), the world has emitted a total of 545PgC, using 55% of the budget.

2015-2045

There is only 455PgC left in the world carbon budget. If we do not take action, we will overspend in *2045*.

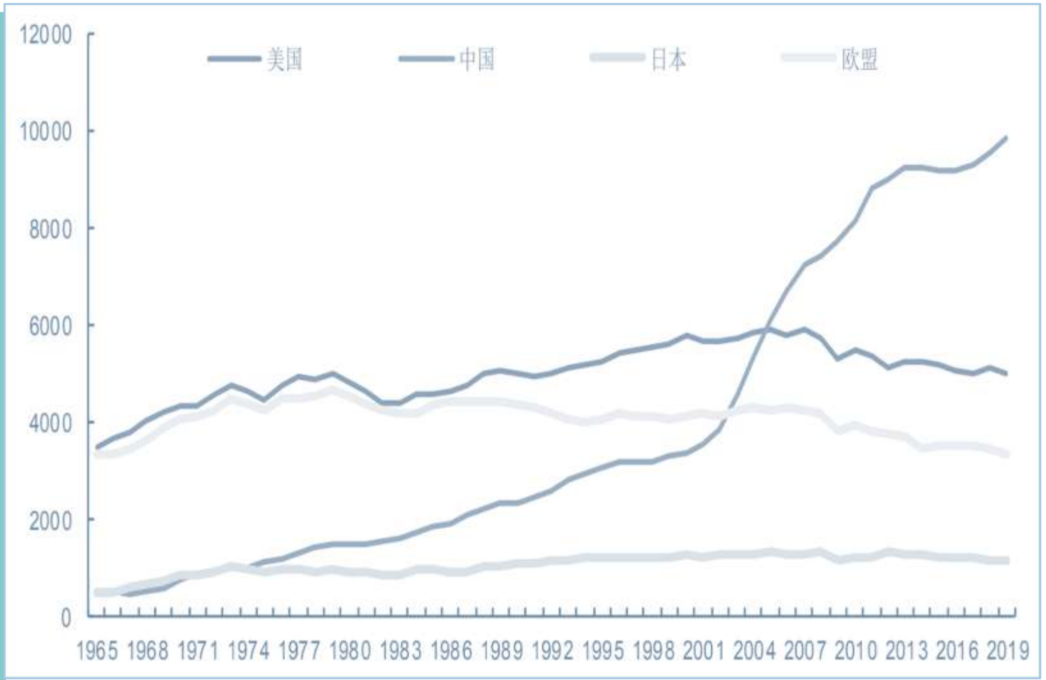
PgC: petagrams of carbon (Pg = petagram billion tons)

Carbon emission forces the energy transition to be implemented!

1 Severe Global Warming Situation Gave Birth to the EI

If the world formulates policies in accordance with the 1.5°C temperature rise target, according to previous estimates by the International Energy Agency, global carbon emissions are expected to peak between 2020 and 2030, oil demand will peak between 2020 and 2030, and coal demand before 2020 at the peak, natural gas will reach its peak between 2025-2040.

Europe and the United States achieved carbon peaking in 2010 for more than 100 years, and world main industrial capacity at China.Chinese modernization development and carbon dioxide emissions are still rising. The contribution rate to world economic growth exceeds 30%. Carbon neutral and peak target means a steeper energy-saving and emission-reduction path, which is extremely difficult to achieve with no impact to world economy.



1 Severe Global Warming Situation Gave Birth to the EI

Summary of carbon neutrality time

国家/地区	碳中和目标日期
Finland	2035 年
奥地利	2040 年
冰岛	2040 年
瑞典	2045 年
U.S.A	2050 年
加拿大	2050 年
欧盟	2050 年
England	2050 年
France	2050 年
German	2050 年
智利	2050 年
哥斯达黎加	2050 年

国家/地区	碳中和目标日期
日本	2050 年
韩国	2050 年
斐济	2050 年
丹麦	2050 年
匈牙利	2050 年
爱尔兰	2050 年
新西兰	2050 年
葡萄牙	2050 年
南非	2050 年
瑞士	2050 年
西班牙	2050 年
China	2060 年

1 Severe Global Warming Situation Gave Birth to the EI

China carbon emmision reduction commitment

Target in 2009, “Unit GDP carbon dioxide emissions will be reduced by 40%-45% 2020 compared to 2005”， **realized;**

The 2015 "Paris Agreement" voluntary action target, Unit GDP carbon dioxide emissions will be reduced by 60%-65% 2020 compared to 2005，**realized;**

In 2017, it was proposed that **non-fossil energy** will account for **50%** and the **terminal electrification rate** will reach **50%** by 2050；

In 2020, we will **strive to reach** peak by 2030, and **achieve** carbon neutrality by 2060.

In 2021, new target for reaching peak **before 2030** and carbon neutrality by 2060.

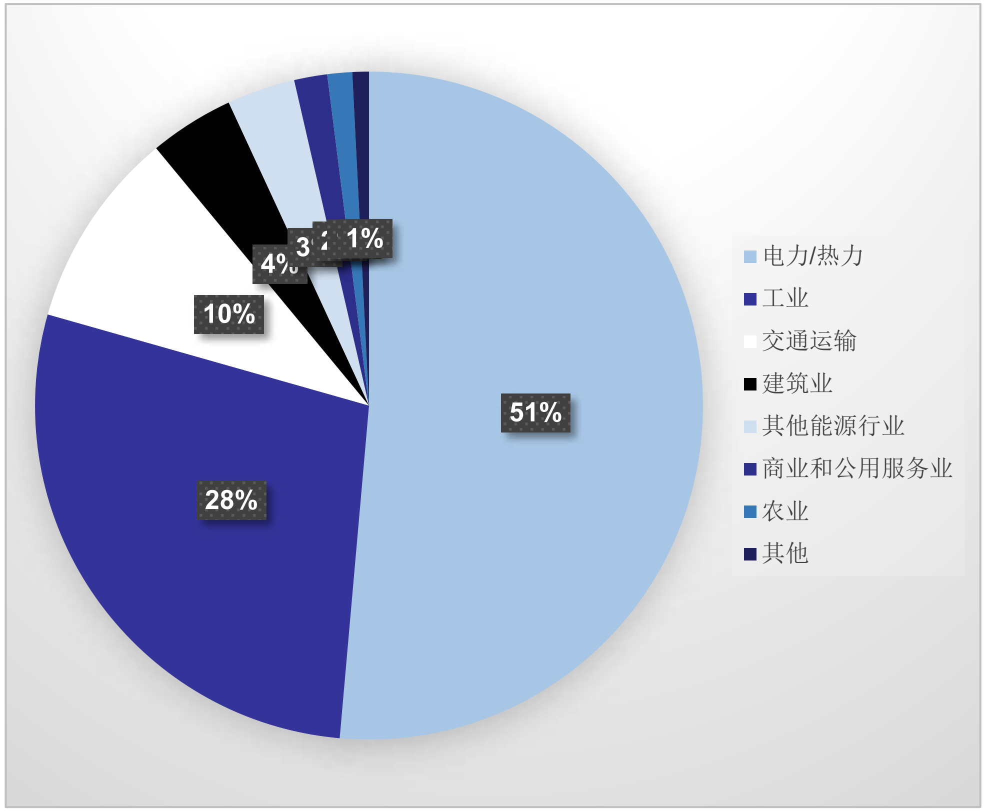
Chinese government is constantly self-reinforcing and self-pressurizing energy conservation and emission reduction.

1 Severe Global Warming Situation Gave Birth to the EI

Key areas: China's forest coverage is increasing, reaching the world average level by 2060, and its carbon absorption capacity can exceed 1.6 billion tons per year.

In China's carbon emissions composition, coal accounts for 43%, mainly used for thermal power generation, oil 25%, natural gas 5%, these three add up to 63%. Based on forest coverage objective, If it can completely replace fossil energy, China's carbon neutrality can completely meet the standard.

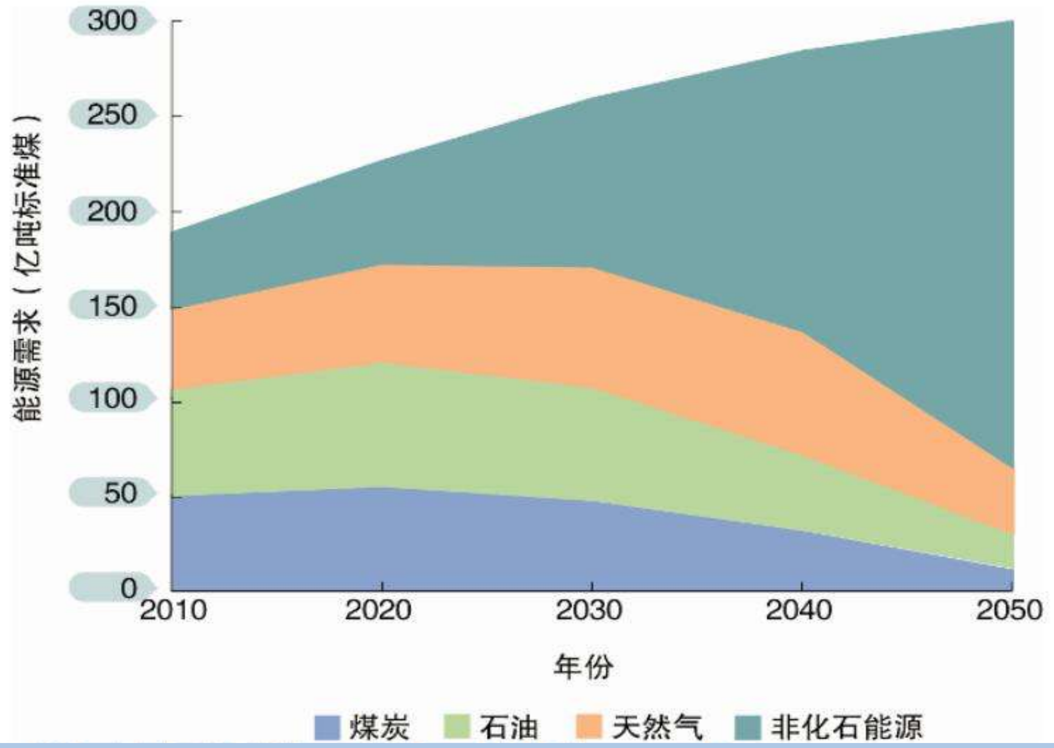
China's CO_2 emissions by sectors in 2019:



1 Severe Global Warming Situation Gave Birth to the EI

Global Energy Structure Transformation

Global Primary Energy Sub-species Demand from 2010 to 2050



Before 2030, the development of hydropower resources will be basically completed, and 2/3 of the global new energy demand will come from renewable energy sources.

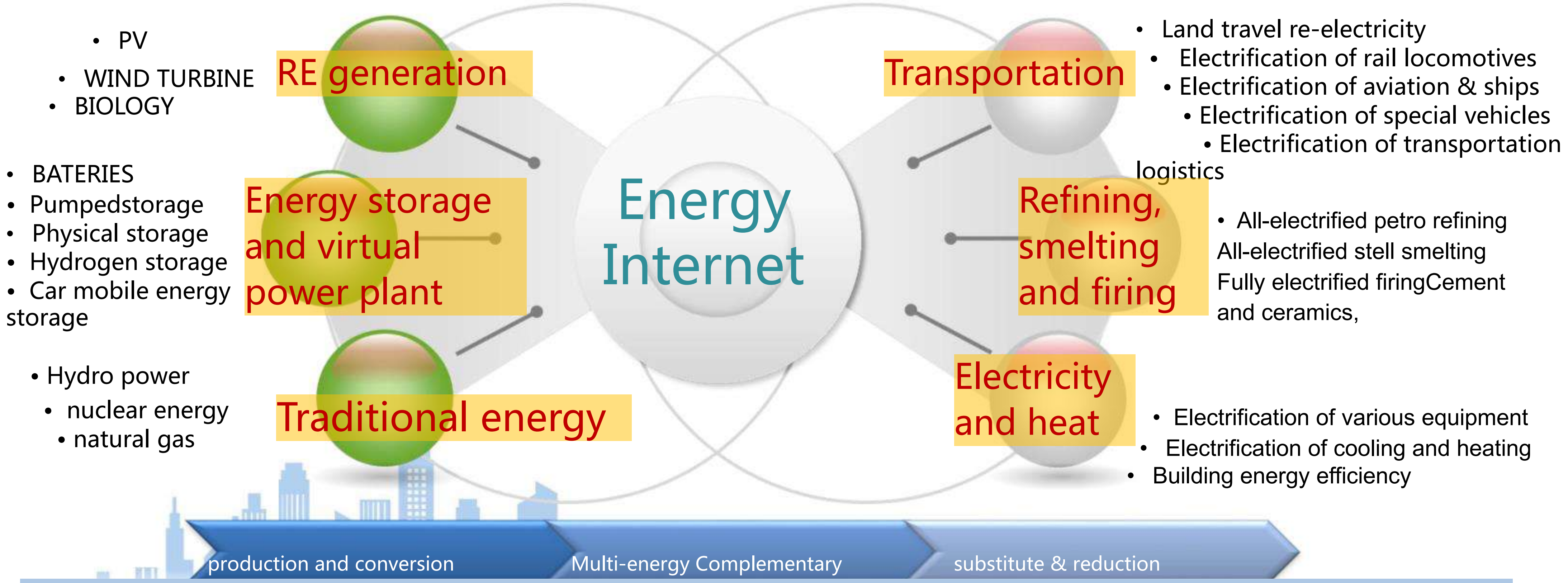
By 2030, non-fossil energy will account for about 1/3 of the total primary energy demand.

By 2050, clean energy will account for 80% of primary energy demand and become the dominant one.

Non-fossil Energy Fundamental Transformation

1 Severe Global Warming Situation Gave Birth to the EI

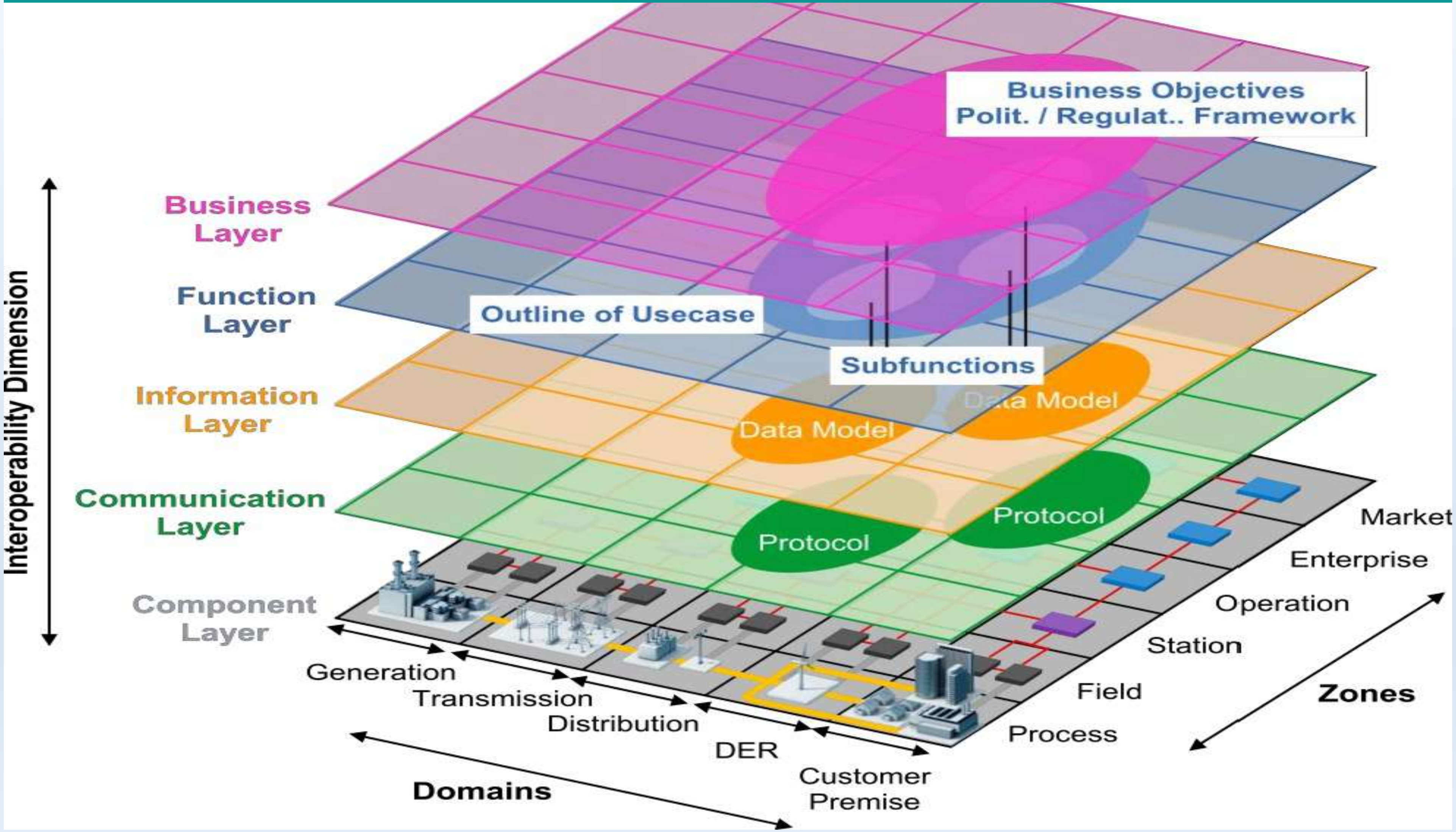
Carbon emission reduction=Energy Internet



Renewable-Energy+Energy Storage+Multi-Energy complementary+Electrification

1 Severe Global Warming Situation Gave Birth to the EI

Power Grid++Tansportation nerwork+Information Inernet



02

Part Two

EI need tight coupling of source-grid-load and storage

2 EI need tight coupling of source-grid-load and storage

The Energy Internet is the system to promote the realization of multi-energy complementary coordination and optimize resource matching. Means energy consumption, energy technology, and energy production revolution.

Energy consumption revolution

1. Consumption form

Under the framework of the Energy Internet, the energy consumption end can realize the optimal configuration and interconnection of various energy forms, and **realize the complementary coordination** of multiple energy sources for energy consumption.

2. Energy service

Energy service providers have changed from a single **"sell energy"** model to a **"sell service"** model. Users can freely switch between multiple energy sources such as oil, coal, natural gas, electricity, and achieve multi-energy complementary coordination of energy services

2 EI need tight coupling of source-grid-load and storage

Energy technology revolution

1. Multi-type integrated energy management platform

In order to promote the realization of multi-energy complementation and coordination, the future energy management platform will have the ability to integrate multiple types of energy such as electricity, gas, heating/cooling, and organically integrate with basic social support systems such as transportation, information, and medical care. The scientific dispatching and complementary advantages among the various energy sources within the country can achieve the goals of energy conservation and emission reduction, efficient use of energy, cascade utilization of multiple energy sources for users, and safe and reliable social energy supply.

2. Multi-energy integrated information processing technology

Realize three technical integrations: horizontal integration, vertical integration and diversified energy port integration. At the same time, highly integrated information processing technology will appear, which will ubiquitous sensors, embedded terminal systems, intelligent control systems, and communication facilities to form an intelligent network through virtual networks and CPS. Realize interconnection with machines and various types of energy services.

2 EI need tight coupling of source-grid-load and storage

Energy production revolution

1. Energy supply model

The production and supply of energy will shift from a **single** supply model to a **diversified** supply model. Energy suppliers will no longer only provide a single type of energy, but have the ability to provide multiple energy sources including electricity, natural gas, and oil.

2. Energy investment participant

Traditional power companies, coal companies, oil companies, natural gas companies, etc. will transform into **comprehensive energy suppliers** that master multiple energy resources

2 EI need tight coupling of source-grid-load and storage

能源互联网
Energy Internet

Dec 2020, The National Energy Administration of China issued guidelines to build an energy Internet and an integrated energy system to achieve multi-energy complementarity and promote a new energy revolution in the energy sector.

For the Energy Internet, it is very important to ensure the safe and stable operation of the core network power system. The tight coupling of new energy source-grid and non-traditional loads based on power electronic equipment, such as electric vehicles and energy storage equipment, will produce synergistic effects and reduce system costs.

2 EI need tight coupling of source-grid-load and storage

能源互联网
Energy Internet

In the energy Internet with power electricity grid as the core network, with the advancement of power electronics technology, large-scale clean energy power generation has become a trend.

It is not applicable that the traditional power system transient stability analysis method was used for the multi-machine coupling system model of power electronic equipment and traditional synchronous machines.

The essential characteristics of power electronic power system, such as non-linearity, multiple time scales, and complexity, make it the basic problems and challenges of transient stability that are the current research direction.

2 EI need tight coupling of source-grid-load and storage

能源互联网
Energy Internet

The development of power electronics technology has enabled many non-traditional power loads, such as electric smelting furnaces, to be directly energized, which laid the foundation for the full electrification of power grid load terminals.

The traditional power system based on synchronous generators is transforming to a power system based on diversified power electronic equipment. As a result, the power system is facing a major change that has never been seen in more than 100 years. The construction of a new power system is in Must do.

2 EI need tight coupling of source-grid-load and storage

Energy supply side: Promote energy Internet

To achieve the **2030 peak** and **2060 carbon neutral** goal.

In 2020-2025, the newly installed PV/wind capacity has 20% for improvement; In 2025-2030, the capacity has 40% for improvement;

The proportion of non-fossil energy power generation needs to be increased to more than 90% in 2050;

It is an inevitable trend to increase the proportion of clean energy to realize the replacement of traditional energy from new energy source. This will need huge of effort and fill huge room.

2 EI need tight coupling of source-grid-load and storage

User demand side: Promote integrated energy system

Four major measures can be taken to replace traditional energy sources and increase the proportion of clean energy consumption:

(1) Increase the proportion of clean energy consumption structure;

(2) Speed up the electrification process of various sectors;

(3) Reduce unnecessary energy consumption;

(4) Use carbon sequestration or removal technology.

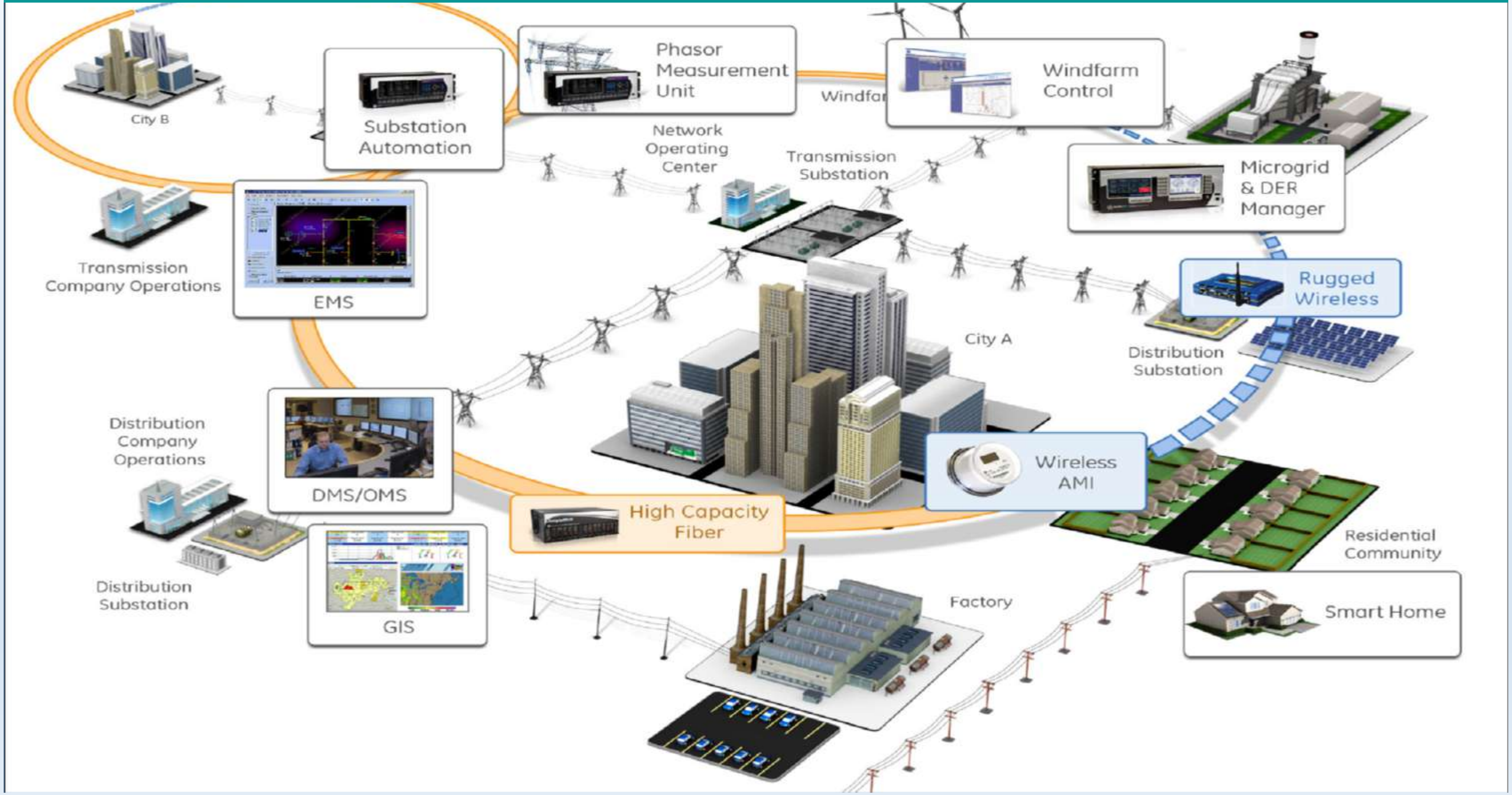
2 EI need tight coupling of source-grid-load and storage

If the power consumption structure changes and the consumer end is re-electrification, the Power Grid Planning must change its mindset for coupling source-grid-load-storage, and transform the traditional spinning reserve and pumped storage modes into mixed with energy storage modes.

The energy storage capacity configuration requirements of renewable energy projects range from 5%-20%. An enduser integrated energy system will support the electric vehicles application and establish active distribution network.

2 EI need tight coupling of source-grid-load and storage

Energy Internet Smart City Scenario



2 EI need tight coupling of source-grid-load and storage

Electric Vehicle, as the representitive of new power load, its future development can achieve a regional balance between supply and demand, which can completely smooth the fluctuation of large-scale new energy and solve the high abandonment of PV/wind. At the same time, the power grid can effectively resist the impact of natural disasters. Even if a large area local blackout occurs, the millions of cars can become black start power supply and voltage stability support.

