Hydrogen Energy Vision and Technology Roadmap Report for China

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Progress

- The Renewable Energy Law has been promulgated on Feb. 28, 2005. It will come into force on Jan. 1, 2006.
- The China national medium and long term S&T development plan takes the hydrogen and fuel cell technology as one of its impotant thematic priorities.
- Fuel cell buses and passenger cars have been developed sucessfully by Chinese reserch institutes and commpanies. One of the fuel cell bus has completed a 4000 km long trial running.

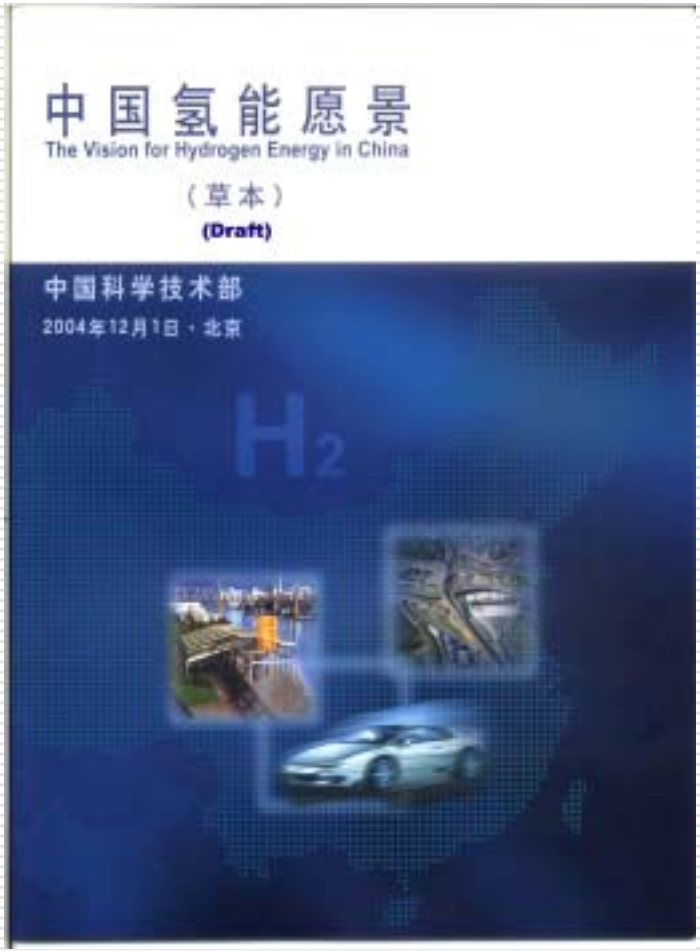
Progress

- Demonstration projects of hydrogen production and refueling station for fuel cell bus are already on agenda, and a hydrogen park is planed to build in Beijing.
- Progress has also been made in high temperature fuel cells, biomass hydrogen production and solid state hydrogen storage.
- National standards are being established for PSA hydrogen purification, water electrolysis, hydrogen fueling station design and fuel cells.
- China has been involved in international cooperation on hydrogen energy development with the United States, the European Union, Canada, Italy, IPHE, and other international organizations.
- The 2nd international hydrogen energy forum and the 2nd steering committee meeting of IPHE were successfully held in Beijing last year.

Vision

On May 23, 2004, a workshop on China Hydrogen Vision was held in Beijing. The participants included 54 Chinese experts and 9 U.S. experts representing government, industry and research institutions.

Vision



- Executive Summary
- Introduction
- Overview of HE Opportunities in China
- Factors Affecting the Development of HE in China
- The Vision for HE in China
- The Transition to the HE in China
- Conclusion

