Renaissance and Global EV Development

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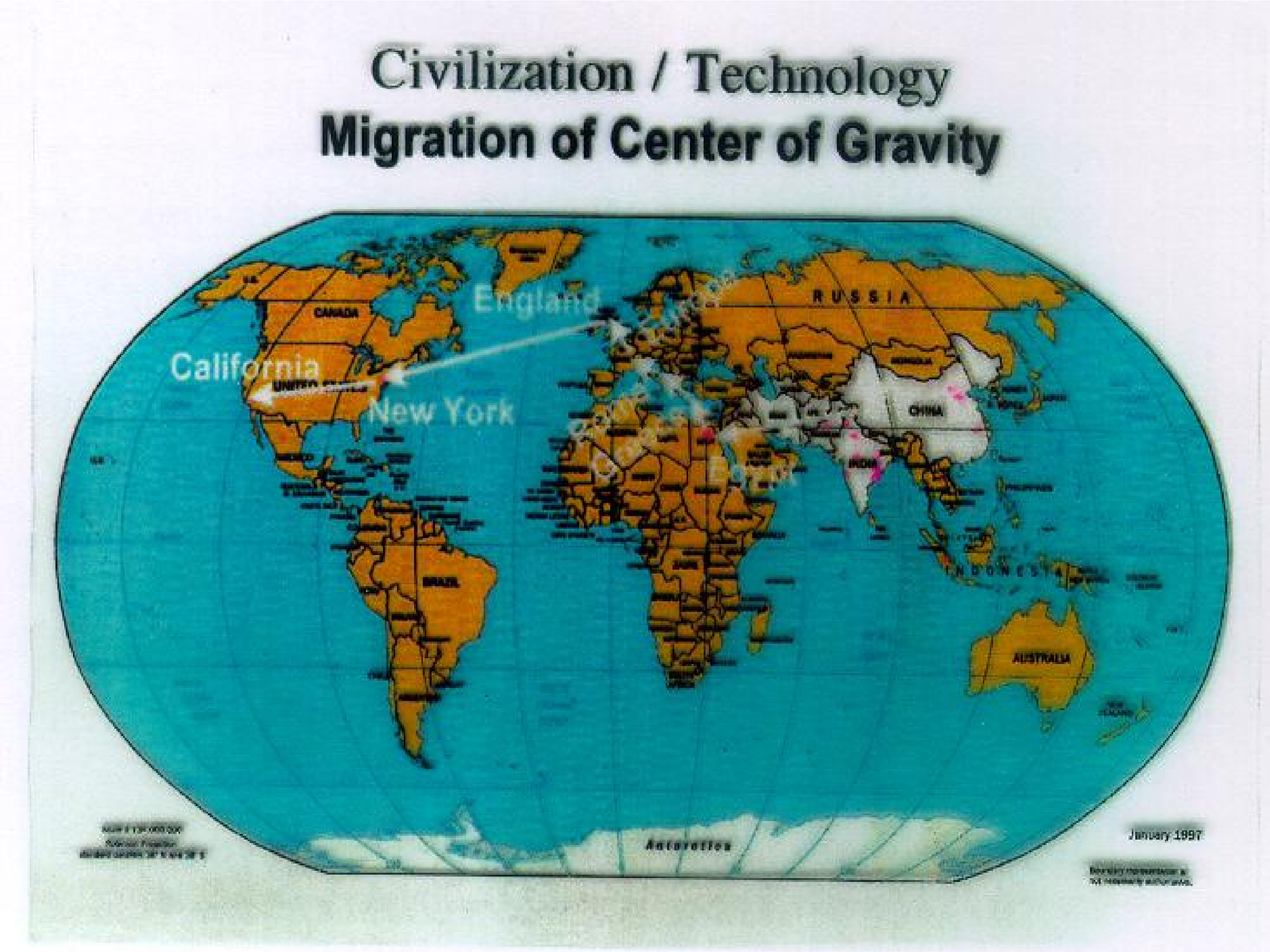
Civilization & Open Mind

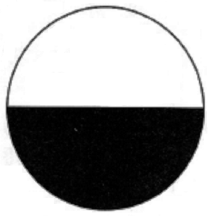


Civilization / Technology
Migration of Center of Gravity
England
Europe
California
New York
Rome
Greece
Egypt
RUSSIA
CANADA
CHINA
INDIA
BRAZIL
INDONESIA
AUSTRALIA
Antarctica
January 1997

Think Globally
Civilization / Technology
Migration of Center of Gravity
Act Globally
England
Europe
California
New York
Rome
Greece
Egypt
RUSSIA
CANADA
CHINA
INDIA
BRAZIL
INDONESIA
AUSTRALIA
Antarctica
January 1997

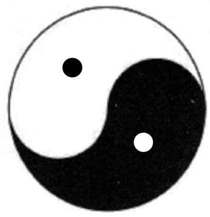
Yi-jing basic principles:
Change, Periodic, Balance, Unity of Opposites

Straight Forward Approach



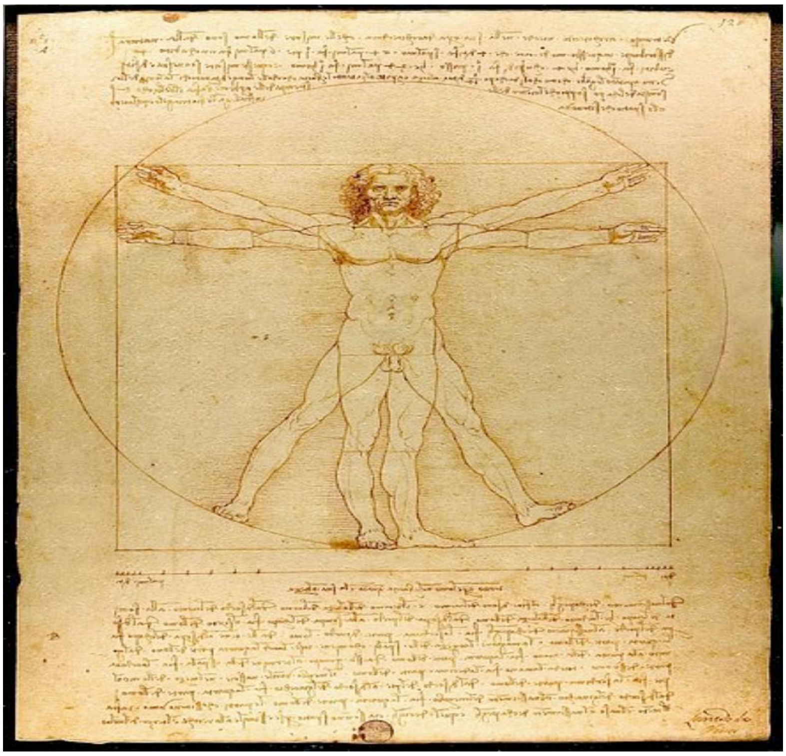
" "Yes" is "Yes"
"No" is "No"

Holistic, Dialectic Approach



"Yes" can be turned into "No"
"No" can also be turned into "Yes"

The beginning of the cultural movement of the Renaissance



Leonardo da Vinci`s Vitruvian Man, an example of the blend of art and science during the renaissance

Open Mind

- **A closed Mind Can Not Change!**
- **Saw Beyond What Was, to See What is!**

Renaissance Scientists & Engineers

Renaissance Scientists & Engineers are those not only understand WHY and HOW THINGS work but also on WHY and HOW the WORLD works!

Characters of Renaissance Scientists & Engineers

Think the World and not just the THINGS

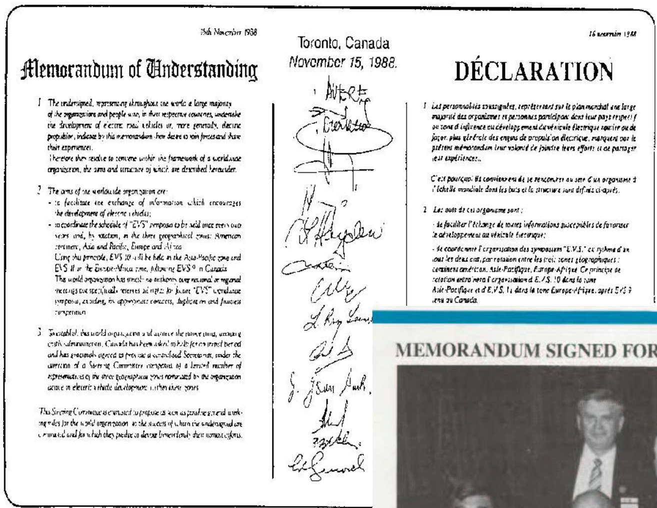
- **Global thinking instead of local thinking;**
- **Harmony thinking between human and nature;**
- **Circle thinking instead of linear thinking;**
- **Closed loop thinking instead of open loop thinking;**
- **Life cycle thinking instead of partial life thinking;**
- **3R thinking (Reduce, Re-use, Recycle).**

EV Development

Mobility is Freedom. Mobility is the most apt expression for our

Historical Document Signed at EVS.9

Committing Support to Formation of World Electric Vehicle Association



15th November 1988

Memorandum of Understanding

Toronto, Canada
November 15, 1988.

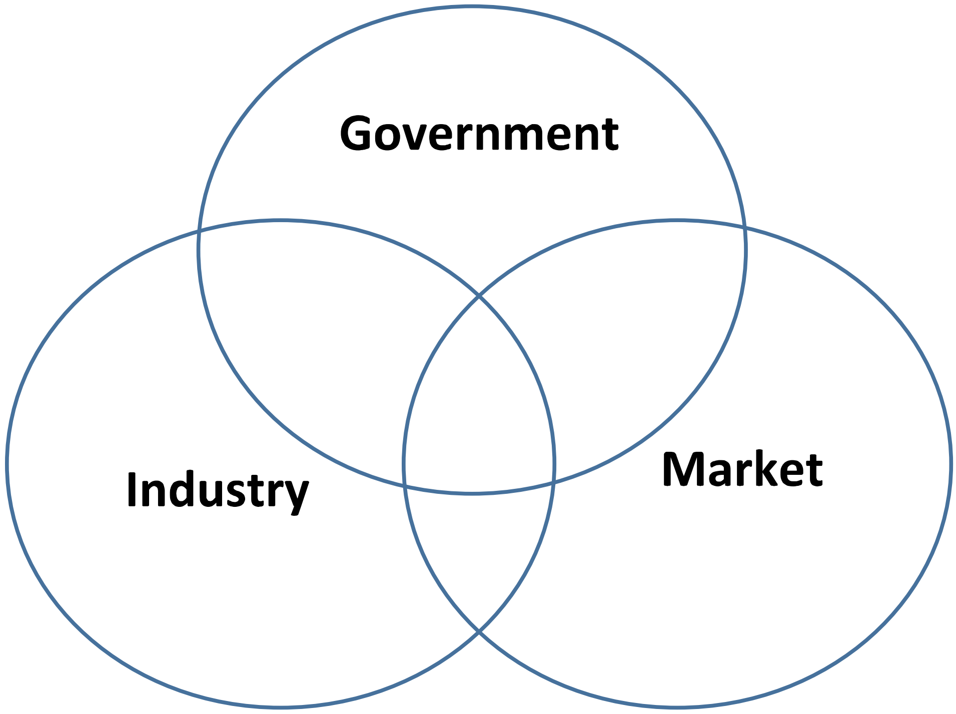
16 novembre 1988

DÉCLARATION

MEMORANDUM SIGNED FOR WORLD ELECTRIC VEHICLE ASSOCIATION

Participants from Top left: B. Fijalkowski (Poland), R. Atanassov (Bulgaria), H. Payot (France), C. Hayden (U.S.), Z. Feng (China), W.A. Adams (Canada), Bottom left: M. Chiogioji (US), R. Leembruggen (Australia), J. Lea (Korea), L. Secord (Canada), C.C. Chan (Hong Kong), F. Dierkens (A.V.E.R.E.), A. Ananthakrishna (India), T. Matsuo (Japan). The above gentlemen signed the memorandum of agreement for the formation of a World Electric Vehicle Association during EVS.9 last November. Cliff Hayden (US), Ferdinand Dierkens (Europe) and Dr. C. Chan (Asia) have been appointed a steering committee.

