Hydrogen-Fuel Cell Vehicle Development in China

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“Demonstration for Fuel Cell Bus Commercialization in China”

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Outline

Part I Sustainable Development Energy and Environmental Problems in China

Part II Sustainable energy for transportation system

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Part IV Challenges and prospect

Part I Sustainable Development Energy and Environmental Problems in China

★ Energy and environmental problems in China

★ Chinese policies and legislation

★ A series of measures have been carried out

★ Developing renewable energy

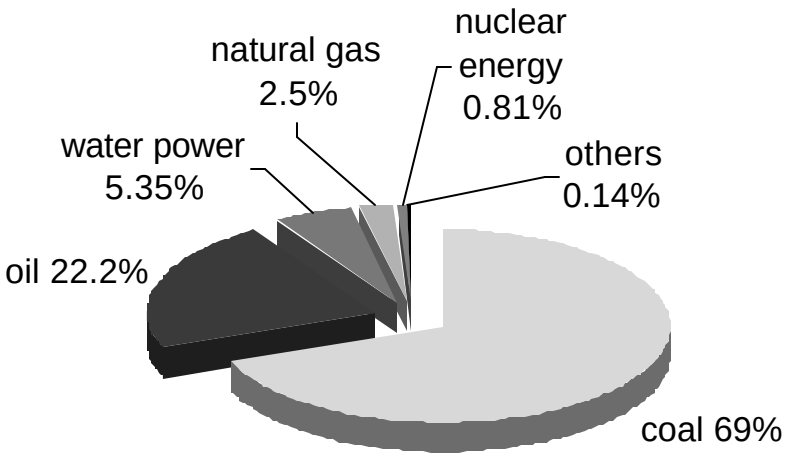
1. Energy and Environmental Problems in China

★ Total primary energy consumption in China in 2004 reached 1386.2 million tons oil equivalent, accounting for 13.6% of global consumption as the second largest consumer of energy in the world behind the U.S. (22.8%).

★ China has abundant coal and scarce of oil and gas, 90% of primary energy was self-sufficient. 69% is coal

★ The average energy consumption per capita in China is quite low now, about 1/2 of global average, 1/4 of European and Japanese level, 1/8 of American and Canada level.

★ In 2004, China oil consumption was 292 million tons accounting for 8.2% of total oil consumption in the world.



China's primary energy consumption construction

★ In 2004, China produced 175 million tons oil, and imported 117 million tons oil accounting for 40% of total oil consumption. Base on forecast, oil import dependence will be 50% by 2010, and over 60% by 2020.

★ Coal and oil consumption provide the major source of air pollution in China

★China is the second largest emitter of CO2 in the world, making up roughly 13% of global emission.

2. Chinese policies and Legislation

President Hu gave a speech on the 60th Anniversary of the United Nations on 15th September 2005, emphasizing on enhancing energy cooperation around the world and aiming to provide sufficient, safe, economical and clean energy environment for economic development.

President Hu visited Ballard company

- ★ **A national energy leading group headed by Premier WEN Jiabao had been established in June 2005. National energy office was set up as well.**
- ★ **The Chinese government has adopted the strategies of "sustainable development" and the policy of "energy saving production, environmental friendly, and resource cyclic economy manner."**
- ★ **Renewable energy law came into effect on 1st Jan. 2006.**

3. A series of measures have been carried out

★ On 30th May 1998, China signed Tokyo Commitment which was put in effect in Feb.2005.

★ By 2010 energy consumption per GDP unit will reduce 20%, and pollution per GDP unit will reduce 10% announced in coming 11st five-year (2006-2010) economic development plan.

★ Priority to public transportation development in urban.

★ Developing various energies. such as the largest coal-to-liquid (gasoline, diesel etc.) refine factory in the world was set up in 2004, planning to consume 9.7 million tons coal to produce 3.2 million tons various oil. Promoting to use CNG, LPG, coal methane gas etc..

4. Developing renewable energy

★ Medium-long term renewable energy development program was drafted for reviewing and approval. The overall goals are to increase the percentage of supply of renewable energy from 7% in 2005 to 15% in 2020 in China, generated electricity power generation capacity from renewable energy reaches 30% of total volume.