2 EI need tight coupling of source-grid-load and storage

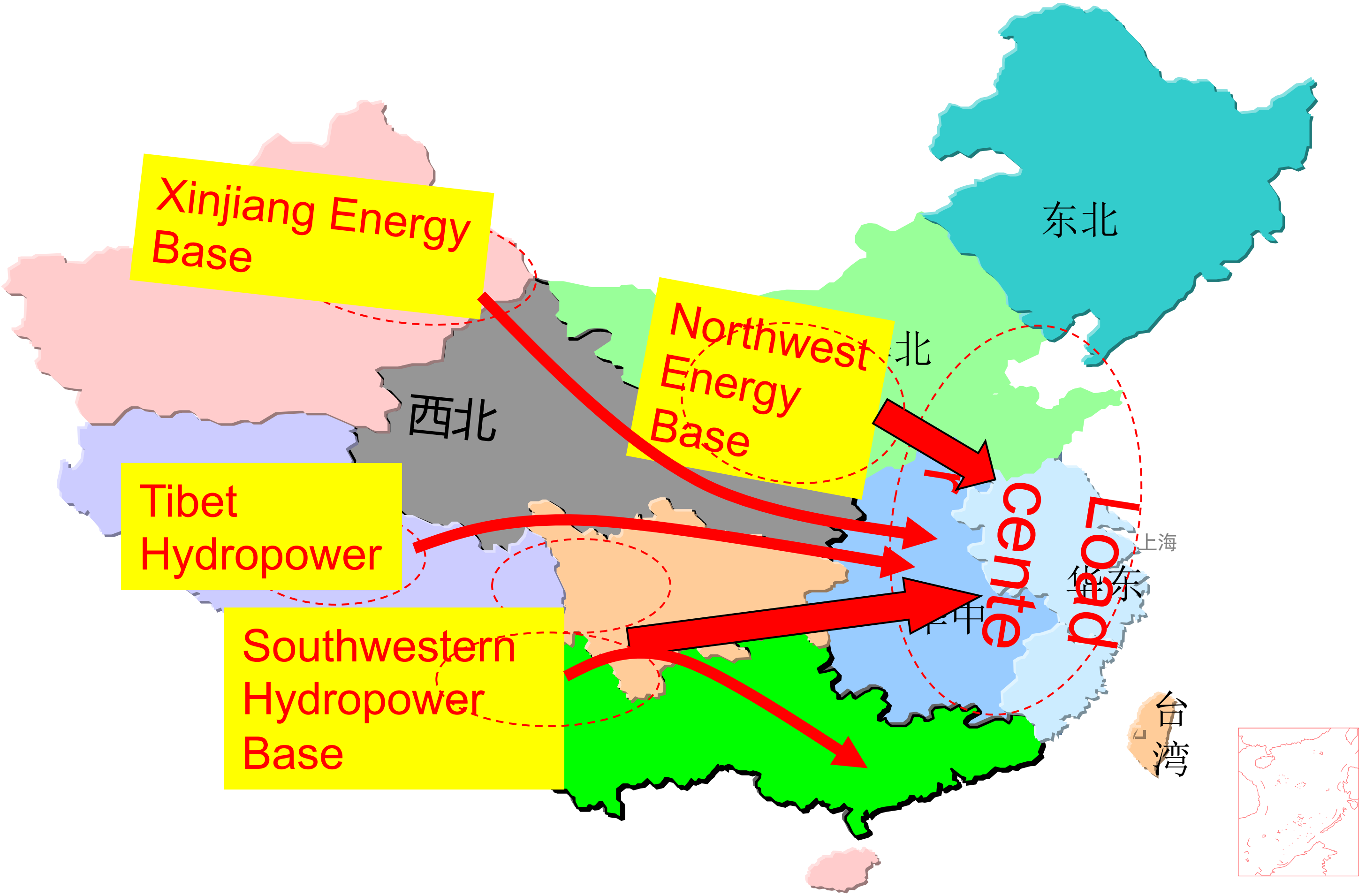
Energy Internet Connected Car Scenario

发电企业的最大挑战是公司经营思维和员工工作方式的转变。

Part Three

03 Grid Planning upgrated to energy Internet planning

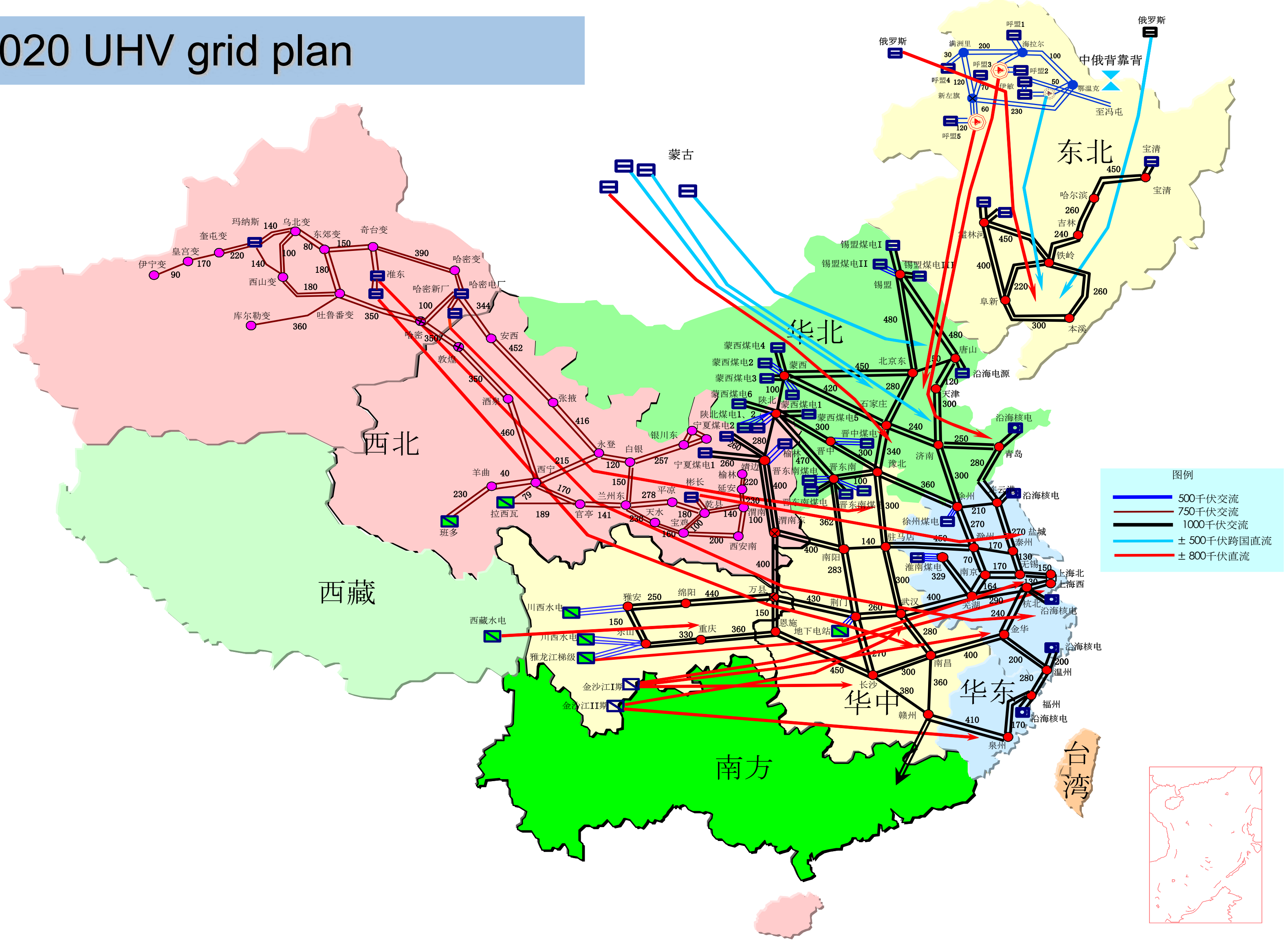
3 Grid Planning promoted to energy Internet planning



China's energy landscape-large-scale interconnected grid as the core of energy transfer

3 Grid Planning promoted to energy Internet planning

2020 UHV grid plan



3 Grid Planning promoted to energy Internet planning

A strong smart grid has been built from 2005 to 2020

Based on the UHV grid as the backbone and the coordinated development of power grids at all levels, the use of advanced communication, information and control technology , China has built a strong smart grid, which characterized by informatization, digitization, automation, and interaction. Through the integration of power flow, information flow, and business flow, flexible access and convenient use of diversified power sources and power users with different characteristics are realized.

Smart grid greatly improves the ability of the power grid to optimize resource allocation, greatly enhances the service capacity of the power grid, and drives power Industry and other industries upgraded to meet the requirements of comprehensive, coordinated and sustainable economic and social development in the country. Chinese power grid is Internationally leading, independent innovation and Chinese characteristics.

3 Grid Planning promoted to energy Internet planning

A strong smart grid has been built from 2005 to 2020

The national architecture planning and construction of China's power grid has been relatively complete and has entered the conventional development stage, which can meet the needs of economic development. However, in the face of the future carbon peak and the realization of carbon neutral goals, the large-scale integration of new energy, and the re-electrification of the user side, China's power grid planning is again facing profound changes.

3 Grid Planning promoted to energy Internet planning

2021-2035 Energy Internet Plan

On April 26, 2021, State Grid issued the "State Grid Corporation Energy Internet Plan", emphasizing that the electricity-centric energy Internet is the part of the broad energy Internet that has direct electrical connections and coupling relationships. It is the important and core of the broad energy Internet. It is an advanced stage of upgrading the technical form and function from the traditional power grid.

Vertically, energy grid, information support, and value creation, forming a matrix-style as a whole grid planning.

3 Grid Planning promoted to energy Internet planning

Energy Internet Network Planning

3 Grid Planning promoted to energy Internet planning

Energy Internet planning targets

The Chinese government department proposes that by 2030, carbon dioxide emissions per unit of GDP will be reduced by more than 65% compared to 2005, non-fossil energy will account for about 25% of primary energy consumption, and forest stock will increase by 6 billion cubic meters compared with 2005. The total installed capacity of wind power and solar power will reach more than 1.2 billion kilowatts.

According to the above guidelines, State Grid plans to fully build an internationally leading energy Internet with Chinese characteristics by 2035, with electricity accounting for 30% of terminal consumption, and cross-provincial input capable of reaching 300 million kilowatts.

3 Grid Planning promoted to energy Internet planning

Energy Internet planning targets

Closely focus on the realization of the dual-carbon reduction goal and the construction of a new power system, and to realize the energy Internet.

The first is to use a strong grid as a platform to promote multi-energy complementation and multi-interaction to ensure safe energy supply.

The second is to comprehensively improve security capabilities through the digital transformation of the power grid, and promote the upgrade of smart grid to intelligent grid.

The third is to promote the expansion and upgrade of traditional values to emerging values, and build a complete energy Internet ecosystem.

3 Grid Planning promoted to energy Internet planning

1. Green Development

Through measures such as the integration of source, grid, load and storage, and multi-energy complementation, we will accelerate the development of new energy from the main body of newly installed capacity to the main body of total installed capacity, surpassing coal power to become the largest power source, promote the construction of new power systems and the green transformation of energy systems, and actively serve national "dual carbon" target.

1. Fully support the scale development of new energy
2. Actively promote multi-energy complementation on the power supply side
3. Improve the level of large-scale cross-regional allocation of resources
4. Improving the new energy consumption capacity of the distribution network

3 Grid Planning promoted to energy Internet planning

1. Green Development

5. Actively promote the development of microgrids

Build grid-connected and independent microgrids according to local conditions, promote the aggregation and interaction of multiple loads such as distributed power sources, electric vehicles, energy-using terminals, and new energy storage, realize the integration of consumer-side source-network-load-storage, and participate in grid peak shaving and optimized operation.

6. Improve the electrification level of terminal energy consumption

Expand the breadth and depth of electric energy substitution in the five major areas of industrial manufacturing, power supply, transportation, residential heating, and home electrification. During the "14th Five-Year Plan (2021-2025) " period, the replacement electricity in the company's business area reached 600 billion kwh.

3 Grid Planning promoted to energy Internet planning

1. Green Development

7. Improve system to regulate energy

Accelerate the construction of pumped-storage power stations, encourage flexible transformation of coal-fired power and peak-shaving gas power construction, support the development of new energy storage services, promote multiple models of "new energy + energy storage", "microgrid + energy storage", and actively tap demand Side response resources.

3 Grid Planning promoted to energy Internet planning

2. High level Security

Through the construction of a strong backbone grid, flexible distribution network, and platform cloud network integration, etc., build an energy Internet security defense system, improve the grid anti-disturbance ability and self-healing ability under the background of "double high" and "double peak", and improve information Security situation awareness and intelligent and dynamic network security protection levels can achieve a higher level of power security.

1. Speed up the construction of strong backbone power grids in various regions
2. Improve the reliable power supply capacity of the distribution network
3. Improve the design standards for disaster prevention in key areas
4. Strengthen the power supply guarantee ability of important users
5. Improve the level of information security protection in all scenarios

3 Grid Planning promoted to energy Internet planning

3. Intellegent Enpowerment

Comprehensively improve the capabilities of information collection, transmission, processing, and application, and promote the integration of traditional power grid infrastructure and new digital infrastructure, promote smart power grid dispatching and operation and smart operation management, and realize smart empowerment based on digital transformation.

1. Improve the level of power grid intelligence
2. Build an information processing platform
3. Build a smart grid operation system

3 Grid Planning promoted to energy Internet planning

4. Value Creation

On the basis of continuously deepening the value of energy distribution, social and people's livelihood, and industrial development, etc., by opening up the three types of emerging values of energy transformation services and energy platforms, realizing value sharing for the economy and society, people's lives, industry and enterprises, and promoting strategic emerging industries The development of the country, creating an ecosystem of sharing, co-governance and win-win.

1. New value of energy transition services
2. New value of energy digital products
3. New ecological value of energy platform
4. Strengthen the power supply guarantee ability of important users
5. Improve the level of information security protection in all scenarios

3 Grid Planning promoted to energy Internet planning

The effectiveness of the Energy Internet

The new power system realizes the optimal allocation of large-scale resources, and the clean energy transformation is mainly based on the consumption of new energy. The energy supply is diversified, clean and low-carbon, and the level of cleanliness has reached a new level. Energy consumption is highly efficient, reduced, and electrified, and the level of electrification has been improved.

The new power system promotes the interconnection and mutual benefit of multi-energy sources, and the deep integration of source, network, load and storage.

3 Grid Planning promoted to energy Internet planning

Energy Internet Industry Chain Scenario

基于互联网的交易与分析中心，除提供交易服务外，提供大数据运行支持，同时包含了需求预测、设备管理、电力期货等

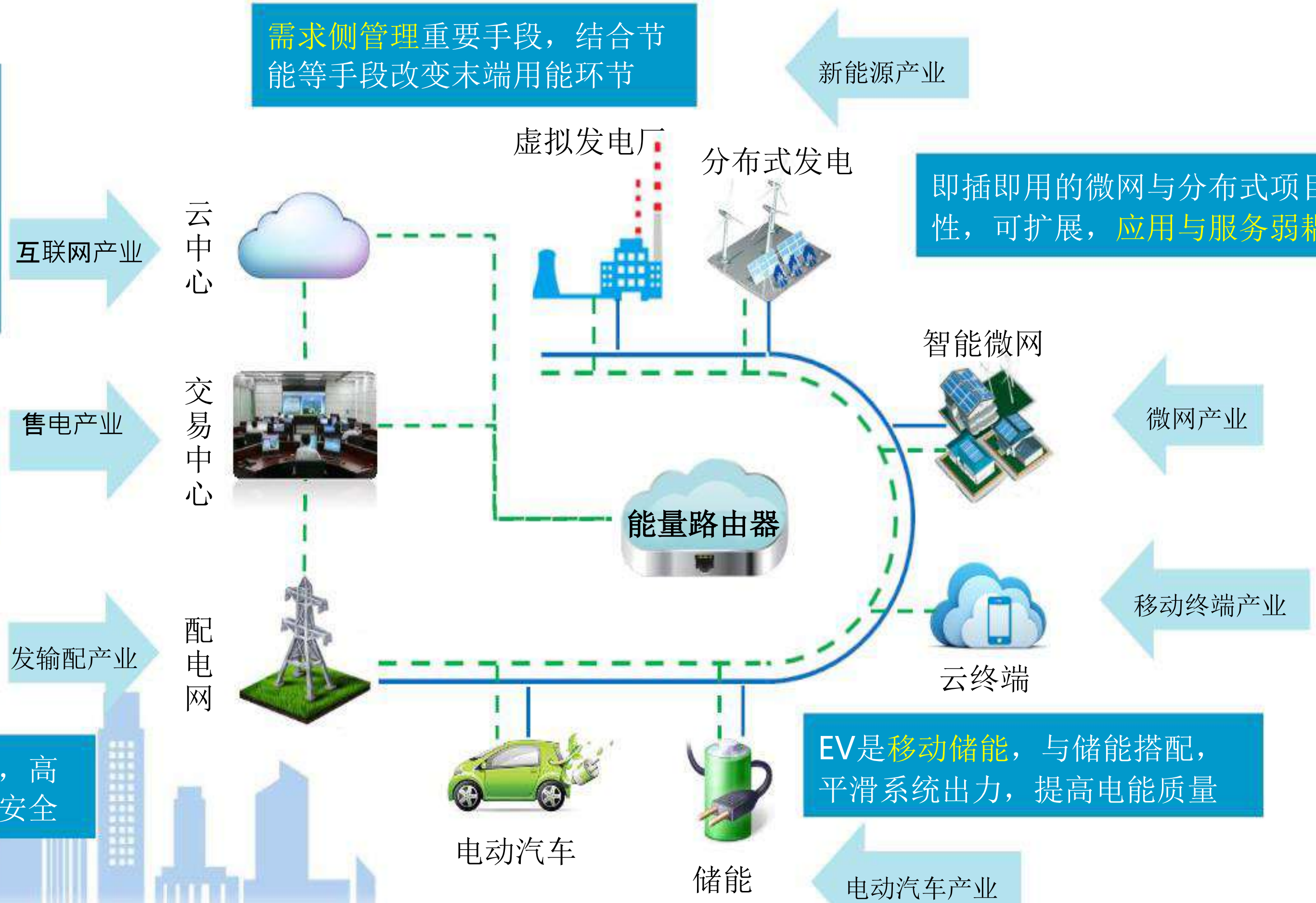
自由电能交易市场，本次电改重点方向

主动配电网架构，高度可靠，强壮，安全

需求侧管理重要手段，结合节能等手段改变末端用能环节

即插即用的微网与分布式项目，柔性，可扩展，应用与服务弱耦合

EV是移动储能，与储能搭配，平滑系统出力，提高电能质量



04

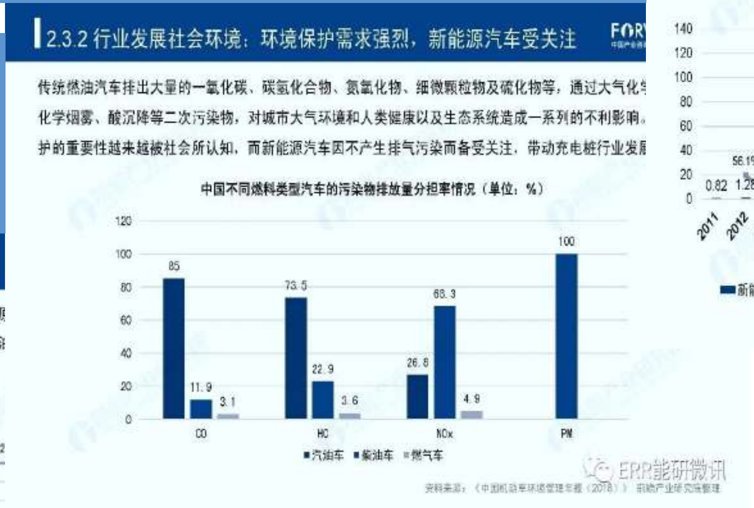
Part Four

Ele-transportation development requires grid adapting

4 Eletric transportation requires grid adapting

The acceptance of new energy vehicles in the whole society is getting higher and higher

Environmental pollution caused by traditional fuel vehicles is getting more and more serious



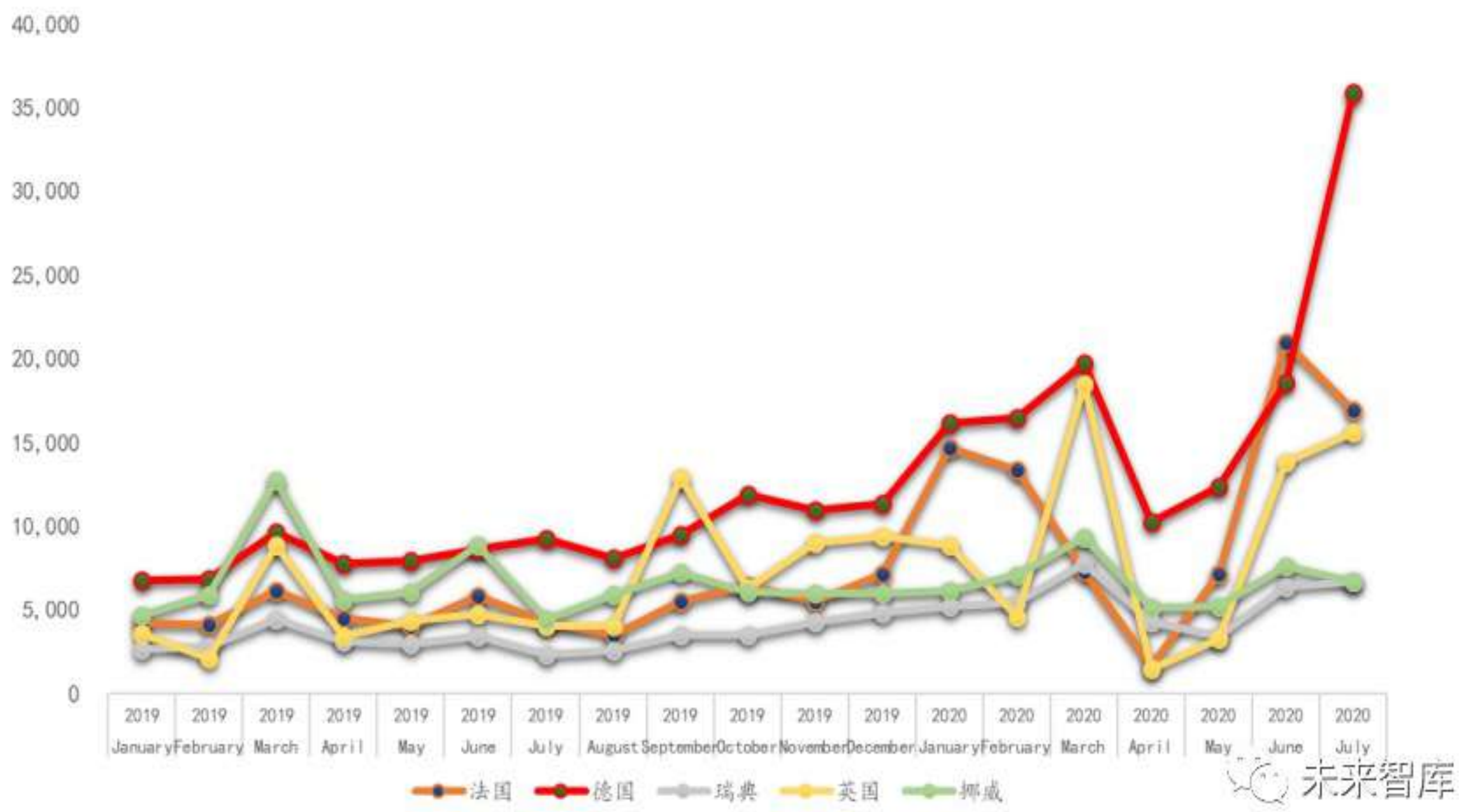
China's dependence on crude oil imports reached 72% in 2019, and it is urgent to find alternative energy sources

4 Eletric transportation requires grid adapting

New energy vehicles are gradually separated from subsidies, costs continue to decrease, and performance continues to be optimized

4 Eletric transportation requires grid adapting

Market situation of major new energy vehicles in Europe



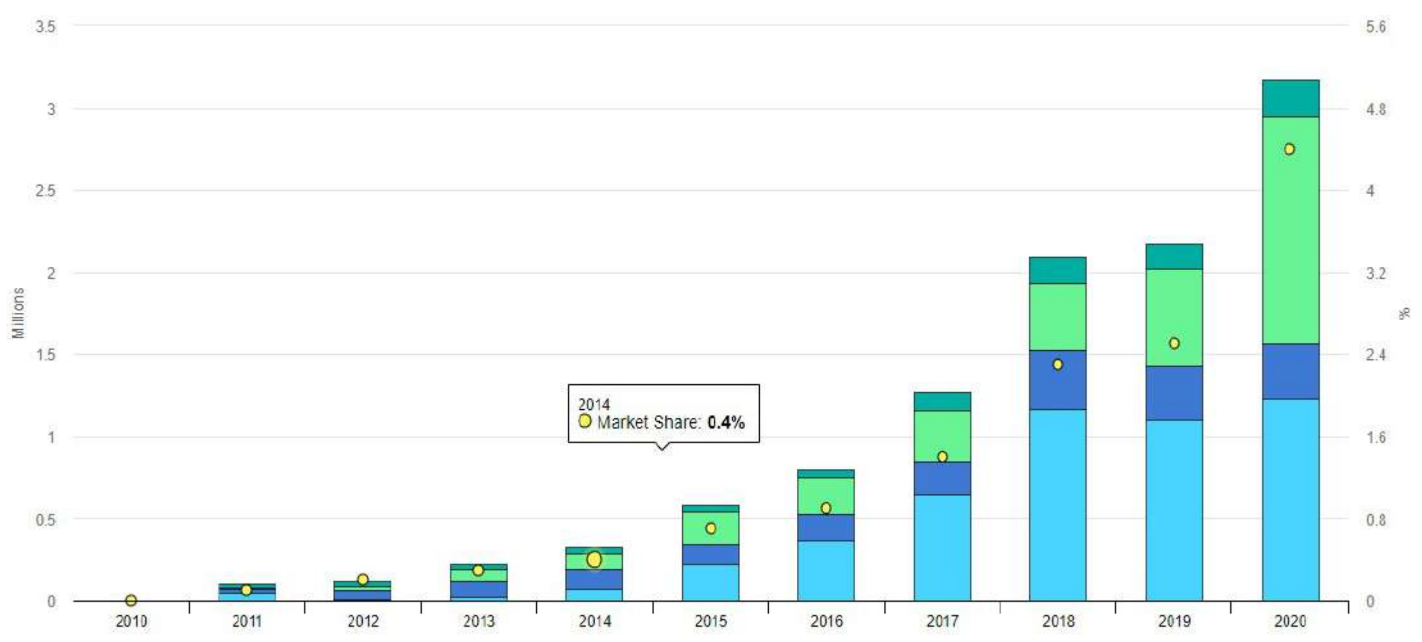
4 Eletric transportation requires grid adapting

Global electric car sales by key markets, 2010-2020e

Last updated 28 Jan 2021

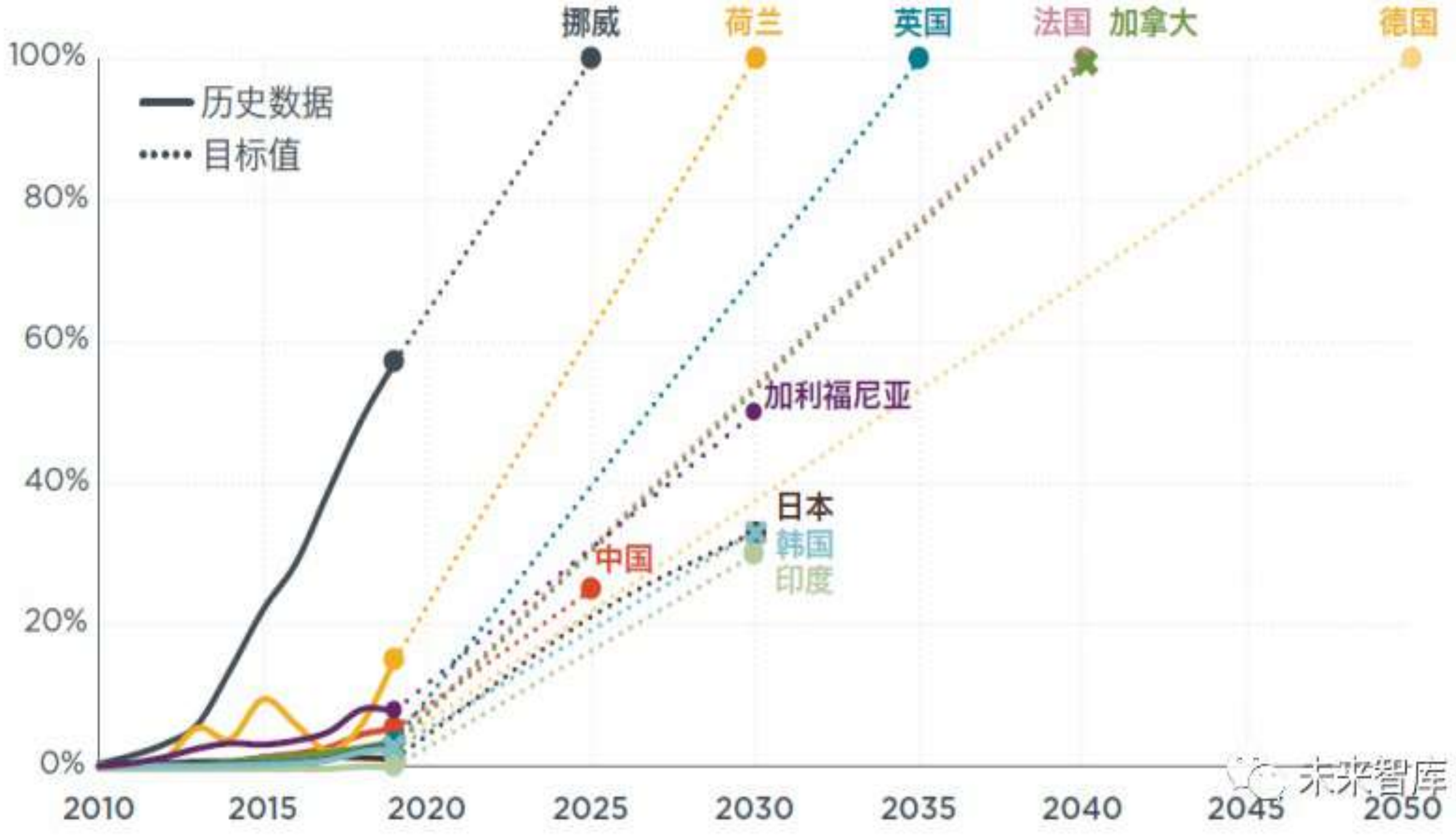
Download chart ↓

Cite Share



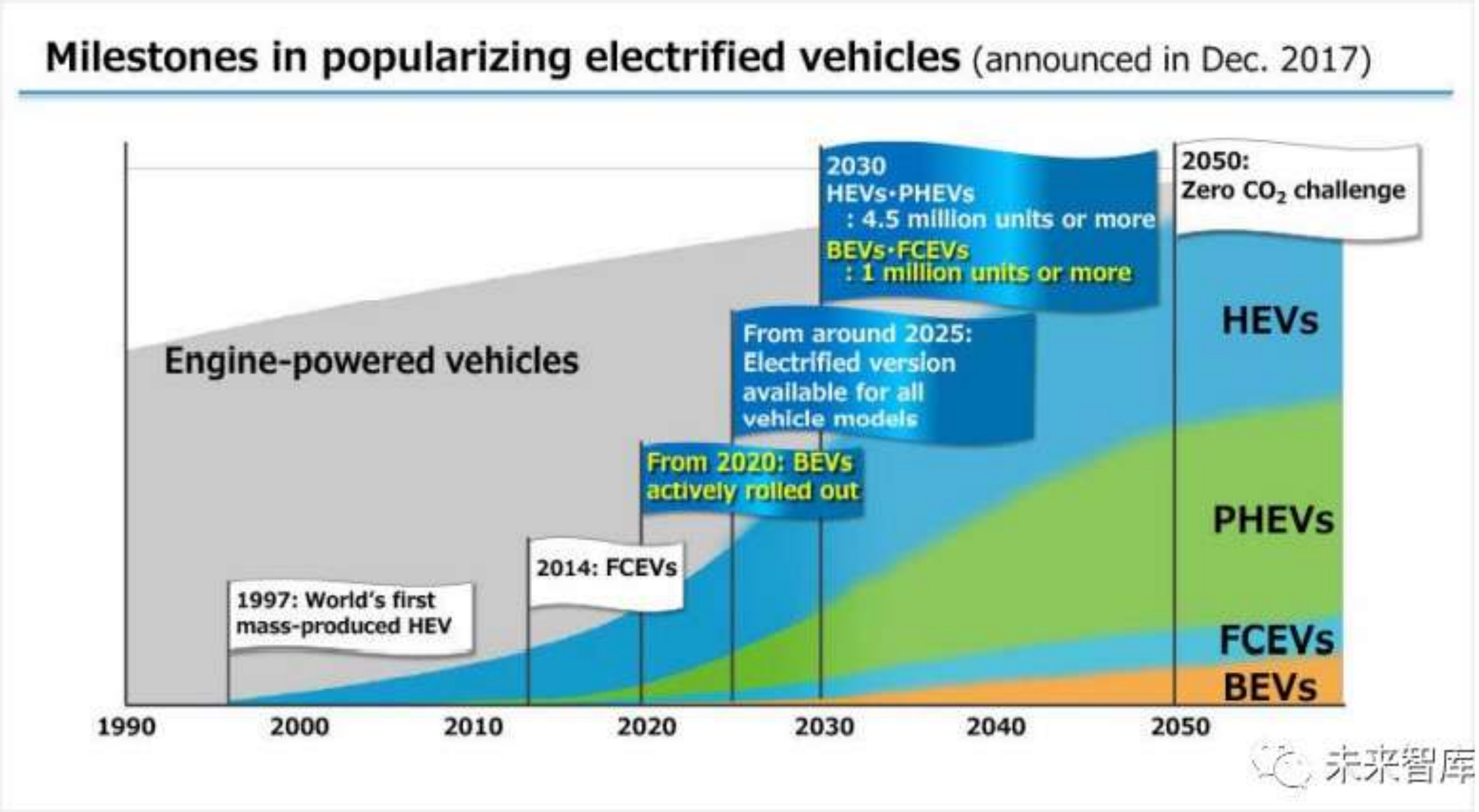
4 Eletric transportation requires grid adapting