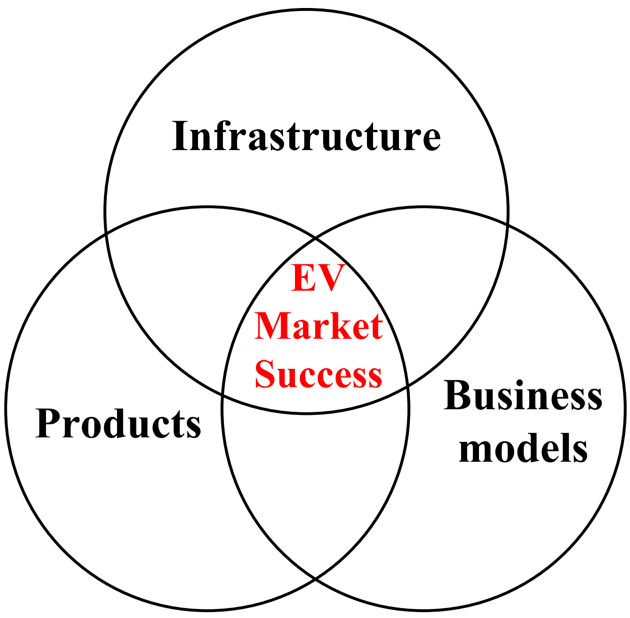
Government, Industry and Market



Key Issues

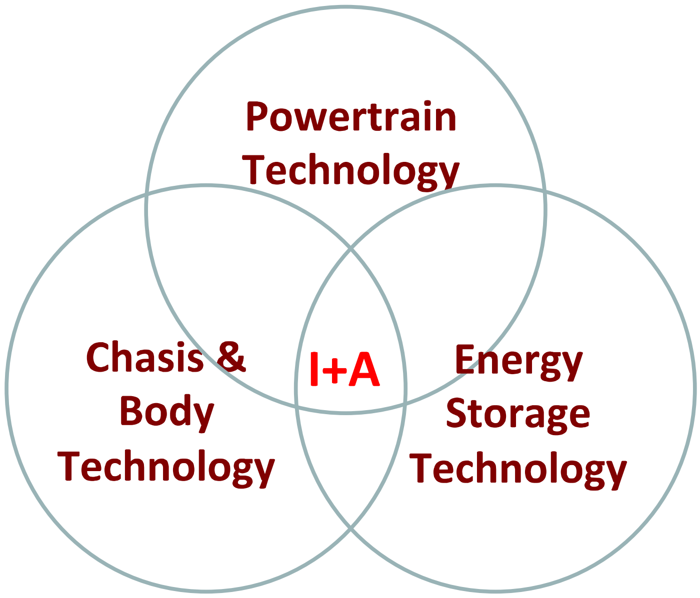
Three Goodness Factor :

Good Products; Good Infrastructure; Good Business Model



Good Products:
High Performance @ Reasonable Cost

I: Integration of Automotive Technology and Electrical Technology
A: Alliance among Auto Makers and Key Component Suppliers



Executive Summary

- **The train of EV commercialization has taken off. We are seeing the dawn. Key challenges of success: Cost; Usage Convenience; Energy Saving and Emission Reduction. The market will not do it by self. Government incentives are essential at the beginning.**

- **Innovative Regulatory Leadership is essential. Technical solutions are available. The shake hand and compromise between auto industry and electric power industry is crucial.**

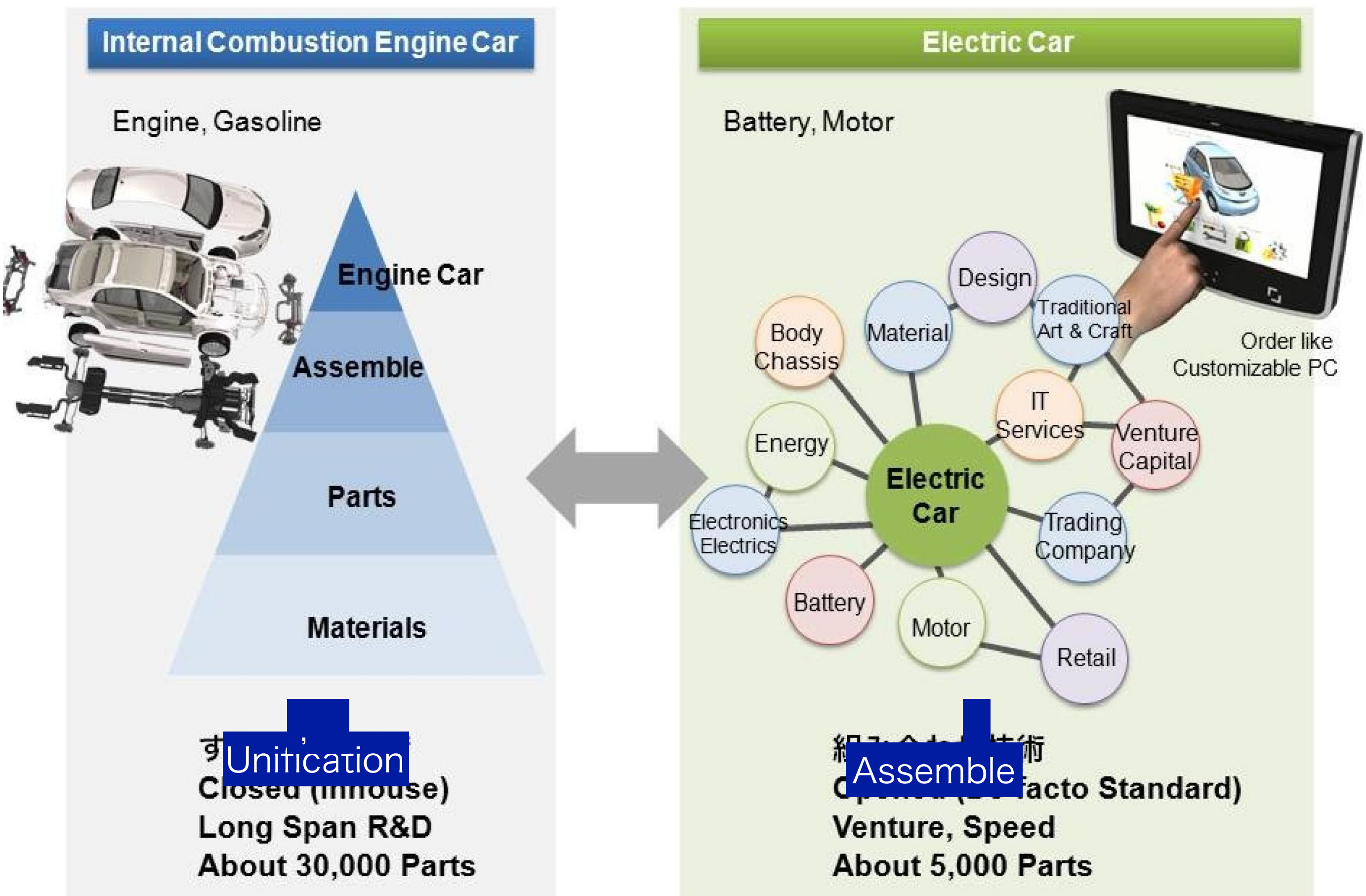
Key Issues – Three Goodness
关键因素 – 三好因素

The success of commercialization of electric vehicles depends on the satisfactory tackling of four factors:

Initial cost; 成本；
Convenience of use; 方便；
Energy consumption and exhaust emission. 节能减排。

Therefore, we need three goodness factors:

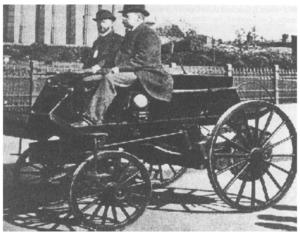
- 1. Availability of **Good Products** at affordable cost; **好产品**
- 2. Availability of **Good Infrastructures** that is efficient and friendly to use; **好的基础设施**
- 3. Availability of **Good Business Model** to leverage the cost of batteries. **好的商业模式**



History of Electric Vehicles: Rise & Fall 1828 -1932

- Early Inventions–Horseless Age

Thomas Parker EV, 1884, England



Morris & Salom Electrobat 1895, U.S.A

- Early Commercialization & Infra.

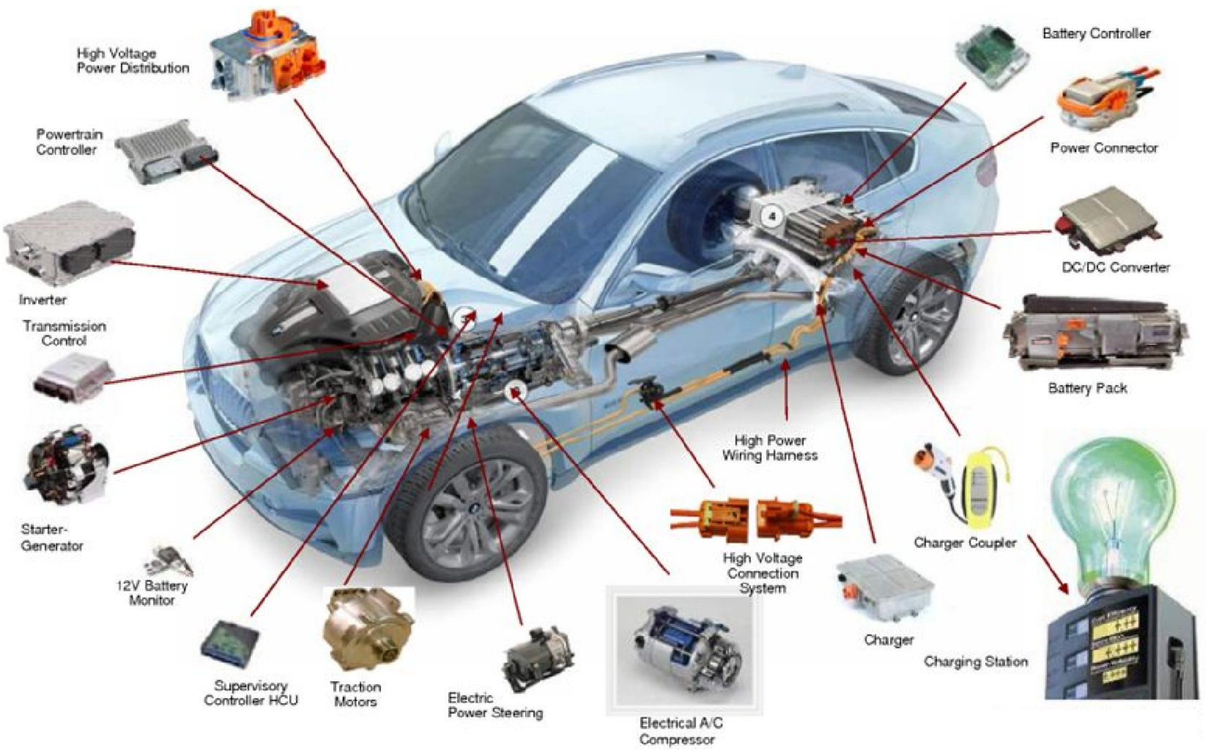
City Taxi, 1901, New York, U.S.A

Charging Station, 1900's GE, U.S.A

- Lessons to Learn: Key Issues:
- Cost,
- Convenient Use
- Fuel Consumption,
- Environment Impact.
- Philosophy of Engineering: ***System Integration and Optimization***

  Key Points: ***Open mind; Courage; Yes, It Can Do!***

Electric Key Components Play Vital Role in EV/HEV



EV Key Technologies

- **Three Big Electricity：**

  Motor

  Battery

  Controller

- **Three Small Electricity：**

  Electric Steering

  Electric Air-conditioning

  Electric Braking

Global EV Development Status

Global EV Population

- In 2014: Total 500,000
  - USA No.1; Japan No. 2; China No.3
  - Norway per capita No.1 , 4EVs/1000 persons, Nation wide charging stations, quick charge along highway per 30-60 km.

- In 2012: Total 380,000
  - Japan No.1; USA No.2; China No.3

Global Electric Vehicles Population

Country	PEV fleet (Cum sales or registrations)	Population as of December 2013	PEV market penetration per 1,000 people (Dec 2013)	PEV market share of total new car sales in 2013	Comments
United States	172,000	320,050,716	0.53	0.62%	(a)
Japan	74,124	127,143,577	0.58	0.85%	(b)
China	38,592	1,385,566,537	0.03	0.08%	(c)
Netherlands	28,673	16,759,229	1.71	5.37%	(d)
France	28,560	64,291,280	0.44	0.65%	(e)
Norway	20,486	5,042,671	4.04	5.60%	(f)

Note: Plug-in electric vehicle fleets include only highway-capable vehicles except where noted in comments. French and Norwegian registrations do not include plug-in hybrids.

Comments: (a) Sales between 2008 and December 2013. Includes only plug-in electric passenger cars. (**b**) Sales since July 2009 through December 2013. Kei cars not included for market share estimate. Includes plug-in electric cars and all-electric utility vans. (**c**) New energy vehicle sales between 2011 and 2013. Includes a significant number of all-electric buses. (**d**) Registrations between 2009 and December 2013.Includes plug-in cars and all-electric commercial vans. (**e**) Registrations between 2010 and December 2013. Includes only all-electric cars and 11,304 utility vans. Market share is 0.49% if only all-electric cars are considered. (**f**) Registrations between 2003 and December 2013. Includes only all-electric cars, vans and over 1,500 heavy quadricycles.