PART II Sustainable energy for transportation system

- ★ Oil resource sufficiently supply in coming decades with uncertain elements.
- ★ Automobile rapidly increasing in forecast future.
- ★ Three kinds fuel are recognized as potential sustainable transportation fuel.
- ★ Benefits of hydrogen
- ★ Great progress in fuel cell vehicle in last ten years.

1. Oil resource

★ In 2004, total no-exploited proved oil was 161.9 billion tons in the world. Comparing with 3.87 billion tons oil was produced, the rate of reserves/production was 40.5.

★ New traditional oil fields and potential oil reservation certainly will be obtained. In addition, some unconventional oil is existing as well, such as oil sand, oil shale, superdeep offshore oil and natural gas hydrate. Therefore, we can expect that oil still can be used for vehicle for several decades. The optimists say that oil is still enough for 70-80years.

2. Automobile increasing rapidly

★ The vehicle production volume was 64.16 million units in the world in 2004, and total number of vehicles in operation was about 900 million units.

★ According to Department of Energy, U.S. forecast, the number of vehicle in operation will be 3.5 billion units in the world by 2050.

★ Average 1000 people had 135 vehicles in 2004 in the world. However, 70% of vehicles were owned by the people living in industrial countries. In U.S., average 1000 people have about 750 vehicles. Average 1000 people have 400-600 vehicles in European countries and Japan.

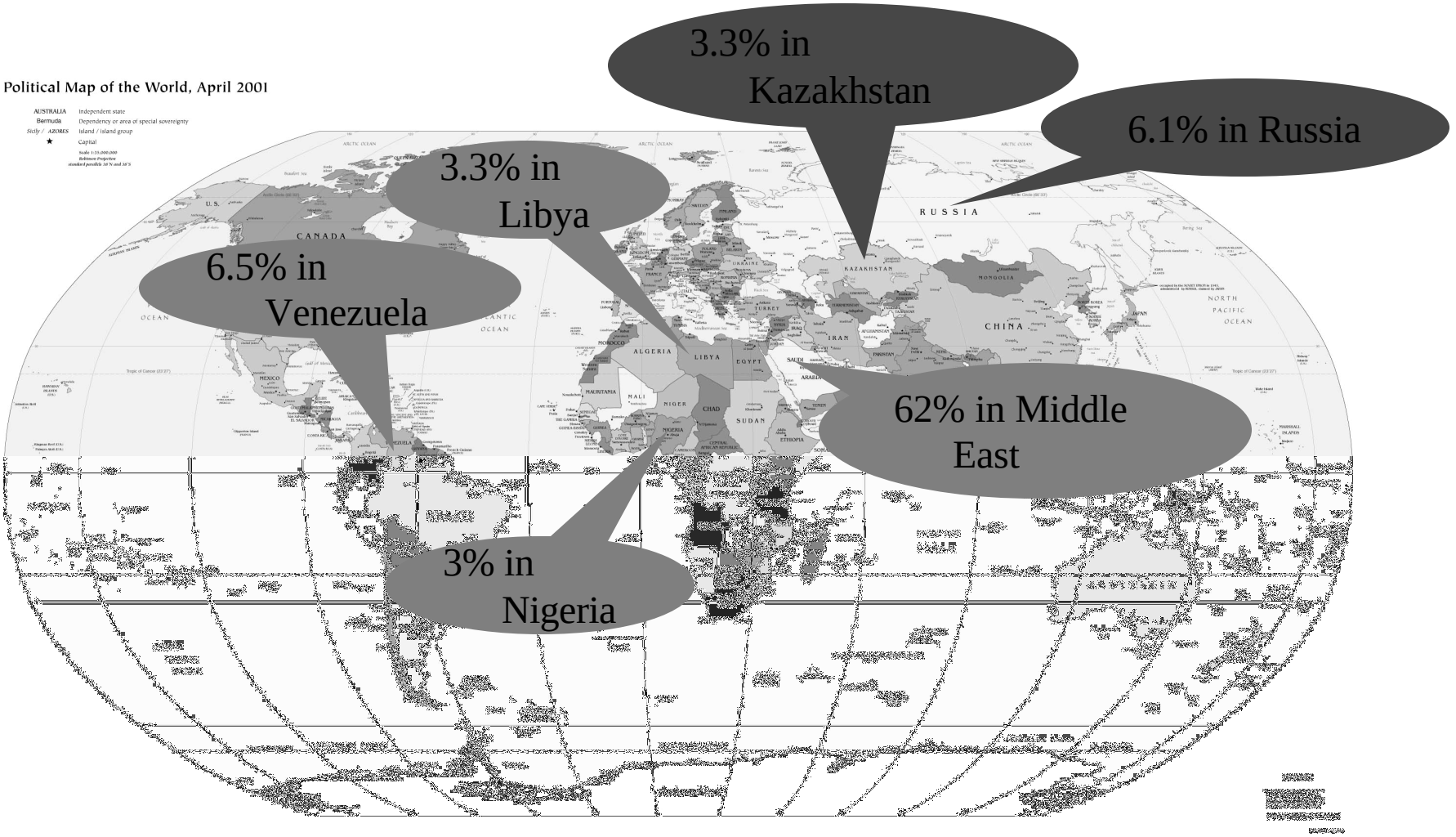
- ★ In 2004 the vehicles production volume in China was 5.07 M units, and number of vehicles in operation reached 27 M units. There were only 20 vehicles per 1000 people.