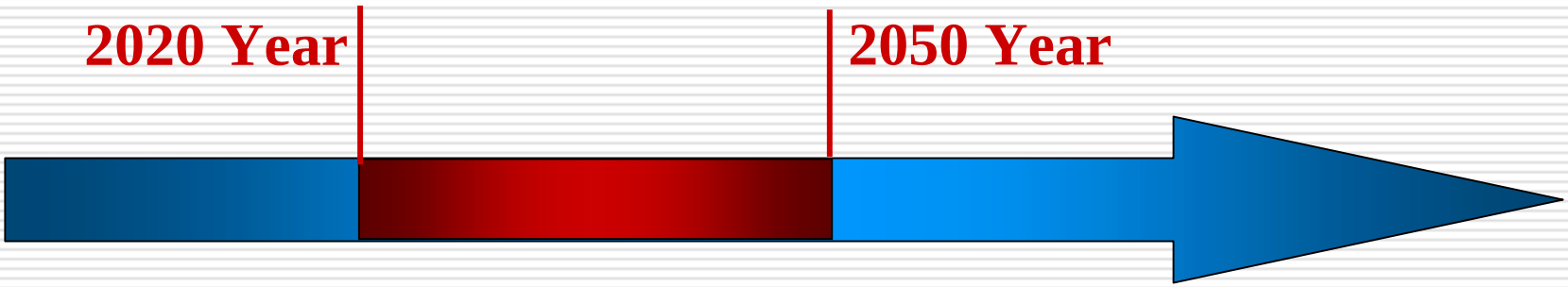
Vision

Main Features of Hydrogen Economy in China

Transportation	Electric Power	Infrastructure
●Hydrogen energy vehicles will develop in harmony with economic growth. ●Public transportation is expected to lead the transportation sector in use and acceptance; extensive use of hydrogen in urban public transportation. ●Use in cars, trucks and other vehicles. ●Both fuel cells and hydrogen engines will be used.	●Hydrogen-based electric power will be for mobile applications and distributed energy systems. ●Some use of fuel cells in remote areas for distributed power and heat supply, with hydrogen produced by renewable technologies.	●Developed according to market demands. ●Integration and coordination of central and local government policies will be key to hydrogen development. ●High costs and risks dictate co-development with traditional energy infrastructure.

Vision

Timetable of transition to the hydrogen economy in China



Vision

Phase 1: R&D and Demonstration (to 2020)

- With strong government support and international collaborations, China's hydrogen focus is on research, development, and demonstrations.
- Demonstration running of fuel cell buses in Beijing and Shanghai.
- Before 2020, hydrogen-based electric power and small scale back-up power generation units will enter into the market.

Vision

Phase 2: Market Entry (2020-2050)

Market entry phase depends on desires of consumers, presence of favorable energy and environmental policies, and costs and performance of hydrogen energy relative to other forms of energy.

Vision

Phase 2: Market Entry (2020-2050)

- The public will begin to gain access to economically competitive fuel cell vehicles in 2030.
- After 2020, limited pipeline systems will augment, and extending the reach of hydrogen to a wider area.
- Before 2050, hydrogen will be used in distributed power plants.

Vision

Phase 3: Hydrogen Economy (beyond 2050)

Hydrogen energy becomes competitive with other forms of energy and generally accepted by the public. China's hydrogen infrastructure co-exists with conventional and other sustainable energy systems.

Vision

Phase 3: Hydrogen Economy (beyond 2050)

- **Chinese transportations sector will greatly rely on hydrogen as a major energy source.**
- **Use of hydrogen in the electric power sector is likely to accelerate, provided it is supported by government policies and can compete economically.**
- **Hydrogen stations and regional pipelines will spread across China.**

Roadmap

From Jan.18 to 19, 2005, a workshop on Hydrogen Energy Technology Roadmap was held in Beijing. The main purpose is to identify:

technology challenges	**technology goals**
actions and priorities	**technology pathways**