EV Market Share

Top 10 countries by market share of new car sales in 2013 by electric-drive segment[a]

Ranking	Country	PEV market share (%)	Ranking	Country	BEV market share (%)	Ranking	Country	PHEV market share (%)
1	Norway	6.10%	1	Norway	5.75%	1	Netherlands	4.72%
2	Netherlands	5.55%	2	Netherlands	0.83%	2	Sweden	0.41%
3	Iceland	0.94%	3	France	0.79%	3	Japan	0.40%
4	Japan	0.91%	4	Estonia	0.73%	4	Norway	0.34%
5	France	0.83%	5	Iceland	0.69%	5	United States	0.31%
6	Estonia	0.73%	6	Japan	0.51%	6	Iceland	0.25%
7	Sweden	0.71%	7	Switzerland	0.39%	7	Finland	0.13%
8	United States	0.60%	8	Sweden	0.30%	8	United Kingdom	0.05%
9	Switzerland	0.44%	9	Denmark	0.28%	9	France	0.05%
10	Denmark	0.29%	10	United States	0.28%	10	Switzerland	0.05%

Note: (a) Market share of highway-capable electric-drive vehicles in the corresponding segment as percentage of total new car sales in the country in 2013.
Source: Zachary Shahan (2013-03-07). "Electric vehicle market share in 19 countries". ABB Conversations.

Sales of highway-capable new electric cars in China by model between 2011 and March 2014

Model	Total sales 2011-1Q 2014	Market share[a]	Total Sales 1Q 2014[1]	Total Sales 2013[2][3]	Total Sales 2012[4]	Total Sales 2011[5][6]
Chery QQ3 EV	11,528	25.4%	2,016	4,207[b]	5,305	
JAC J3 EV	6,731	14.8%	163	2,500	2,485	1,585[c]
BYD e6	4,287[d]	9.4%	619	1,544	2,091	401
BYD F3DM	3,284[d]	7.2%		1,005	1,201	613
BYD Qin	2,526	5.6%	2,384	142		
BAIC E150 EV	1,354	3.0%		710	644	
Zotye TD100 EV	845	1.9%			845	
SAIC Roewe E50	648	1.4%	4	406	238	
Zotye M300 EV	354	0.8%		220	134	
Venucia e30	246	0.6%	30	216		
Chery Riich M1 EV	197	0.4%	107		90	
Zotye 5008 EV	142	0.3%			142	
Zoyte Zhidou E20	142	0.3%	142			
Chang'an CX30 EV	100	0.2%			100	
BAIC Senova EV	52	0.1%		52		
Shanghai-GM Springo EV	11	0.02%			11	
Zoyte T200 EV	8	0.02%	8			
Tesla Model S	2	0.004%	2			
Chevrolet Volt	2	0.004%	2			
Total sales[e][7][8][9][1]	45,445	71.5%	6,853	17,642	12,791	8,159

Notes: (a) Market share as percentage of the 45,445 new electric vehicles sold between 2011 and March 2014.(b) Only includes sales between January and October 2013[3] (c) Includes units sold during 2010 and 2011[6] (d) BYD e6 total includes 33 units sold in 2010. F3DM total includes 417 units sold in 2010 and 48 in 2009[10,11] (e) Total annual sales figures include all-electric bus sales.

Sources:

[1] China Auto Web (2014-05-20). "6,853 PEVs Were Sold in China in Q1 2014". China Auto Web.
[2] Staff (2014-01-10). "Plug-in EV Sales in China Rose 37.9% to 17,600 in 2013". China Auto Web. Retrieved 2014-02-09.
[3] Colum Murphy and Rose Yu (2013-11-27). "China Hopes Cities Can Help Boost Electric Car Sales". The Wall Street Journal (China Real Time). Retrieved 2013-11-30. A total of 4,207 QQ3 EVs, 1,005 F3DMs and 1,096 e6s were sold between January and October 2013.
[4] China Auto Web (2013-03-25). "Chinese EV Sales Ranking for 2012". China Auto Web. Retrieved 2013-04-20.
[5] Mat Gasnier (2013-01-14). "China Full Year 2012: Ford Focus triumphs". Best Selling Car Blog. Retrieved 2013-04-21. A total of 613 F3DMs and 401 e6s were sold during 2011 and 1,201 F3DMs and 1,690 e6s in 2012.
[6] China Auto Web (2012-09-30). "JAC Delivers 500 J3 EVs ("ievs")". China Auto Web. Retrieved 2014-05-31. A total of 1,585 of the first and second generation models were sold during 2010 and 2011..
[7] Jiang Xueqing (2014-01-11). "New-energy vehicles 'turning the corner'". China Daily. Retrieved 2014-01-12.
[8] China Association of Automobile Manufacturers (2012-01-16). "5,579 electric cars sold in China in 2011". Wind Energy and Electric Vehicle Review. Retrieved 2014-01-12.
[9] Cars21.com (2013-02-13). "EV sales increase 103.9% in China in 2012- Electric China Weekly No 17". Cars21.com. Retrieved 2014-01-12.
[10] "BYD Delivered Only 33 Units of e6, 417 F3DM in 2010". ChinaAutoWeb. 2011-02-23. Retrieved 2014-05-31.
[11] "BYD Plans to Start European Car Sales Next Year (Update 2)". Bloomberg News. 2010-03-08. Retrieved 2014-05-31. 48 F3DMs were sold in 2009.

China EV Development Strategy

Pressure on Energy & Environment

Oil Consumption & Energy Saving

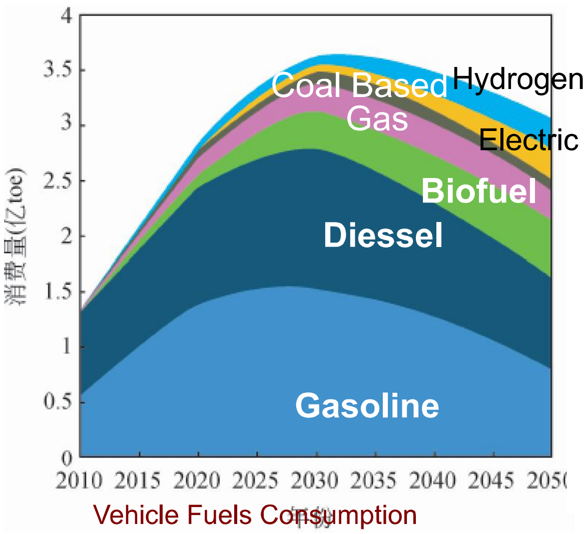
▮China Road Map of New Energy Vehicles

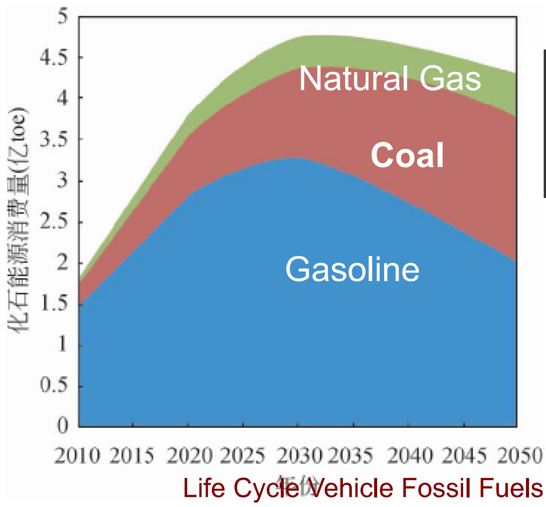
Period	Now~2020年	2020年~2030年	2030年~2050年
Driving Force	PM2.5为主 Mainly PM2.5 Reduction	Mainly Energy Conservation	Mainly CO_2 Reduction
Land Mark		Gas production exceed oil	
Strategy	Focus on Bus, Taxi, Logistic, Small EV,	EVs in various applications	Large scale hydrogen fuels and fuel cells; Increase in biofuels
Penetration %	2%	10% - 15%	50%

By 2020 focus on emission; By2030 on fossil fuel consumption.

Chinese Electric Mobility Achievement

◆ Contribution of New Energy Vehicles to Energy Consumption



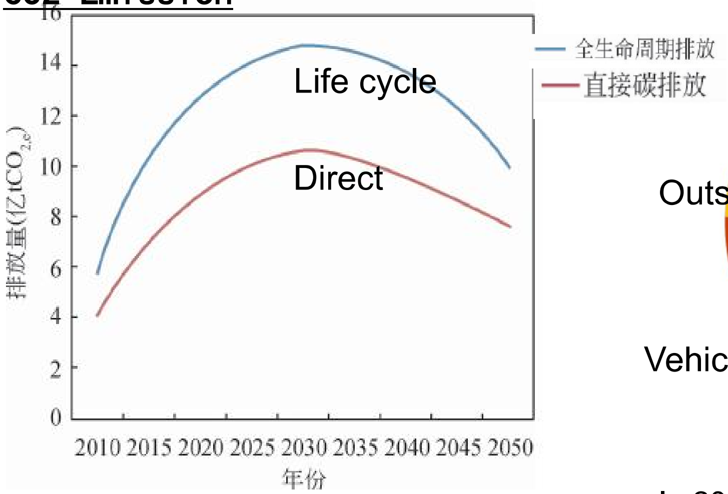


China Vehicle Fuel Consumption reach max in 2030年

来源：《中国车用能源展望2012》清华大学中国车用能源研究中心

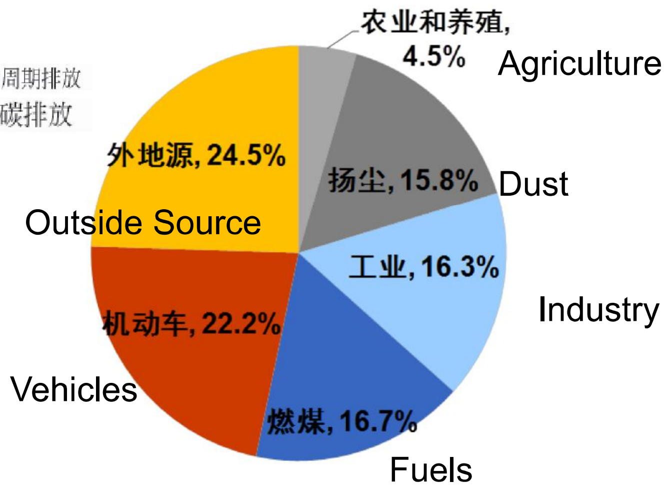
◆ Contribution of New Energy Vehicles to Environment

CO_2 Emission



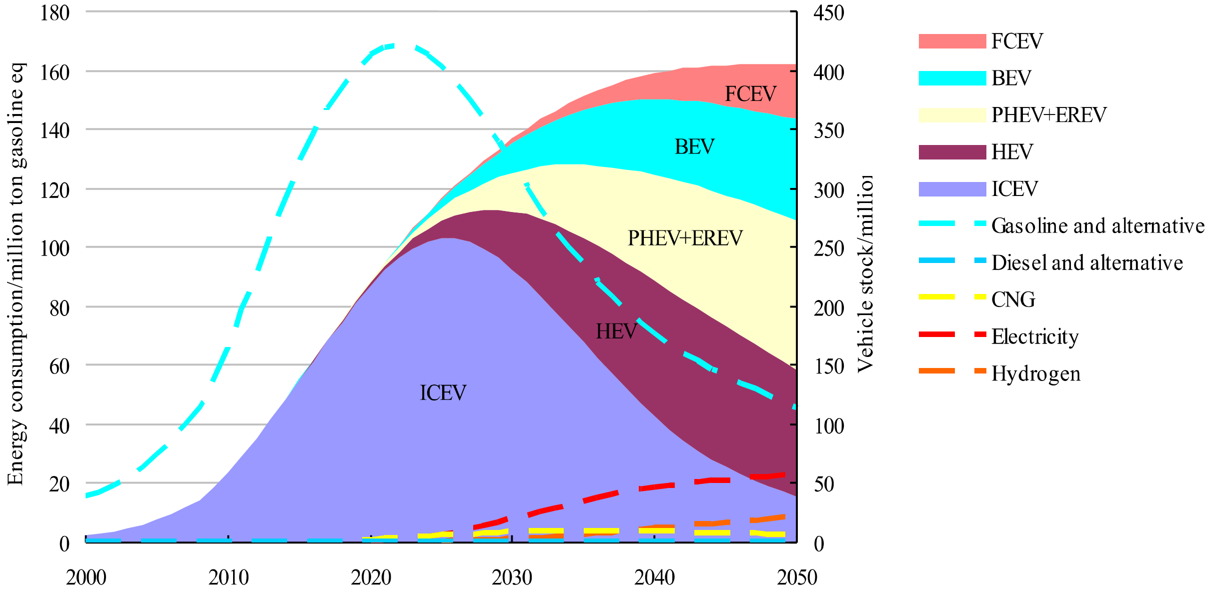
Year 2050WTW **CO_2 Emission** reduces 53.5%左右，per capital vehicle **CO_2 Emission** WTW 0.68 Ton；

Beijing PM2.5 Sopurces



In 2017 if New Energy Vehicles penetration will be 3 % , it will contribute 13% of total vehicles emission

Outlook of China Various Vehicle Types



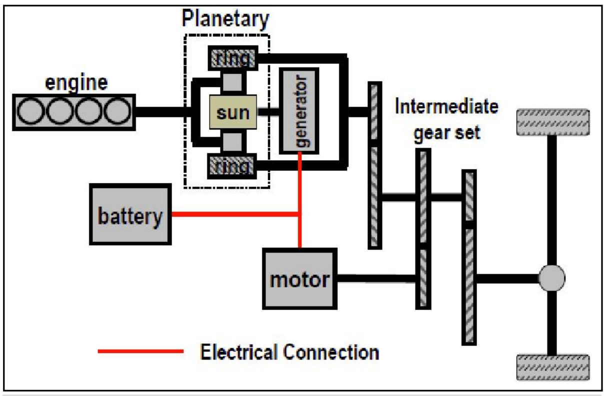
Vehicle Population and Fuel Consuption

Under the constrain of CO2 emission, considering various fuels, sedan annual production maintain at 300 million。If EV popular, than China can afford 100 million more vehicles.