- ★ Based on a study, china annual vehicle demand will reach 9 million units by 2010, and about18 million units by 2020. The registered vehicle in China will be 120-150 million units by 2020, roughly average 100 vehicles per 1000 people.

Thus vehicle increasing significantly will be a great challenge for oil supply.

Traffic in Beijing

Uncertain elements existed



Total 84.2% of oil of total proven oil in the world

- **Security of oil transport**

  For example, China imported 1.17 million tons oil in 2004, including 50% from Middle East, 22% from Africa, 12% from East and South of Asia. The 1.10 million imported oil was transported by seaway.

- **Oil price increases rapidly. It was 2.93 USD dollar per barrel in 1970's. Until last month, oil price reached to 73.7 USD per barrel.**

- **Pollutants control are difficult for moving ICE vehicles, such as CO, HC,NOX, CO2,particles etc..**

3. Potential sustainable vehicle fuels

★ Oil can not be expected as energy for sustainable transportation system due to

its un-renewable.

★ Renewable primary energy can not be used as vehicle fuel directly.

★ Three second energy carriers are recognized as the most promising sustainable “fuels” for vehicles.

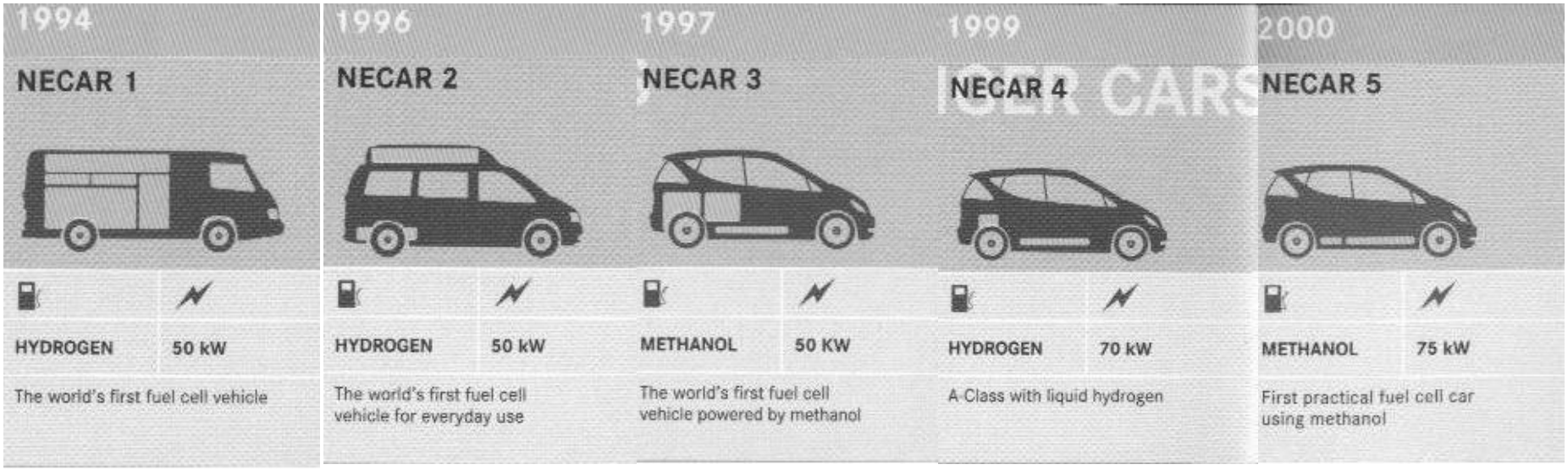
--Biomass fuel

--Electricity

--Hydrogen

5. Great progress in FCV

★ Fuel cell stack power density improved by 20 times. Size and weight of fuel cell engine can be integrated in vehicle, nearly equal to diesel level.



- ★ Noble metal is used as the primary catalyst for fuel cells. In recent year, the amount of platinum usage has been reduced significantly by 10 times.