Fitting of target values of automobile electrification in various countries with actual data



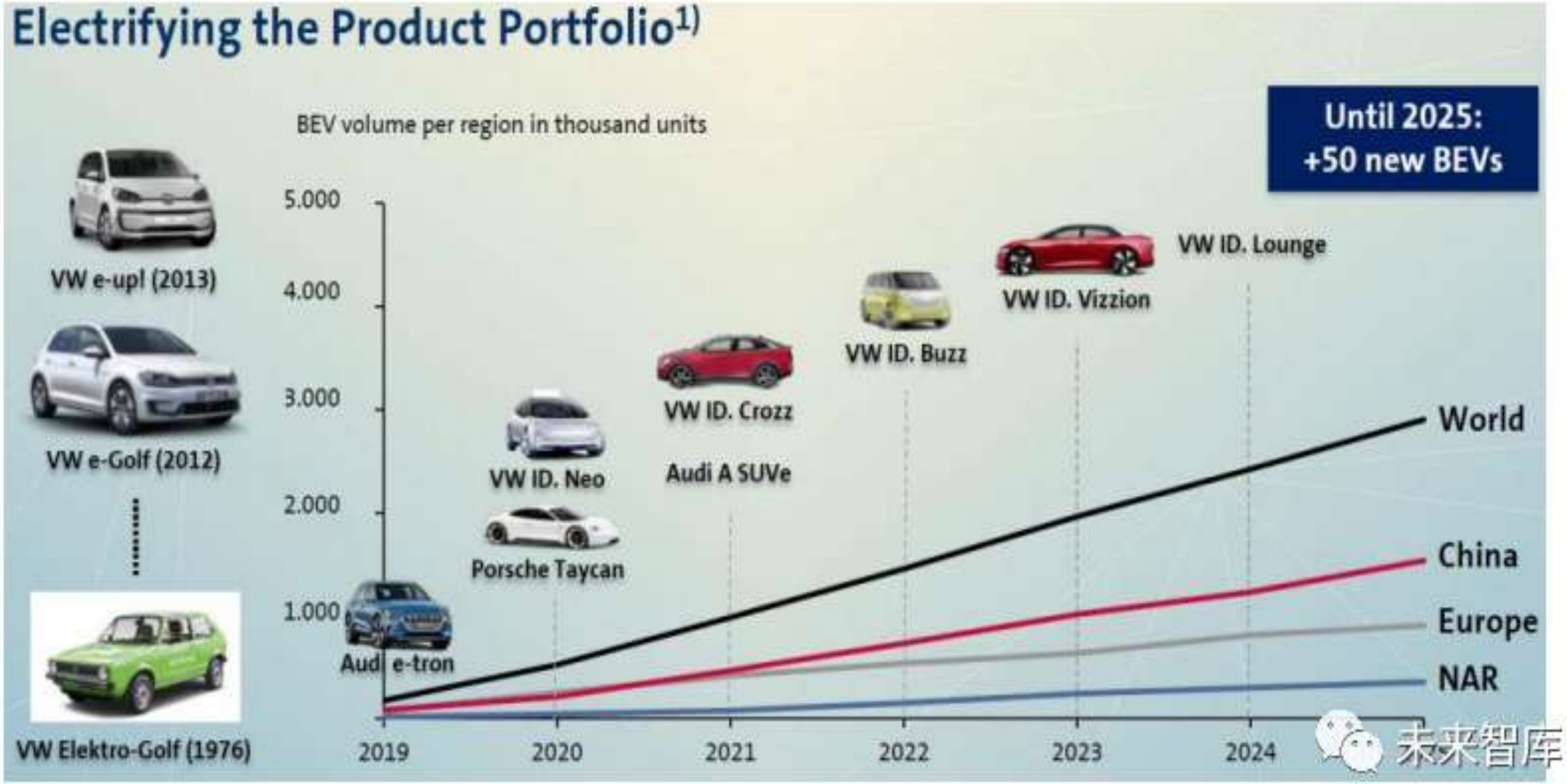
4 Eletric transportation requires grid adapting

Toyota Group's electrification goals



4 Eletric transportation requires grid adapting

Volkswagen Group's electrified model planning



4 Eletric transportation requires grid adapting

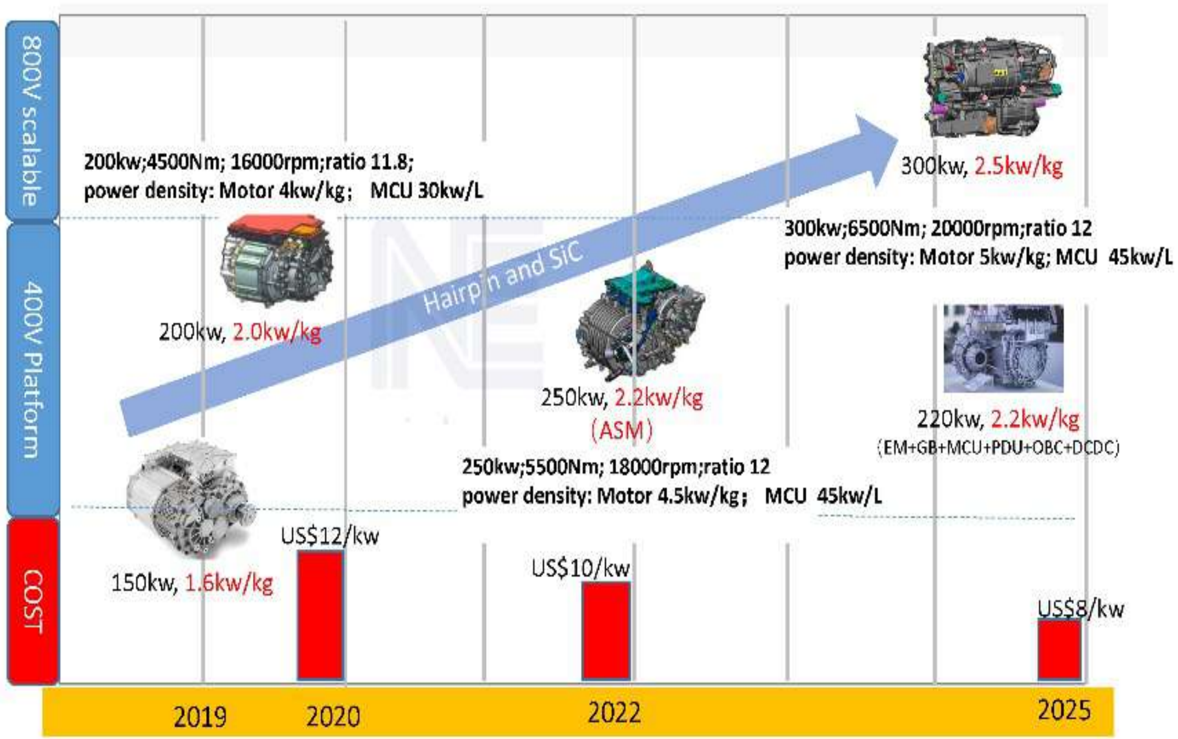
KEY TECHNOLOGIES

Light Weight Body （轻量化车体）
Integrated Power Train (动力总成一体化)
High Performance Safety Battery Pack (高性能安全电池包)
Intelligent Charging (智能充电)
Intelligent Manufacturing (智能制造)
Intelligent Connected Vehicles (智能网联汽车)

4 Eletric transportation requires grid adapting

动力总成一体化趋势　Trend of electric drive system

- Higher System voltage
- Larger Power
- Higher power density
- Lower cost



提高功率密度、矩密度增、效率，可靠性，降低成本。采用新材料例如碳化硅电力电子器件

ncrease power density, torque density, efficiency, reliability while reduce cost. New material e.g. SiC Power Devices

4 Eletric transportation requires grid adapting

Batery technology Road Map

Current: Lithium Iron phosphate, Ternary Lithium, Lithium Titanite

New Generation: Lithium-sulfur,Solid Lithium iron
Wafer Technology

At present latest news, Metal na-material batteries are becoming a new choice with low cost, convenient use and fast charging speed.

4 Eletric transportation requires grid adapting

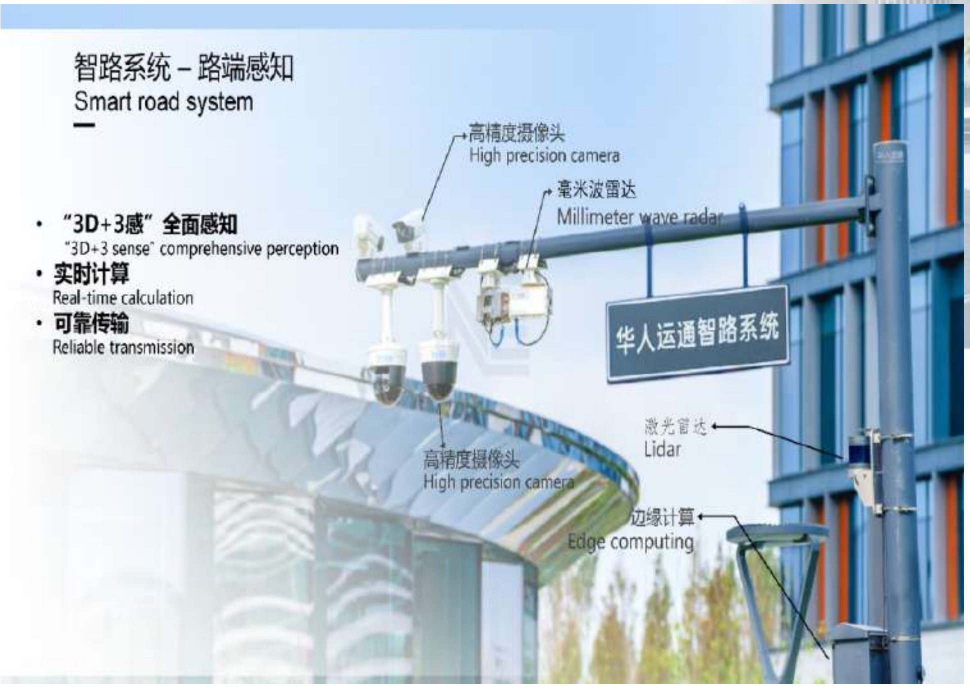
Intelligent Connected Vehicles

Intelligent connected vehicles are not only transportation means,but also

(1) Nodes of IoT
(2) Sources of Big Data
(3) Terminals of Mobile Broad Band
(4) Promoter of 5G Communication
(5) Computers and Distributed Energy Source

4 Eletric transportation requires grid adapting

Intelligent vehicles and Intelligent road system



4 Eletric transportation requires grid adapting

国产新能源交通工具　China Made Electric High Speed Train, Maglev and Aero plane

复兴号CR400BF型动车组（中车长客）

速度350km/h，牵引功率10MW

高速磁浮交通系统（中车四方、同济大学）

速度600km/h， 牵引功率24MW

复合翼垂直起降无人机（中国商飞），最大功率150kW

氢燃料电池电-电混合动力，巡航速度120km/h，

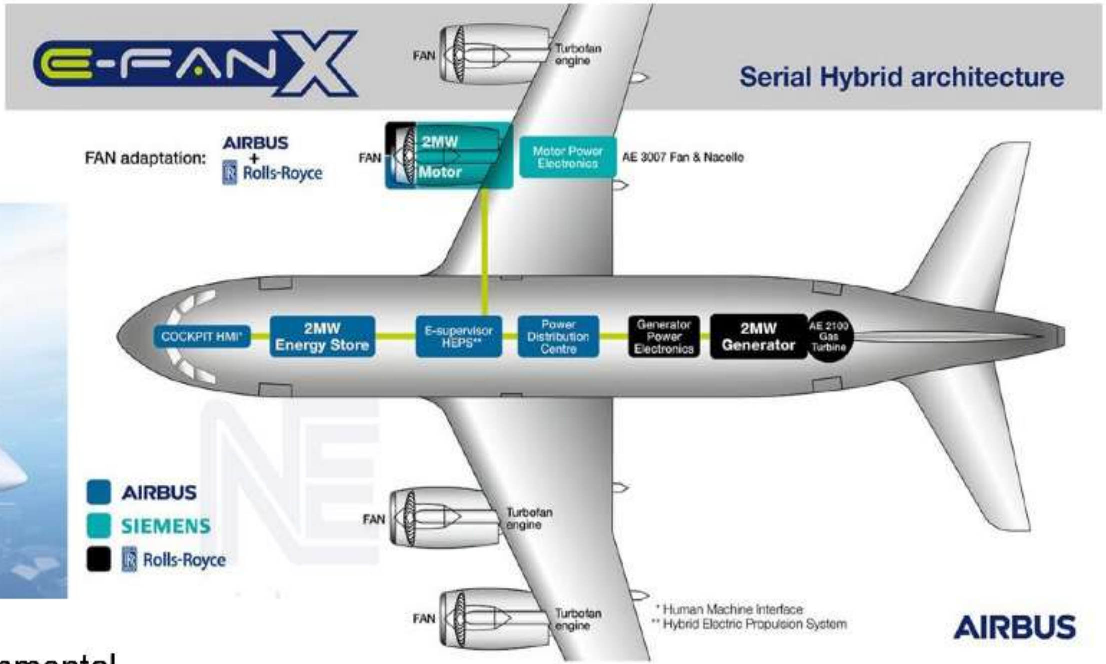
锐翔RX4E电动飞机（辽宁锐翔），最大功率140kW

4座通用飞机， 巡航速度200km/h

4 Eletric transportation requires grid adapting

电动船 Electric Boat and Ship

4 Eletric transportation requires grid adapting



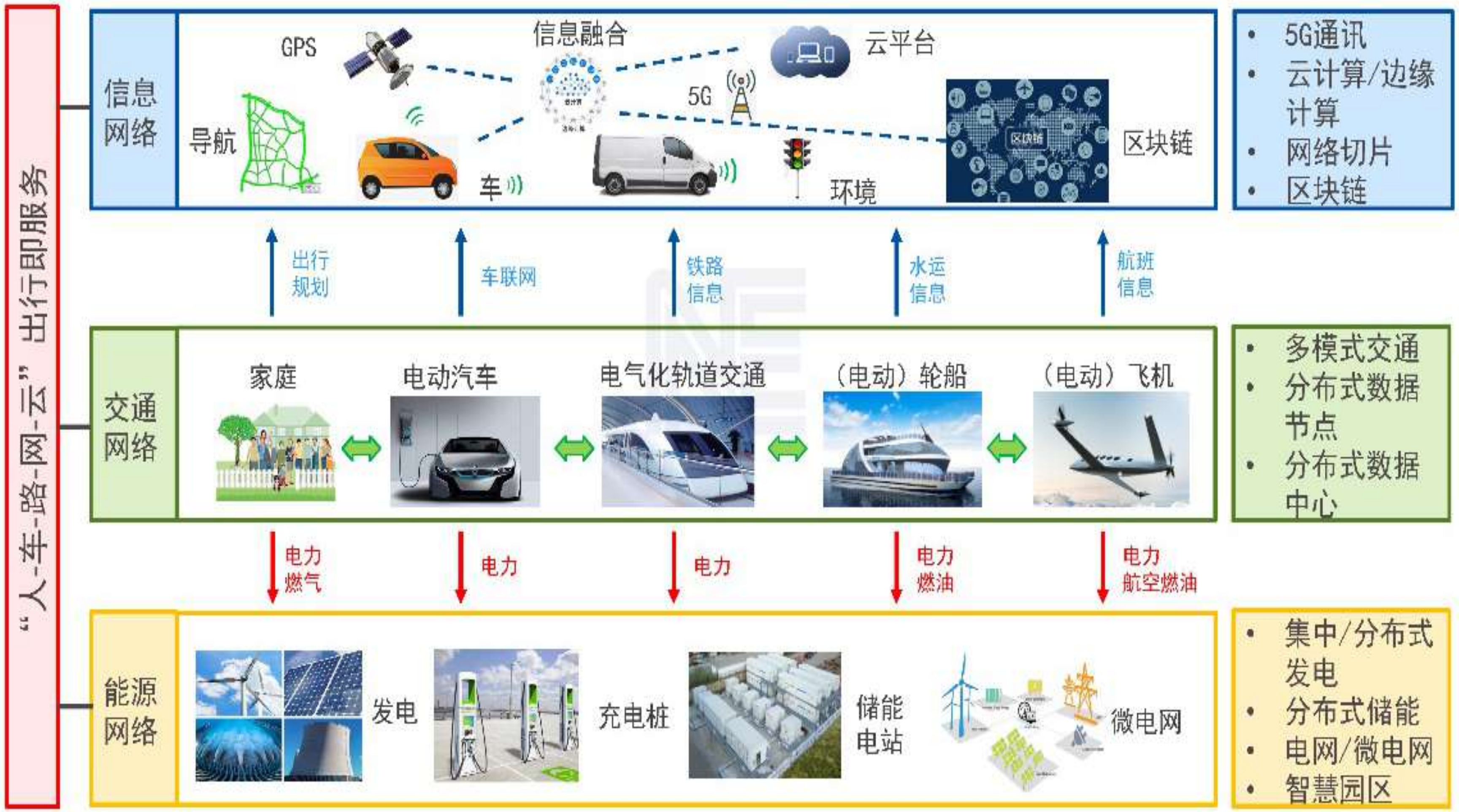
To meet the EU technical environmental goals of the European Commission's Flightpath 2050 Vision for Aviation (reduction of CO2 by 75%, reduction of NOx by 90% and noise reduction by 65%).

The E-Fan X demonstrator will explore the challenges of high-power propulsion systems, such as thermal effects, electric thrust management, altitude and dynamic effects on electric systems and electromagnetic compatibility issues.

https://www.rolls-royce.com/media/our-stories/insights/2018/paul-stein-talks-about-e-fan-x.aspx

4 Eletric transportation requires grid adapting

The Future of Energy Internet and Intelligent Transportation



05 *Part Five*

How to plan interactive Vehicles-grid and innovation

Huge Impact on Grid with Large-scale Integration of E-vehicles

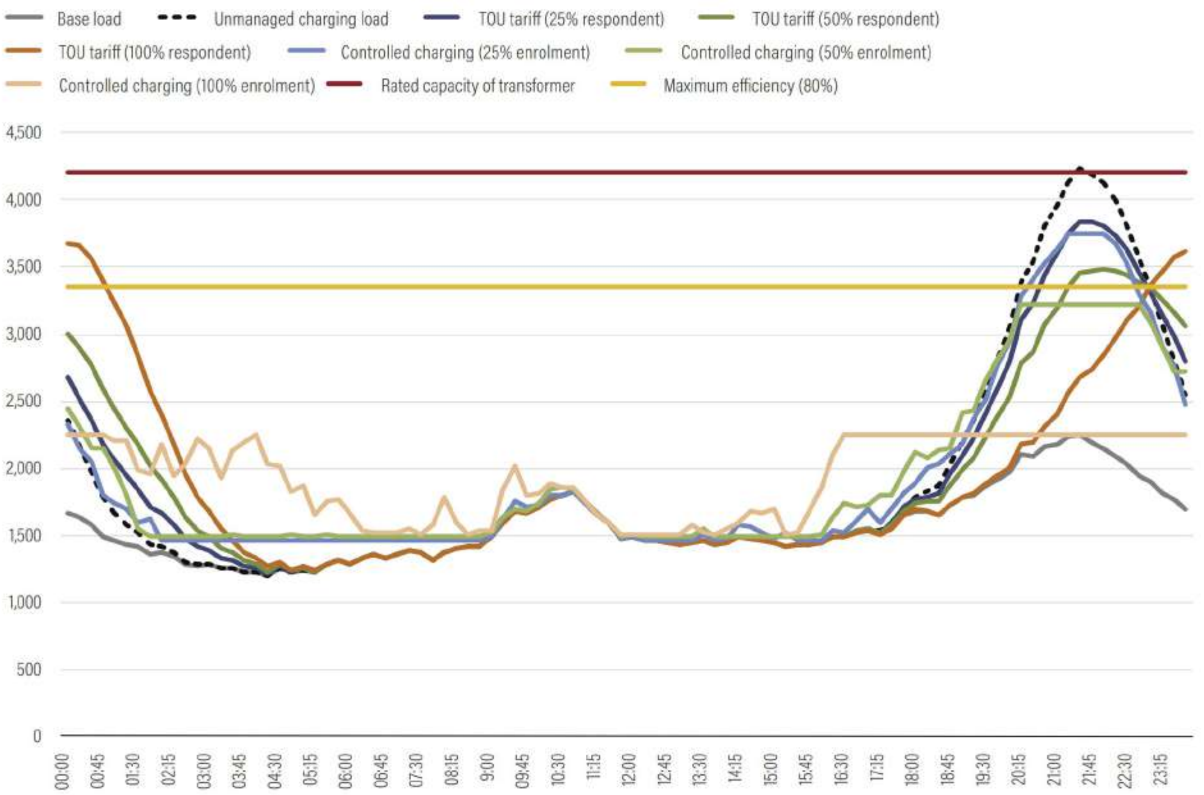
Electric Vehicle Industry Development Plan (2021-2035)

The top-level planning of the new power system gives the solution

5 How to plan interactive Vehicles-grid and innovation

Huge Impact on Grid with Large-scale Integration of E-vehicles

Figure ES-3 | Optimized Transformer-level Load: Peak-shaving Effects of Managed Charging (100% vehicle electrification, unit: kW)



Source: calculated by this study

5 How to plan interactive Vehicles-grid and innovation

Huge Impact on the Grid of Large-scale Integration of E-vehicles

After the large-scale promotion of electric vehicles, the problem of disorderly charging bring challenges to generation, transmission, distribution and supply sides.

1. From the perspective of the entire network, electric vehicles will have a greater impact on the electricity load curve of the entire network due to the future promotion of new energy vehicles, as well as the proportion of fast charging of private cars and the simultaneous charging rate. In extreme areas, there will be problems such as insufficient installed capacity, line overload.

2. From the perspective of the local power grid, the impact on the distribution system is greater than the impact on the entire grid. In the disordered charging mode, the peak load increase varies from 5% to 129%; especially when the proportion of vehicles is electrified When it reaches 50%, most distribution transformers face the risk of overload.

5 How to plan interactive Vehicles-grid and innovation

Huge Impact on Grid with Large-scale Integration of E-vehicles

3. Different regions or cities have different financial subsidies and different development stages of electric vehicles. Differentiated measures need to be taken based on their own characteristics. Especially when high-power fast charging has a great impact on the power grid, it can lead to expensive joint investment in the power grid.

4. Lack of overall measures in terms of vehicle-network coordination. Intelligent and orderly charging and two-way charging and discharging are facing the challenge of business models, technical obstacles and limited public acceptance;

5. Electric market design.

5 How to plan interactive Vehicles-grid and innovation

By the end of May 2021, China has 5.8 million new energy vehicles, accounting for about 50% of the global total of new energy vehicles.

中国新能源汽车的发展规划

Development Planning of New Energy Vehicles in China

2020年 12月 国办颁布新能源汽车产业发展规划2021-2035：2025年占比20%，能耗12kWh/100km.2035年占比成为主流。2020年预计130万辆，2022年预计180万辆

2012年4月，国务院常务会通过《节能与新能源汽车产业发展规划(2012—2020年)》，到2015年，纯电动汽车和插电式混合动力汽车累计产销量达到50万辆，到2020年产能达200万辆以上，累计产销超过500万辆。In April 2012, the Standing Committee of the State Council adopted the Development Plan for Energy Conservation and New Energy Vehicle Industry (2012-2020). By 2015, the cumulative production and sales of EV and PHEV will reach 500,000 vehicles, and by 2020, the production capacity will reach more than 2 million vehicles, and the cumulative production and sales will exceed 5 million vehicles.

	2015	2020	2025	2030
汽车产销	2450万辆	3000万辆	3500万辆	3800万辆
乘用车油耗	6.98L/100km	5.00L/100km	4.00L/100km	3.20L/100km
新能源车销比	1.39%	7 %	15 %	40 %
新能源车销量	34万辆	210万辆	525万辆	1520万辆

数据源：2016年10月《节能与新能源汽车技术路线图》

中国新能源汽车的发展速度必然会超过发达国家！

The development speed of new energy vehicles in China is bound to surpass

5 How to plan interactive Vehicles-grid and innovation

Electric Vehicle Industry Development Plan (2021-2035)

The "New Energy Vehicle Industry Development Plan (2021-2035)" proposes that there is a two-way flow between electric vehicles and the grid. A large number of electric vehicles can be used as a buffer between the grid and renewable energy, and play the role of a dynamic balance of electricity. Specifically, during low-cost electricity and non-peak hours, electric vehicles use the power grid to charge; during peak power consumption, electric vehicles can sell electricity back to the grid.

5 How to plan interactive Vehicles-grid and innovation

Electric Vehicle Industry Development Plan (2021-2035)

Electric vehicles can achieve coordination with the grid through two methods:

1. orderly charging;
2. or bidirectional charging and discharging (Vehicle-to-Grid or Vehicle-to-Building, hereinafter referred to as "V2G", "V2B" or "V2X").

However, in actual promotion, it is necessary to improve **standards and regulations** and accelerate **technological and business model innovation**. Relevant authorities should strengthen coordination, strengthen research on technologies such as **high-cycle-life power batteries**, **high-performance two-way charging and discharging**, accelerate the construction of standard systems such as **V2G interfaces and vehicle-network interaction**, and encourage qualified places to explore and develop **V2G application demonstrations**.

5 How to plan interactive Vehicles-grid and innovation

Electric Vehicle Industry Development Plan (2021-2035)

The "New Energy Vehicle Industry Development Plan (2021-2035)" proposes that every new energy vehicle is an energy storage unit. China's power grid is well constructed, and dual-circuit guarantees are basically implemented even in some rural areas. In some remote areas, distributed energy is very useful. Especially when encountering some major and sudden natural disasters, every new energy vehicle is an emergency power source.

The "New Energy Vehicle Industry Development Plan (2021-2035)" is of great significance for leveraging the advantages of distributed energy storage for new energy vehicles, reducing the electricity cost of new energy vehicles, and improving grid peak and frequency ajustment and safety emergency response capabilities.

5 How to plan interactive Vehicles-grid and innovation

The top-level planning of the new power system gives the solution

The Chinese government proposes to build a new power system during the "14th Five-Year Plan" period, in-depth research and demonstration in the fields of source, grid, and load, do a good job of top-level design, clarify the medium and long-term strategic direction, development thinking and implementation path, in the following four aspects Do a good job in grid planning.

1. The new power system urgently needs to stimulate the potential of the load side and new energy storage technologies to form a pattern of coordinated consumption of new energy by the source network and load storage, so as to adapt to the large-scale and high-proportion new energy development and utilization needs. This requires electric vehicles to play multiple roles.

5 How to plan interactive Vehicles-grid and innovation

The top-level planning of the new power system gives the solution

2. In response to the demand for on-site development and utilization of large-scale distributed new energy, the construction of power distribution infrastructure and new energy microgrids should be accelerated. Through the flexible mutual assistance of microgrids and large power grids, the ability to absorb distributed new energy and the reliability of power supply for users are effectively improved. Carry out demonstration projects such as flexible charging of electric vehicles, reasonable configuration of energy storage facilities for new energy vehicles, and intelligent dispatching of big data centers, so as to realize independent peak shaving and efficient utilization of new energy power.

5 How to plan interactive Vehicles-grid and innovation

The top-level planning of the new power system gives the solution

3. Large-scale electric vehicles are connected to the system, so that the new power system has the characteristics of a high proportion of new energy sources and a high proportion of power electronic devices. Therefore, the system's moment of inertia is reduced, the frequency adjustment capability is reduced, and the power grid performance standard is reduced, which is likely to cause problems such as disconnection and system oscillation. It has a significant impact on the safety, stability and economic operation of the power system. Pay close attention to the operating mechanism and key technologies of the "double-high" power system, and solve problems with new models, new algorithms, and new mechanisms through digitization and intelligence.

5 How to plan interactive Vehicles-grid and innovation

The top-level planning of the new power system gives the solution

4. The market and mechanism are the basic guarantee for building a new power system. During the "14th Five-Year Plan" period, it is necessary to speed up the cracking of various market mechanism obstacles, improve the enthusiasm of various entities to participate in the market, and promote the implementation of new technologies and business models with a sound market system, sound price mechanism, and innovative system and mechanism. Establish and improve a market system that combines medium and long-term transactions, spot markets, and ancillary service markets, and form a unified power market transaction standard system. Promote market-oriented and diversified business model innovation. Speed up the reform of electricity prices, and orderly liberalize electricity prices that have not yet been formed by the market. For new energy storage, the "new energy + new energy storage" integrated business model should be supported, and social capital should be guided to actively participate in the construction.

