IPHE Country Paper – CHINA

A. RD&D ACTIVITIES IN CHINA

1. Past activities

China started study and implementation of liquid hydrogen production and processing, mainly for space propulsion since the 1960s. About 30 years ago, the government launched the Chinese hydrogen fuel cell project, involving over 300 researchers on systematic research of kilowatt-scale alkali fuel cell. The concern on hydrogen and fuel cell research has been emphasized in the following consecutive five-year plans.

The Chinese government started to support electric vehicle R&D in the early 1990s, although, until 2000, the focus was mainly on battery technology and electric motors. In the absence of private commercial companies, most of the grantees were universities. Since about 1999, the government has extended the electric vehicle R&D investment towards fuel cell technology as well.

2. Current R&D Programs in China

2.1 Outline

There are two major state technology programs related to fuel cells and hydrogen research in China. First, the national basic research program (973 Program, named after the start date in March 1997) aims to strengthen the original innovations and to address the important scientific issues concerning the national economic and social development at a deeper level and in a wider scope, so as to improve China's capabilities of independent innovations and to provide scientific support for the future development of the country. Second, the national high technology research and development program (863 program, named after the start date in March 1986) aims at enhance China's international competitiveness and improving China's overall capability of R&D in high technology. Besides the above-mentioned fundamental and development research programs, some strategic study projects were launched recently.

2.2 973 Programs

1) **Fundamentals of Large-scale Production, Storage and Transportation of Hydrogen and the related Fuel Cells**

Project periods: April 2000- March 2005

Implementing Agency: Ministry of Science and Technology (MOST)

Executing Agency: Ministry of Education, China (MOE)

Chinese Academy of Sciences (CAS)

Budget: 30 million RMB

Research Content: key fundamental problems were addressed to solve in hydrogen production, storage, application, standard and stratagem.

On the basis of analysis on the project general, ten subprojects were selected to be carried out.

1) Hydrogen Production from on Board reforming technologies processes

2) Hydrogen from Biomass

3) Hydrogen Storage in Nanocarbon Tube and Nanographite

4) Hydrogen Storage in Super Active Carbon

5) High Capacity Hydrogen storage Alloy

6) Hydrogen transfer in Slurry of Hydrogen Storage Alloy

7) Hydrogen Storage in Organic Liquid.

8) Novel Catalyst for PEMFC

9) Basic Technology for Key Materials of Fuel Cell

10) Fundamental research for Fuel Cell and Stack

2) **Basic Research of Hydrogen Production in Scale Using Solar Energy**

Project periods: December 2003- November 2008

Implementing Agency: Ministry of Science and Technology (MOST)

Executing Agency: Ministry of Education, China (MOE)

Chinese Academy of Sciences (CAS)

Budget: 22 million RMB

The key scientific issues to be solved are as follow:

1) The principle for constructing stable reaction systems for continuous hydrogen production and novel micro multiphase reaction system and the reaction dynamics.

2) The relations of composition, process, structure and performance of the catalysts and promoters for continuous multiphase hydrogen production, the mechanism of the catalytic activity formation, and the measurement, characterization of the catalysts and the promoters.

3) The theories of mass hydrogen production from water and biomass by solar thermal chemical

decomposition, and from water by solar visible light assisted photolysis.

The project will be divided into the following six subprojects:

1) Construction theory of novel hydrogen production system in multiphase flow continuous reaction mode.

2) Thermodynamics and micro multiphase flow kinetics of complex process in hydrogen production reaction system.

3) Theories for design, synthesis and modification methods of catalysts used in multiphase flow continuous hydrogen production process.

4) The microcosmic catalytic mechanism and the measure and characterization of structure and performance of catalysts in multiphase flow continuous hydrogen production process.

5) The theories for high efficiency heat exchange, multiphase mixture transport, energy conversion and system stability in hydrogen production by solar thermal chemical decomposition.

6) Theory of energy metabolism control, multifunction coupling and optimization of hydrogen production by water photolysis.

2.3 863 Programs

During the 10th five-year plan (2001-2005) China's Ministry of Science and Technology (MOST) approved a 880 million Yuan (US$106 million) R&D program to develop advanced hydrogen technology, hybrid-electric drive and fuel cell vehicles.

1) **Post-Fossil Thematic Project on Hydrogen Technology**

Project periods: 2001- 2005

Goals and Objectives to 2005:

1) Demonstration of the animalcule H_2-made system with daily hydrogen output of 1,200m^3

2) Demonstration of the metal-hydride hydrogen storage system

3) Development of the hydrogen storage equipment compatible with Fuel Cells

Subject arrangements:

1) High efficiency hydrogen storage equipment and technology

2) Research on light quality and high pressure hydrogen storage system

3) Research on new technique of two-step biology hydrogen-generation in organic castoff

4) LNG cooling energy for hydrogen-made technique

5) Biology hydrogen-made technique from industry organism waste water

6) Demonstration project aiming at production of the biology hydrogen-made technique from organic waste water

7) High efficiency animalcule hydrogen-made system and craftwork

8) Solar energy light decomposition hydrogen-made technique

9) Research on the key technique of hydrogen-made from sulfureted hydrogen

2) **Post-Fossil Thematic Project on High-Temperature Fuel Cell Technology**

Project periods: 2001- 2005

Goals and Objectives to 2005:

Development of key component and integrated system for 50-kilowatt molten carbonate fuel cell and 5-kilowatt solid oxide fuel cell.