Roadmap

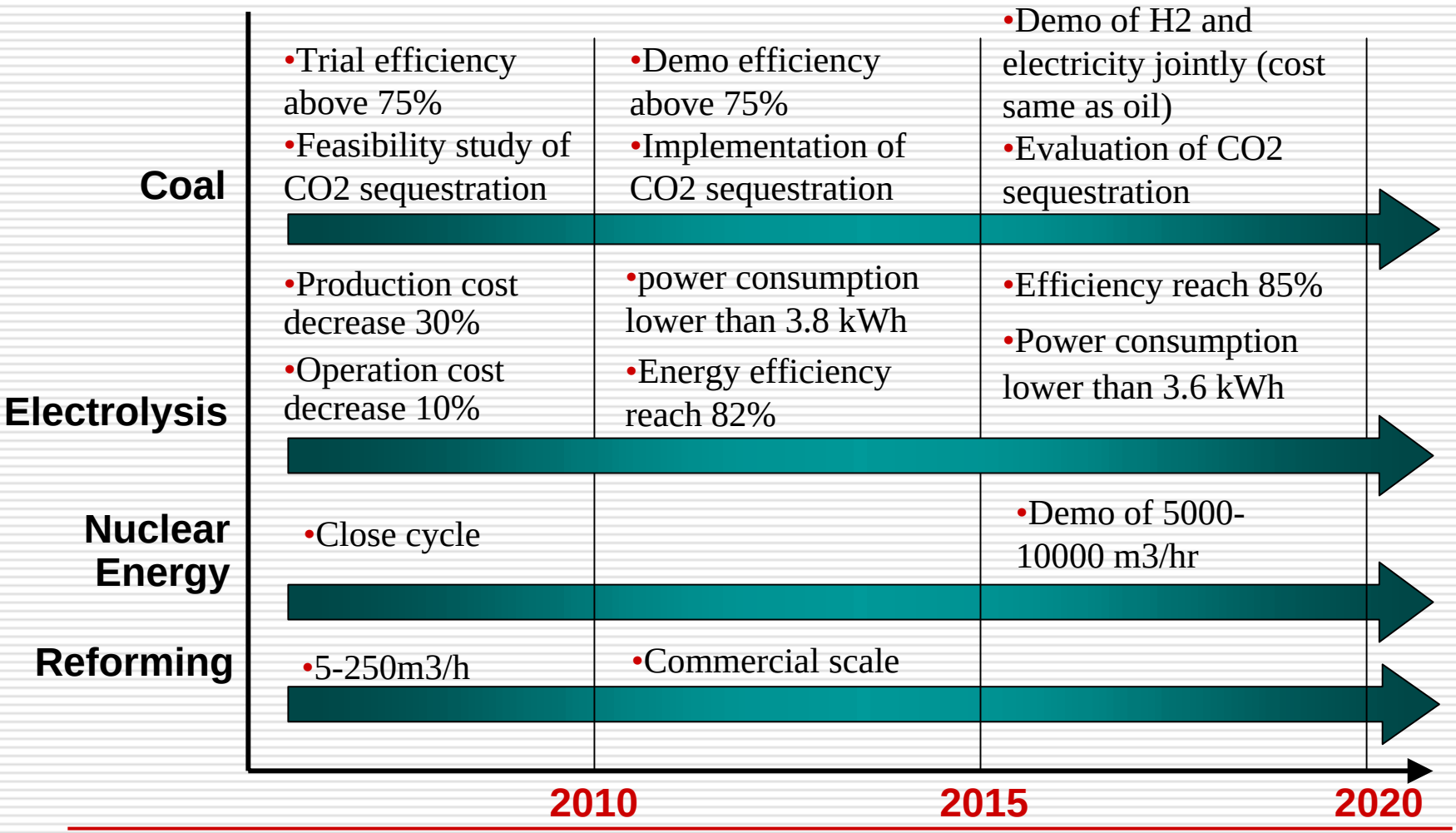
5 breakout discussion:

- Production
- Storage
- Delivery
- Conversion
- Standards & codes

Objectives + Challenges + Actions

Roadmap

Production-Objectives



Roadmap

Production-Challenges

- Lack of large scale, high efficiency and low cost process and technology.
- Technology breakthrough is required for hydrogen production from coal as well as carbon capture and sequestration techniques in the long term.
- Electrolysis technology is too costly and energy inefficient
- Biomass feedstocks are dispersed and expensive to be converted into H2.
- Solar and wind electric power costs too high.
- Lack of cost effective thermo-chemical techniques.

Implementation

Production-Actions

- ✓ Analysis and evaluation of various H2 production systems and their full cycle life.
- ✓ Coal: new technique development integrating gasification, purification, exchange and carbon capture.
- ✓ Biomass: set up thermo-chemical and bio H2 production demo engineering
- ✓ Nuclear energy: set up experimental device for H2 production by thermo-chemical technique and high temperature electrolysis equipment.
- ✓ Solar energy: develop water decomposition H2 production by photo catalyzing
- ✓ Electrolysis technique: devote to high voltage electrolysis tank design and process development, develop high temperature electrolysis equipment and coupling of heat source.