- ★ Power efficiency of fuel cell engine reaches to 45%-50%, plus high efficiency of driving motor, therefore, power efficiency from tank to wheel is one time higher than petrol vehicle.

★ Reliability and durability

--In 2002, NECAR 5 crossed the American, setting a long-distance record of 5,250 kilometers for a fuel cell vehicle.

--In 2004, GM FC vehicle drove 9.696 thousand km across Europe.

GM FC drive route

Part III Hydrogen Fuel Cell Vehicle development in China

Hydrogen fuel cell vehicles development in 1990s in China

UNDP-GEF-China fuel cell bus project

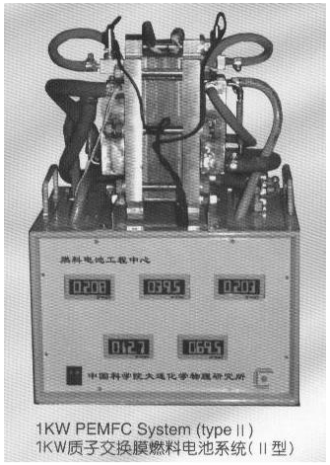
Domestic FCV development projects

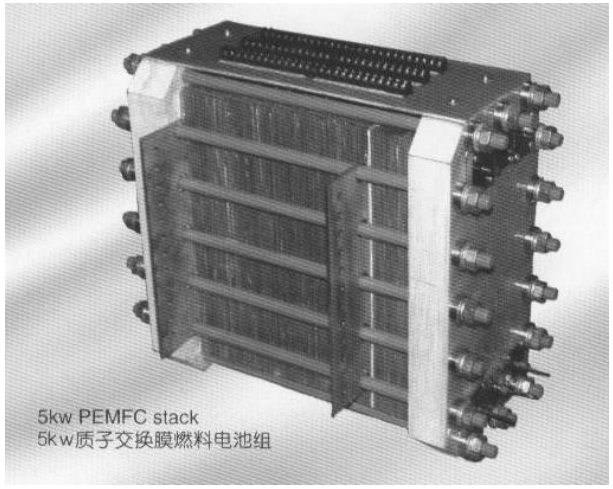
Beijing hydrogen park

1. Hydrogen Fuel Cell Vehicle Development in China

★ China have paid attention on PEMFC R&D since 90's, main researchers include:

- Dalian Institute of Chemical and Physics, Chinese Academy of Sciences
- Beijing FuYuan Pioneer New Energy Material Co.,Ltd.
- Shanghai Sun Li High Technology Co., Ltd
- Beijing Lu Neng Power Sources Co., Ltd


1KW PEMFC System (type II)
1KW质子交换膜燃料电池系统(II型)


5kw PEMFC stack
5kw质子交换膜燃料电池组

★ Several prototypies of fuel cell vehicle have been made

Developer	Tsinghua University	Dong Feng motors Corp	Tsinghua University	Pan Asia Automotive Technology
Type	Cart	Light Bus	Light Bus	Mini Van
				
Developed	1999	Jan, 2001	April, 2001	Oct, 2001
Max Speed km/h	20	65	80	113
FC Type Power KW	PEM 5	PEM 25	PEM 18	PEM 25
Motor Power KW		AC Inductive 27	AC Inductive 36	AC Inductive
H_2 Supply Pressure Mpa		Compressed 25	Compressed 25	Compressed