5 How to plan interactive Vehicles-grid and innovation

A concrete plan to form a market-oriented mechanism for vehicle-network collaboration

The specific route for China's future promotion of car-network synergy needs to be combined with external conditions such as power market reform and battery cost reduction. It also needs to consider the advantages of electric vehicles and explore suitable application scenarios in phases and steps.

1. Nearly before 2025: Electric vehicles can give full play to their flexible load advantages, participate in user-side peak shaving and valley filling, distributed photovoltaic charging, demand response based on manual response, and peak shaving "valley filling" in an orderly charging method. Auxiliary services, spot market balance, and even frequency modulation applications.

2. Mid-to-long term and beyond 2025: As the electricity market reform releases more dividends and the cost of power batteries decreases and life increases, electric vehicles can further play the role of energy storage and distributed power sources, combined with microgrids and virtual Pilot platforms such as power plants provide frequency modulation, spot power balance, and climbing services in V2X mode, and strive to form demonstration projects and models from 2025 to 2030.

5 How to plan interactive Vehicles-grid and innovation

A concrete plan to form a market-oriented mechanism for vehicle-network collaboration

To achieve the above planned roadmap, government departments and industry associations also need to provide important institutional guarantees. By optimizing policy systems and issuing technical standards, leveraging the commercial potential and public acceptance of car-network synergy. For orderly charging, the following measures can be considered to build a business model to form vehicle-pile-network communication protocol standards and technologies that support orderly charging:

1. For separately metered electric vehicle charging piles, such as private pile charging in residential communities, a peak-to-valley price system for electric vehicles is specifically designed to increase the peak-to-valley difference.

2. Provide subsidies for the construction of orderly charging facilities and DC transformation costs for AC piles; priority is given to purchasing facilities that support flexible and smart charging in the procurement of public charging facilities; charging operators are allowed to participate in medium and long-term, spot, peak shaving and demand response power Market activities, purchase electricity or provide related services, and improve the business model of charging infrastructure.

5 How to plan interactive Vehicles-grid and innovation

A concrete plan to form a market-oriented mechanism for vehicle-network collaboration

Encourage property companies and owners' committees to cooperate with the development of orderly charging pilots, and guide different entities (grid companies, charging operation service providers) to participate in orderly charging.

1. For the vehicle-pile charging communication protocol: Prioritize the revision of the national standard for DC charging to support orderly charging of DC; encourage the renovation of residential communities with limited open capacity for power distribution, and allow the energy storage adjustment in the area to support orderly charging of DC; it is recommended that The tripartite organization tests the interface standards and strictly enforces the standards for market access.

2. Targeting the pile-network communication protocol: Encourage distribution network operators to share necessary non-sensitive information such as local electric vehicle charging and discharging load limits, vehicle flow, and degree of aggregation, and support diversified implementation entities to participate in innovation.

5 How to plan interactive Vehicles-grid and innovation

A concrete plan to form a market-oriented mechanism for vehicle-network collaboration

Carry out V2G pilot demonstration projects to provide system and technical standard guarantee:

1. In the form of scientific research funds or national demonstration projects, encourage V2G pilots to carry out demonstrations of technical feasibility and economic feasibility, and strengthen technical research in big data analysis, vehicle-network collaborative control software, and renewable energy output forecasts.

2. Gradually clarify the positioning of individual or aggregate electric vehicles as a distributed power generation system, and formulate technical standards, engineering specifications, and related procedures and management methods for electric vehicles to connect to the grid.

3. Carry out the attenuation test of the power battery under the collaborative working conditions of the vehicle network, optimize the battery management system and the two-way battery charging and discharging strategy, and plan to determine the market energy storage price step by step.

5 How to plan interactive Vehicles-grid and innovation

The BM of interaction between E-vehicles and the grid

1. One-way electricity trading mode. New energy vehicles are connected to the grid only as a system load.

1. 1 Disorderly charging behavior. For new energy vehicles to obtain electricity from the Internet, time is prioritized.

New energy vehicle users connect to the grid only as a system load, do not take the initiative to avoid peaks, and receive higher electricity costs. The main purpose is to meet the emergency travel needs of users.

2.1 Orderly charging behavior. For new energy vehicles to obtain electricity from the Internet, queuing order and price are given priority. Coordinate new energy vehicle charging and power dispatch requirements, comprehensively use peak and valley electricity prices to effectively adjust new energy vehicles to actively avoid peaks, reduce electricity costs, and improve grid peak and frequency ajustment, safety emergency response capabilities. At the same time, it also reduces the operating costs on the grid side.

5 How to plan interactive Vehicles-grid and innovation

The BM of interaction between E-vehicles and the grid

2. V2G energy interactive mode. Users allow electric vehicles to participate in the regional power balance for a longer period of time, and the new energy generators in the region will transfer their profits to participate in application scenarios such as peak shaving and valley filling, distributed photovoltaic charging, demand response, frequency modulation auxiliary services, backup services, and alleviation of transmission line congestion , Make it technically and economically feasible in the design of market mechanism. China, the United States, and Europe have all done useful pilot projects for car-network collaboration in terms of business models, policy support, and technical standards.

The BM of interaction between E-vehicles and the grid

3. Active distribution network or energy storage service provider model. Promote the user-side reform process of the Chinese power market, and allow aggregated electric vehicles (bus charging stations or battery swap stations) to participate in high-frequency and high-precision wholesale market transactions, especially for group users or large communities, using the model of electricity dealer , Carrying out pilot projects for collaborative market transactions between vehicles and networks, encouraging group electric vehicles to participate in power wholesale market transactions, focusing on solving the problem of insufficient capacity matching on the distribution network side and optimizing distribution network investment. The planning and layout of energy Internet charging piles should focus on realizing this business model and forming an economic incentive mechanism.

5 How to plan interactive Vehicles-grid and innovation

The BM of interaction between E-vehicles and the grid

4. Removable disaster recovery energy storage mode. Where there is a demand for flexible energy storage facilities close to the power generation side, and where the user side has a demand for adjustable load resources (such as heating and electric boilers, building air conditioning), a competitive power price can be provided for system disaster recovery and attract users Stop and charge in V2G mode at a designated time or at a designated place. As a movable energy storage element, electric vehicles can adjust the load and flexibly match energy on the power supply side and the demand side.

5 How to plan interactive Vehicles-grid and innovation

The BM of interaction between E-vehicles and the grid

5. Computing power and data service model. New energy vehicles themselves are supercomputers. With the improvement of grid intelligence and digitalization, grid operations and power market transactions have a strong demand for computing power and data services. In addition to the normal Internet of Vehicles information communication between electric vehicles and the grid, The redundant capacity is sold to the power grid or a third-party company to meet the management, control and transaction needs. For example, during the stay of the vehicle, blockchain technology can be used to provide redundant data backup and system computing power for the grid system, which can reduce the computing power and information infrastructure investment of the whole society, and also provide a profit model for the vehicle.

5 How to plan interactive Vehicles-grid and innovation

The BM of interaction between E-vehicles and the grid

6. Smart travel service model. With the intelligent and unmanned development of new energy vehicles, users' vehicles do not need to be parked in private or public exclusive locations. After the user sets his own usage requirements, the vehicle is handed over to the social intelligent travel platform (such as Didi) to provide social public services at other times, and the user can know the status of the vehicle and the rental income at any time. At the same time, this type of vehicle intelligently matches urban parking resources, parks and flexibly charges where it meets the needs of grid peak-shaving and valley-filling according to the platform command, further reducing the cost of vehicle use.

5 How to plan interactive Vehicles-grid and innovation

Case No.1

V2X：Pilot Project of Renji Building,State Grid Electric Vehicle Service Co., Ltd.

This project is a pilot project for exploring two-way charging and discharging of electric vehicles in China. Realize partial load peak-shaving and valley-filling, and achieve the goal of reducing electricity costs during peak hours and increasing the load rate of transformers during low valley periods. The charging and discharging station of the pilot is composed of 5 AC and DC bidirectional charging and discharging piles, with power ranging from 7kW to 150kW. The electric vehicle participating in charging and discharging is BYD e6-400 pure electric vehicle, and a station-level monitoring room is deployed to charge V2G. The operation of the discharge station is monitored, and the total investment of the project is about 2.7 million yuan. This project not only realizes the two-way current flow between the vehicle-pile-network, but also establishes a two-way intelligent control device, that is, when a vehicle supporting V2G technology is connected to the grid, the vehicle can charge and discharge the real-time capacity, state of charge (SOC), etc. The information will be provided to the cloud management system. The charging and discharging of the vehicle will be controlled by the cloud management system, which will charge the electric vehicle during the low load period according to the actual load situation of the building, increase the load rate of the transformer, discharge during the peak load period, and adjust the discharge power according to the load condition.

Case No.2

Orderly charging: Beijing State Grid Corporation of Haidian Xibali Community Orderly Charging Pilot

The project is designed to cut peaks and fill valleys for local loads, delaying investment in local transformer capacity expansion. The pilot set up 30 orderly controlled AC charging piles with a charging power of 7kW. The types of electric vehicles participating in orderly charging are diversified, involving multiple models of brands such as BYD, Roewe, and BAIC. The project is based on the State Grid Smart Energy Service System, which can monitor the community load in real time. According to the community load, the energy router installed on the side of the charging pile can control and adjust the output power of the charging pile to achieve orderly charging. At the same time, the project has realized the shared charging mode of adjacent parking spaces through "one pile of dual charging", and improved the utilization rate of charging piles.

At present, State Grid Shanghai Electric Power Company and State Grid Jibei Electric Power Company have organized electric vehicles (charging piles) to participate in demand response and peak shaving auxiliary services; in the Guangdong spot market, large electric vehicle charging stations are participating in the trial operation of the electric spot market in. In the future, as electric vehicles are officially incorporated into the frequency adjustment auxiliary market with a third-party independent auxiliary supplier, it is expected to provide more diversified market services such as FM in an orderly charging method.

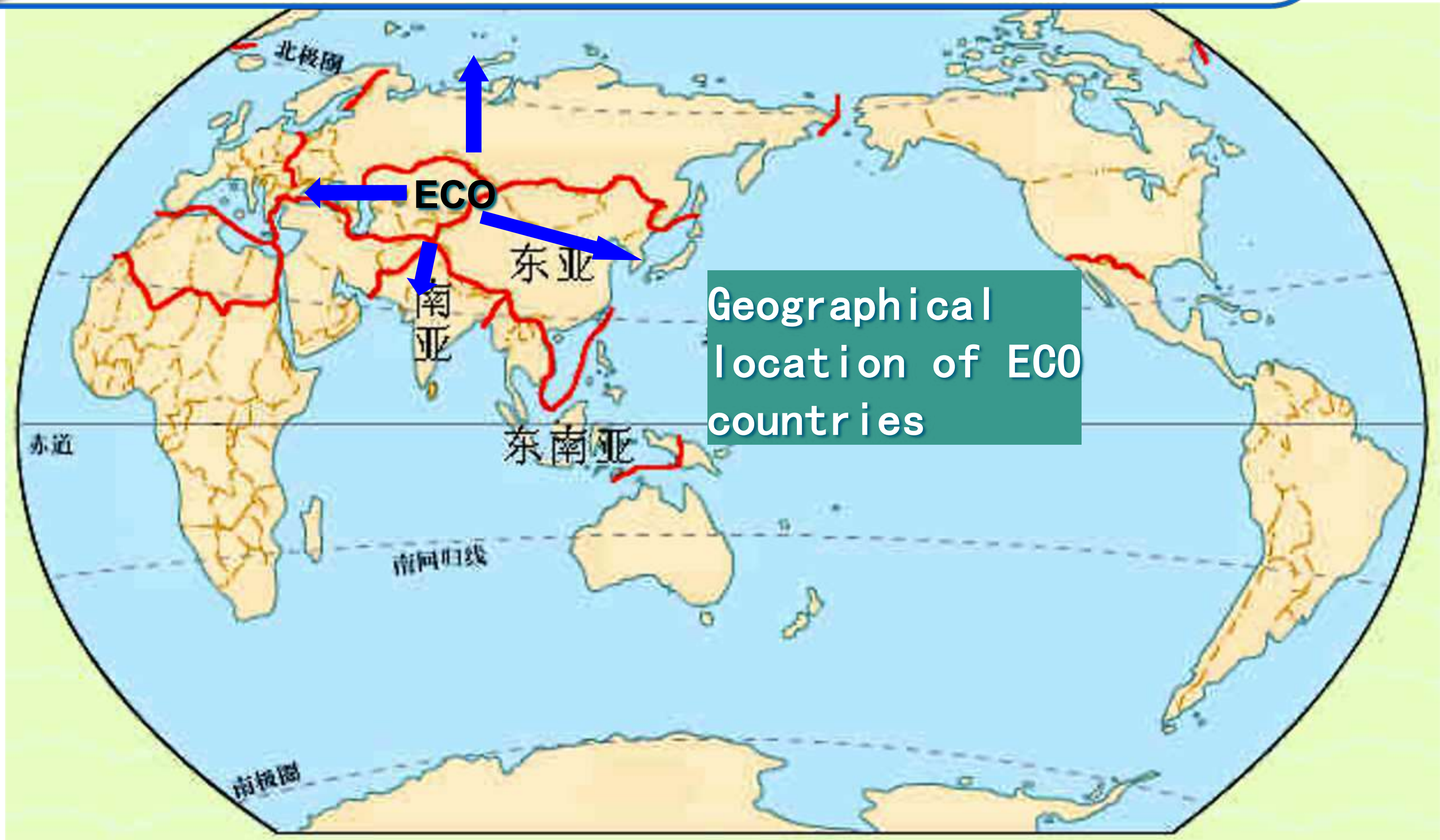
06

Part Six

Prospects of EI Cooperation between China and ECO

- Geographicallocation of ECO countries
- Promoting ECO development great significance to China
- Collaboration in Energy Internet and E-vehicles planning
- Renewable Energy cooperation on the "Belt and Road"

6 Prospects of EI Cooperation between China and ECO



To the east connecting China
To the north connecting Russia,
To the west connecting Europe,
To the south connecting the Middle East and North Africa

6 Prospects of EI Cooperation between China and ECO

From the ancient Chang'an in the east, through the Hexi Corridor, along the Tianshan and Kunlun Mountains, through the Central Asia Regions to the Mediterranean coast. Central Asia is a must pass through the ancient "Silk Road"

6 Prospects of EI Cooperation between China and ECO

Comparison of global shipping volume among countries

6 Prospects of EI Cooperation between China and ECO

Lianyungang Port—Central Asia——West-Europe （Rotterdam）

In 2020, the traffic volume of the New Eurasian Land Bridge reach a record high of 1 million TEUs, 70% of which went to Europe and 30% to Central Asia.

In 2019, the global container shipping volume reached 198 million TEUs, and China's total shipping volume reached 140 million TEUs. Even 5% of the total shipments from Western Logistics will reach 7 million TEUs. so the development potential is huge.

6 Prospects of EI Cooperation between China and ECO

Promoting ECO development great significance to China

1. The ECO region is rich in energy, and China has diversified its channels for importing oil from here, reducing dependence on a single source;

2. Open up safer inland oil channels and reduce the dependence of oil imports on the Strait of Malacca.

3. Historically, Western China and ECO countries have frequent trade exchanges, and their language and ethnic habits are similar or closely. China's westward cooperation and trade promote each other's prosperity and development;

6 Prospects of EI Cooperation between China and ECO

Promoting ECO development great significance to China

4. By promoting the interconnection of infrastructure in the ECO region, it can become the lowest cost logistics route, and trade between China and Europe will certainly promote the prosperity of countries along the route;

5. Energy cooperation with the ECO region can form a pan-Asian global energy land bridge and promote the development of clean energy in the region.

6. Cooperating with ECO regions to carry out education and technical training which is of great significance to the sustainable social and economic development of countries along the route, can reduce poverty and reduce the influence of extremist religious forces.

6 Prospects of EI Cooperation between China and ECO

Collaboration in Energy Internet and E-vehicles planning

The chinese "Energy Internet Development Plan (2021-2035)" and "New Energy Automobile Industry Development Plan (2021-2035)" explained in this article reflect the results of long-term research conducted by the government and industry institutions, and have good guiding significance.

Based on the in-depth study of the development of energy internet, ECO countries can cooperate with china in power and vehicle industries.To encourage to establish energy internet and improve the electric vehicle industry chain, and explore application demonstration pilot projects. Scientifically promote the achievement of the carbon peak and carbon neutral goal.

6 Prospects of EI Cooperation between China and ECO

Renewable Energy cooperation on the "Belt and Road"

At present, the "Belt and Road" cooperation is mainly focused on oil and gas resources. China has rich experience in the integration development of coal, hydropower, wind energy, solar energy and other resources. China has advanced UHV power transmission technology and outstanding power transmission equipment construction capabilities. In terms of clean energy, wind energy, hydropower, solar energy development and equipment manufacturing are ranked first in the world.

If the ECO countries can actively promote cooperation in clean and renewable energy, promote integration in the processing and transformation of energy resources on-site, and form upstream and downstream energy resources Integrated industrial chain. One is to support local transportation, residencial, industries electrification , another is to delivery the power to china and europe through UHV technology.

6 Prospects of EI Cooperation between China and ECO

Renewable Energy cooperation on the "Belt and Road"

Recommendations for the interconnection of power infrastructure are as follows:

1. Development and cooperation of the industrial chain of electrical and intelligent transportation tools (including electric vehicles, heavy truck, aviation);
2. Information and communication technology integrated with power grid and transportation network;
3. Planning and development of transnational power grid networks to balance spinning reserve and promote renewable energy comsumption;
4. Planning and development of transnational power market and electricity trade;
5. Planning and development of electrical charging system along railway and highway network to support development of transnational electrical transportation tools；
6. Cooperation in education,standard and training of engineering and technical

Thanks！

High energy density and high safety Solid-state Batteries(SSBs): From Basics to Applications in New Energy Vehicles

Jin Xiang

Jul 7th, 2021

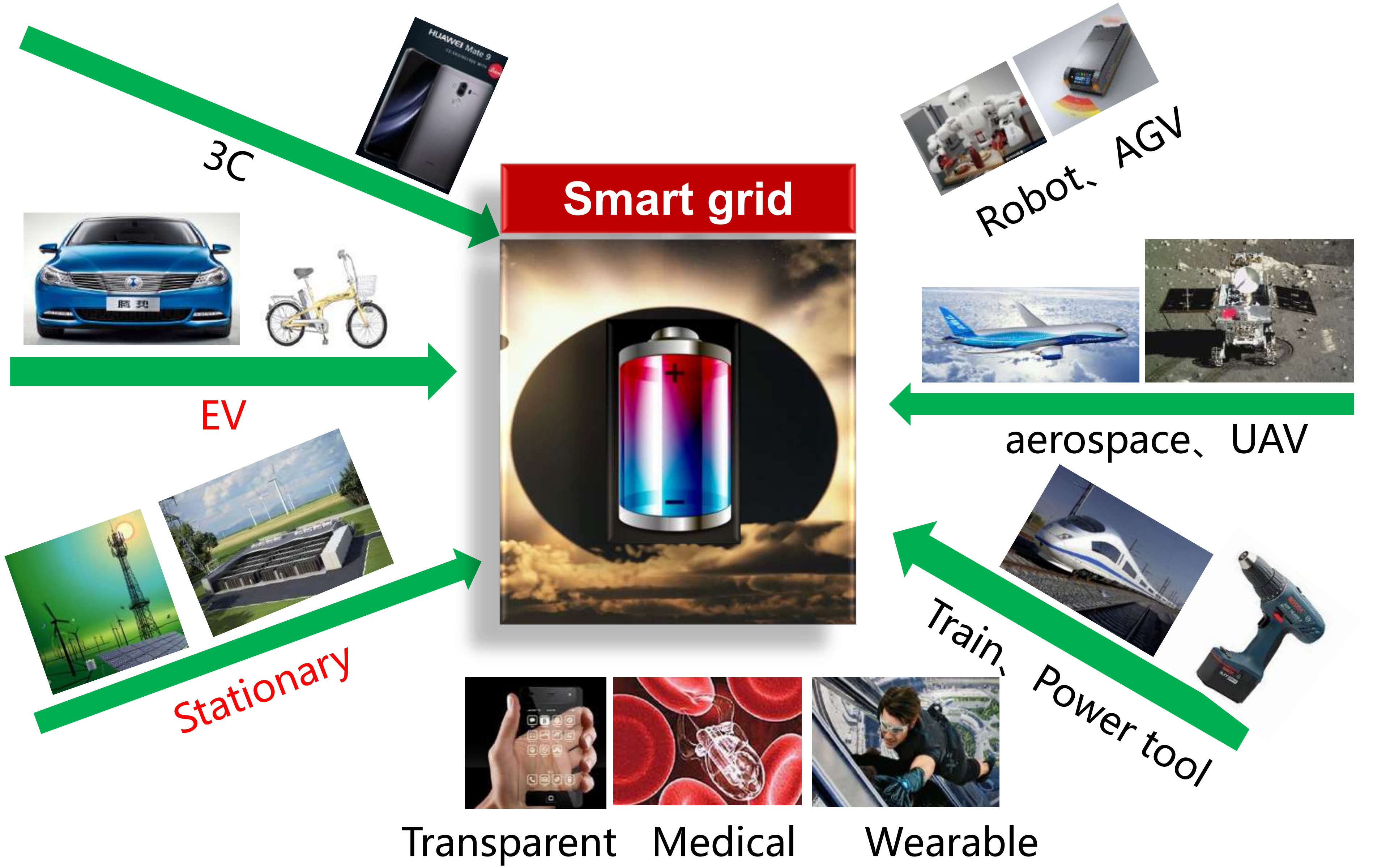
Together For Blue Sky　Leading Solid Power

CATALOG

PART 01

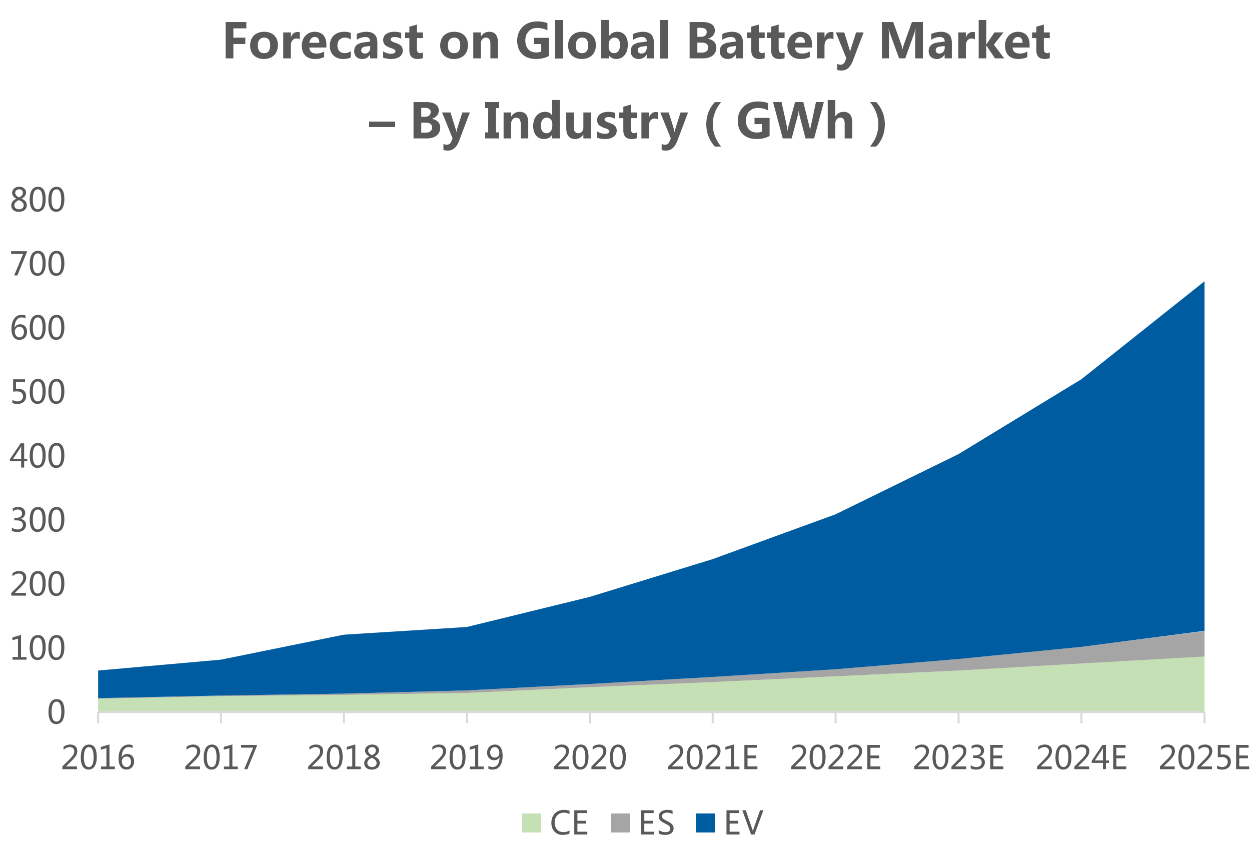
Development background of SSBs

Advanced batteries: everywhere but not very satisfied



Jiayue Peng, Chenxi Zu, Hong Li, Energy Storage Sci Tech, 2013, 2, 55-62

Forecast on global battery market



Data Scource：GGII, EV Sales, wind

Consumer Electronic (CE)

Demand is large and stable with good profit.

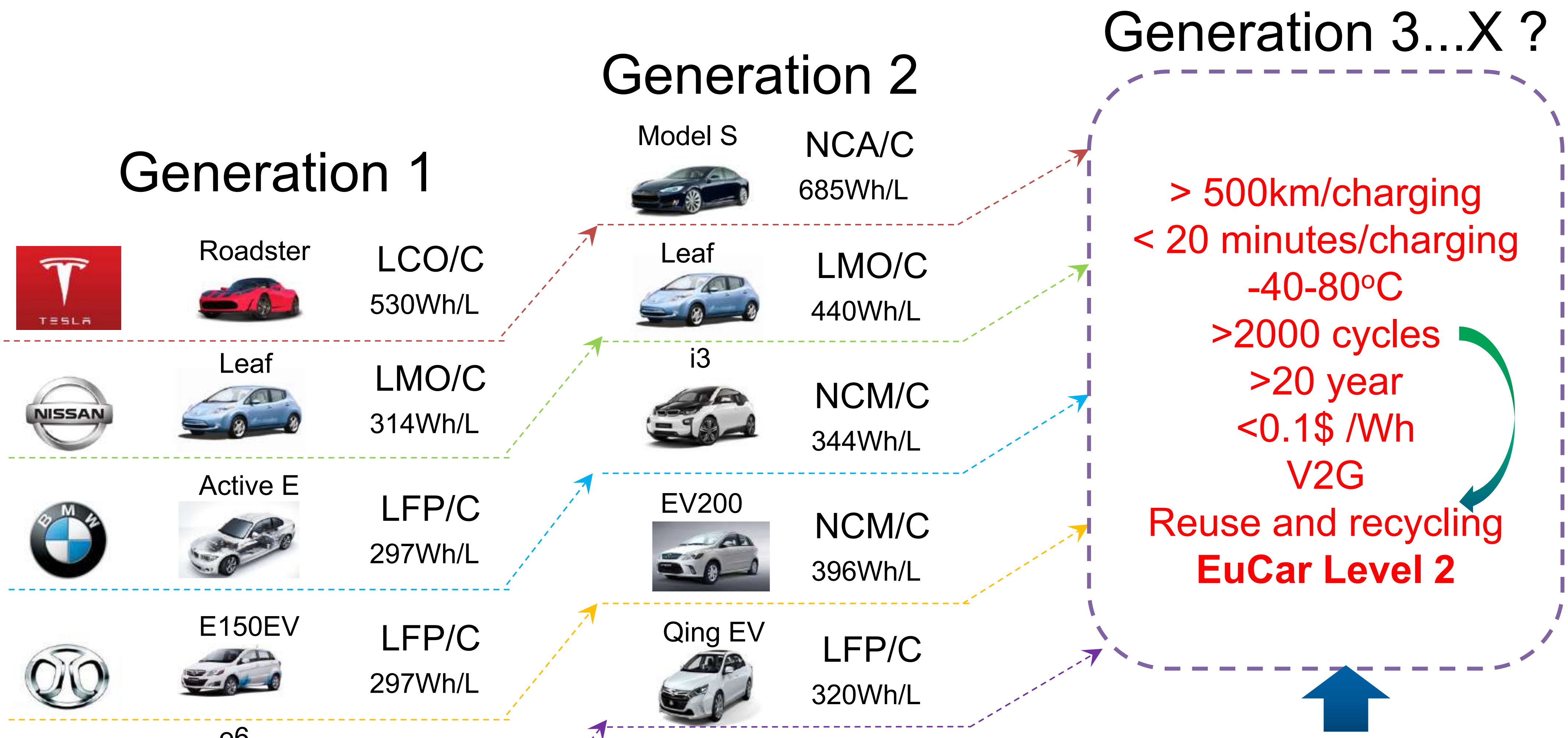
Energy Storage (ES)

Market demand is on upward path.