Roadmap

Objectives-storage

Parameters	2010	2015	2020
Gravimetric storage capacity (Wt%)	4.5-6	7-8	9
Volumetric storage capacity (kgH2/m3)	35-40	45-50	70-80
Cost (RMB/kgH2)	5000	2000	1000
Operation Temperature (C)	-20/50	-30/50	-40/60
Cycle life (times)	500	1000	1500
Fuel filling rate (kgH2/min.)	0.5	1.5	2
H2 loss ((g/hr)/kg H2)	1	0.1	0.05
Toxicity	Meet or exceed the application standards		
Safety	Meet or exceed the application standards		

Implementation

Challenges-storage

- Hydrogen storage density too low and cost too high in mobile application.
- Lack of public accepted and accurate testing methods and standards.
- Lack of unified and strict evaluation methods on safety.
- Mechanism unclear about the new solid hydrogen storage materials.
- Hydriding and dehydriding conditions too rigorous and speed too slow.

Implementation

Actions-storage

- ✓ Integrate the hydrogen storage with other links of the system, to fully display the technology development level of hydrogen energy including hydrogen storage.
- ✓ Establish independent testing platform, testing standards and methods.
- ✓ Strengthen fundamental research, explore the new series of hydrogen storage materials, and assess the application perspective.
- ✓ Analyze the energy efficiency of the full cycle life and the effect on environment.

Roadmap

Objectives-delivery

- Develop 30-70Mpa H2 compressing tech.
- Strengthen international cooperation in terms of liquid hydrogen
- Develop hydrogen delivery equipment, standards and codes

- Set up 5 mobile or fixed refueling stations
- Completion of evaluation of hydrogen delivery by pipeline, testing in the demo refueling stations
- Develop 70Mpa hydrogen compressor tech.
- Develop hydrogen delivery device with capacity of 6wt% and 40Kg/m3
- Carry out training

- Extension of refueling demo project
- Hydrogen delivery by using the existing pipelines (2025)
- Implementation of the standards and codes

2010 2015 2020

Implementation

Challenges-delivery

- Necessary to familiarize and develop hydrogen delivery infrastructure and lower costs including compressor, pipeline, liquid hydrogen, hydride, mobile refueling station and fixed refueling station.
- Lack of hydrogen delivery equipment and safety standards.
- Lack of technology development and infrastructure standards.