2. UNDP-GEF-China Project

Operational Program 7 “Reducing long-term costs of low GHG-emitting energy technologies”

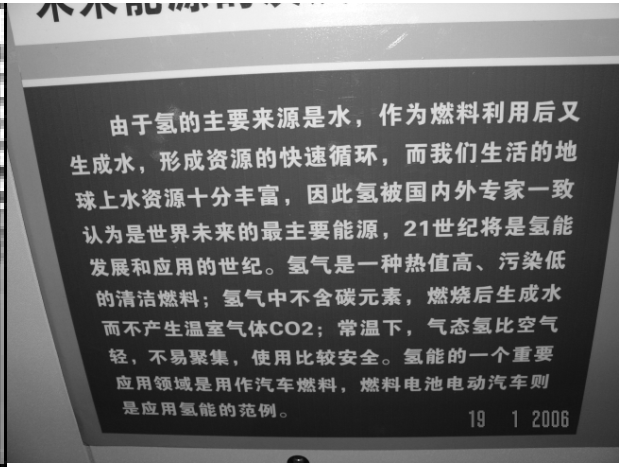
Operational Program 11“Promoting environmentally sustainable transport”

- ★ UNDP/GEF approved five countries who carry out total 46 FCB demonstration projects in six cities respectively.
- ★ The Demonstration for Fuel Cell Bus Commercialization in China was launched on 27th March 2003 in Beijing.

The projects represented the UNDP-GEF guideline of promoting sustainable transportation in the developing countries

- ★ To promote development of public transportation system
- ★ To rely on new technologies, especially sustainable new technologies to develop pub transportation
- ★ To improve performances and reduce cost by demonstration in small scale, then expand demos in large fleet and more cities to achieve commercialization finally.

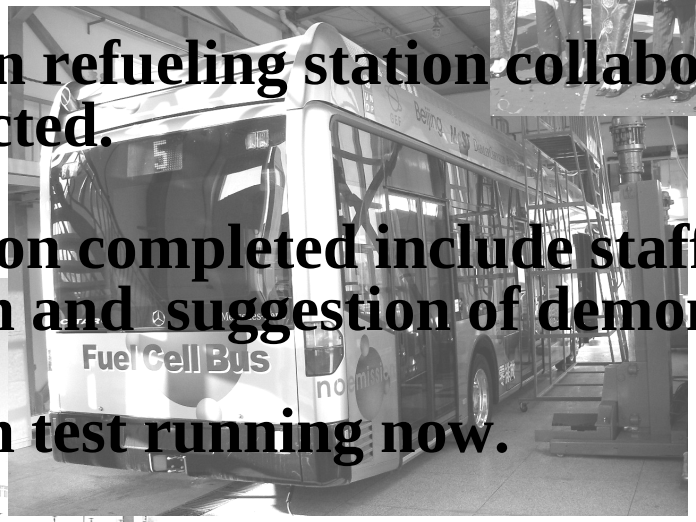
★ Buses are used by many people and can become an effective tool to advertise environmental protection and sustained development concepts. It also performs as a “moving classroom” teaching people about new transportation technologies and their advantages through their real experience..

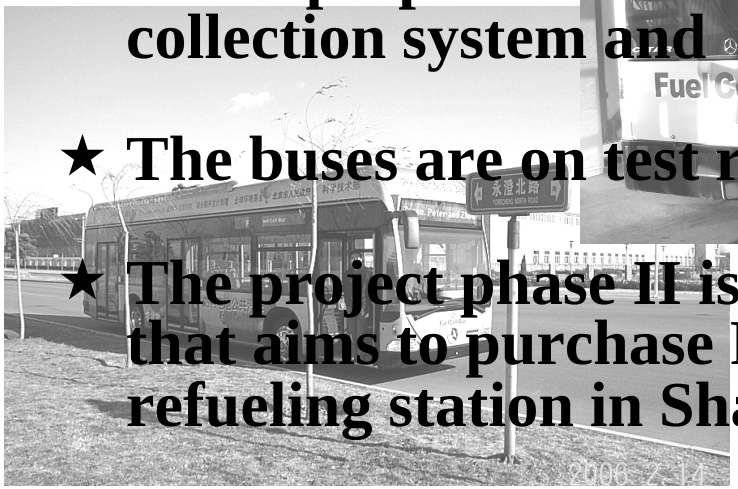


★ The project was incepted officially in Beijing in March 27, 2003.