Electric Vehicle (EV)

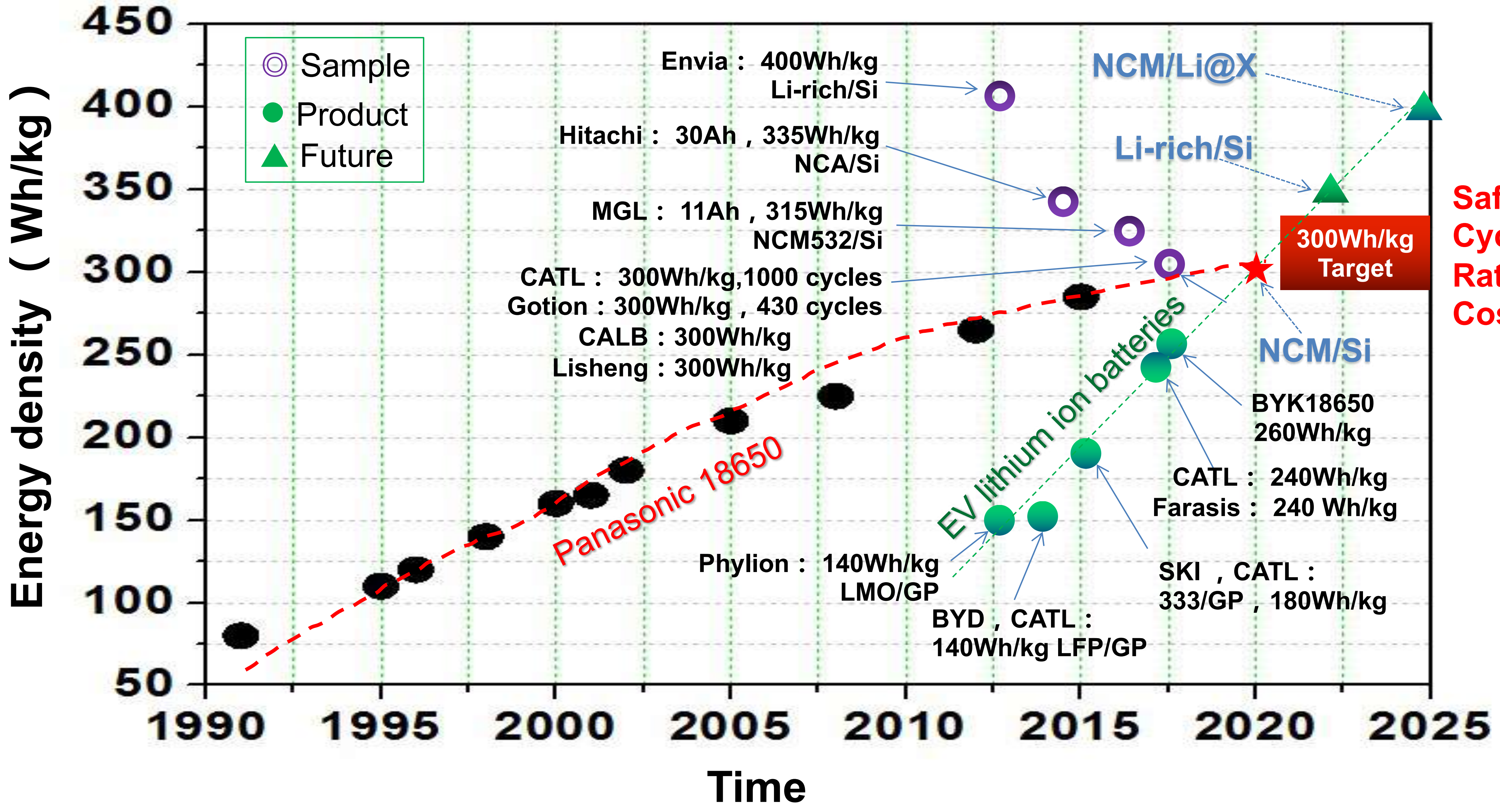
Forecast demand of worldwide EV batteries will reach 1800GWh in 2030.

Status of EV battery for EV



current battery technology is still not very satisfied, but can be improved significantly

Energy density of lithium batteries



Safety
Cycle life
Rate
Cost

Problems of LIB and possible solutions

Problems

- Volume expansion
- Cracking of particle
- Irriversible phase transition
- SEI reactions
- Gas release
- TM dissolution
- Formation of Li dendrite
- Thermal runaway

Unsatisfied Performances

- Poor safety
- Low energy density
- Capacity fading
- Poor rate
- Low energy efficiency

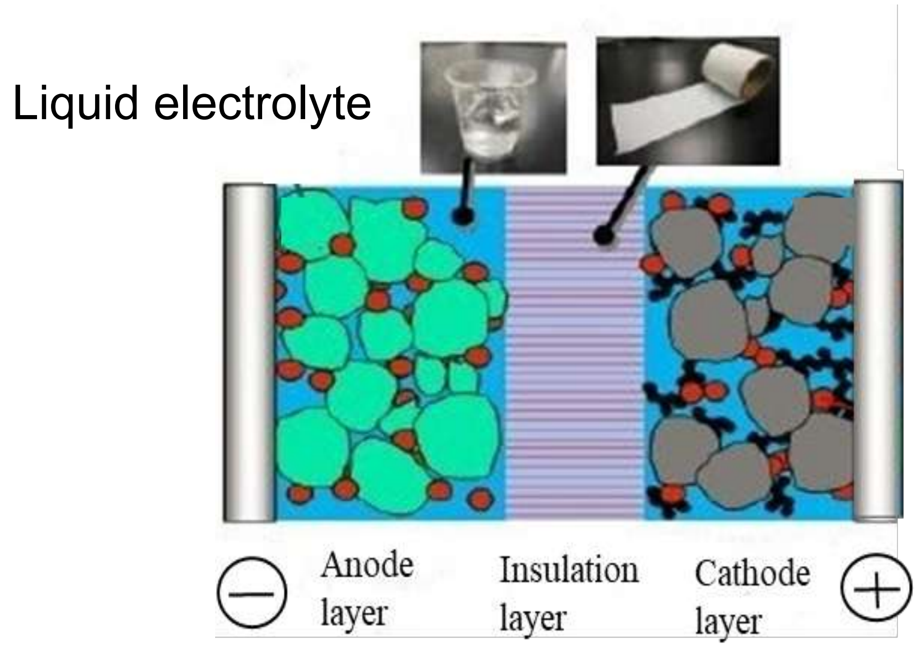
New materials

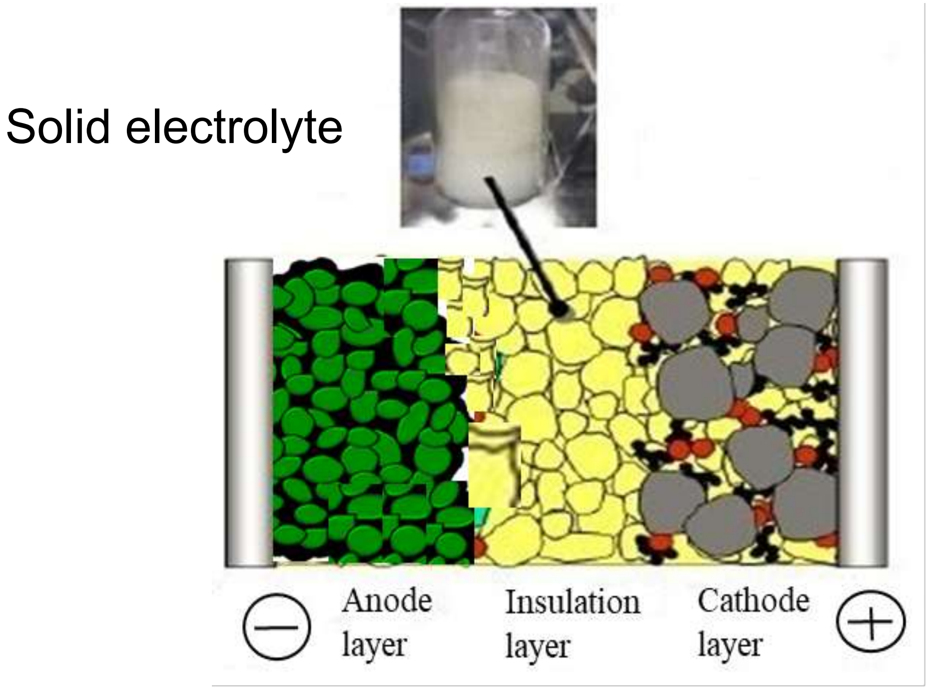
- High energy density material
- Lattice doping
- Grain boundary doping
- Surface coating
- Gradient structure
- Prelithiated anode (Si)
- Hybrid/all solid electrolyte
- Functional separator
- Interfacial layer
- CNT additive
- new binder
- 3D curent collector

Traditional liquid battery *VS* Solid state battery

Traditional liquid battery

Solid state battery

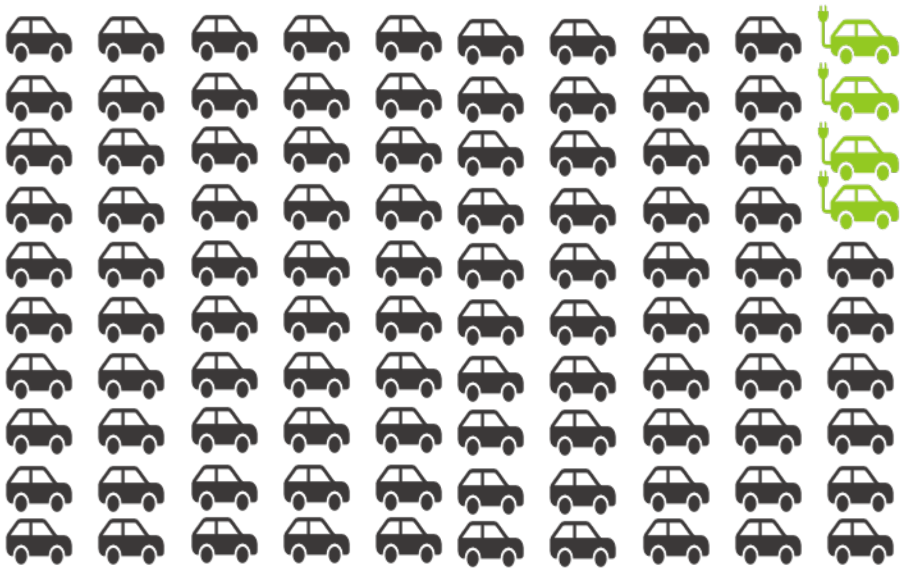




Some high energy density cathode and Li composite anode can only be used in solid state battery

Traditional liquid battery VS Solid state battery

EV penetration rate is 4% in China vehicle market in 2020. The local authority requirement is 20% in 2025. Liquid electrolyte cell cannot meet the need of safety and energy to support the growth of EV industry.



	Liquid Electrolyte	Solid-State
Energy	500-600KM (Cell 270-280Wh/KG)	>1000KM (Cell 300-400Wh/KG)
Safety	Flammable	Intrinsically Safer
Lifetime	Battery pack use for 8-10years	Battery lives exceed EV lives
Cost	¥ 0.7-1.0/Wh	Cell cost similar to liquid electrolyte; Saving pack cost.

Data source: TECHNOLOGY ROADMAP FOR ENERGY SAVING AND NEW ENERGY VEHICLES 2.0, by China Association of Automobile Manufacturers, China Society of Automotive Engineers, MIIT of China.

Classification of lithium batteries

Liquid electrolyte batteries

Contain only liquid electrolyte

- nanoaqueous
- aqueous
- gel polymer

Hybrid solid/liquid electrolyte batteries

Contain both solid and liquid electrolyte

- half-solid, semi-solid
- quasi-solid
- solid

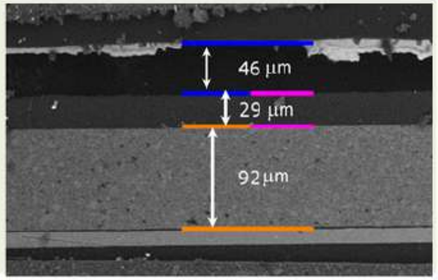
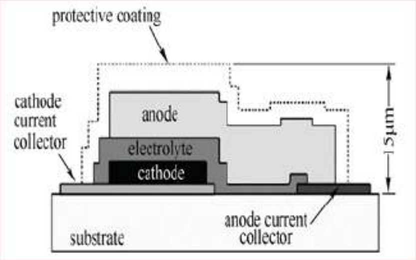
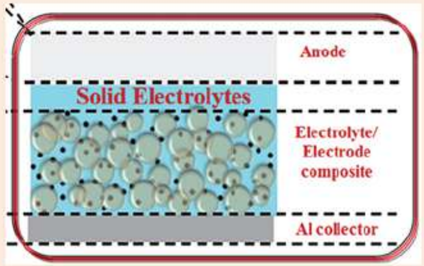
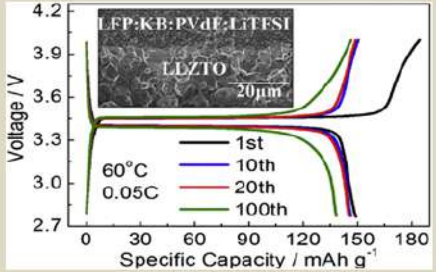
All solid electrolyte batteries

Contain only solid electrolyte

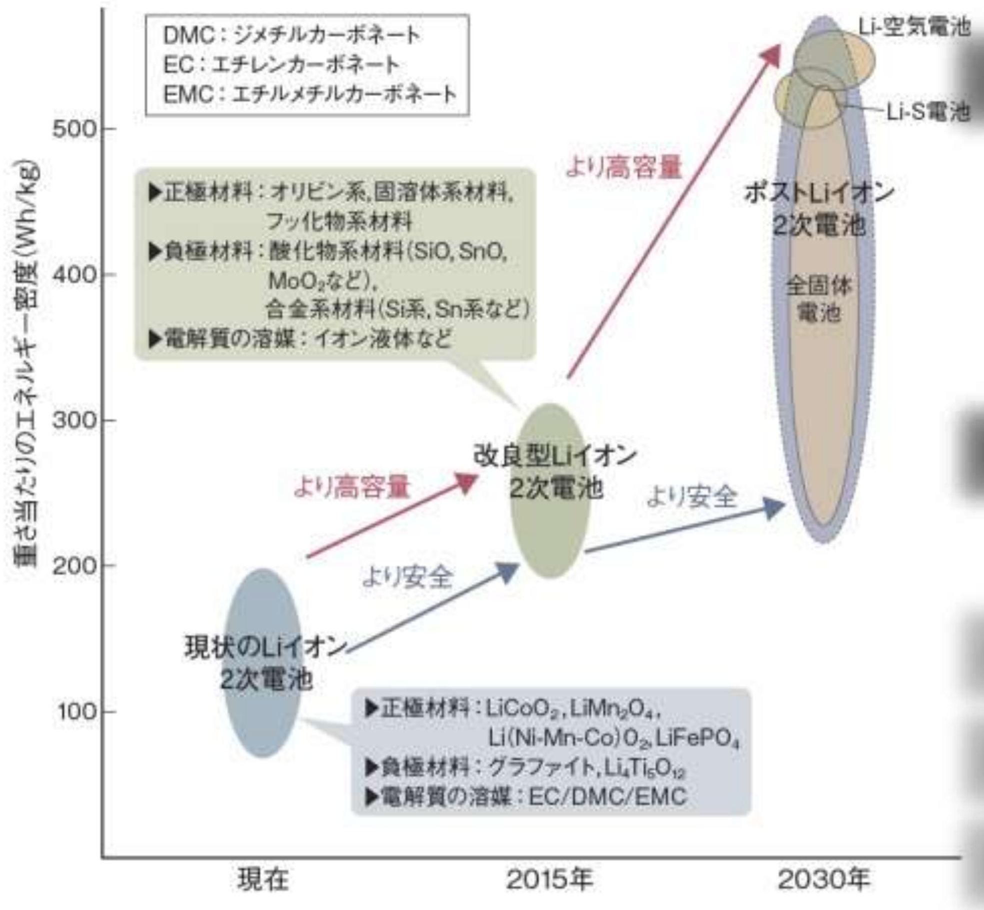
- oxide
- sulfide
- polymer
- composite

Which one is more practical and better solution?

Review of different types of solid state lithium batteries

Polymer all-solid lithium battery		**Li** **PEO-LITFSI/PS..** **$LiFePO_4$, V_2O_5**	● Easy to process. ● Large capacity battery cells can be prepared. ● Running in 60°C-85°C. ● Easy to short circuit. ● 220Wh/kg	SEEO Bollore QIBBT	● Double layer polymer electrolyte membrane ● Polymer/inorganic composite diaphragm ● Positive surface modification
All-solid-state thin film lithium batteries		**Li** **LiPON** **LCO, LNM**	● Good circulation. ● Adaptive high voltage. ● It's difficult to prepare the Large capacity battery cells. ● Low energy density. ● High cost.	Oak-ridge Sakit3	● Flexible coiling process ● Positive and negative interface modification technology
Sulfide solid state lithium battery		**Li, Graphite…** **LPS, LPSCl…** **LCO, NCM…**	● High ionic conductivity. ● Adapted to high voltage basically. ● Solid - solid contact leads to deteriorate continuously. ● Low volume energy density. ● Air sensitivity and high cost.	Toyota Misui Hitz NIMTE ….	● Doping cladding improves stability ● Composite membrane with Polymer ● Liquid coating ● The liquid phase to modify
Oxide solid state lithium battery		**Li** **LLZO, LiSICON…** **LFP, LCO, NCM…**	● Withstand high voltage. ● Safer. ● The electrolyte sheet is easy to crack. ● High interfacial resistance. ● It's difficult to prepare the Large capacity battery cells.	Ohara, Mie Univ. Julich …	● Composite membrane with Polymer ● Particles and electrode gel layer ● Amorphous membrane was prepared at low temperature ● Positive polar particles cladding

NEDO-roadmap disclosed on year of 2008



Li-ion battery

$LiCoO_2$, $LiMn_2O_4$
NCM, $LiFePO_4$
C, $Li_4Ti_5O_{12}$
$LiPF_6$, EC-DMC

2015-2020

Next LIB

2030年

All solid Li Batt

All solid Li/S

All solid Li/air

Strategies to improve both energy density and safety

Drawbacks of nonaqueous LIB which are expected to be solved by solid lithium batteries

- Continuous growth of SEI
- Al corrosion
- Dissolution of TM
- Oxygen release from cathode
- Lithium plating
- Internal short-circuit
- Operation below 4.5V
- Relative low energy density
- Leakge of electrolyte
- High temperature storage risk
- Thermal runaway
- Explosion

NEDO’s estimates of automobile market shares in Japan

Japan Market of Passenger Vehicles

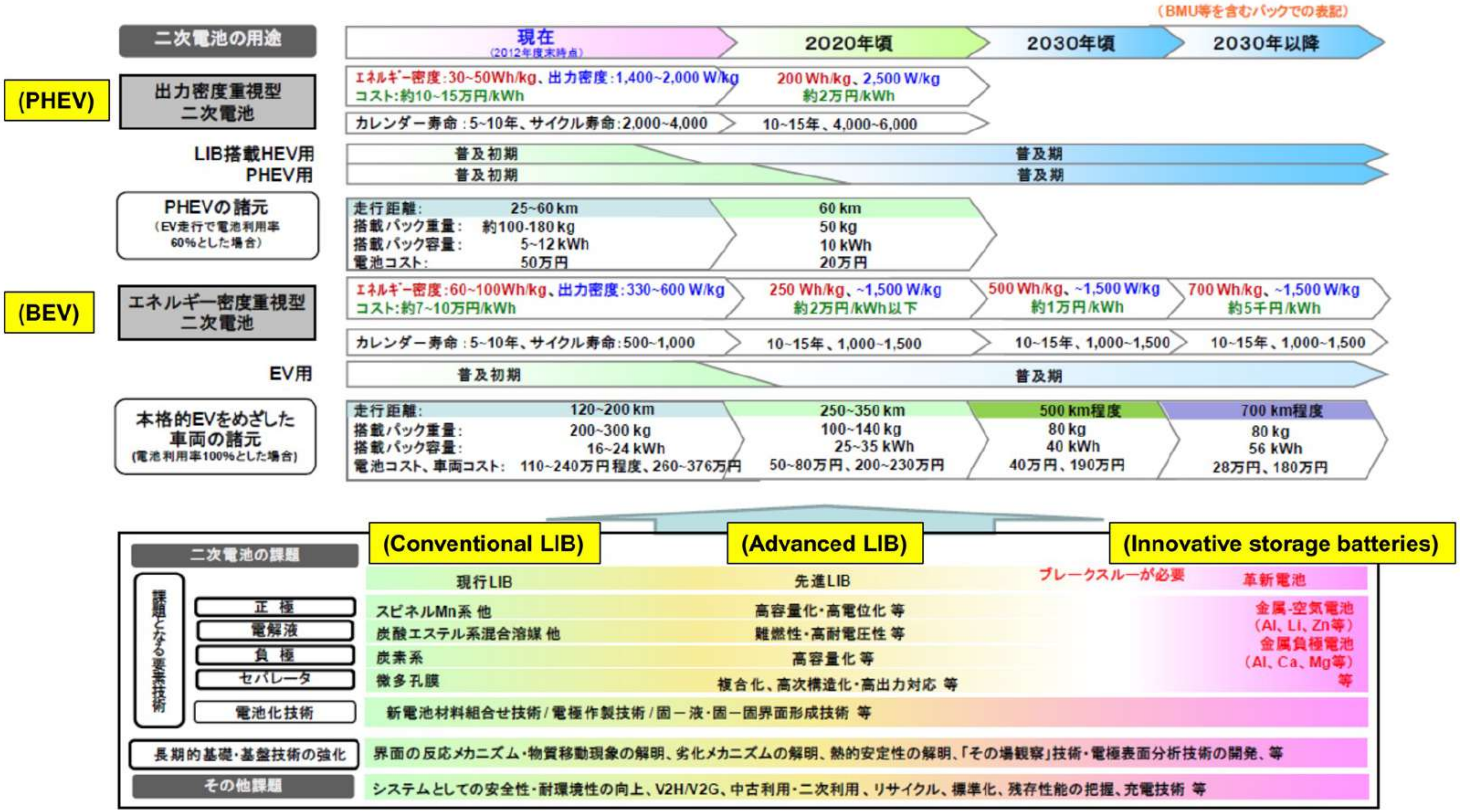
NEDO

		Actual Market Shares of Annual New Vehicle Sales (Actual Number of Sales *1)								Japan’s Target *2	
		2009	2010	2011	2012	2013	2014	2015	2016	2020s	2030s
Conventional vehicles		90.9% (3,570,300)	88.3% (3,719,677)	86.6% (3,052,061)	79.2% (3,619,831)	77.5% (3,536,929)	76.0% (3,571,717)	73.5% (3,099,480)	65.1% (2,701,686)	50-80%	30-50%
Next-generation vehicles	HEV	8.9% (347,999)	11.4% (481,221)	12.8% (451,308)	19.4% (887,863)	20.2% (921,045)	21.6% (1,016,757)	22.2% (937,575)	30.8% (1,275,560)	20-30%	30-40%
	PHEV	0.0% (0)	0.0% (0)	≒0.0% (15)	0.2% (10,968)	0.3% (14,122)	0.3% (16,178)	0.3% (14,188)	0.2% (9,390)	15-20%	20-30%
	EV	≒0.0% (1,078)	0.1% (2,442)	0.4% (12,607)	0.3% (13,469)	0.3% (14,756)	0.3% (16,110)	0.2% (10,467)	0.4% (15,299)		
	FCV	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	≒0.0% (7)	≒0.0% (411)	≒0.0% (1,055)	1%	3%
	CDV	0.1% (4,364)	0.2% (8,927)	0.2% (8,797)	0.9% (40,201)	1.7% (75,430)	1.7% (78,822)	3.6% (153,768)	3.5% (143,468)	5%	5-10%
		9.0% (353,441)	11.7% (492,590)	13.4% (472,727)	20.8% (952,501)	22.5% (1,025,353)	24.0% (1,127,874)	26.4% (1,116,409)	34.8% (1,444,772)	20-50%	50 -70%
Total sales		3,923,741	4,212,267	3,524,788	4,572,332	4,562,282	4,699,591	4,215,889	4,146,458		

Source
*1 : The Motor Industry of Japan 2017 (Japan Automobile Manufacturers Association, Inc.)
*2 : Automobile industry strategy 2014 (METI, Nov., 2014)

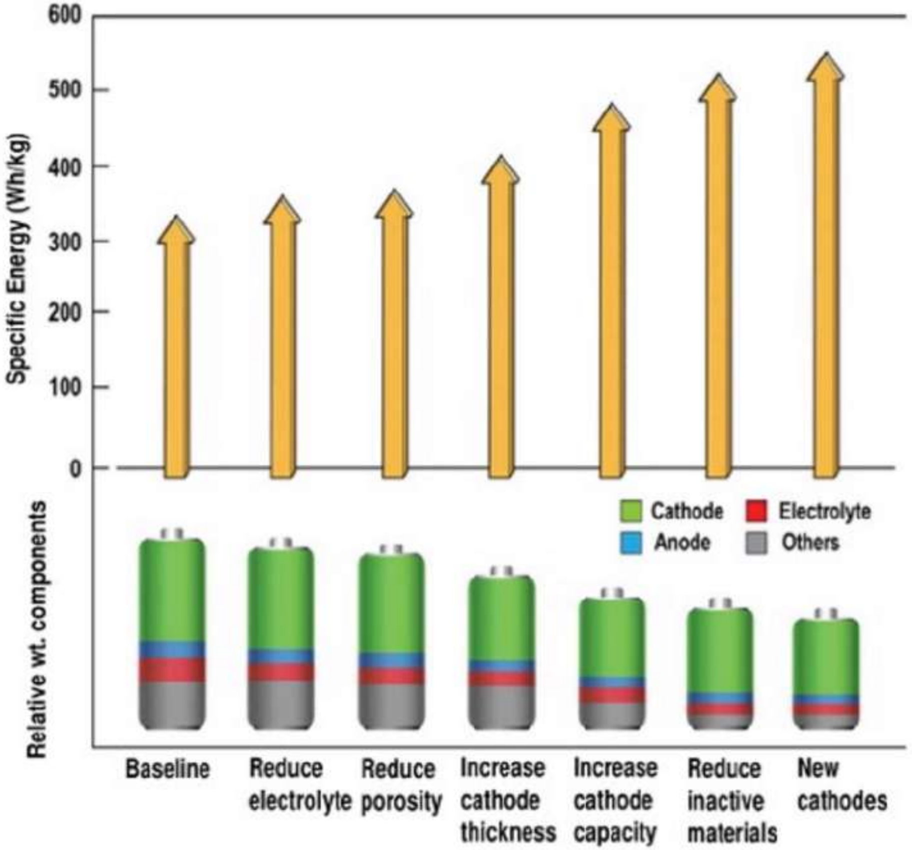
Dominic Bresser, Kei Hosoi, David Howell, Hong Li, Herbert Zeisel, Khalil Amine,Stefano Passerini, J. Power Sources 382 (2018) 176–178

NEDO’s development program for Japan’s EV batteries



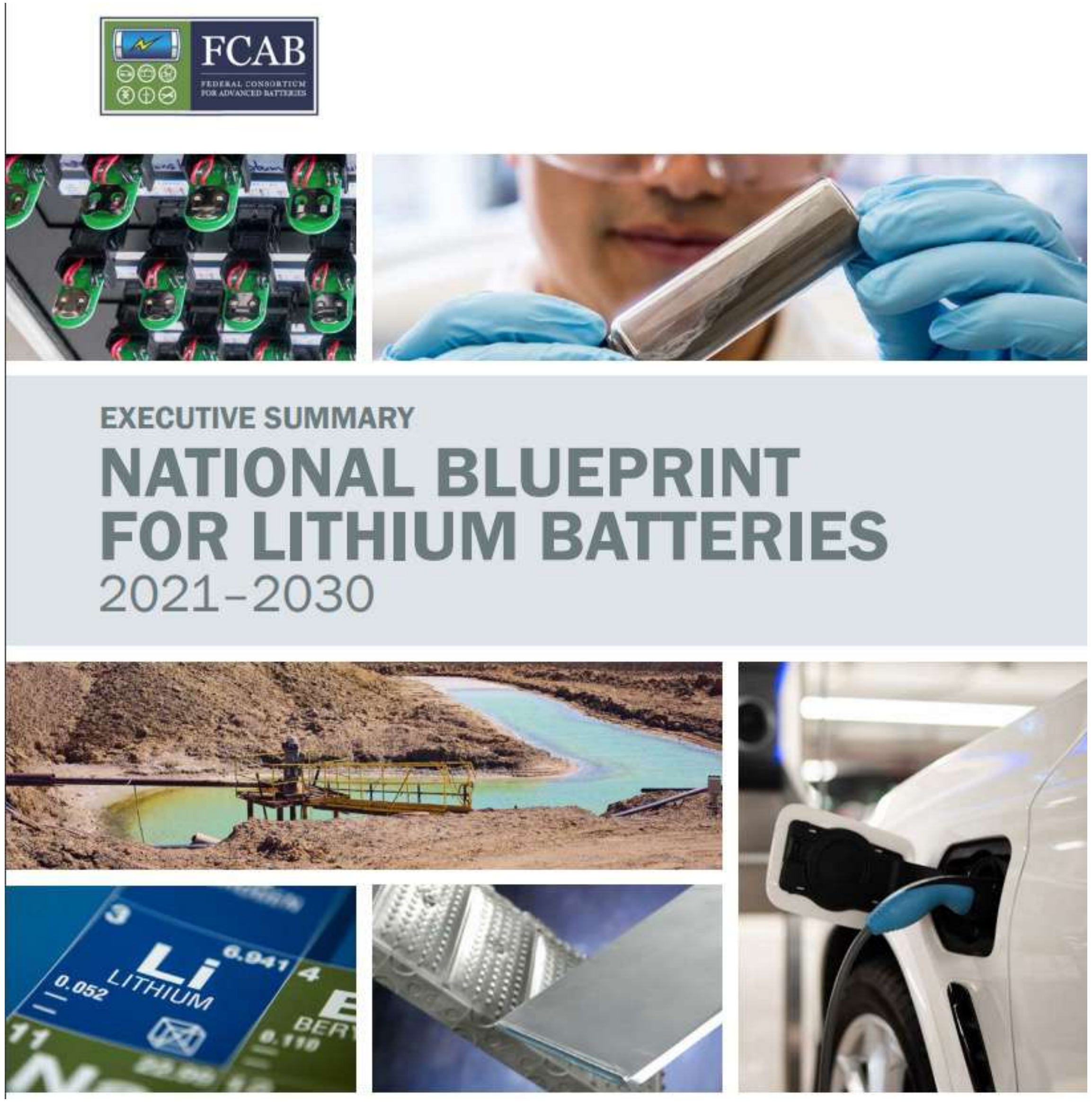
DOE : Core concepts of Battery500 consortium

Advancing the materials limits to meet Battery500 goals



- Achieve dendrite-free Li deposition with more than 99.9% Coulombic efficiency.
- <100% excess Li (compared to cathode).
- Increase cathode capacity to over 220 mAh/g and achieve stability over 4.4V.
- Increase stability window of electrolytes and achieve interfacial stability at both cathodes and anodes.
- Develop thick (>120 mm) and dense (<23% porosity) electrode architectures.
- Reduce inactive materials (electrolyte, current collectors, separator).
- Optimize materials properties at the cell level.