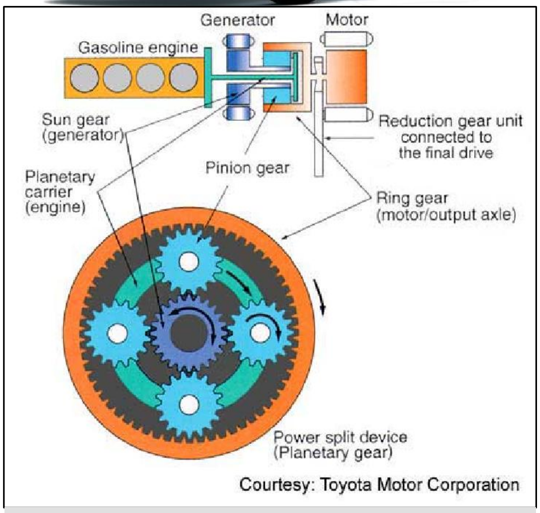
HEV/EV Architecture

Typical Hybrid Powertrain

✓ Planetary Gear Power Split



Ford FHS

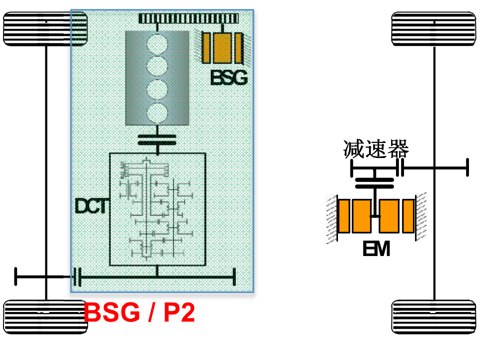


Toyota THS

Power-split是丰田、福特的主流构型方案，已有多款HEV车型量产，并推广到PHEV。

Typical PHEV Powertrain

✓ Four wheel drive



Volvo V60 PHEV

	Volvle V60 PHEV
Gross Weight	1724kg
Engine	160kW/440Nm
Real Axis Motor	52kW/200Nm
Battery	12Wh
Electric Range	50km

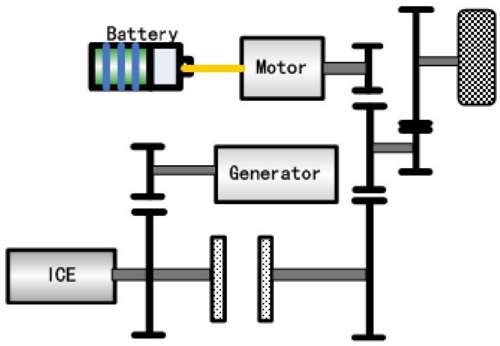
PSA 3008 PHEV

BMW i8 PHEV

- 四驱电桥方案也被多家公司采用，典型的为PSA公司，该构型易于PHEV化；
- 在原有混动技术基础上加入电驱动桥实现PHEV，也是国内值得重点研究的技术方案。

Typical Sedan PHEV Powertrain

✓ Two Electric Machines Drive



i-MMD Structure

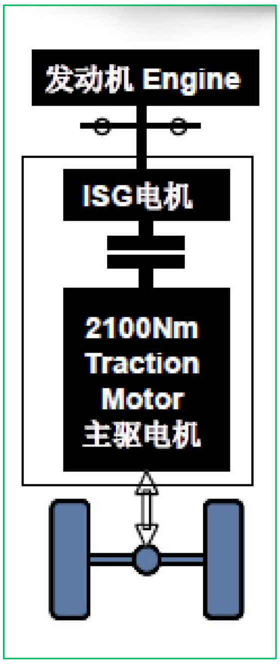
	Honda Acxcord Plug-in	
Gross Weight		1724kg
Engine		105kW/165Nm
Motor		124kW/307Nm
Generator		105kW
Generator Gear Ratio		8.38
Motor Gear Ratio		2.74
Battery		6.7kWh/41kW
Electric Range		20km
Fuel Consumption （FTP75）	CD阶段	2.03L/100km
	CS阶段	5.06L/100km

Features:
1） Integration of Transmission & Motor/Gen;
2） Motor & Generator different gear ratio;

- i-MMD技术应用于本田雅阁PHEV车型，是本田全新开发的高效混动系统；
- 通过创新高效的构型方案，是国内OEM取得技术优势的可选之路。

Typical Chinese Hybrid Bus Powertrain

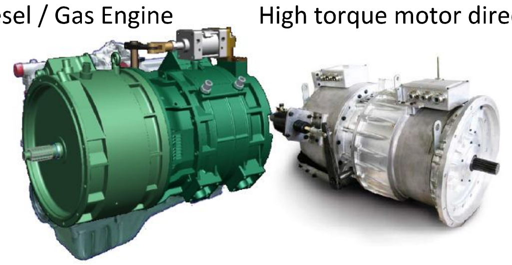
Without AMT



发挥我国永磁同步电机技术优势，取消变速器，用高转矩高效率电机直驱技术打破跨国公司电驱动变速器的垄断

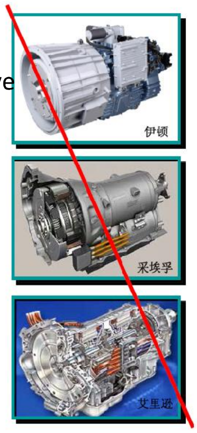
Diesel / Gas Engine

High torque motor direct drive



柴油机或气体燃料发动机

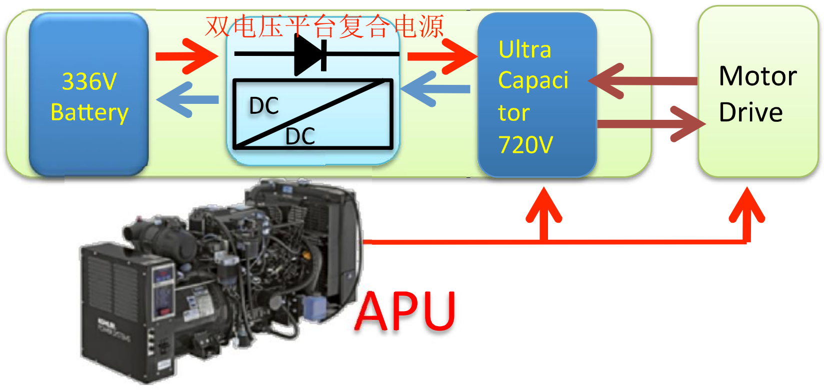
双电机直驱混合动力单元（无变速箱）

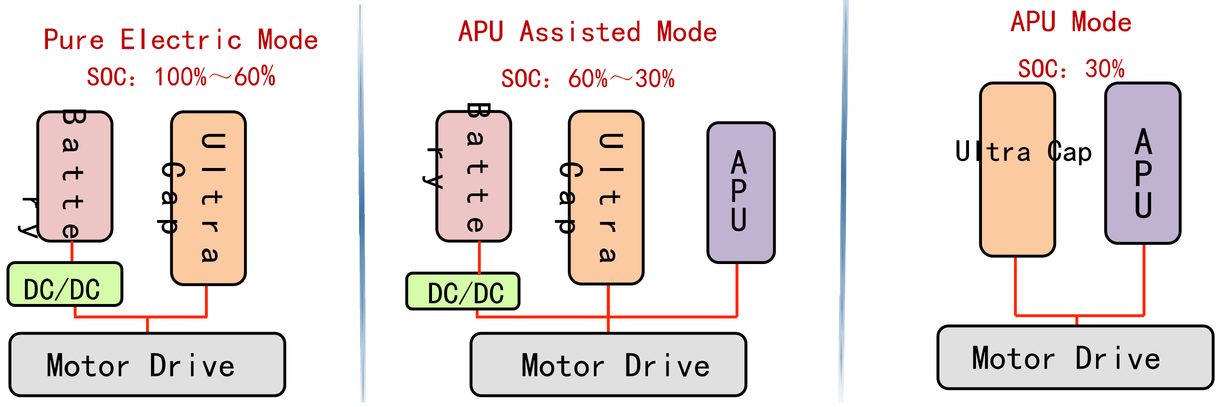


12 m Bus Oil Consumtion 20L/100 km, oil saving over40%

Range Extender Bus

Range Extender Configuration

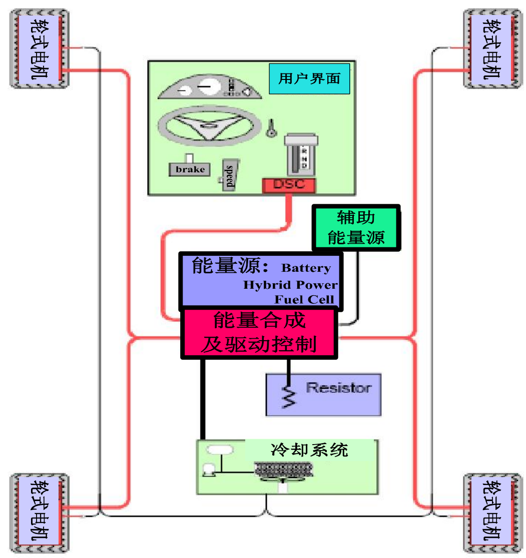




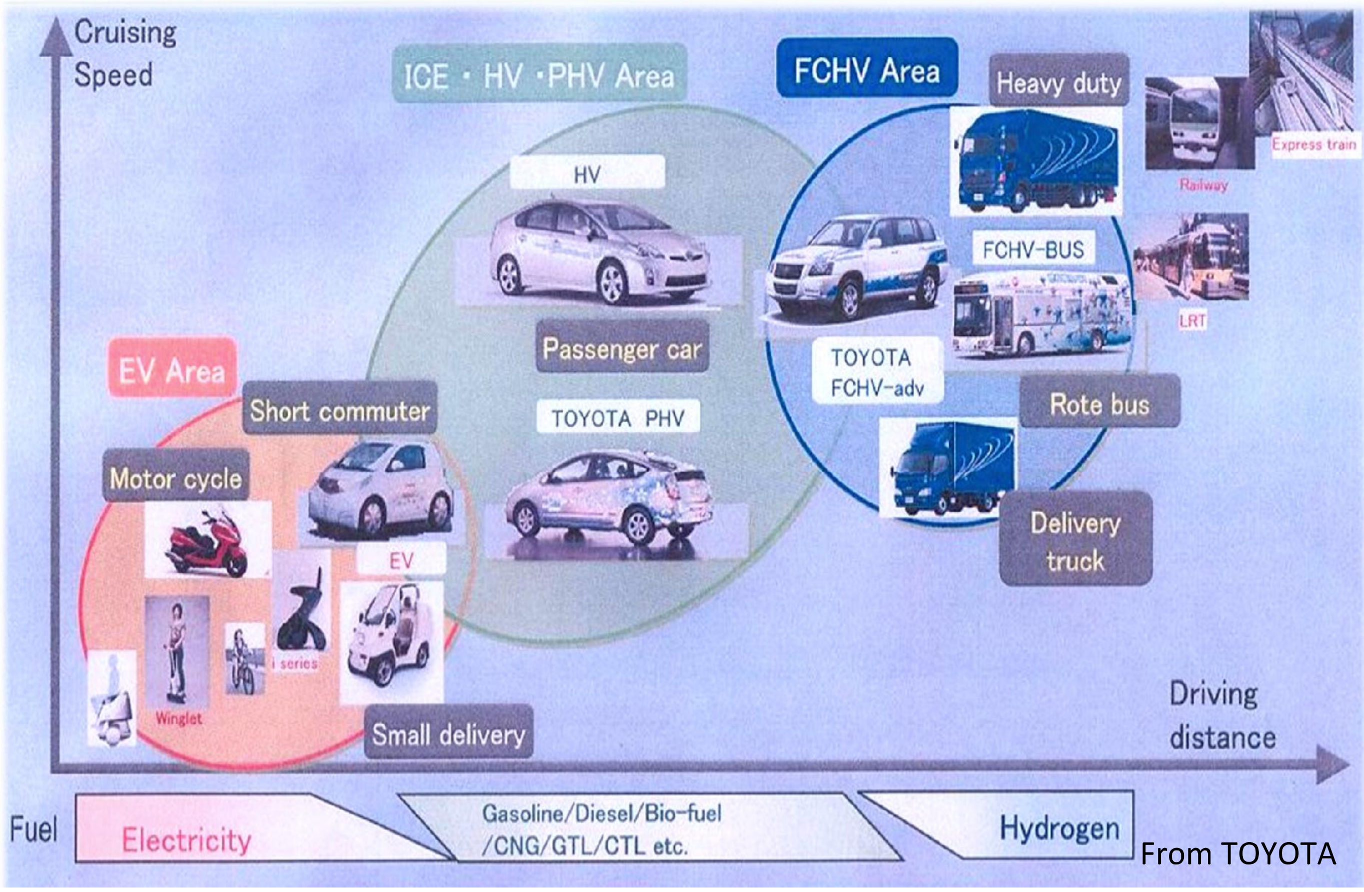
Mini EV Architecture

light electric vehicle → small battery electric car → full function electric car

(lithium battery + in-wheel motor + chassis electrification + charge with household power