★ A supply contract for three Citaro fuel cell buses (FCBs) was signed by MOST, Beijing government and DaimlerChrysler who was announced as the bids winner on 25 May 2004.

- ★ **The Fuel Cell Bus (FCB) Handover ceremony was launched on 23rd November 2005 in Beijing.**
- ★ **FCB maintenance workshop and garage are in-service now.**
- ★ **Beijing hydrogen refueling station collaborating with BP is being constructed.**
- ★ **Other preparation completed include staff training, data collection system and suggestion of demons route.**
- ★ **The buses are on test running now.**
- ★ **The project phase II is in the process of GEF approval that aims to purchase FCBs and construct hydrogen refueling station in Shanghai.**





3. Domestic FCV development projects supported by Chinese government

★ The development of fuel cell vehicle technology. Fuel cell systems, fuel cell sedans and city buses are listed in “High Technologies Development” 5 year plan（ 2001-2005). The Ministry of Science & Technology of China contributed 106 million USD dollar towards support for battery-power, hybrid and fuel cell electric vehicle R&D and demonstration during the 10th 5 Year Plan (2001-2005).

★ China’s research on fuel cells has made important progress in recent years.

★ Through three generations, total five FC busess and ten cars with hybrid configuration developed by Tsinghua and Tongji Universities separately, got evident progresses

Generation I FC City Bus

Produced in 2002 (50kw)

Generation II FC City Bus

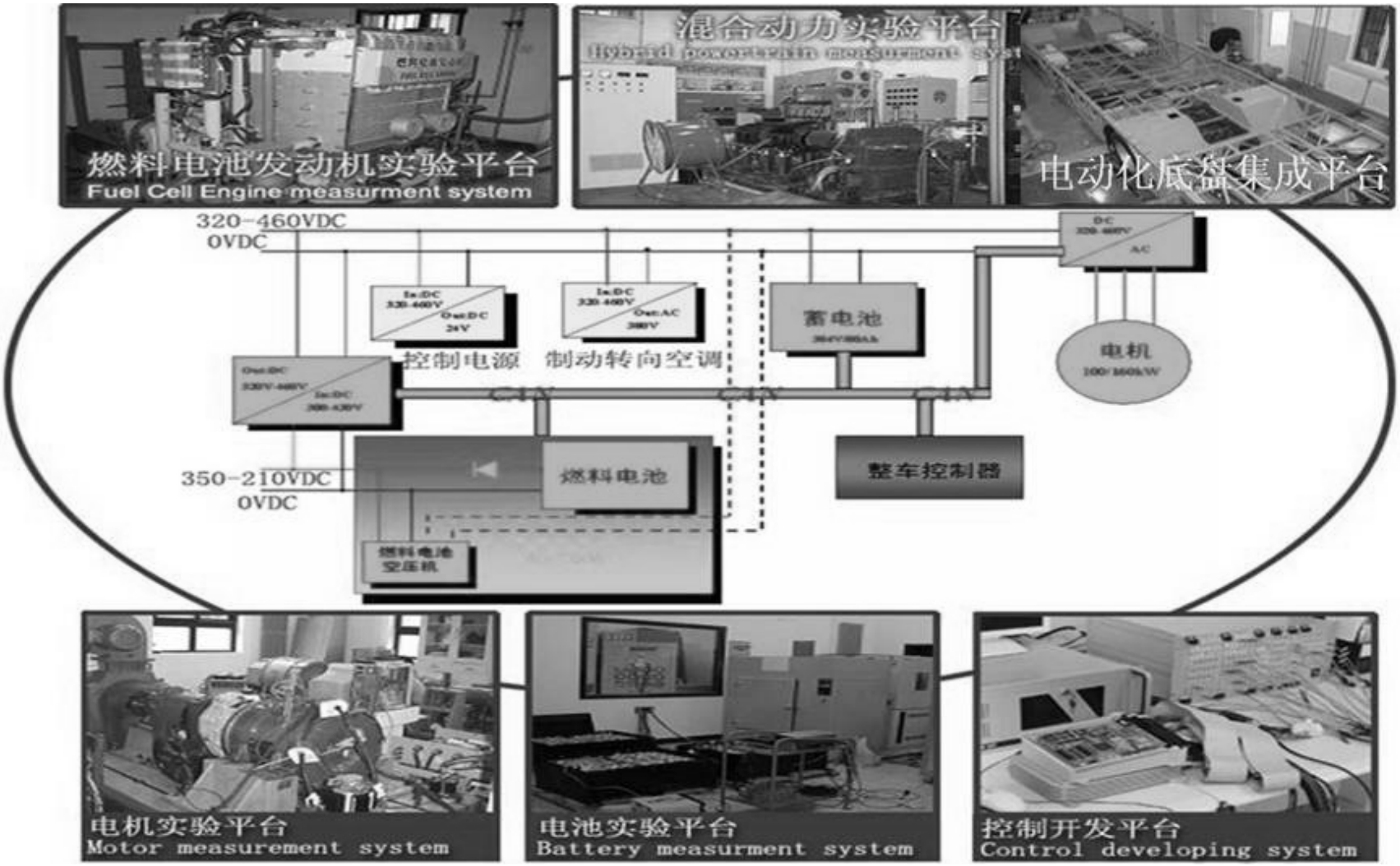
Produced in 2003 (60kw)