FCAB: National blueprint for lithium batteries 2021-2030



GOAL 5 Maintain and advance U.S. battery technology leadership by strongly supporting scientific R&D, STEM education, and workforce development

Establishing a competitive and equitable domestic lithium-battery supply chain in an accelerating EV and grid storage market is only the initial phase in a global surge to higher performance and lower costs with reductions in climate impact. The pipeline of R&D, ranging from new electrode and electrolyte materials for next-generation lithium-ion batteries, to advances in solid-state batteries, and novel material, electrode, and cell manufacturing methods remains integral to maintaining U.S. leadership. The R&D will be supported by strong IP protection and rapid movement of innovations from lab to market through public-private R&D partnerships such as those established in the semiconductor industry.

NEAR-TERM OBJECTIVES (2025)

1. Support research to develop cobalt-free cathode materials and electrode compositions focused on important metrics such as energy density, electrochemical stability, safety, and cost that outperform their current commercial, imported counterparts
2. Develop partnerships for technology transfer and standardization of pre-application testing protocols to ensure battery technology invented in the U.S. stays in the U.S.
3. Launch government-wide standardization of lithium-based battery technologies and configurations, enhancing the ability of niche government markets such as defense to rapidly transition lithium-based battery technology to their programs and benefit from a robust, equitable, sustainable domestic supply chain
4. Develop a plan for enhancement of IP protection strategies, research security, domestic manufacturing export-control policies, and for engagement of international allies
5. Work with industry partners to identify workforce needs and support educational programming

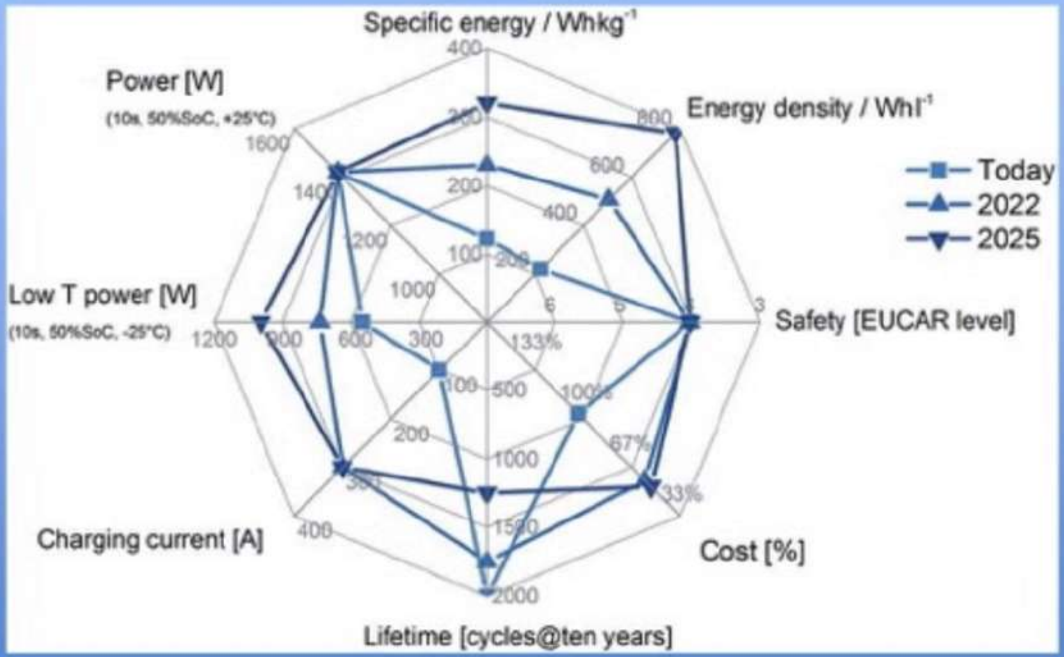
LONG-TERM OBJECTIVES (2030)

1. Develop cobalt- and nickel-free cathode materials and electrode compositions that improve important metrics such as energy density, electrochemical stability, safety, and cost and outperform their current commercial, imported counterparts
2. Accelerate R&D to enable the demonstration and at-scale production of revolutionary battery technologies including solid-state and Li-metal, that achieve a production cost of less than \$60/kWh, a specific energy of 500 Wh/kg, and are cobalt- and nickel-free.

FIGURE 8. The U.S. has a strong R&D pipeline encompassing discovery of new materials, material and device manufacturing, performance characterization, and recycling. Source: Images courtesy of Argonne National Laboratory, April 2021.

Technical indexes published by German government

Demand Automotive:



Source: Andre et al., *J. Mater. Chem. A* **2015**, *3*, 6709-6732. 10.1039/C5TA00361J

Battery cell technology:

1st use in EV

Battery cell technology	Year
Alternative battery cell systems Lithium-O2, Lithium-Air	2030(?)
Alternative battery cell systems All-solid-state (Lithium-Anode), conversion materials (e.g. Li-S)	2025
Advanced Lithium-Ion-battery cells Kathode: up to High Energy NCM, High Voltage spinel Anode: Si/C	2020
Lithium-Ion-battery cells Kathode: up to NCM 622 Anode: 100% C	2015

Source: Inspired by Roadmap Integrated Cell- and Battery production Germany, NPE 2016

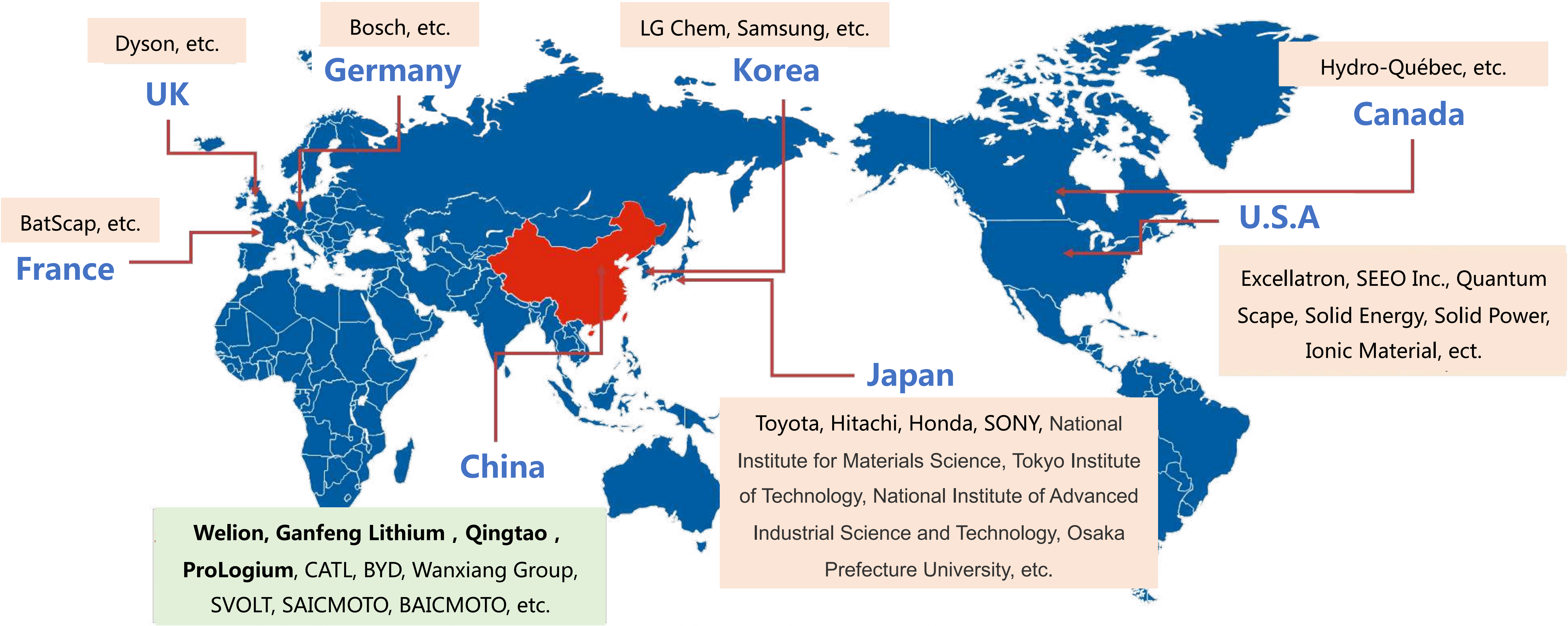
Targets for EV batteries in China's national plans on new energy vehicles

Plan	Targets
"Development plans for energy saving and new energy vehicles " (2012—2020)	Energy density of battery module: >300 Wh/kg Cost:<1.5￥/Wh
The 13th Five-Year Plan— Key research and development projects of new energy vehicles (2016-2020)	Industrialized lithium-ion batteries: >300 Wh/kg, <0.8￥/Wh Battery systems: >200 Wh/kg，>1200 Cycles，<1.2￥/Wh Innovative lithium-ion batteries：>400 Wh/kg Batteries with innovative material systems: >500 Wh/kg
"Made in China 2025"	2020：energy density>300 Wh/kg 2025：energy density>400 Wh/kg 2030：energy density>500 Wh/kg
Plan for the middle and long-term development of the automobile industry	2020：Energy density of cells >300 Wh/kg (try to reach 350 Wh/kg) Energy density of battery systems >260Wh/kg Cost<1￥/Wh 2025：Energy density of battery systems >350Wh/kg

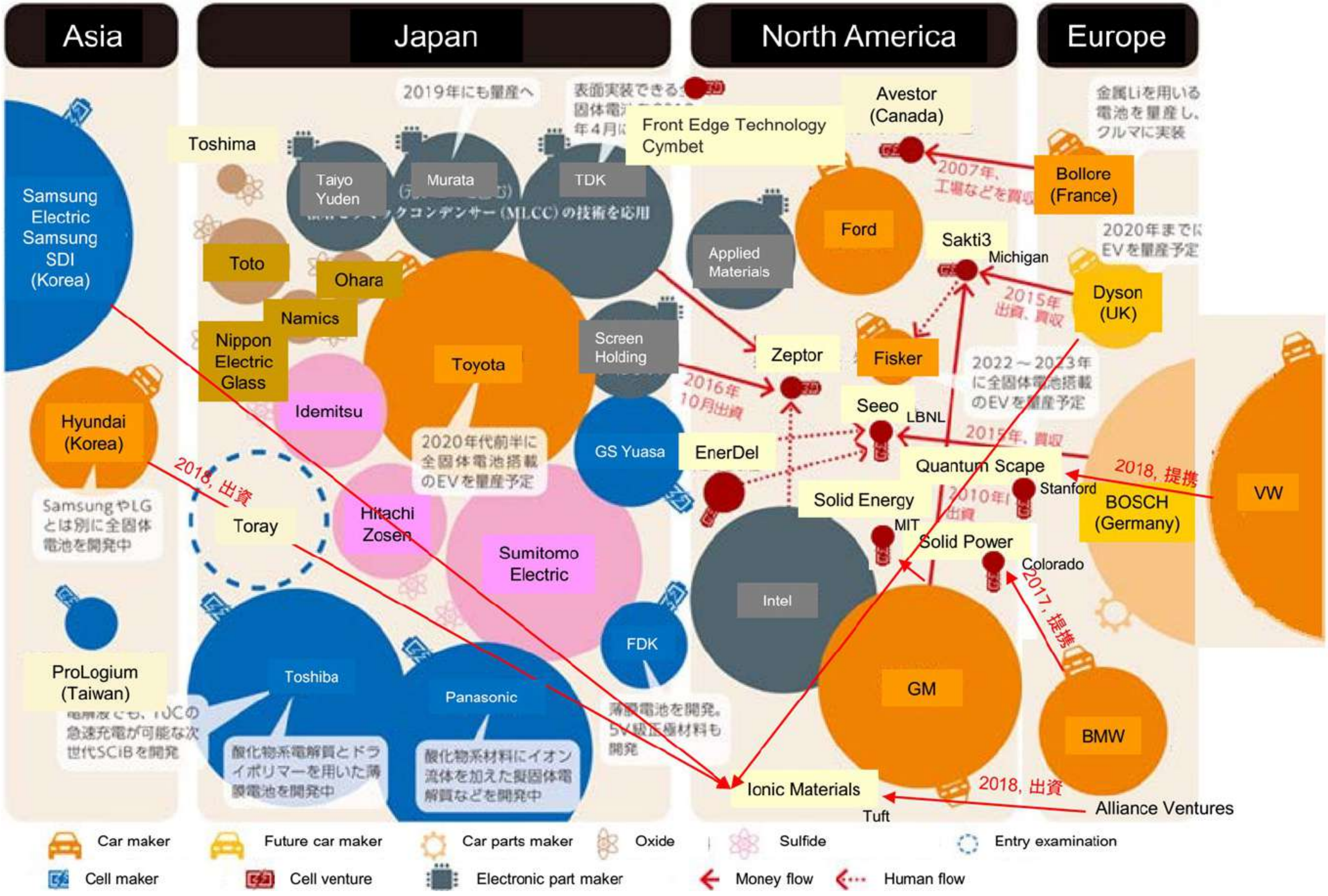
PART 02

Global R&D Introduction of SSBs

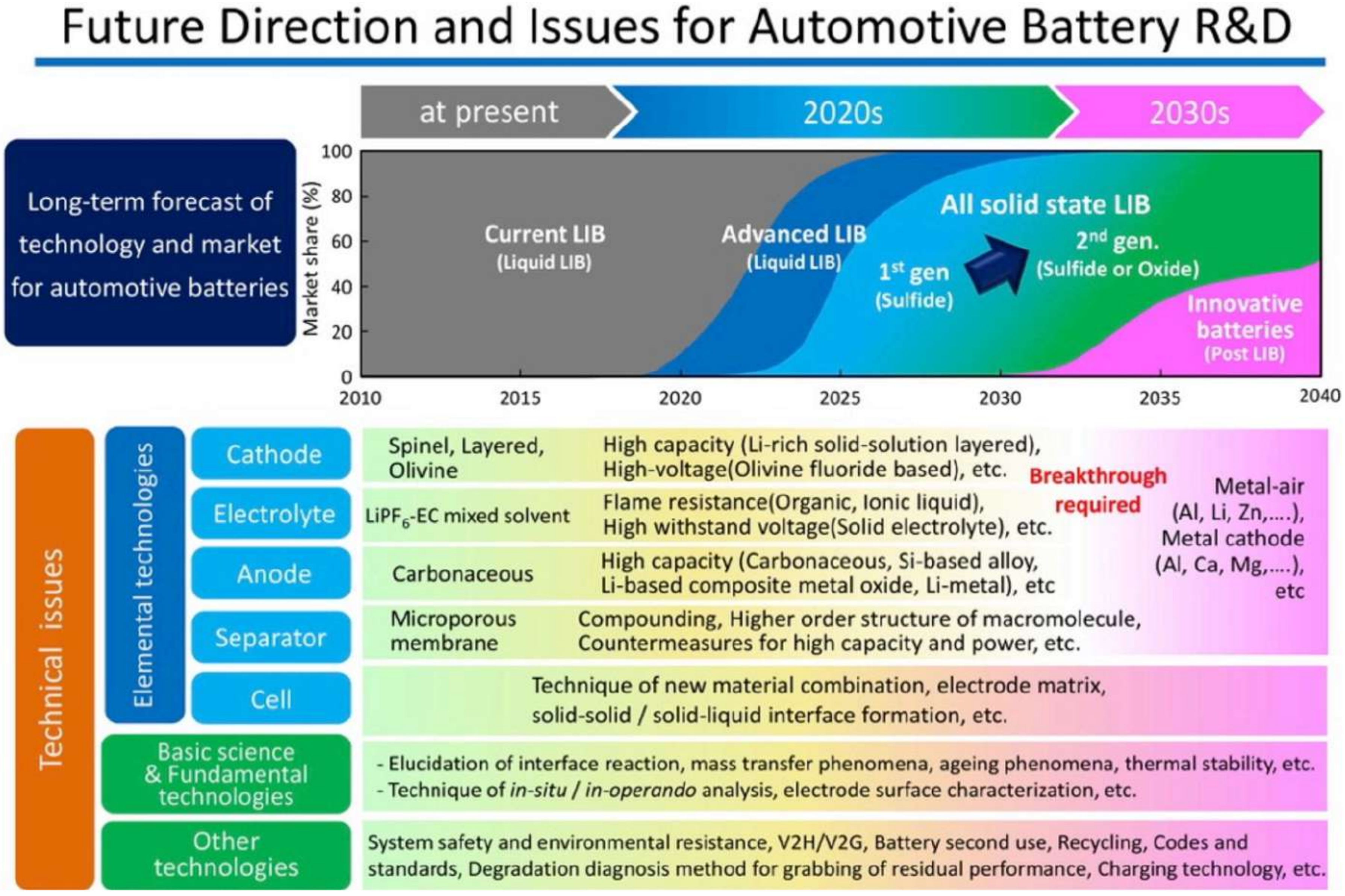
Global R&D enterprises of solid-state batteries



JST's statistics about global R&D enterprises of solid-state batteries

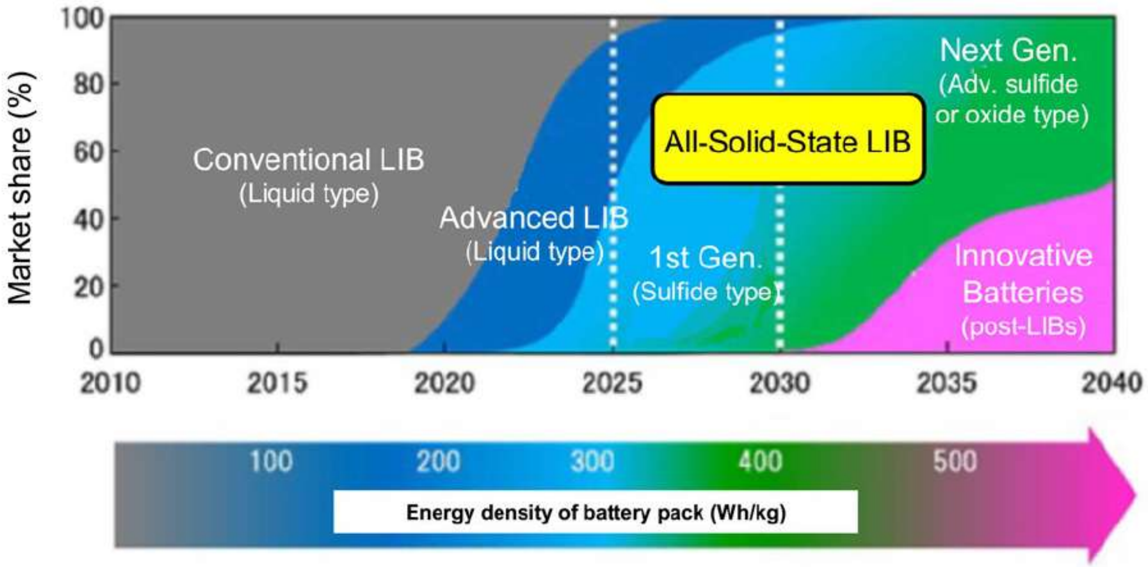


NEDO's forecast of technology and market for EV batteries



Japan's lithium battery R&D project No.3: SOLiD-EV

Restart of NEDO PJ (2nd stage: 2018-2022) SOLiD-EV



2018.6.15

Representatives of organizations and companies participating in this project

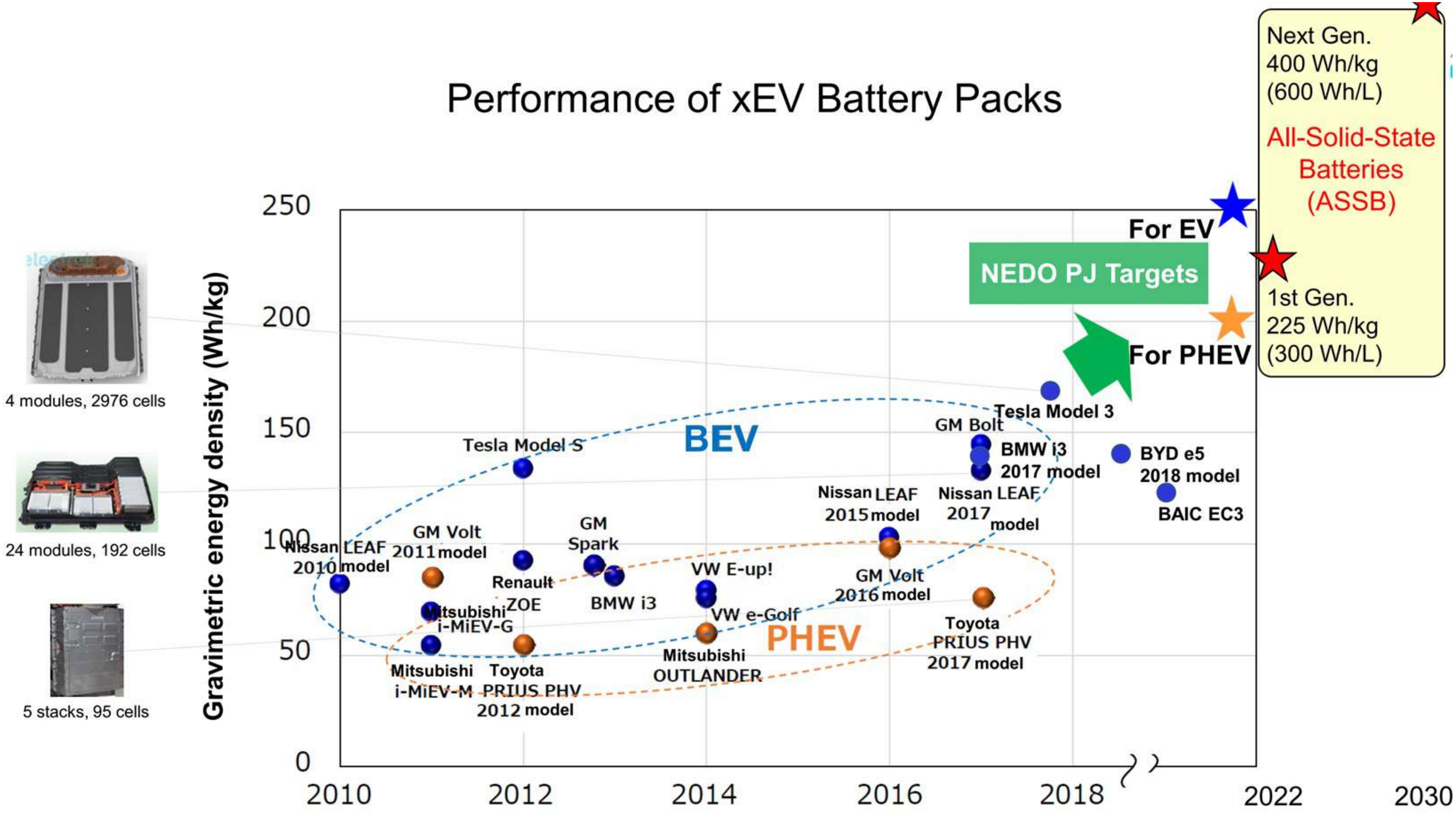
From left front row, Mr. Keiichi Aida, MEO of Honda R & D Co.; Mr. Hideki Iba, GM of Battery Materials Technology & Research Dept., Toyota Motor Corp.; Mr. Kei Hosoi, DG of NEDO Electricity Storage Technology Development Div., Mr. Yoshiteru Sato, DG of NEDO Advanced Battery and Hydrogen Technology Dept.; Mr. Akira Yoshino, President of LIBTEC, Mr. Yasuo Ishiguro, Managing Director/PL of LIBTEC; Mr. Haruhito Mori, GM of Research Planning Div., Nissan Research Center; Mr. Eiji Fujii, GM of Resources/Energy Area, Panasonic Technology Innovation Division,.

Lithium Ion Battery Technology and Evaluation Center (LIBTEC)
All-solid-state batteries: $90 million 2018-2022

1. Toyota Motor Corporation
2. Nissan Motor Co., Ltd.
3. Honda R & D Laboratories
4. Panasonic Corporation
5. GS Yuasa Corporation
6. Hitachi Automotive Systems Co., Ltd.
7. Maxell Corporation
8. Murata Manufacturing Co., Ltd.
9. Yamaha Mr. Motor Co., Ltd.
10. Asahi Kasei Corporation
11. JSR Corporation
12. Sumitomo Metal Mining Co., Ltd.
13. Dai Nippon Printing Co., Ltd.
14. Toppan Printing Co., Ltd.
15. Toray Industries, Ltd.
16. Nippon Shokubai
17. Fujifilm Corporation
18. Mitsui Chemicals Corporation
19. Mitsubishi Chemical Corporation
20. Kuraray Co., Ltd.
21. Nissan Chemical Industries Ltd.
22. Idemitsu Kosan Co., Ltd.
23. Mitsui Mining and Smelting Co.
24. National Institute of Advanced Industrial Science and Technology
25. National Institute for Materials Science
26. National Institute of Physical and Chemical Research (RIKEN)
27. Osaka Industrial Technology Research Institute,
28. Kyushu University;
29. Kyoto University
30. Gunma University;
31. Tokyo Institute of Technology
32. Toyohashi University of Technology
33. Nagoya University
34. Hyogo University of Teacher Education
35. Hokkaido University
36. Osaka Prefecture University
37. Konan Gakuen
38. Japan Automobile Research Institute

http://www.nedo.go.jp/news/press/AA5_100968.html [2018.6.15, NEDO]

R&D targets of SOLiD-EV

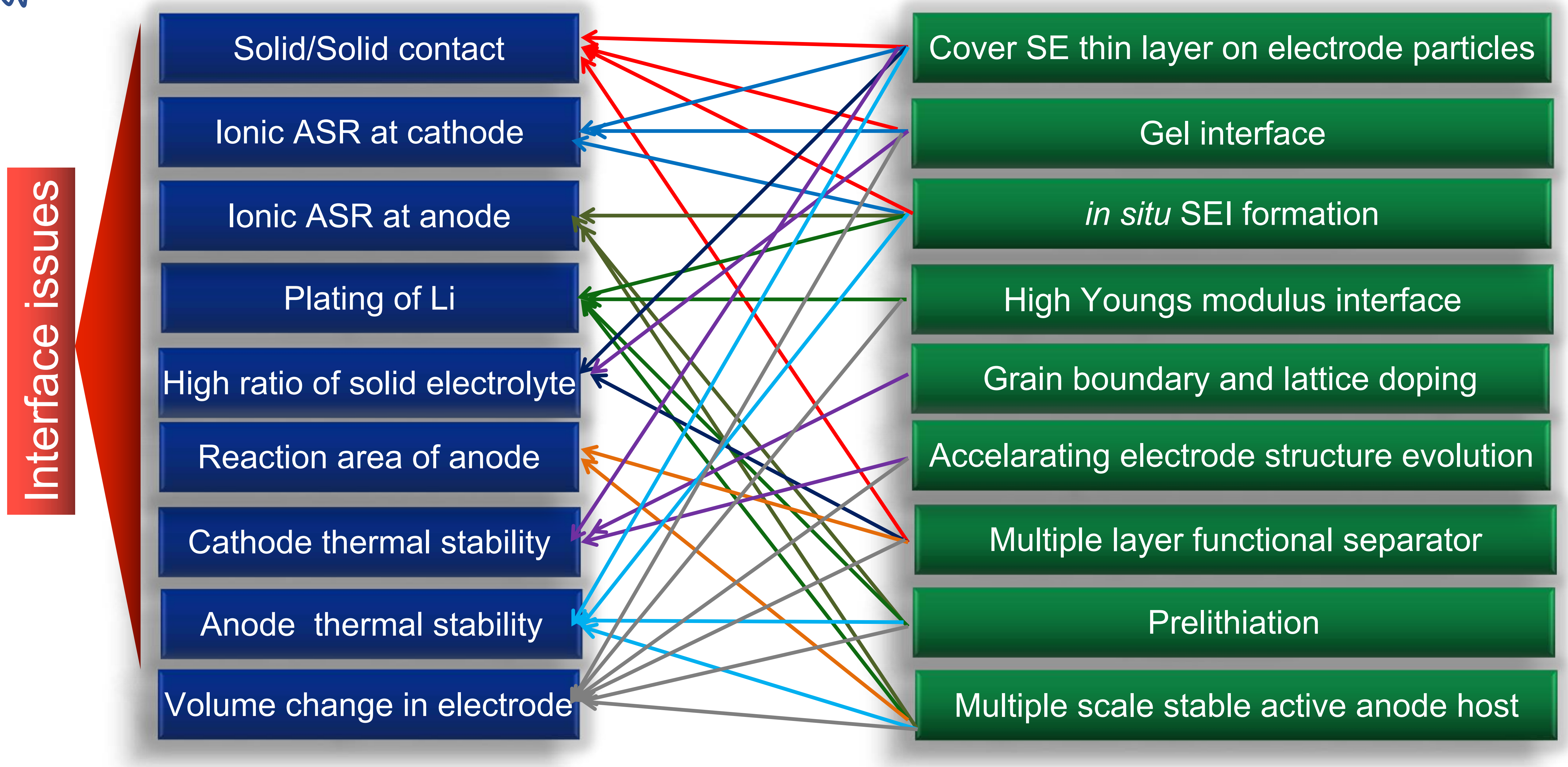


SOLiD-EV's Long-term targets of ASSLBs

Examples of Battery Pack Targets using ASSLB

Spread period	Year 2025 model		Year 2030 model	
Battery type (Electrolyte type)	1st gen. ASSLIB (Sulfides) Cathode: NCM, etc. Anode: Graphite, etc.		Next gen. ASSLIB (Advanced Sulfides or Oxides)	
Vehicle type	EV	PHEV	EV	PHEV
Electric mileage	400 km	200 km	480 km	240 km
Vehicle price	2000～2200 k¥		1800～2000 k¥	
Electric energy	40 kWh	20 kWh	40 kWh	20 kWh
Cost	600 k¥	300 k¥	400 k¥	200 k¥
Energy cost	15 k¥/kWh		10 k¥/kWh	
Weight	133 kg	67 kg	100 kg	50 kg
Gravimetric energy density	300 Wh/kg		400Wh/kg	
Volume	67 L	33 L	50 L	25 L
Volumetric energy density	600 Wh/L		800 Wh/L	
Volumetric power density	2,000 W/kg		2,500 W/kg	
Calendar life	10 year		15 year	
Cycle life	1,500 cycles		2,000 cycless	
Vehicle environmental temperature	-30～60 °C		-30～60 °C	
Safety	Equivalent to gasoline cars		Equivalent to gasoline cars	
Charging time (Normal charge)	6 hr	3 hr	6 hr	3 hr
Charging time (Fast charge)	20 min	10 min	20 min	10 min

Some problems of ASLB and possible solutions



Possible solutions for keeping good solid/solid contact

A. Not very seriosu since one phase is deformable

+

B. solid electrlyte grows on active particles or/and electrode

- A1. Polymer electrolyte (Hydro Quebec, SEEO)
  - PEO-type
  - Other type
- A2. Sulfide electrolyte (Toyota,TIT)
  - Mixing/pressing
  - Solution

    +
  - Cathode Interface

- B1. Low T interfacial sintering
  - Microwave
  - Ultrasonic
  - Laser
- B2. Chemcial deposition of SE
  - Precipitation
  - Polymerization
  - Conversion
- B3. Electrochemical deposition (SEI)
  - Anode: SEI
  - Cathode: CEI

Industry chain of solid state battery

Raw Materials
- Lithium ore
- Cobalt ore
- Manganese ore
- Nickel Ore
- Graphite mine
- Silicon powder ore
- Rare-earth ore

Battery Materials
- cathode material
- Li anode material
- Solid electrolyte
- Current collector
- Conductive dditives
- Adhesives
- Packaging materials

Solid-state Battery
- Sizing agent
- Pole piece
- Battery Cells
- formation
- battery pack
- Power management
- System integration

Battery Application
- power grid stored energy
- Reserve power supply
- EV
- Industrial Energy Saving
- Consumer Electronics
- Aerospace
- National security

Recycle
- step utilization
- Waste recycling
- test & diagnosis
- performance evaluation
- Security warning
- Failure Analysis

- Lithium-ion battery +Lithium metal battery+Solid electrolyte membrane=Mixed solid-liquid/All solid state
- The solid state battery intelligent manufacturing line needs to add 20% new equipment.