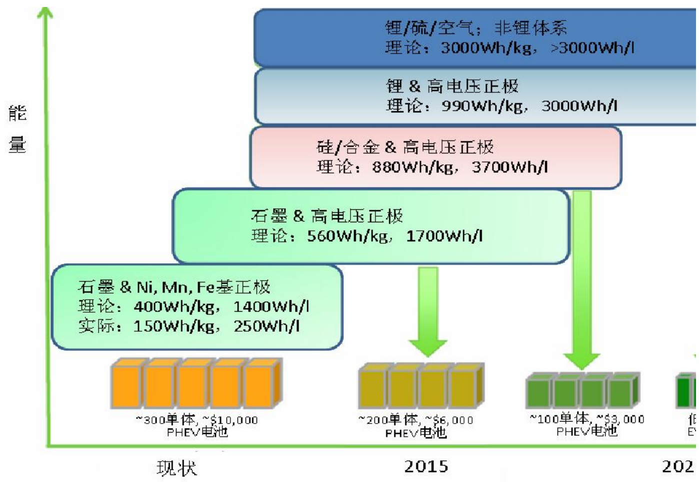
Spectrum of New Energy Vehicles



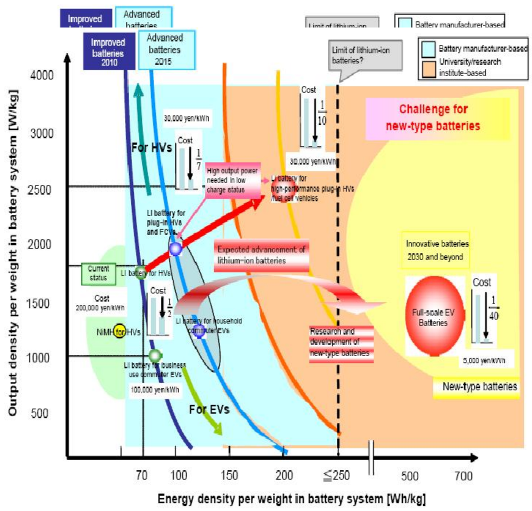
From TOYOTA

Battery Technology

动力电池技术 Road Map of Battery Technology



USA 美国动力蓄电池研发路线图

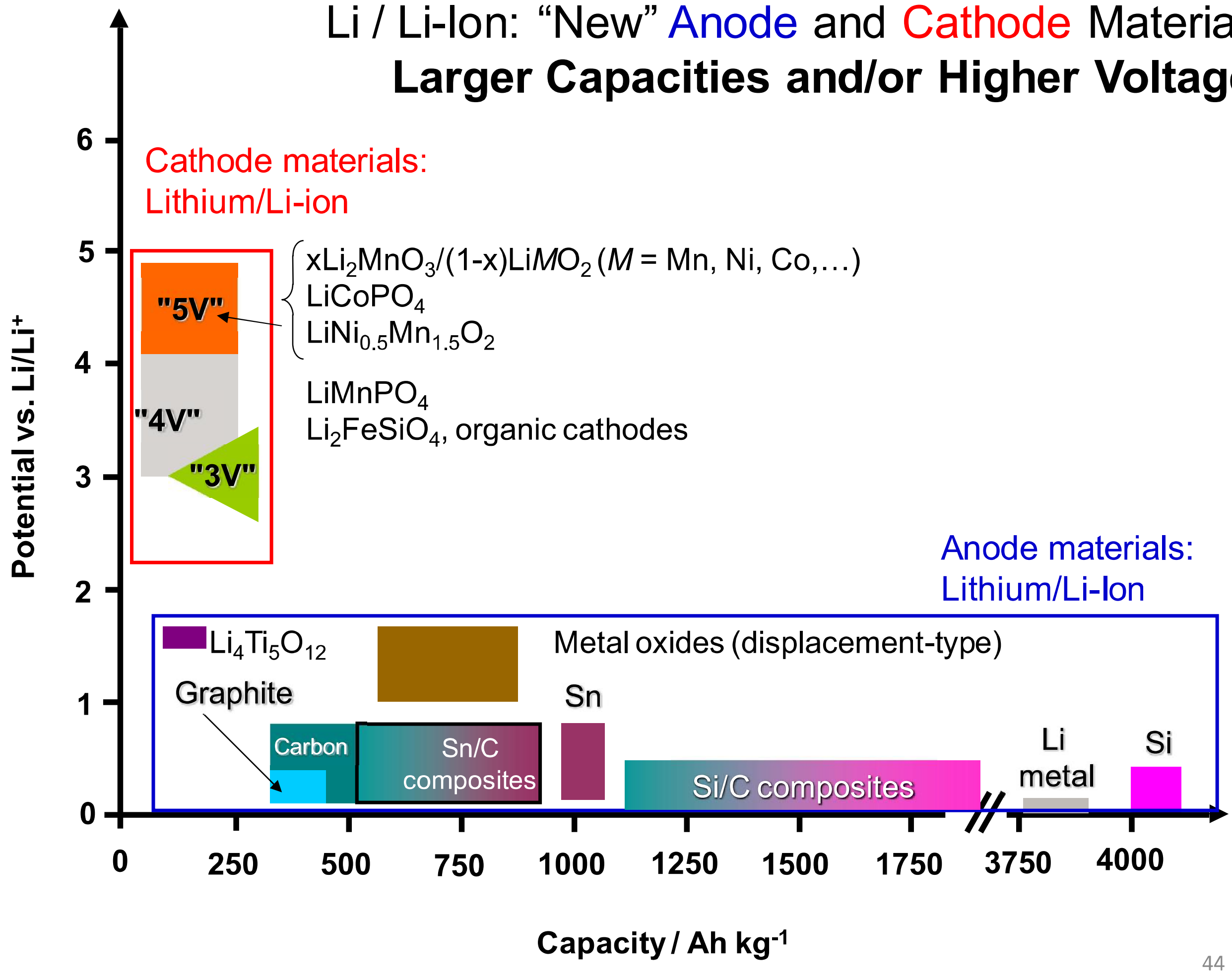


Japan 日本动力蓄电池研发路线图

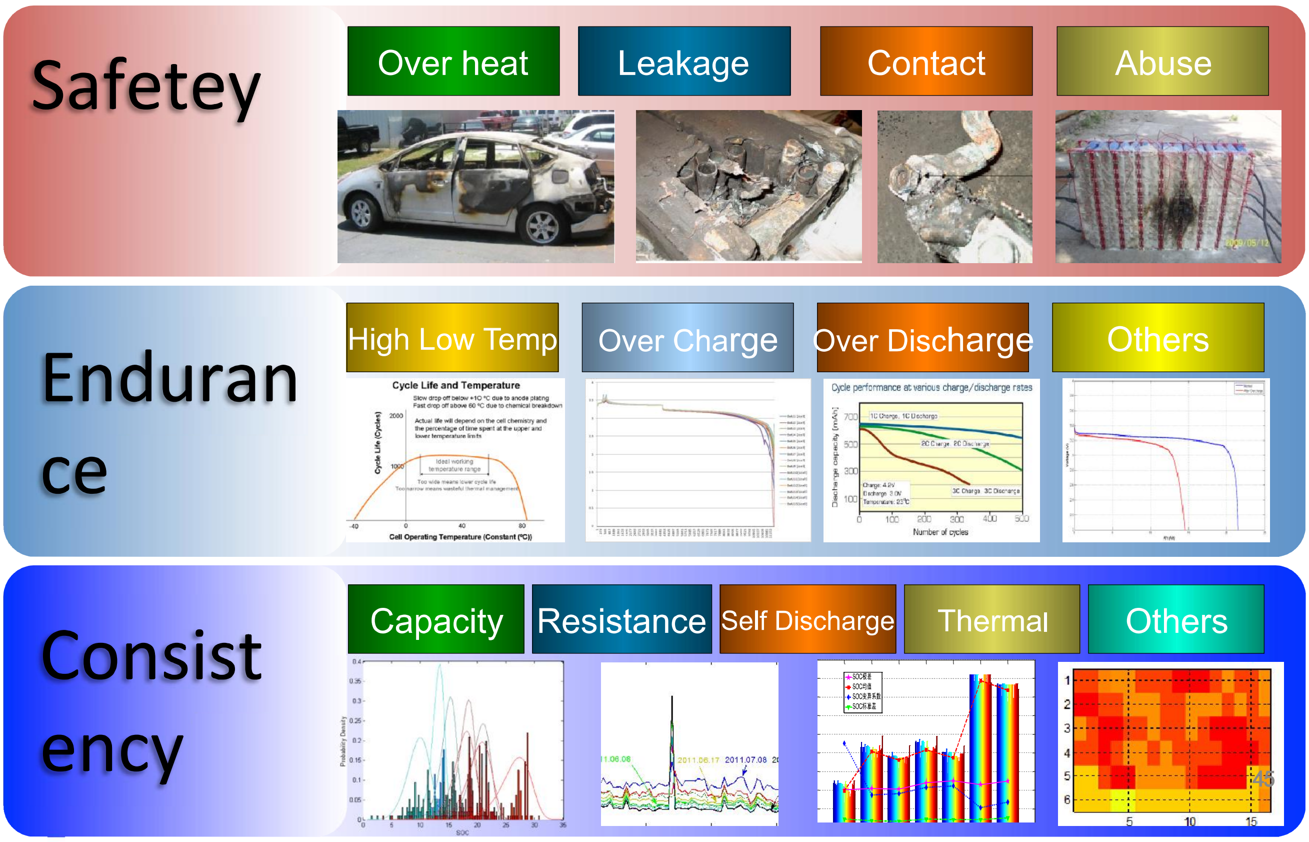
我国动力电池发展建议：

- 持续提升磷酸铁锂、锰酸锂、三元等正极材料和硬碳、硅基等负极材料的先进制备技术和工艺攻关功能电解液、高安全性隔膜等高性能动力电池的关键技术，支持锂离子电池材料行业的技术进步；
- 组织国内的优势研发机构，跨领域联合开展新一代高容量锂离子正负极材料和以锂聚合物电池锂硫、锂空气、钠空气为代表的新型体系电池深度的基础研究和制造技术工艺研究开发，在下一代电池和材料发展过程中形成我国的高价值专利。

Li / Li-Ion: "New" Anode and Cathode Materials: Larger Capacities and/or Higher Voltage