Subject arrangements:

1) 5-kilowatt flat type of middle temperature solid oxide fuel cell

2) 50-kilowatt natural gas-fueled molten carbonate fuel cell for generating electricity system

3) Research on direct methanol fuel cell with alkalescence hydronium exchange membrane

4) Research on systematic integration of key techniques for direct methanol micro- fuel cell

5) Research on key technique of direct methanol fuel cell

6) Manufacture of the direct methanol fuel cell

7) Manufacture of novel portable direct methanol fuel cell

3) **Target-Oriented Key Project on Electric Automobile**

Project periods: 2001- 2005

Goals and Objectives to 2005:

Breakthroughs (with proprietary intellectual property rights) in key unit technology, system integration technology and entire-car technology of electric automobile through the implementation of key projects , and to promote the formation of China's R&D system, mechanism and contingent for electric automobiles.

Two subprojects were approved under the priority: the development of entire-car technologies for fuel cell-powered automobile and hybrid power electric automobile, and the establishment of industrial technology bases for parts and components of electric automobiles. A series of supporting projects

were also established around the industrialization policy, hydrogen source infrastructure and patent protection measures. 88 projects were selected in 2001.

2.4 Strategic Projects

Strategic Study on China's Energy Sustainable Development

Project periods: March 2003- March 2004

Implementing Agency: Chinese Academy of Sciences (CAS)

Two pertinent subprojects were selected to be carried out.

1) Hydrogen and China's energy sustainable development (By the Institute of Engineering Thermophysics, CAS)

2) Fuel cell – its current status and future (By the Dalian Institute of Chemical Physics, CAS)

3. Current Demonstration Programs in China

The Government of China, through the Ministry of Science and Technology (MOST), is undertaking a project with the Global Environmental Facility (GEF) and the United Nations Development Program (UNDP). This US$ 32 million co-funded project is intended to catalyze the cost-reduction of fuel-cell buses (FCBs) for public transit applications in Chinese cities and stimulate technology transfer activities by supporting significant parallel demonstrations of FCBs and their hydrogen fueling infrastructures in Beijing and Shanghai. Its long-term objective is to reduce air pollution and GHG emissions through widespread commercial introduction of FCBs in urban areas of China.

The 5-year project will facilitate the commercial introduction of FCBs in China through three broad objectives: 1) determining the current technical and operational viability of FCBs and accumulating knowledge regarding their current and future potential cost and performance, 2) building the technical, operational, managerial and planning capacity for long-term use of FCBs, and 3) stimulating national-level awareness of FCBs and developing a coordinated strategy for the next phase of FCB commercialization in China.

Major activities of the project are to purchase and operate 12 Fuel Cell Buses and related hydrogen refueling stations (6 FCBs for each city) in Beijing and Shanghai. The project is divided into two parts. Part I will principally involve the purchase of the hydrogen fueling infrastructures and the first set of 6 FCBs. Part II will principally involve the purchase of the second set of 6 buses and operate them. Beijing 2008 Olympic Games and Shanghai 2010 World Expo will provide a good opportunity to show the FCBs to the world.

The project has been launched at an Inception Workshop in Beijing on March 27, 2003. After

rounds of discussion and study tours, the international procurement document was released on Dec 18, 2003. The bids are opened on March 18, 2004.

B. CHINA'S HYDROGEN FUTURE AND IMPLEMENTATION

In the 19th century, large-scale utilization of coal and steam engine vehicles triggered the industrial revolution in Europe; in the 20thcentury, utilization of oil and ICE vehicles promoted the fast economy development in America; now in the 21st century, the hydrogen economy based on utilization of hydrogen and fuel cell may be ideal option for human's sustainable development.

China will keep up with the global energy trend and strive to realize hydrogen economy in mid 21st century. To achieve the long-term goal, China will aim at series of technical breakthroughs and key industrial development, and boost the development of hydrogen and fuel cell in phases as follow.

-2008 Establishment of technical platform for PEM fuel cell and relevant vehicle power system, maturing of core technologies through technical development and commercial demonstration;

-2015 Market entry of hydrogen-fueled dynamic system for PEM-FC vehicles, which is cost competent to conventional system in mainstream application;

-2020 Large-scale industrial use of hydrogen in more than 10 key cities and several major fields, commercial demonstration of novel hydrogen production and storage technology;

-2040 Establishment of national hydrogen infrastructure based on ultra-large-scale hydrogen production technology featured with multi-feedstock and zero carbon dioxide emission, market spread of fuel cell vehicle systems.

C. RECOMMENDATIONS FOR FUTURE R&D

1 Capability building

Education and training, information and personnel exchange, program plan and project management, etc.

2 Hydrogen standards and codes

Filling station, storage, performance test

3 Hydrogen production from carbon-containing material

Coal (biomass, waste) –based hydrogen production technology with CO_2 sequestration-ready

D. EXPECTATIONS FROM THE IPHE

China's effort on hydrogen and fuel cell technologies has been significant taking the account of her GDP power. However, compared to government funding efforts in the USA, Canada, Japan or Europe,

the spending on hydrogen and fuel cells in China is generally lower. From the point of view, China welcomes any type of cooperation in fields of standard and code, stratagem study, fundamental research (especially direct coal-to-hydrogen process), and demonstration. Only through close cooperation can we reduce national financial demand, repeated development and research risk. In this context, we expect that IPHE become one of the platforms for the international cooperation in this area.