PART 03

R&D progress and layout of SSBs of Beijing WeLion

Introduction of WeLion

1977

Professor Liquan Chen started research of lithium-ion conductors at Institute of Physics CAS

2016

Prof. Chen, Prof. Hong Li, Mr. Huigen Yu set up Welion.

2017

Institute of Physics CAS took Welion as its exclusive implementation platform for solid-state battery.

2018

300Wh/KG hybrid solid-liquid EV batteries used in a test vehicle.

2019

270Wh/KG（3-5C）UAVs battery tested by clients, which can prolong 20-30% UAV flying time.

2020

Won four top prizes in July. One of the entries is 550Wh/KG GED. The other is 1700Wh/L VED.

2020

0.2GWh advanced production line went into operation from August. UAVs battery sold for ¥12M in 2020

2021

Start the cooperation on next generation battery with strategic EV partner.

2022

2GWh advanced EV battery production line will be ready for mass production in Huzhou Zhejiang.

WeLion Manufacturing Bases

Beijing Base

Headquarter, R&D Centre,

Flagship EV Battery Line

Area：50000m^2

Capacity：1GWh

Date：2022

Liyang Base, Jiangsu

UAVs Battery Line

Area: 20000m^2

Capacity：0.2GWh

Date：2020

Huzhou Base，Zhejiang

EV Battery Line

Area：40000m^2

Capacity：2GWh

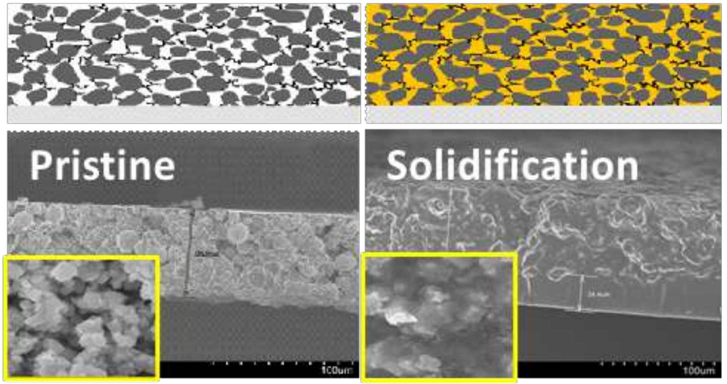
Date：2021

The core technology of WeLion company

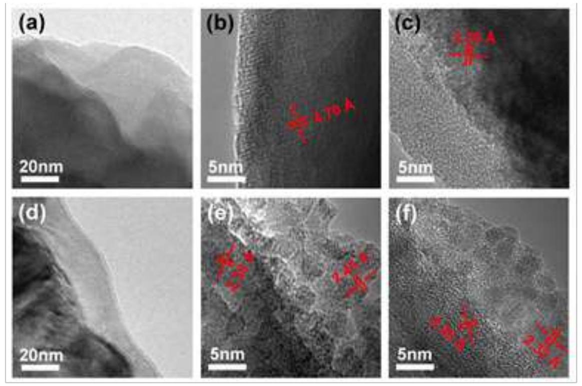
Beijing WeLion New Energy Technology Co., LTD.

Members: over 350 members

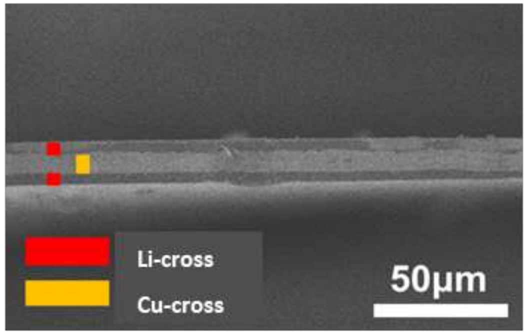
Valuation: $350 million (Series B Round)



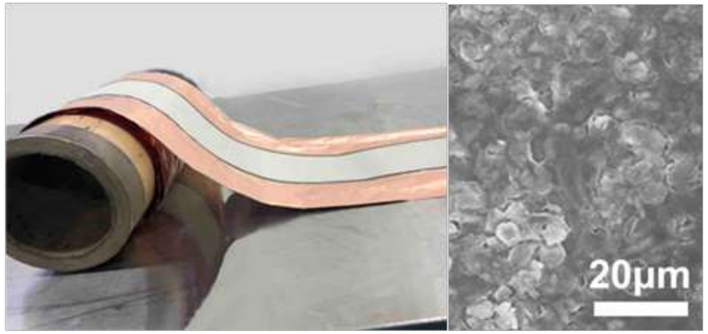
In situ solidification



Fast ion conductor coated cathode



Ultra-thin lithium metal foil

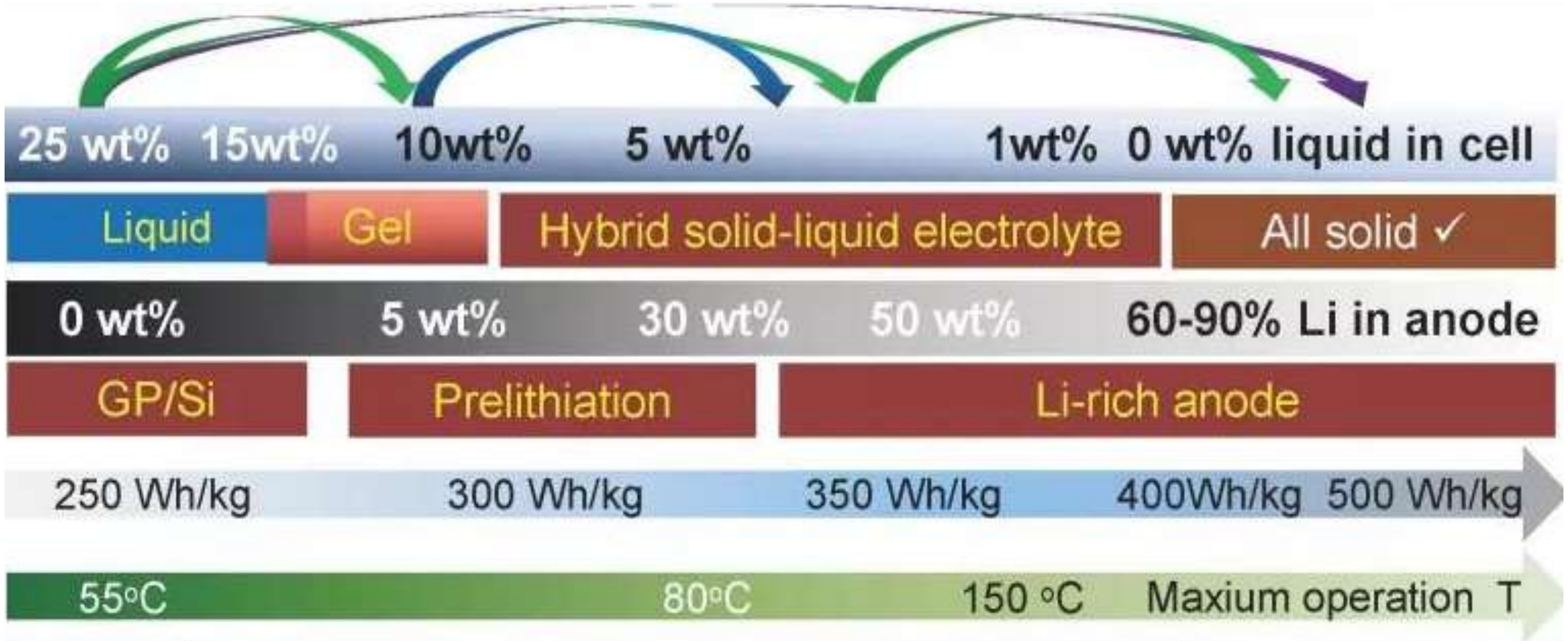


Electrode pre-lithiation

Ionic conducting separator

Over 200 Patent applications on key technologies of HELBs

Practical solution: from liquid to all solid



	Nonaqueous (liquid)	Hybrid solid/liquid	All solid
Cathode	NCM， NCA，Li-rich, LNM	NCM， NCA，Li-rich, LNM	NCM，LCO， LI-rich, LNM, S, MFx / coating
Anode	GP，C@SiOx, C@nano-Si/C	Li+ HC, SC, C@SiOx, C@nano-Si/C /SEI	Li, Li-alloy, Li-composite / SEI
Electrolyte	EC-DEC-EMC-DMC $LiPF_6$ BP, FEC, VC, BS, LiFSI, LiODFB..	LATP, LLZO, LiSx + LiTFSI, LiODFB，LiFSI+polymer	LLZO/PMMA-LiX; sulfide Others
Separator	Al_2O_3/PE/PVDF-HFP	LATP/PE/PVDF-HFP	

Hybrid L&S electrolyte battery: Relativie easy to realize

ASSB: Still need basic research

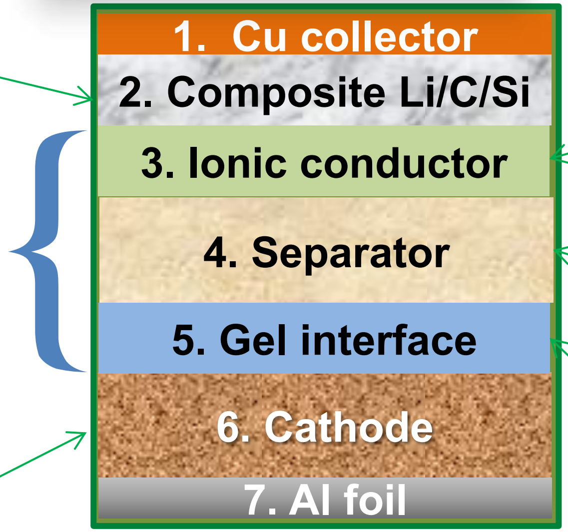
ASSB' s safety need to be verified.

hybrid solid/liquid electrolyte HELB with in situ solidification

1. Lithiated host (Si/C) + SE + SEI

Perforated copper foil

2. Inorganic solid electrolyte (LAGP, LATP) pasted layer + SEI



3. Polymer separator （PP/PE) /polymer-ceramic-Li salt /LLZO

5. Solid electrolyte coated cathode + SE +Li salt / CEI + high T electrolyte

Carbon-coated Al foil

4. PVDF-HFP-PMMA / LATP

Key: Converted liquid into solid electrolyte via SEI/CEI/polymerization reactions

WeLion Code

1- High-Energy Density

Cell GED is 300-500Wh/KG. Vehicle can run **1000 KM** after full charge.

1- Long Lifetime

Excellent cycle performance. Battery lives exceed EV lives (**100M KM**).

0 - Intrinsically Safer

Eliminate flammable separator. Cell don’t catch fire, smoke or explode during nail test. **0** risk.

0 – Comparable Cost

Compatible with existing processes. Mature raw materials supply. **0** increase in Cost.

Welion Code : 1100

Typical products of WeLion Company

Solid state lithium battery with high specific energy density and high safety

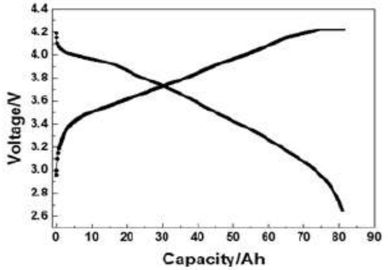
UAV battery pack

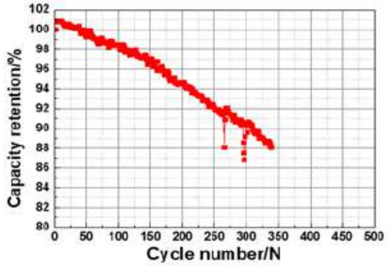
High power intelligent energy storage cabinet

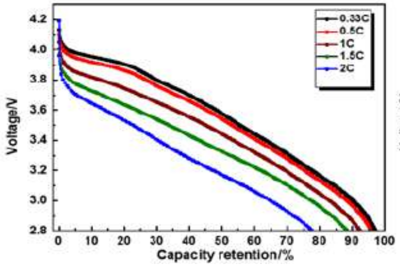
Typical products of WeLion Company

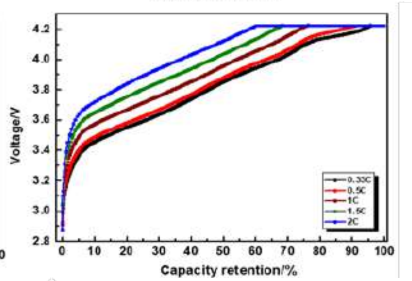
The EV car can travel 700 km after loading this 300Wh/kg sample. When we improve the energy density to 350 wh/kg , it can travel 1000 km for one charge, and the cycle performance of the battery is 600 cycle.

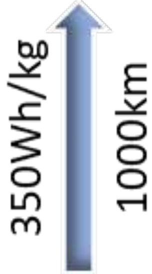
电芯尺寸	容量（Ah）	电压（V）	重量（g）	能量密度（Wh/kg）
310×100×12	81	3.53	806	355

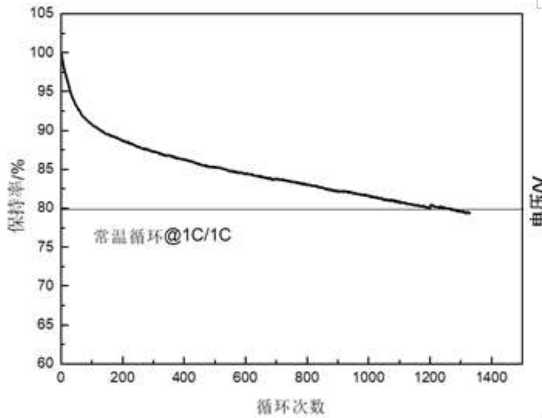


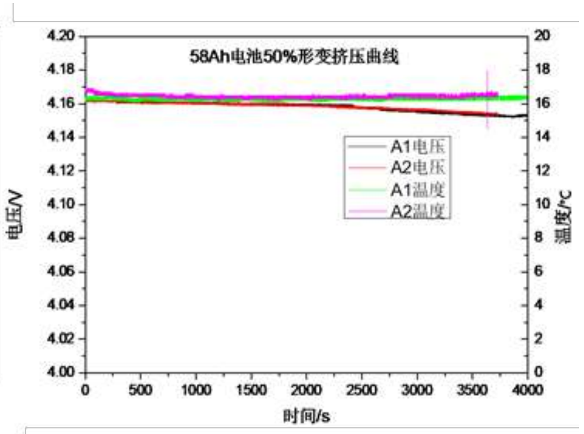


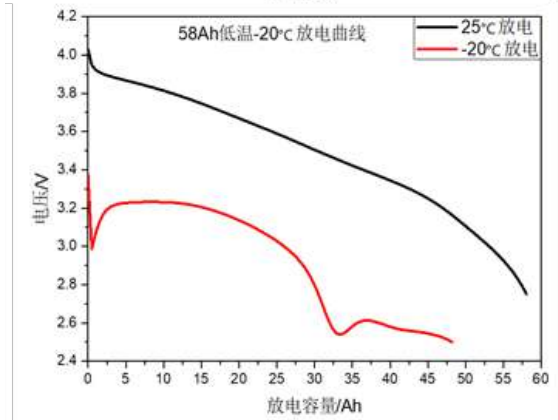


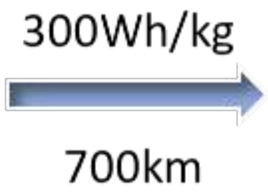


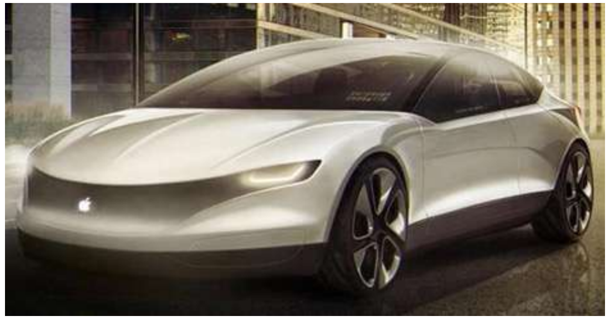




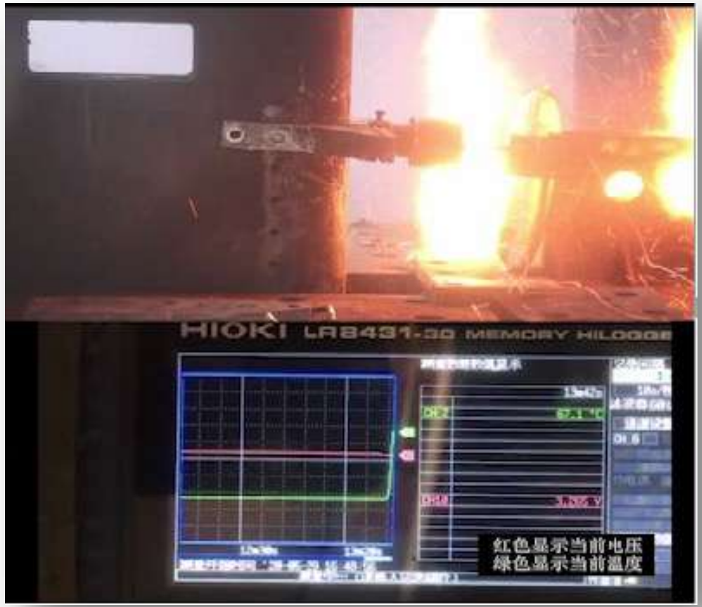








Excellent safety properties of welion EV batteries

Liquid Electrolyte	WeLion Battery (300Wh/KG)
	

The 300Wh/kg Welion EV battery don’ t catch fire, smoke or explode during penetration test and 150 ℃ thermal shock test.


“We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten.” ——Bill Gates

2021-2030

Solid State Battery

Change the World

换电
让用户摆脱充电的烦恼
让电池共享出最大价值

Remove Charging Trouble. Maximize Shared Value.

奥动新能源 Aulton

2021.6

Jun. 2021

极速 · 共享 · 焕新

交通工具电动化
带来能源体系的变革

Electrification of Vehicles Brings Transformation of Energy System

汽车新四化趋势
New Trend of Automobile

能源全新结构
New Energy Structure

补能多元场景
New Scenarios for Energy Supplementary

奥动 Aulton

用户对电动汽车能源服务体系的核心诉求

Core Demands of Users for Electric Vehicle Energy Service System

网络便捷 Convenient	补能高效 Efficient	安全可靠 Safe and reliable	经济实惠 Economical

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换电，从To B 走向 To C

from Operating Vehicles to Private Cars

安全、高效、便捷 Safe, Efficient, and Convenient	无固定车位、无私桩是主流人群 Mainstream users without fixed parking space or private charging piles	充电网络与社会资源的矛盾 Contradictions caused by scarcity of public resources	可充、可换、可升级 极致效率与体验 Perfect Efficiency and Experience
B 端用户体验 User Experience of Operating Vehicles	C 端需求场景 Demand scenarios from Private uses	社会痛点 Pain Points	终级解决方案 Ultimate Solution

奥动 Aulton

商用车换电，势在必行

Swapping Battery for Commercial Vehicles is Imperative

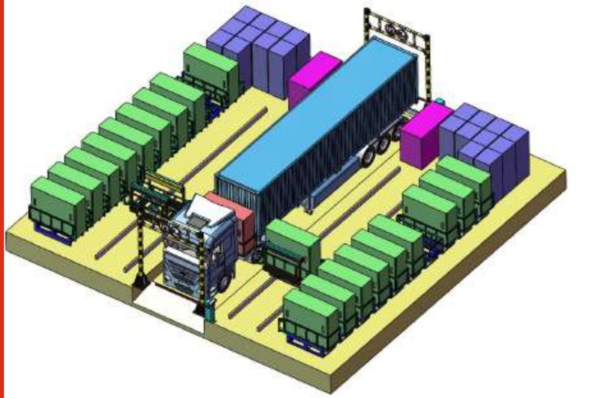
电池系统通用性
Generality of Battery System

多车型共享换电站
Multi-model Sharing Battery Swapping Station

模块化快速建站
Rapid Construction of Battery Swapping Station

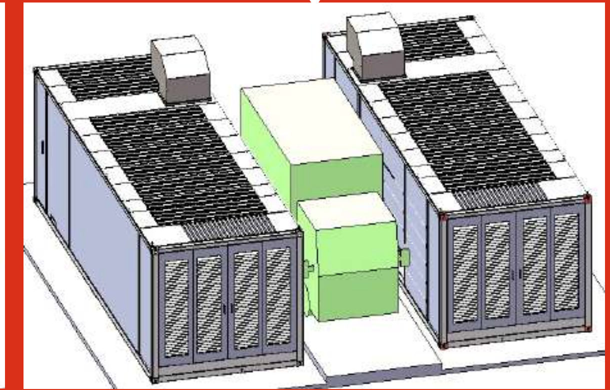
快速、安全、稳定
Rapidity, Safety and Stability

牵引车换电
For Tractors

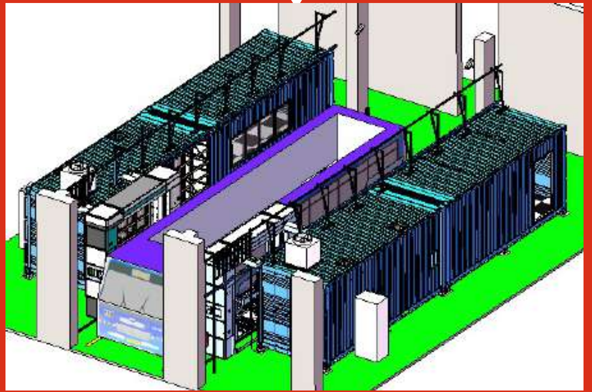


自卸车换电
For Dump Trucks

轻卡物流车换电
For Light Trucks



大巴车换电
For Buses



奥动 Aulton

换电，让电池共享出最大价值

Let the battery share the greatest value

电池更安全、电池更健康
Safe and Environmental-friendly

车电物理分离让电池价值发挥更充分
Give Full Play to Battery Value

降低用户购车成本
Cost to Save

让电池资源变成社会公共资源
Let Battery be Social Public Resource

奥动

Aulton

李克强总理

Li Keqiang

Premier of China

辛国斌 副部长

Xin Guobin

Vice-minister of Industry and Information Technology

2021年3月 政府工作报告
Government Work Report of March 2021

增加停车场、充电桩、**换电站**等设施
加快建设动力电池回收利用体系

Increasing Parking Lots, Charging Piles, Battery Swapping Stations and Other Facilities, and Speeding up the Construction of Battery Recycling Systems

2020年7月 国新办新闻发布会
Press Conference of State Council Information Office in July 2020

换电模式具有**7大优势**

Seven Advantages of Battery Swapping Mode

奥动新能源，全球换电开创与引领者

Aulton, an innovator and pioneer of global battery swapping model

全球最快 **20秒** 极速换电
Battery Swapping within 20s

13家主流车企合作
Cooperation with 13 Automakers

21款换电车型
21 Battery-swappable Models

规模化换电运营经验：7年，23城，50,000车，84,190吨碳减排，单车换电将达100万公里
7-year Experience in the Large-scale Commercial Operation

21年探索换电技术与模式
21-year Exploration of Battery Swapping Technology and Mode

友好安全：
共享换电，**0** 重大安全事故
No Safety Incident

全球2,000 多项换电专利

More Than 2,000 Global Patented Battery Swapping Technologies

多品牌车型共享
20秒极速换电

奥动
Aulton

奥动
Aulton

2021-2025全新发展规划

5-year Development Stipulation

投建 10,000 座换电站

To Build 10,000 Battery Swapping Stations

形成 1000万辆 服务能力

To Serve 10 Million Vehicles

奥动 Aulton

换电，不仅是换电

More Than Battery Swapping

车辆的能源交互

Energy Interaction with Vehicles

车辆是能源载体
可实现双向交互

电网的能源交互

Energy Interaction with Power Grid

换电站与电网
的能源双向互动

奥动 Aulton

助力中石化 加速双碳实施

To Achieve China's Carbon-neutral and Emission-peak Target with SINOPEC

能源转型的高度与行动力

Energy Transformation

电池银行促进行业标准统一

Battery Standardization

加速新能源行业发展

Industry Development

赋能主机厂提升用户体验

Experience Improvement

奥动在德国 / 欧洲的国际化合作与开拓

International cooperation and expansion in Germany/Europe

INFRADianba is a Chinese-German Joint Venture and established in 2019 in Germany;

欧亚电巴国际
中德合资公司
2019年正式注册于德国

Nearly ten years of efforts in Sino-German innovation cooperation
近十年不懈努力 - 中德创新合作

During German Chancellor Angela Merkel ‘s visit to China in 2016, Aulton/Dianba and the German partner signed successfully the contract at the 8th Sino-German Economic and Technical Cooperation Forum
2016年德国总理默克尔访华期间，中德双方在第八届中德经济技术合作论坛上成功签约