EV Battery System Research

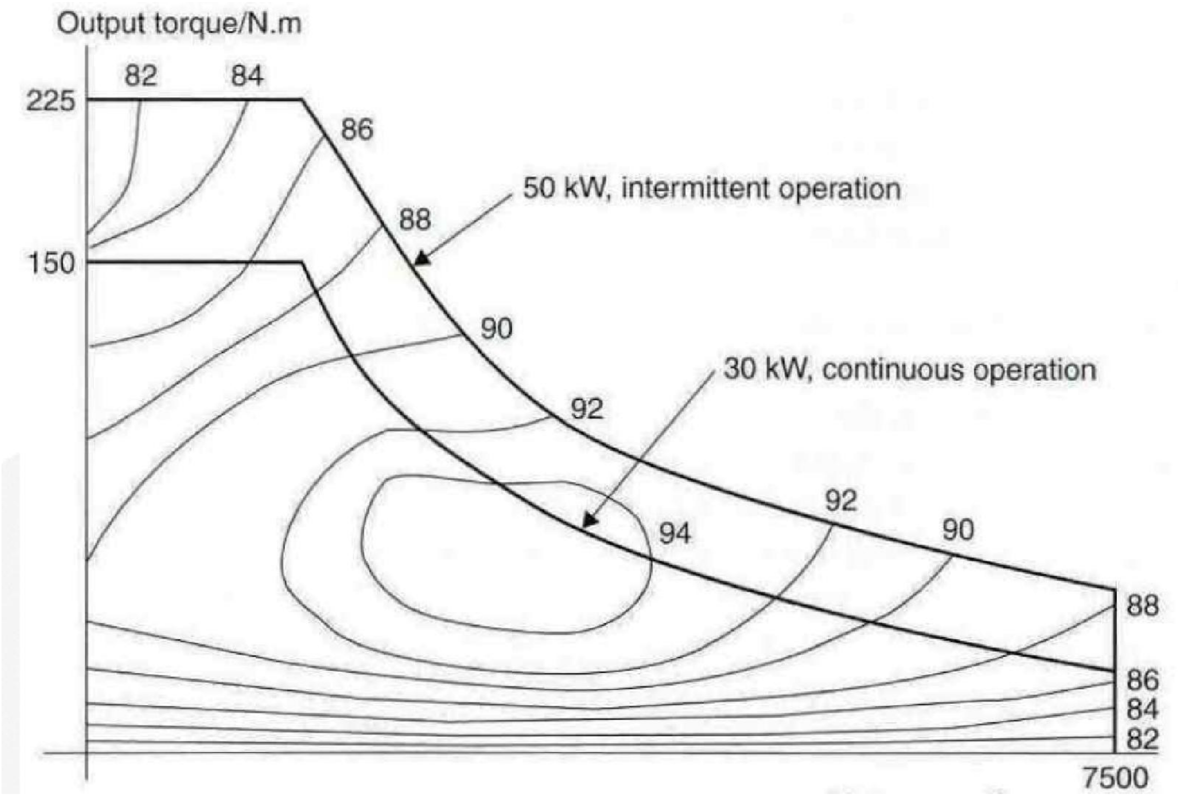


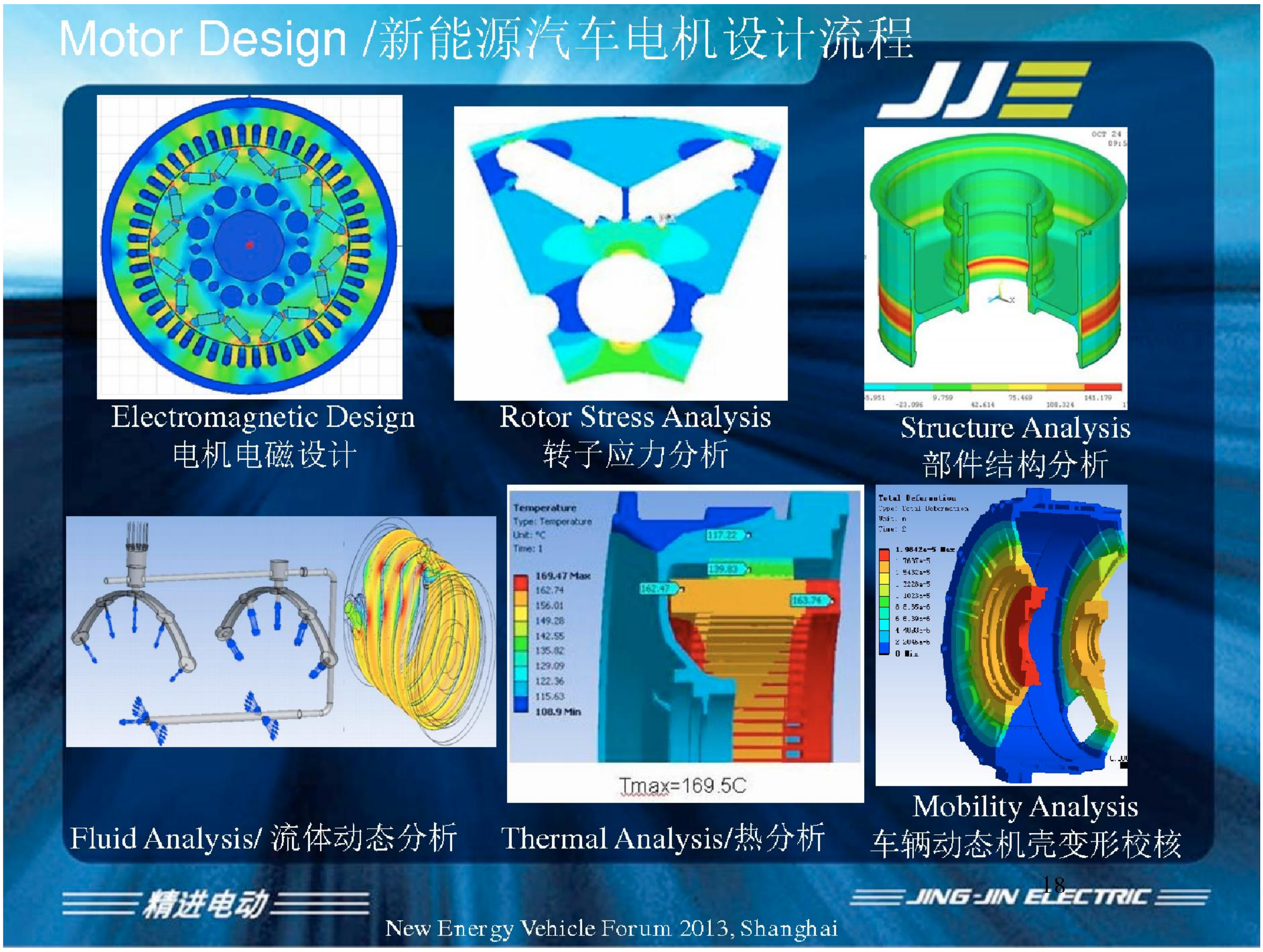
Research on Battery Safety

- Composite Separator & Short Circuit Protection
- Voltage Sensitive Separator & Over Charge Protection
- Safety Electrode Materials & Self Temperature Protection
- Ionic Liquids & Safety Composite Electrolyte
- Battery Safety Design

Motor Drives Technology

Typical Torque-Speed Characteristics





EV Infrastructure

Features of EV Charging

Complex Systems: Involved science, technology, engineering, industry, finance and business model.

Connected: The charging plug is connected to the grid, affect the grid at various levels. Unlike the gas station is decoupled with oil pipeline.

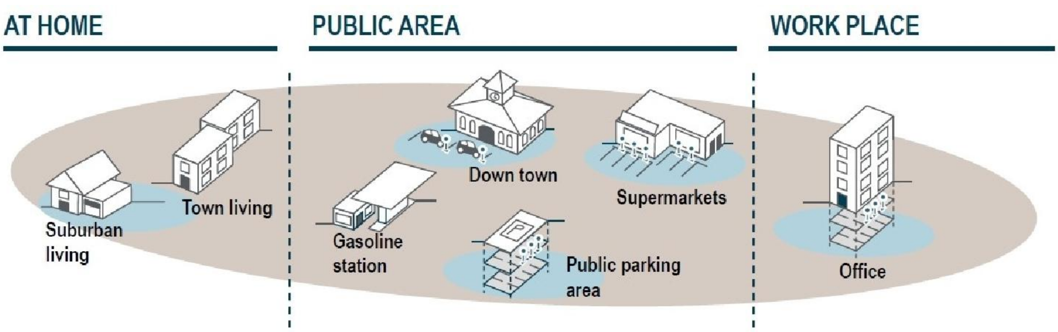
Dynamics: The charging has instant impact to the grid, unlike the gas station has no impact to the pipeline.

Interactive: The mode of charging, the status of the grid and the status of the batteries are mutually interactive.

Integration: V2G, Active Distributed Power Systems, Smart City…..

Key issues: Integration of energy and information, win-win situation to grid, battery and user.

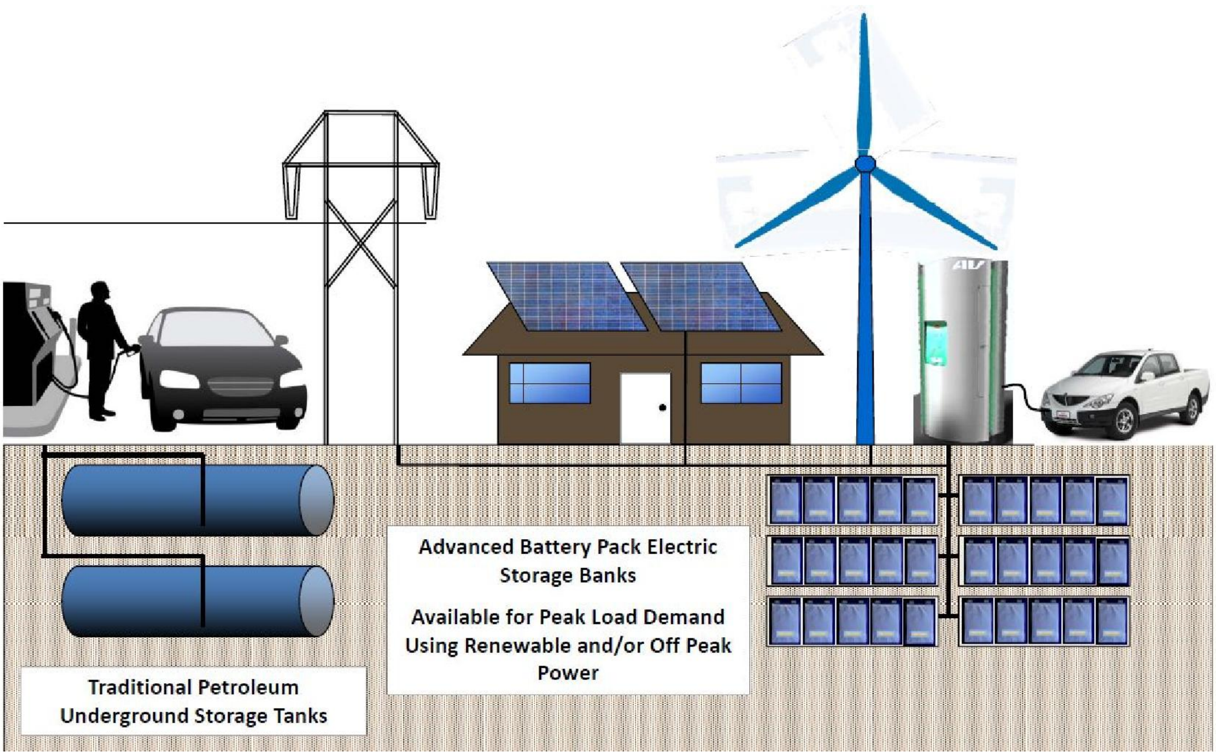
Good Infrastructure: Efficient & Convenience



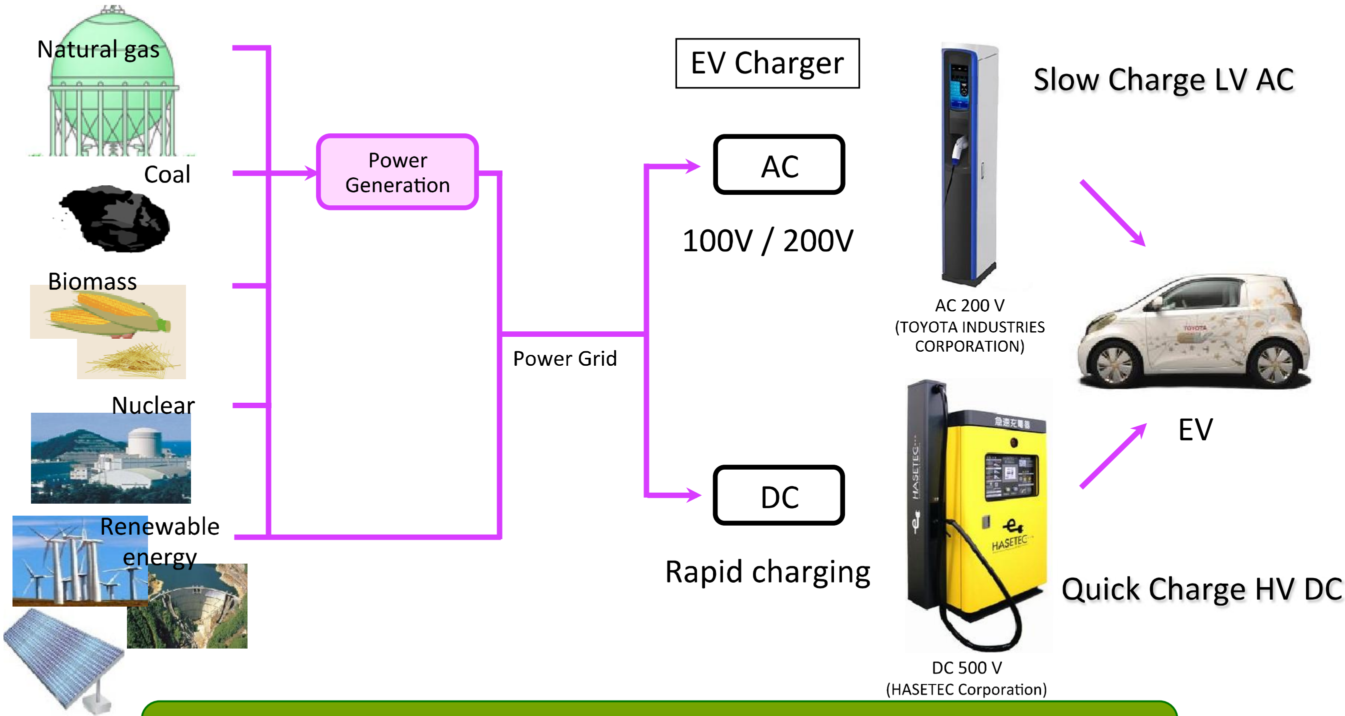
Parking Durations	14 hrs per day	2 hrs per day	7 hrs per day
Charging Points	1 charging point per vehicle	< 0.5 charging point per vehicle	1 charging point per vehicle
Power & Charing time Requirements	Low power and normal charging (e.g. 3kW, 10 hrs)	High power and quick charging (e.g. 22 kW, 2 hrs)	Low power and normal charging (e.g. 3kW, 7 hrs)