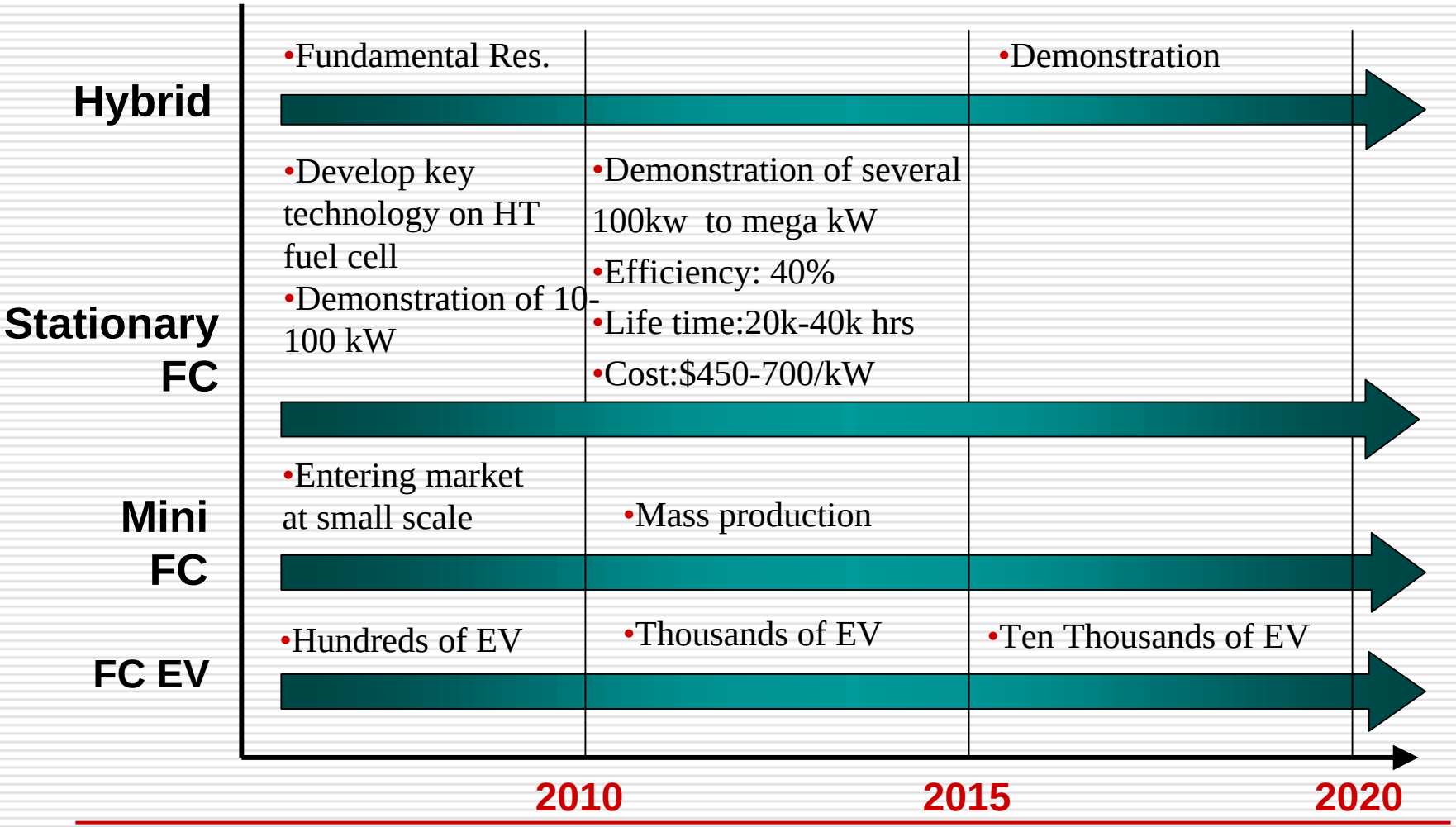
Implementation

Actions-delivery

- ✓Identify regional hydrogen delivery network, cooperate between regions, implement hydrogen delivery project and establish demo.
- ✓Cost analysis on full cycle life of delivery system: alternative fuels, maintenance of existing facilities, feasibility study on existing pipeline used for hydrogen delivery.
- ✓Develop R&D project on advanced hydrogen delivery.
- ✓Develop key technologies: refueling device, centralized and distributed delivery system, and devices for delivery system;
- ✓Establish certification agent

Roadmap

Objectives-conversion



Implementation

Actions-conversion

- ✓ Strengthen fundamental and application research, lower cost and localization of key materials for fuel cells.
- ✓ Government-industry R&D partnership to accelerate industrialization of FC and improve hydrogen ICE designs to lower costs and improve performance.
- ✓ With government support, industry led effort to demonstrate fuel cells in both stationary and mobile applications as well as FC/turbines power system.

Implementation

Challenges-conversion

- High costs of manufacturing and materials for all types of fuel cells, lack of fundamental research and information about performance, reliability and durability, as well as high specific energy hydrogen source.
- ICE technologies: lack of fundamental research on hydrogen engine and fuel cell/steam turbine (gas turbine) joint power generation system.
- Lack of H2 fueling infrastructure

Roadmap

Objectives-standards & codes

- 2006: integrate the existing codes and standards to propose the Chinese hydrogen codes and standards system;
- 2008: publish the hydrogen safety technology manuals;
- participate in ISO for the standards development on hydrogen refueling and storage;
- Support and facilitate the adoption of a Global Technical Regulation (GTR) for hydrogen fuel cell vehicles

Implementation

Challenges-standards & codes

- Public awareness on hydrogen safety.
- Lack of technical data to develop hydrogen standards.
- Insufficient share of information, experience and data.
- Lack of hydrogen standards and codes system.

Implementation

Actions-standards & codes

- ✓ Strengthen cooperation and exchange with international organization, work with industry to develop new safety codes and standards for hydrogen and fuel cells.
- ✓ Identify critical gaps between domestic and foreign codes and standards, recommend corrective actions based on the characteristics in China.
- ✓ Strengthen information exchange, training and public education on safety codes and standards.

Thank you!