Generation III FC City Bus

Produced in 2005 (100kw)

Total trial mileage 33,000km

★Laboratory for R&D Fuel Cell City Bus



4. Beijing Hydrogen Park

- ★ Promoted and funded by China MoST and Beijing Municipal Government, the construction of Beijing Hydrogen Park was initiated in 2004.

- ★ Beijing hydrogen refueling station for the Demonstration for Fuel Cell Bus Commercialization in China was set up at Beijing Hydrogen Park.

- ★ Beijing SinoHytec Limited, BP and Beijing Tongfang Co. Ltd as the project stakeholders cooperate to construct the first hydrogen refueling station in China.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中关村国际商城
发 展 区
中医药科技园
环保科技园
Beijing New Energy Demo Zone
Beijing 2008
北京大学
清华大学
中 心 区
Solar Energy
Wind
Clean Power Plant
Wind Power
Hydrogen Education Center
Garages for Hydrogen Vehicles
Electrolyzer Equipment
Steam Reformer of Natural Gas
External Hydrogen Sources
Compressor
Hydrogen Storage
Dispenser
Fuel Cell Bus
Fuel Cell Car
Hydrogen Fueling Station

Part IV Challenge and Prospect

Major challenges	Prospect
1. FCV adaptability to different operational conditions (low temperature, vibration, safety issue.)	Ballard announced in April 2005, their FC system can start-up to 50% rated power at -30 ° C in 30 sec in 2010, FCV will be improved through demonstration.
2. FCV reliability and durability	Ballard announced in April 2005, their stack durability will be reach 5000 hours by 2010. Another FC supplier, UTC FC system seems, their products may be even longer.
3. Hydrogen produced from renewable energy	Great progress in solar-hydrogen direct-producing technology.
4. Hydrogen storage	• compressed hydrogen currently available to 700 Bar for longer range

Major challenges	Prospect
4. Hydrogen storage	•Metal hydride storage weight rate 7%. •Storage hydrogen by nano technology, such as nano fibers and tubes.
5. Infrastructures	In March 2005, German Linde released a study report which supposed 6.1 million FCV in Europe in 2020, the hydrogen demand will be 1.1 million tons annually and 2800 hydrogen fuelling stations which need invest 35 billion Euro. It is predicted that the investment will be returned in ten years.
6. Competitive cost	Ballard announced in April 2005, their FC stack cost will drop down to 30 USD/kw BY 2010. DOE's target is that FC system reaches 45 USD/kw BY 2010, and 30USD/kw by 2015 (same price as gasoline ICE) in mass production of 500,000 unites per year.

2003-2004 OICA correspondents survey of bus production

	Country	2003 (units)	2004 (units)
1	China	66,700	78,712
2	USA	27,943	29,033
3	Brazil	26,990	28,738
4	Russia	17,227	18,760
5	South Korea	16,354	14,000

Regarding larger potential market and lower cost of labor and material, if fuel cell propulsion system and bus production are localized in China, it will be competitive in the future.

Thanks for your Attention