奥动
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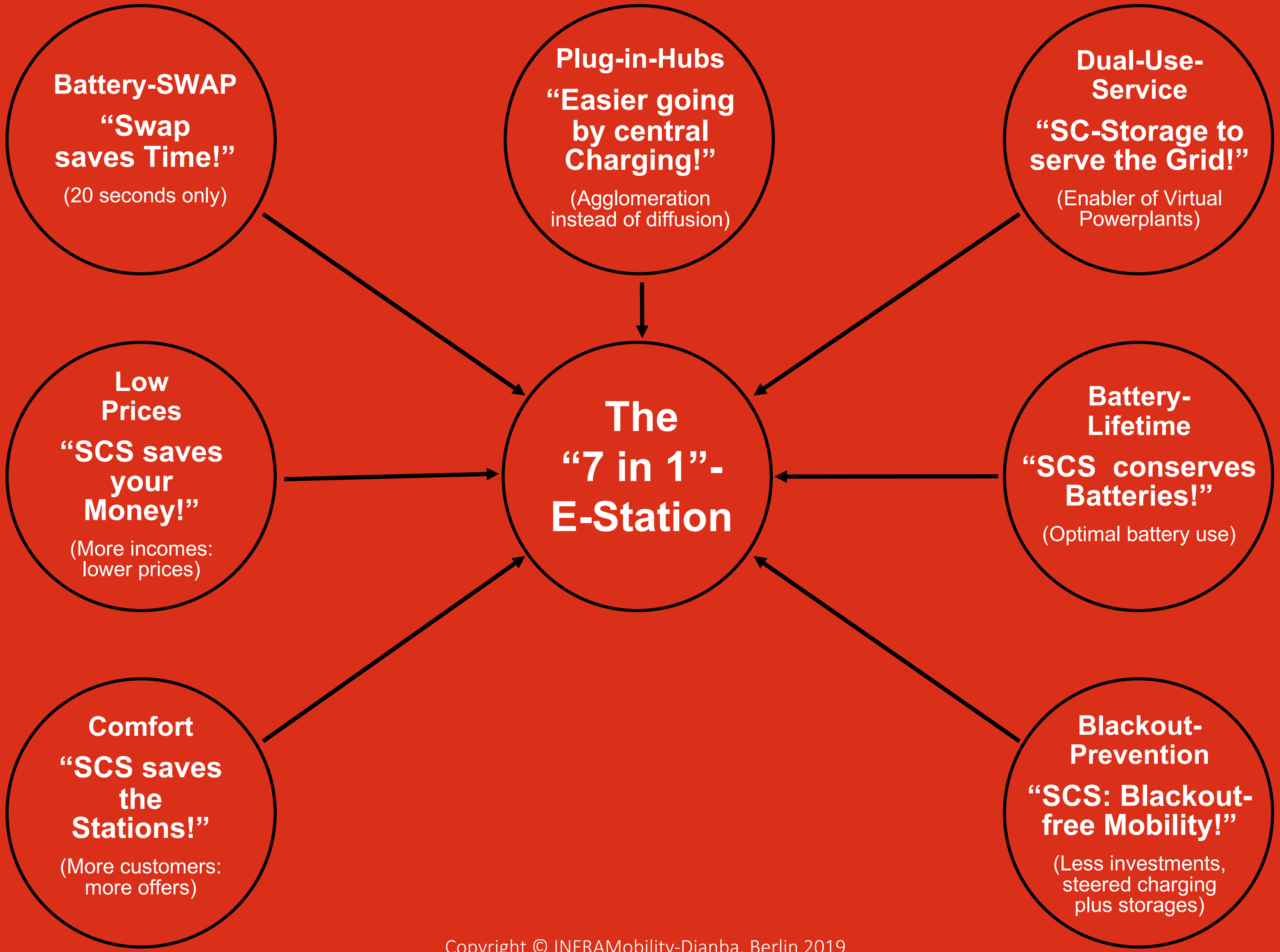
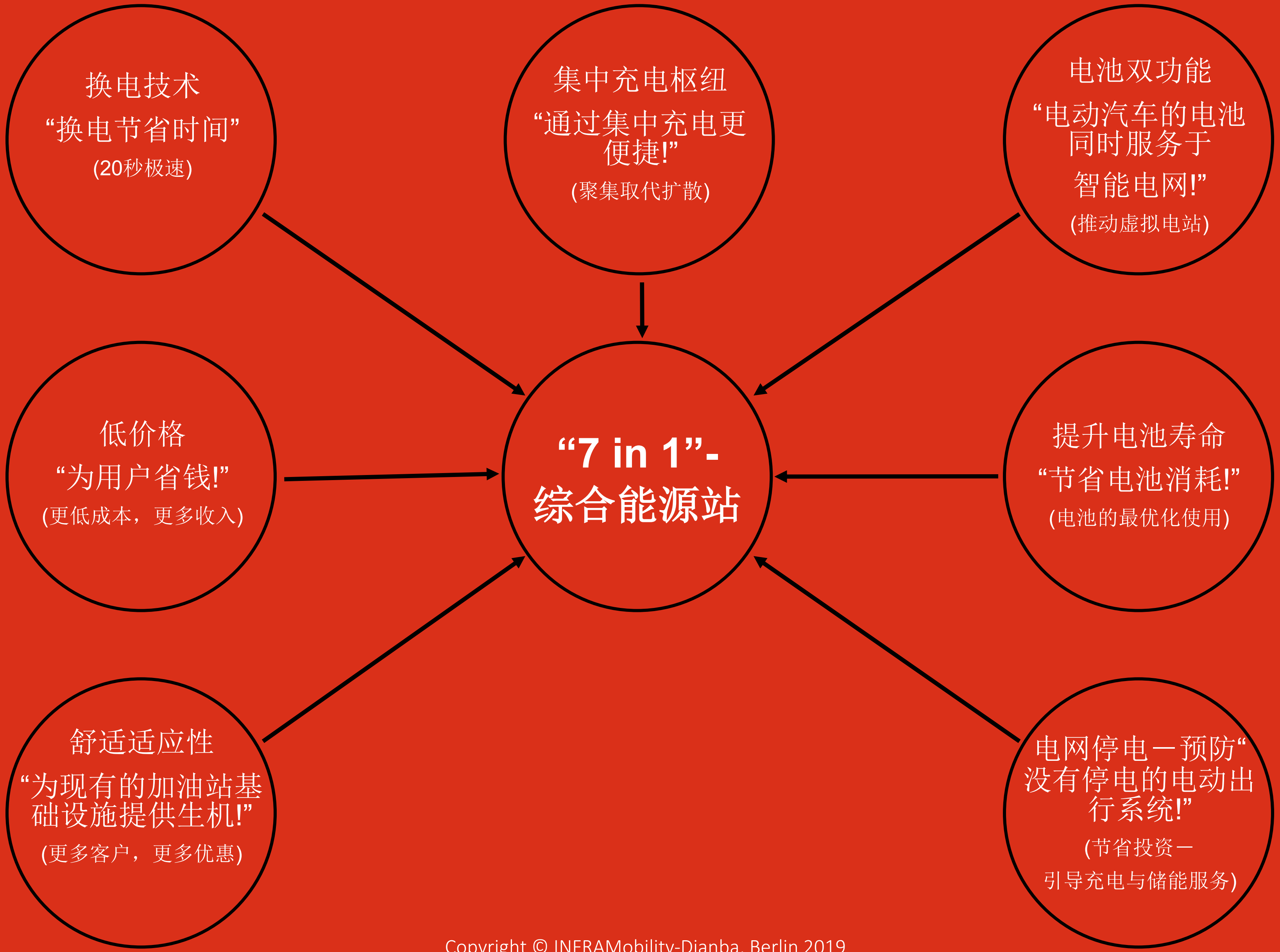
The first battery swapping system for e-taxi in Europe is already being tested in Berlin
全欧第一套电动出租车换电系统已经成功落户

The first battery swapping station for e-buses in Europe as demonstration in Poland
全欧第一座电动大巴换电站系统
在波兰作为样板项目成功演示

The 8 Messages of the Multi-Use E-Station System for Europe



面向欧洲市场的多功能能源站－八个重点



奥动
Aulton

CDU BERLIN

BERLIN IN BEWEGUNG BRINGEN – AUF DEM WEG ZUR MOBILITÄTS-STADT NUMMER EINS IN EUROPA

Beschluss
des Landesvorstandes der CDU Berlin

Berlin, 19.06.2020

BERLIN IN BEWEGUNG BRINGEN – AUF DEM WEG ZUR MOBILITÄTSSTADT NUMMER EINS IN EUROPA

Tankstelle der Zukunft – Wir wollen in Berlin modellhaft eine Tankstelle der Zukunft realisieren. Hier sollen E-Lade-Stationen, Swapping-Stationen für den Batteriewechsel, Wasserstoffbetankung und fossile Brennstoffe zusammen berücksichtigt werden.

Batteriewechselsysteme – Batteriewechselsysteme sind ein Baustein für das Gelingen der Elektromobilität. Wir fordern daher den Einsatz von Batteriewechselstationen für Taxen, Busse, LKW, andere Nutzfahrzeuge und Car-Sharing, um Batterien in wenigen Minuten auszutauschen und die gebrauchten Batterien gesteuert, also batterie- und netzschonend, wieder aufzuladen. Dafür ist die Planung eines stadtweiten Netzes von Batteriewechselstationen für Berlin (unter Nutzung praktischer Erfahrungen), das auch Plug-in-Möglichkeiten anbietet und vor allem vorhandene Tankstellenstandorte, Großparkplätze und Betriebshöfe verwendet, notwendig.

INFRADianba
Gründungsjahr: 2019

2020年6月19日，德国最大的政党之一——德国基民盟柏林州党团委员会决议一项名为《让柏林前进——迈向欧洲第一大出行城市》（译名）的总规划，电动汽车换电系统，被正式提出并纳入总规划。

本次决议规划中，电动汽车换电系统，被正式提出并写入党团规划：“换电系统是实现电动出行的一块基石。我们将促进用于电动出租车、电动大巴、电动卡车、商用车和电动车共享服务等换电站系统建设。电池箱体在短短几分钟内被进行更换，换下的电池安全可控，实现对电网友好型的充电。特此，有必要柏林全城规划一个电动汽车换电站网络（结合实际应用经验），同时也提供传统的插电充电设施，尽可能地利用现有的加油站体系、大型停车场和仓库仓储系统。”

此外，INFRADianba 提倡的“未来能源站”理念被规划采纳：“党团决议，在柏林示范性地建造实现‘未来能源站’，将电动汽车充电站、电动汽车换电站、氢能加氢站及传统石化能源燃料补给站，综合在一个场站使用。”

换电系统写入德国基民党柏林州党团决议 - 中德合作的首次突破

Battery Swapping system proposal was included in the resolution of the Berlin State Party caucus of the German CDU

奥动 Aulton

TAGESSPIEGEL MOBILITÄT & TRANSPORT
BACKGROUND

Das Entscheider-Briefing für den Mobilitäts- & Transportsektor, 09.01.2020

Europa braucht bis 2030 mindestens 33 Millionen E-Autos, wie Tagesspiegel Background am Mittwoch berichtete. Da stellt sich auch die Frage, ob **Wechselakkus** nicht doch eine gute Idee wären – obwohl das „Project Better Place" mit eben dieser Idee 2013 in Israel gescheitert ist. Jetzt nimmt das **deutsch-chinesische Joint-Venture InfraMobility Dianba** einen neuen Anlauf. Bei einem Ortstermin im Berliner Westhafen informierte sich **Verkehrssenatorin Regine Günther** (Grüne) über das patentierte System. Jutta Maier war dabei und erklärt auch, ob das System nicht nur für Pkw, sondern auch für Busse geeignet wäre.

Jutta Maier

Taxis per Wechselakku elektrifizieren

Ein deutsch-chinesisches Joint Venture macht im Berliner Westhafen vor, wie vollautomatische Batteriewechselstationen für Pkw funktionieren können. In China hat sich das Prinzip bereits bewährt, hierzulande fehlt noch ein Hersteller zum Aufbau einer Flotte.

Der Wechseltisch bewegt sich vor und zurück, hoch und runter. Es summt und piept. Schließlich klackt es, und die frisch geladene Batterie ist am Boden der **BAIC**-Limousine verriegelt, die auf einer Rampe steht. Drei Minuten dauert der vollautomatische Wechsel, bei dem ein Roboter-System den gebrauchten 40-Kilowatt-Akku aus dem Fahrzeug löst, aus dem Lager eine neue Batterie holt und einsetzt.

„Eigentlich müsste die Station gar nicht bemannt sein, weil es überall Kameras und Sensoren gibt", sagt **Jörg Hellhammer** von **Infrawind Eurasia**, der den Showcase **am Berliner Westhafen** betreut. Für die Abrechnung wird das Autokennzeichen miterfasst. Der Fahrer muss also nicht aussteigen, um **260 Kilometer Reichweite** zu „tanken". Herausfallen könne die Batterie nicht, betont Hellhammer, weil sie über acht Punkte mechanisch und auch elektrisch verriegelt anstatt – wie bei früheren Systemen – verschraubt sei.

Berlins **Verkehrssenatorin Regine Günther** (Grüne) ist zu Besuch an dem orangefarbenen Container im Westhafen, um sich das patentierte System des deutsch-chinesischen Joint-Ventures **InfraMobility Dianba** zeigen zu lassen. Günther stellt Fragen und posiert für Fotos. Der chinesische **Geschäftsführer** und Energieexperte **Alexander Yu Li** und **Bernd Stumpf** von der **Berliner Taxivereinigung** beantworten ihre Fragen, sie wollen sie für das Wechselsystem begeistern. Als Beiratsvorsitzender mit an Bord ist auch **Dieter Flämig**, **Umweltökonom** und Berliner Staatssekretär im Ruhestand. Zusammen mit Yu Li gründete er 2008 die Initiative Infrawind Eurasia, die die europäisch-asiatische Zusammenarbeit bei erneuerbaren Energien und Smart Grids unterstützen soll.

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09.01.2020 - 15:45

Infradianba: Chinesisch-deutsches Batteriewechsel-Projekt in Berlin

Akku-Tausch Aulton Dianba Batterie Berlin China Deutschland Infradianba InfraMobility

Einen neuen Anlauf in Sachen Batteriewechselstationen für Elektroautos nimmt das im Februar 2019 gegründete Joint Venture Infradianba der Firmen Aulton Dianba aus China und InfraMobility aus Deutschland. Eine erste Anlage im Berliner Westhafen steht bereits.

Das deutsch-chinesische Unternehmen, mit einem Kapital von einer Million Euro in Berlin gegründet, hat im Herbst 2019 die erste europäische Batteriewechsel-Pilotanlage für Taxis im Berliner Westhafen installiert, die aktuell vom TÜV Rheinland überprüft wird. Ziel ist es laut einer Mitteilung des Unternehmens, dass bis Mitte 2020 alle Genehmigungen und Zulassungen für den Einsatz in Deutschland vorliegen.

Auf dieser Grundlage soll dann zusammen mit dem Berliner Taxigewerbe ab Herbst 2020 ein Pilotprojekt mit zunächst fünf und später 50 Elektro-Taxis eingerichtet werden, um die „Taxifreundlichkeit des Systems unter Berliner Bedingungen" zu erproben. Ziel der Initiatoren ist es, bis 2027 oder 2028 mit ca. 70 Stationen stadtweit die Elektrifizierung des gesamten Berliner Taxiverkehrs sicherstellen zu können.

Die Idee von Batteriewechselstationen für E-Autos ist nicht neu, hat sich aber im großen Maßstab bisher nur in einigen chinesischen Städten durchgesetzt. Der Vorteil der Technologie ist, dass der Wechsel auf einen vollständig geladenen Akku nur wenige Minuten dauert – Infradianba verspricht bei seinem System beispielsweise drei Minuten. Zudem können das Fahren und Laden voneinander entkoppelt werden, womit Schnelllade-Vorgänge entfallen. Die entnommenen leeren Akkus können auf diese Weise in der Station langsam und schonend geladen werden und dabei auch netzdienliche Aufgaben in einem Smart Grid übernehmen. Infradianba spricht bei seinen Akkus von einer Verdreifachung der Lebensdauer gegenüber Batterien, die „permanent" schnell geladen werden.

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推进城市更新 实现低碳发展

熊万鹏，中国海外控股集团 党委书记、总裁

Wanpeng Xiong, CEO of China Overseas Holding Group

Promote Urban Renewal and Achieve Low-carbon Development

01
PART ONE

双碳目标提出的背景及重要意义
The Background and Significance of the Twin Pursuits

(The Twin Pursuits: peak carbon dioxide emissions by 2030 & achieve carbon neutrality by 2060)

The Background of the Twin Pursuits (International)

The Paris Agreement

The 195-nation U.N. climate summit concluded with delegates adopting the Paris Agreement, the first-ever global climate deal of this sweep and ambition.

The Long-term Goal

Make sure the global temperature rise to well below 2 degrees Celsius above pre-industrial levels, “pursue efforts" to limit the temperature rise to 1.5 degrees Celsius.

Emissions Targets

Set national targets for reducing greenhouse gas emissions every five years.

The Background of the Twin Pursuits (China)

Building on Past Achievements and Launching a New Journey for Global Climate Actions

Statement by H.E. Xi Jinping
President of the People's Republic of China
At the Climate Ambition Summit
12 December 2020

"China has made important contributions to adopting the Paris Agreement and has made active efforts toward implementing it. I announced in September that China would scale up its nationally determined contributions and adopt more vigorous policies and measures. We aim to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060."

The Significance of the Twin Pursuits

For Man and Nature: Building a Community of Life Together

Remarks by H.E. Xi Jinping
President of the People's Republic of China
At the Leaders Summit on Climate
22 April 2021

"Since time of the industrial civilization, mankind has created massive material wealth. Yet, it has come at a cost of intensified exploitation of natural resources, which disrupted the balance in the Earth's ecosystem, and laid bare the growing tensions in the human-Nature relationship. In recent years, climate change, biodiversity loss, worsening desertification and frequent extreme weather events have all posed severe challenges to human survival and development. The ongoing COVID-19 pandemic has added difficulty to economic and social development across countries. Faced with unprecedented challenges in global environmental governance, the international community needs to come up with unprecedented ambition and action. We need to act with a sense of responsibility and unity, and work together to foster a community of life for man and Nature."

02

PART TWO

城市更新提出的背景和重要性

The Background and Importance of Urban Renewal

The Background of Urban Renewal

World-wide

1958 Netherlands
After the 1950s
1977 United Kingdom
2000 United Kingdom

China

1949-1970s
1980-1990s
1990-2010s
2010s to present

The Background of Urban Renewal

REPORT ON THE WORK OF THE GOVERNMENT

Delivered at the Fourth Session of the 13th National People's Congress of the People's Republic of China on March 5, 2021 Li Keqiang Premier of the State Council

"We will expand city clusters and metropolitan areas, promote urbanization with a focus on county towns, implement an action plan for urban renewal, and improve the housing market and housing support system. "

The Importance of Urban Renewal

As a Chinese poem reads, “Heaven does not speak and it alternates the four seasons; Earth does not speak and it nurtures all things.” Earth is our only and shared home.

Urban renewal has become the key to the twin pursuits. Exploring a development model that conforms to the sustainable development of cities plays a pivotal role in the country’s economic and social development.

03

PART THREE

在城市更新过程中如何实现低碳发展

How to Achieve Low-carbon Development in the Process of Urban Renewal

How to Achieve Low-carbon Development in the Process of Urban Renewal

01 Clean Energy

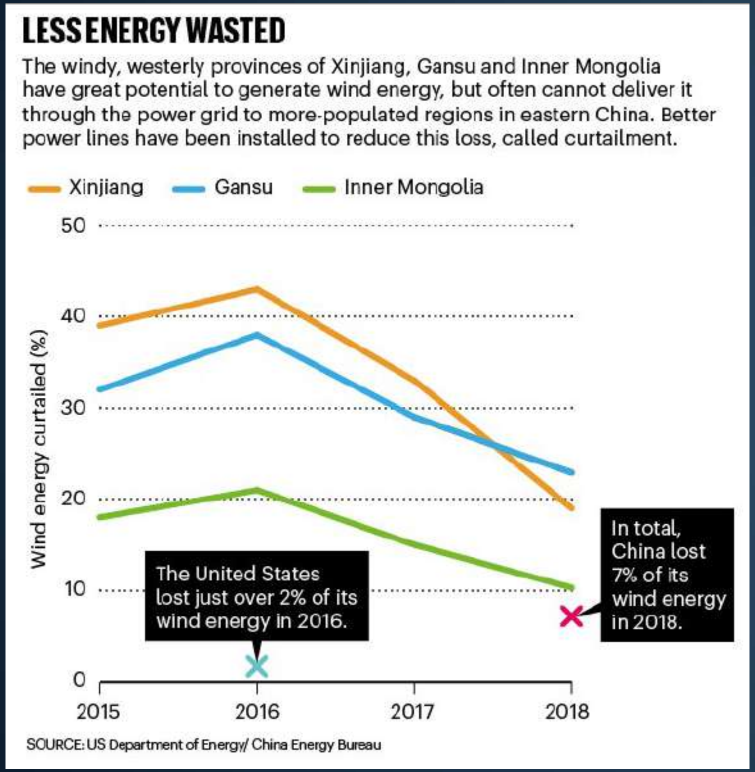
02 Green Transportation

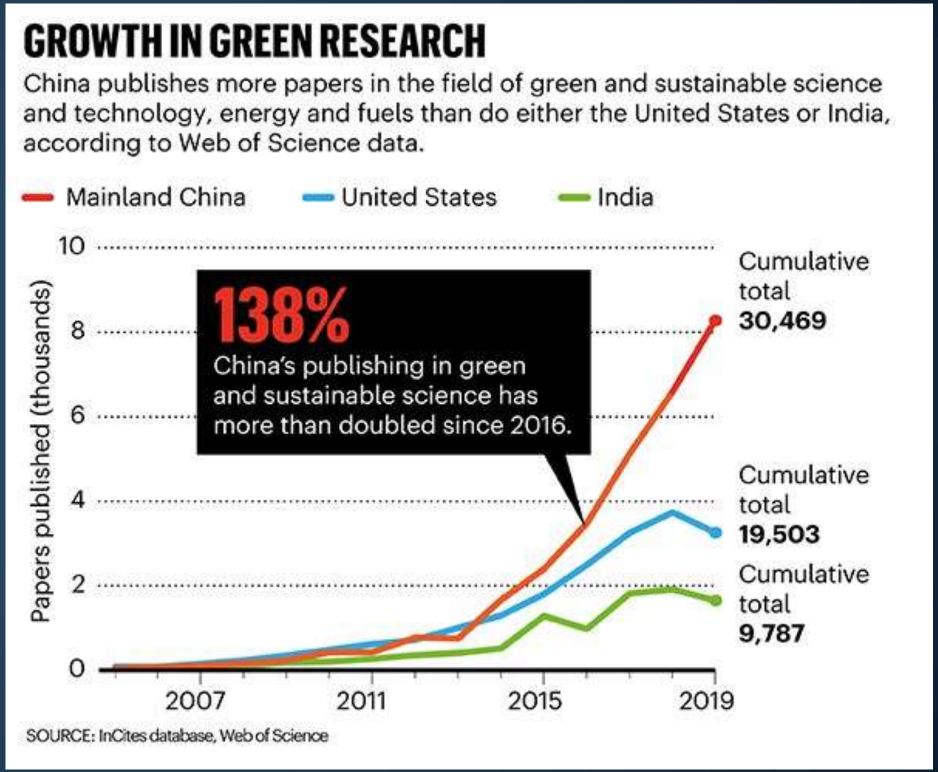
03 Green Construction

04 Financial Support

05 Concept Transformation

How to Achieve Low-carbon Development in the Process of Urban Renewal (Clean Energy)





How to Achieve Low-carbon Development in the Process of Urban Renewal (Green Transportation)

Advocating green transportation is an important development that we need to have in a corresponding urban spatial layout.

China's vigorous promotion of new energy vehicle is an important measure for the low-carbon development of the automotive industry.

We need to consider the entire process of new energy vehicle from fuel production to use. At the same time, we also need to consider another reverse process, that is, the entire process from vehicle production, use to scrapping.

How to Achieve Low-carbon Development in the Process of Urban Renewal (Green Construction)

Supply Source

We need to continuously improve technology, provide high-quality green building materials, reduce material consumption from the source, and reduce carbon emissions.

Demand Source

We need to adopt sustainable and green technical solutions to meet the people's demand for a reasonable increase in building energy use.

How to Achieve Low-carbon Development in the Process of Urban Renewal (Financial Support)

1. Establish and Improve the Bank's “Low-carbon Indirect Financing" System
2. Vigorously Develop Low-carbon Derivative Financial Products
3. Use Foreign Capital Actively

How to Achieve Low-carbon Development in the Process of Urban Renewal (Concept Transformation)

For Man and Nature: Building a Community of Life Together

Remarks by H.E. Xi Jinping
President of the People's Republic of China
At the Leaders Summit on Climate
22 April 2021

"We must be committed to green development. Green mountains are gold mountains. To protect the environment is to protect productivity, and to improve the environment is to boost productivity — the truth is as simple as that. We must abandon development models that harm or undermine the environment, and must say no to shortsighted approaches of going after near-term development gains at the expense of the environment. Much to the contrary, we need to ride the trend of technological revolution and industrial transformation, seize the enormous opportunity in green transition, and let the power of innovation drive us to upgrade our economic, energy and industrial structures, and make sure that a sound environment is there to buttress sustainable economic and social development worldwide."

Thank you

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• 会员计划	• 运营服务	• 控制主板	• 电商平台
• 充电相关数据包	• 维护服务	• 电源模块	• 出行打包
• 内置广告	• 安装服务	• 储能系统	• 光储充一体化
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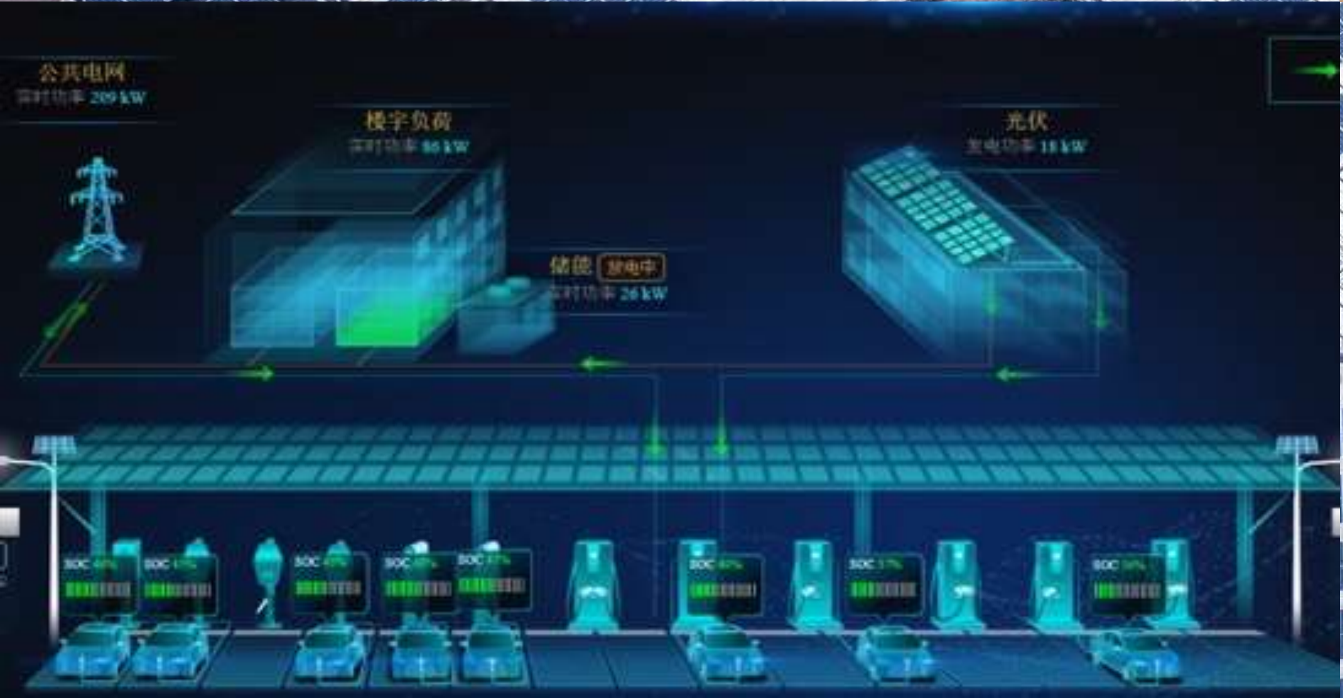

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18 kW

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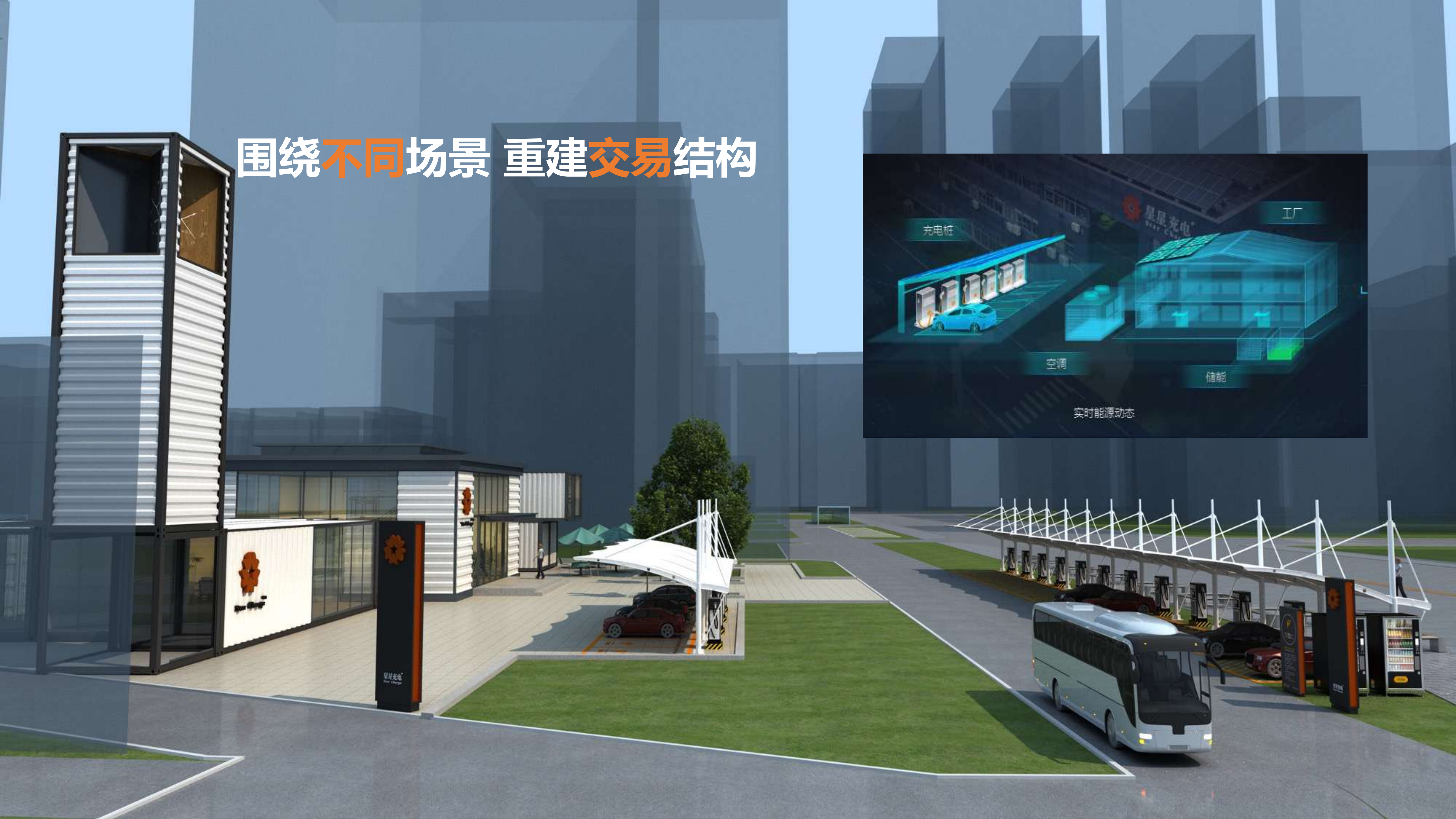


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