EV Charging Infrastructure Solution

Comparison of Gas Station & Storage Quick Charging

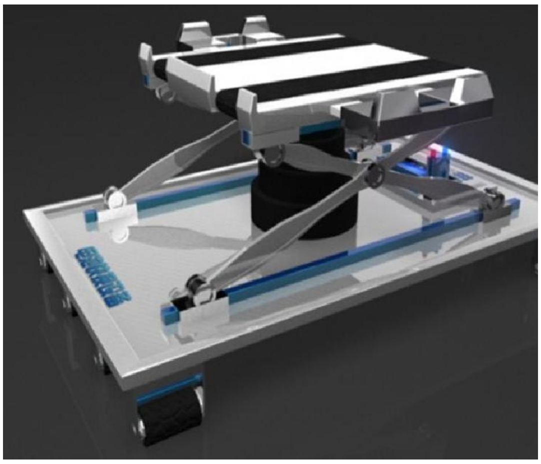


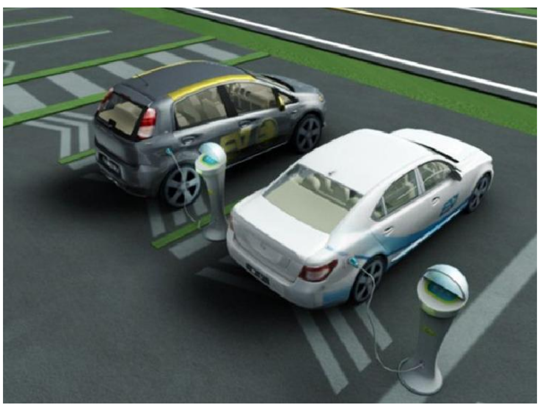
EV Charger



AC charger (100V/200V) for daily use
DC charger (rapid charging) for emergency use

Battery Swapping





Smart Battery Charging, Swapping, Delivery Network





- AC charging
  - Long charging time
- DC charging
  - Battery technology does not support fast charging
  - Grid cannot sustain fast charging
- Battery swapping
  - Immediate replenishment of electricity
  - Easy battery maintenance and longer life

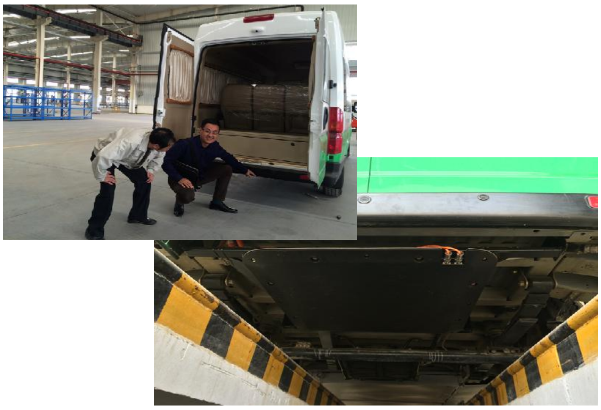

> 对内公开

Inductive Charging for Passenger Cars

- Operation in Chang An EVs,
- Max power 107 kW.

- Operation in Cherry eQ Evs,
- Range 250 km.

Inductive Charging for Commercial Vehicles



- Operation in mid size commercial vehicles

- Operation in Chengdu；
- Operation in short distance van；

> 对内公开

Inductive Charging for Buses. Unit Power 30kW，Max 300kW

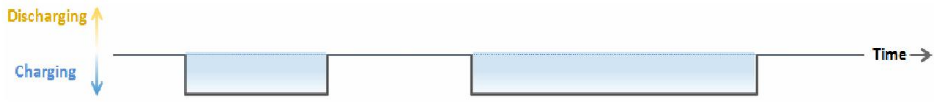
- Power： 30kW
- Gap： 20cm
- Efficiency： 90%
- Space： 1 square meter

Operation in Deng Feng Bus in Xiangyang

Motivation

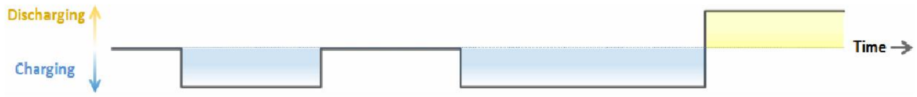
Smart charging

Charging is delayed or advanced in time based on e.g. energy cost or renewable contents.



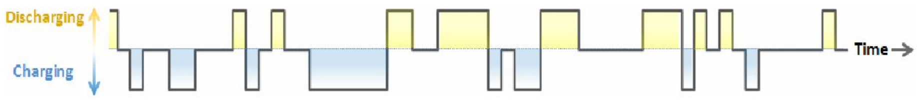
Energy backup

Advance or postpone charging in time and to deliver the energy back to the grid at a later time.



Ancillary services

Continues short-duration charging and discharging operations to balance the grid.

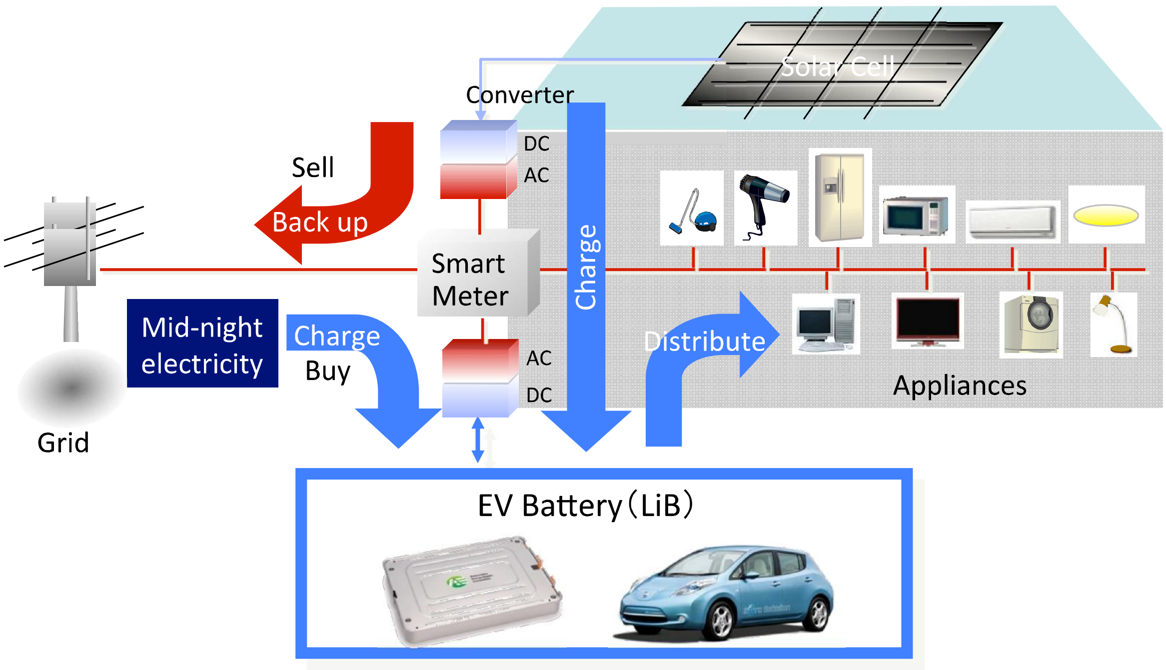


Two Integrations

- Integrate EV with Smart Grid
- Integrate EV with Telemetic / ICT

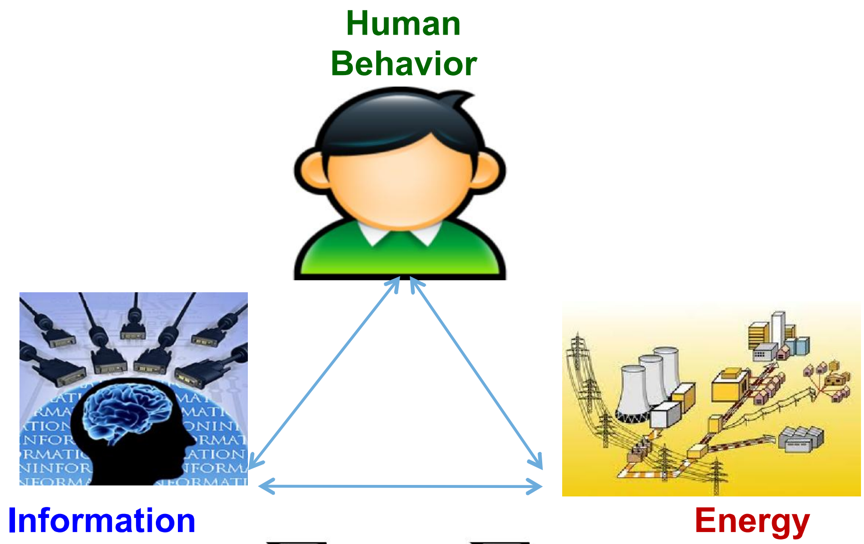
Smart House :

- Increasing low carbon electricity and reduce peak electricity consumed
- Management of electricity storage by EV and/or Lithium ion battery



Energy & Information

能源和信息



$$\sum I \Leftrightarrow \sum E$$

$\sum I$ - Various Information

$\sum E$ - Various Energy

C.C. Chan 2012

Energy and Information

$$\{\langle \Delta F - W \rangle / 1bit\} \leq k_B T \ln 2$$

ΔF - *Free Energy difference between states*

W - *Work done on the system*

k_B - *Boltzmann constant*

T - *Environment Temperature*

— C.C. Chan 2013 at IASS

Energy & Information

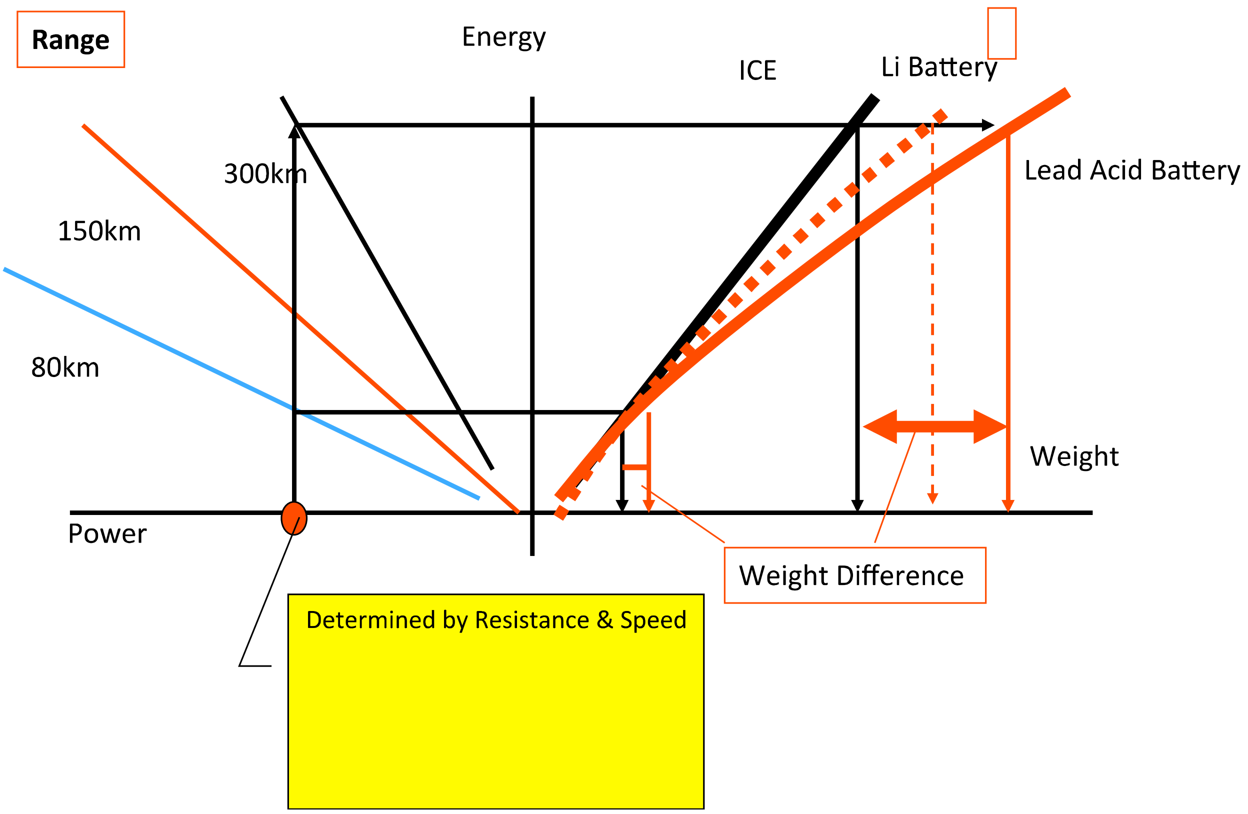
- Not only understand the upper and lower bounds of information,
- But also understand the complex interdependence between the physical limitations of thermodynamic boundaries of energy transfer and the human dimensions of economic, social, and political decisions should be crucially considered.

Low Range Small Electric Vehicles

China Low Range Small EV Specification

- **Max Speed: 80 km/h**
- **Acceleration :0 – 50 km/h , 10s**
- **Climbing Gradient > 20%**
- **Range : 50 km (Urban Driving Cycle)**
- **Vehicle Mass < 1200 kg**
- **Battery Weight: < 30% Vehicle Mass**

Mini EVs are most cost effective
Small EVs: Range, Energy & Weight Relationship

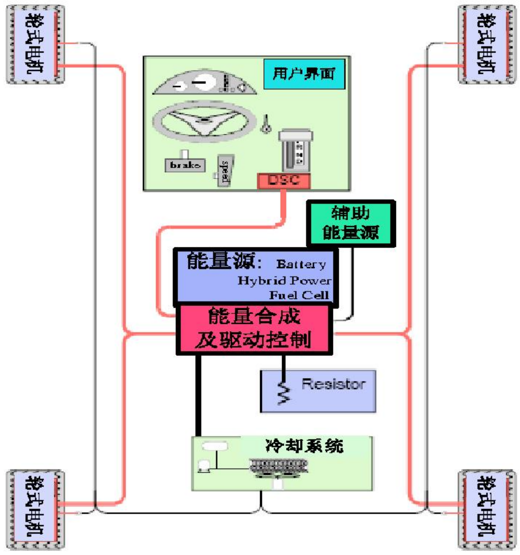


Technology Roadmap_ BEV Miniaturization

Through downsizing to realize scale commercialization

light electric vehicle → small battery electric car → full function electric car

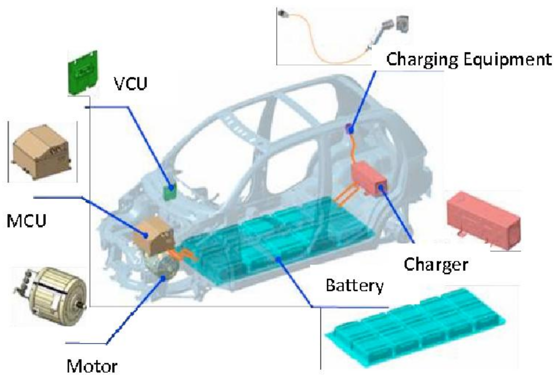
(lithium battery + in-wheel motor + chassis electrification + charge with household power



Typical Chinese Battery Electric Vehicles

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

Maximum speed	100km/h
0~50km/h Acceleration time	6s
Battery type	LFP Li-ion
Energy	18kWh
Peek power	50kW
Driving range	150km
Normal-charging time	6~8h
Quick-charging time	30min



EV of JAC

EV of Chery

EV of Geely

EV of SAIC motor

EV of CHANGAN

EV of FHC-Mazda

Intelligent Electric Vehicles

智能电动汽车

Human being versus intelligent EVs

	Human being (intelligent life)	Future intelligent EVs	Note on intelligent EVs
System architecture	Essentially identical but evolving	Diverse at current development stage	Potentially to be optimized for given applications
Brain (controller)	One	Three: driver; vehicle-oriented; ITS/IV-oriented	Emerging demands in coordinating the 3 'brains'
Energy management	Internal (control management, regen) + external (food, drink,etc)	Internal (control management, regen) + external (charging)	Preliminary stage & potential to optimize
Thermal management	Internal control + external (clothes, air conditioning, etc)	Internal (control management for different subsystems requirements)	Highly challenging
Health management	Evolution: millions of years (physical & mental)	Very new topic; hardware & software (control systems)	Emerging & critical
Performance envelope	Clear performance envelope & limitations while in slow evolution	Clear performance envelope & limitations while in rapid development	Advances in key components & system integration
Status of system synergy	Optimal & evolving	Very preliminary at current development stage	Significant potential & benefit to be synergised

Unmanned Ground Vehicles (UGVs) in DARPA (Defense Advanced Research Projects Agency) Grand/Urban Challenge

•*Grand Challenge 2005*

•*Stanford Stanley*

•*Urban Challenge 2007*

•*CMU, Tartan*

Intelligent Vehicle

Smart Mini EV

Internet of Vehicles

White Paper of Internet of Vehicles (IoV)

1. Concept of IoV

The Internet of Vehicles (IoV) is an integration of three networks: an inter-vehicle network, an intra-vehicle network, and vehicular mobile Internet.

2. IoV Technology Leads Industrial Revolution

The convergence of technology encompasses information communications, environmental protection, energy conservation, and safety. It will become the largest Internet of Things (IoT) infrastructure. The collaboration and interconnection between the transportation sector and other sectors (such as energy, health-care, environment, manufacturing, and agriculture, etc...) will be the next step in IoV development.

White Paper of Internet of Vehicles (IoV)

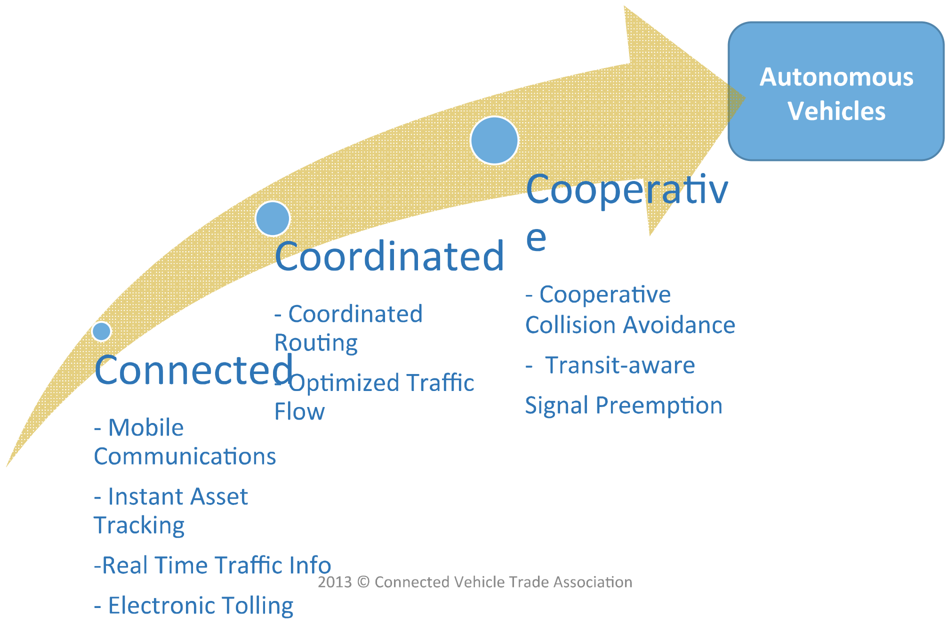
3. Opportunities and Challenges of IoV

The research and development, as well as the industrial application of IoV technologies will promote the integration of automotive and information technology. Lack of coordination and communication is the biggest challenge to IoV implementation. Lack of standards make effective V2V (vehicle to vehicle) communication and connection difficult and prohibits ease in scaling.

4. Reflection and Suggestion about the Development of IoV

- *Staged development and deployment of IoV systems*
- *Strengthen policy guidance and support from governments.*
- *Promote deep integration of IoV and vehicles.*
- *Cooperate to improve standards and industrial specifications.*
- *Plan for IoV data to be accessible as a resource to enable broader research.*

Evolution to Autonomous Vehicles




TECHNOLOGIES FOR THE FUTURE
In-Vehicle Infotainment (IVI)
Advanced Driver Assist Systems (ADAS)
Autonomous /Self Driving
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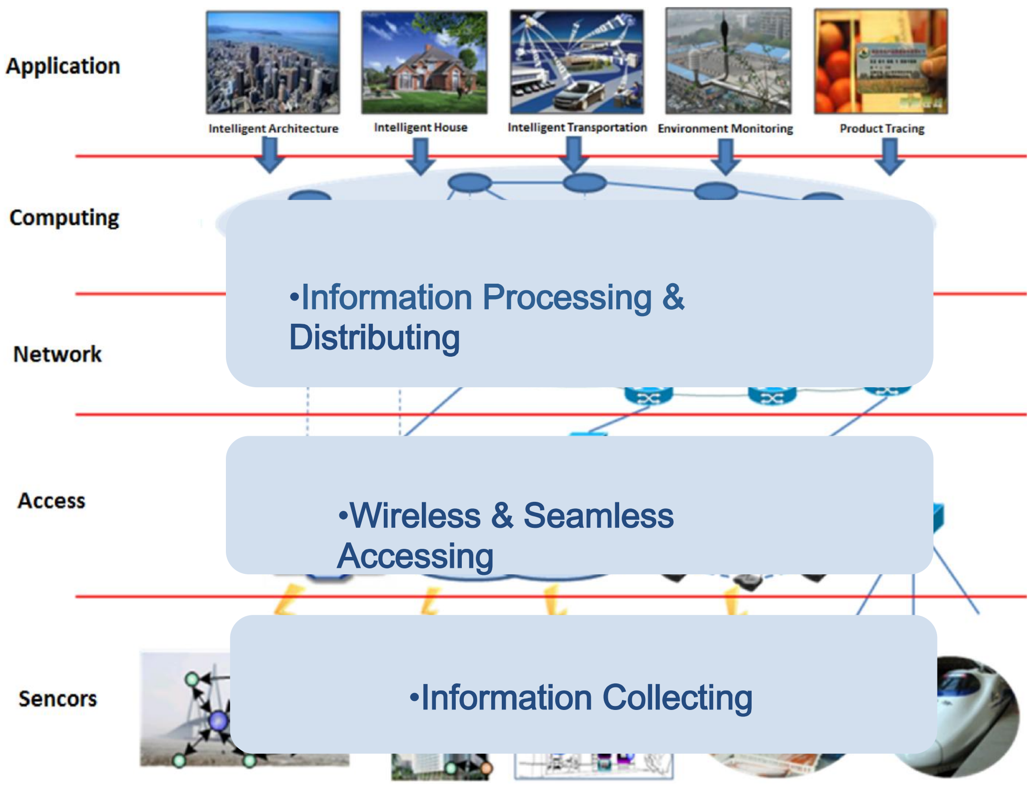
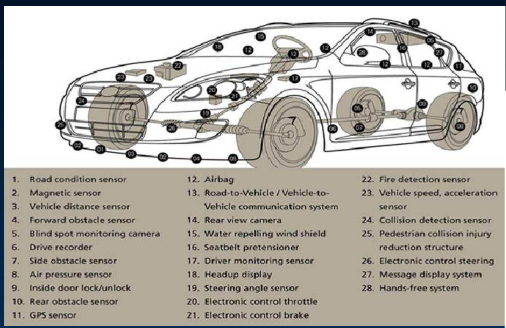

Application
Intelligent Architecture
Intelligent House
Intelligent Transportation
Environment Monitoring
Product Tracing
Computing
•Information Processing & Distributing
Network
Access
•Wireless & Seamless Accessing
Sencors
•Information Collecting

Smart Cars & Autonomous Driving

Electric vehicles and Smart Grid integration

Remote diagnostics



Smart Transportation Systems

Intelligent Traffic Management





Internet of Cars: Unlocking $1,400 in Benefits

per Vehicle, per Year

Internet of Cars Service Providers
- Traffic guidance, navigation, emergency services
- "Google on wheels," PAYD insurance, location-based services

$160

Vehicle User
- Lower insurance
- Lower operation cost
- Less time stuck in traffic, more productivity

$ 550

Auto OEM/OES
- Lower service/warranty costs
- Connected CRM
- New profit pools
- Architectural savings

$300

Society
- Fewer crashes
- Lower traffic/road/toll operation costs
- CO^2 reduction

$420

Benefits per vehicle, per year

Source: Cisco IBSG Automotive and Economics Practices, 2011


COMFORT
Creating enriched and comfortable car utilization experiences for customers by providing a range of services that address various driving situations
ECOLOGY
Optimizing energy use for the entire society and realizing stress-free and environmentally considerate living with a high quality of life
H2Veneli
Support of energy-efficient lifestyle
Toyota Friends
Charge my Prius, please
Guidance based on driving history and understanding of driver intention
FEMS
FEMS
High-efficiency power generation system
F-Grid CEMS
Plant factory
HEMS
Contact-less charging
BEMS
OK!
Enriching Lives of Communities
Thanks
Energy management
EDMS
Next-generation Telematics
VDMS
TDMS
TOYOTA Smart Center
Cooperative-type ITS
Next-generation urban traffic system
Tailored ads
Traffic congestion forecast, probe-based traffic information
Rebuilt or reused batteries
G-Station
Charging station
BEMS
Intelligent parking
Automatic parking
ITS spot
Attention! Curve ahead!
Next-generation HELPNET
Automatic notification based on accident status
Smart mobility park
Ha:mo NAVI
Multi-modal route guidance
Road-vehicle communication system
Pedestrian to vehicle communication system
DSSS
Red light ahead
Ha:mo RIDE
Car sharing system using ultra compact electric vehicles
OK!
Vehicle-to-vehicle communication system
Advanced driving support systems
SAFETY
Toward the realization of Toyota's ultimate goal: zero casualties from traffic accidents
For further information on Toyota's safety initiatives, please see pp 22-25 and also the webpage below
未来汽车社会
CONVENIENCE
Building a stress-free traffic environment where everyone can move around smoothly, exactly as they wish
Details on next page


SUCCESS
SUCCESS

Inspiration	激情
Imagination	想像力
Innovation	創新
Integration	集成
Implementation	實現
Investment	投資

Thank you!