Energy Policy Trends Toward the Hydrogen Society and Future Perspectives

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I. Introduction

There is glowing tendency for the hydrogen society in the future in order to substitute for petroleum among the developed countries. In theory, hydrogen has the potential to solve major energy challenges that confront the World today.

In the United States, approximately 95 percent of hydrogen is currently produced via steam reforming. Steam reforming is a thermal process, typically carried out over a nickel-based catalyst, that involves reacting natural gas or other light hydrocarbons with steam. The current hydrogen industry in the U.S.A is not focused on the production or use of hydrogen as an energy carrier or a fuel for energy generation. Rather, the nine million tons of hydrogen produced each year are used mainly for chemical, petroleum refining, metal, and electronics. United States had initiated several hydrogen laws from 1990 such as Matsunaga Hydrogen Research and Development, Hydrogen Future Act. .And in 2003, Bush administration is willing to make Energy Policy Act.

<Table 1> Hydrogen Development Program in Selected Developed Countries

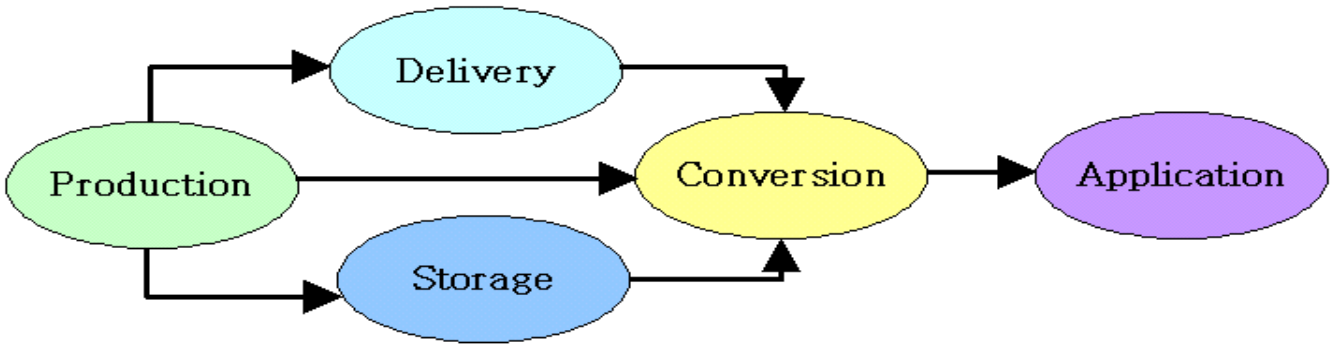
	U.S.A	Japan	Germany
Program	-Vision 21 Program (Hydrogen Future Act) -Freedom car and Fuel Initiative	-WE-NET Program(93-02) -core technology Project	-German Hydrogen Project
Organization	DOE	NEDO	DOE
Investment	-from 1993, 20 million dollars/year -1.7 billion dollars until year 2007	-during 1993-2002 about 20 billion yean/year	-31million DM

Automobile industries are the main field of hydrogen energy use market. According to the Daimler

Chrysler, during the 2005-2010, 50,000 cars will be supplied with fuel cell and in the 2030's 50 million cars will be produced in every year, which is around 10% of total automobiles in that period. California government is planning g to provide 1% of automobiles with fuel cell car until 2005 according to the ZEV (zero emission vehicle) regulation. In summary, world's hydrogen economic is moving with a rather full of continuous support from the domestic demand and environmental reasons. If we solve the oil shortage problems as well as environmental degradation, we will have strong and continuous economic growth in the future. For this reason, hydrogen energy is detrimental for the Korea and the World.

II. Key Issues in the Hydrogen Energy Chain

Many countries are focusing on the research and development efforts on integrating current programs regarding hydrogen production, delivery, storage, conversion and utilization such as fuel cells.



In production side, an estimated 40 million tons of hydrogen will be required annually to fuel about 100 million fuel-cell powered cars, or to provide electricity to about 25 million homes in the U.S.A. There are some obstacles for the production of hydrogen production. First, cost is relatively higher than the conventional fuels and demand is quite low at current. Global warming will occur from the current technology.

<Table 2> Various of Production Methods

100,000 neighborhood electrolyzers	4 million tons
15,000 small reformers in refueling stations	8 million tons
30 coal/biomass gasification plants	8 million tons
10 nuclear water splitting plants	4 million tons
7 large oil and gas SMR/gasification refineries	16 million tons

References: DOE, "A Vision of America's Transition to a Hydrogen Economy - to 2030 and Beyond ," Paper discussed in the National Hydrogen Energy Roadmap workshop, Washington D.C 2002.4

For the delivery system, an economic strategy is required for the transition to a hydrogen delivery system. Full life-cycle costing has not been applied to delivery alternatives. Hydrogen delivery technologies cost more than conventional fuel delivery. Current dispensing systems are inconvenient and expensive.

In the U.S.A, Air Products and Chemicals Inc., Air Liquefied Group, Praxair Inc., and the BOC Group are major producers of merchant hydrogen. Together these companies operate about 80 plants in the United States that are dedicated. Currently hydrogen pipelines are used in only a few areas of the United States. Air Liquide Group, Air products and Chemicals Inc. and Praxair Inc. operate hydrogen pipelines in Texas, Louisiana, California, and Indiana. Hydrogen is also distributed via cylinders and tube trailers that are transported by trucks, railcar, and barges. Eleven plants have the capacity to produce 283 tons of liquid per day in North America. The factors affecting hydrogen's potential are rooted in these issues..

<Table 3> Top Priority for Hydrogen Conversion

Fuel cell	Combustion	Demonstrations	Codes and Standards	Analysis
Expanded Fundamental Research program in Advanced materials, Interfaces and Electrochemistry Lower cost designs Enhanced Manufacturing Capabilities Lower cost balance-Of-plant components	Higher efficiency and Lower cost engine and Turbine designs Instrumentation and Controls optimized for Hydrogen combustion Parameters Analysis of hydrogen-Natural gas blending For lower emissions	Expand number of Sites to include wider range of technologies, applications, and environmental conditions Expand information dissemination Expand validation of hydrogen combustion	Product safety standards. Building codes(fire, safety, plumbing) Vehicle standards Utility interconnection standards	More credible Market analysis Catalog existing Research results and disseminate widely Software tools to simulate collisions to enhance fuel cell engine designs

References: DOE, "National Hydrogen Energy Roadmap," Paper discued in the National Hydrogen Energy Roadmap workshop, Washington D.C 2002.4

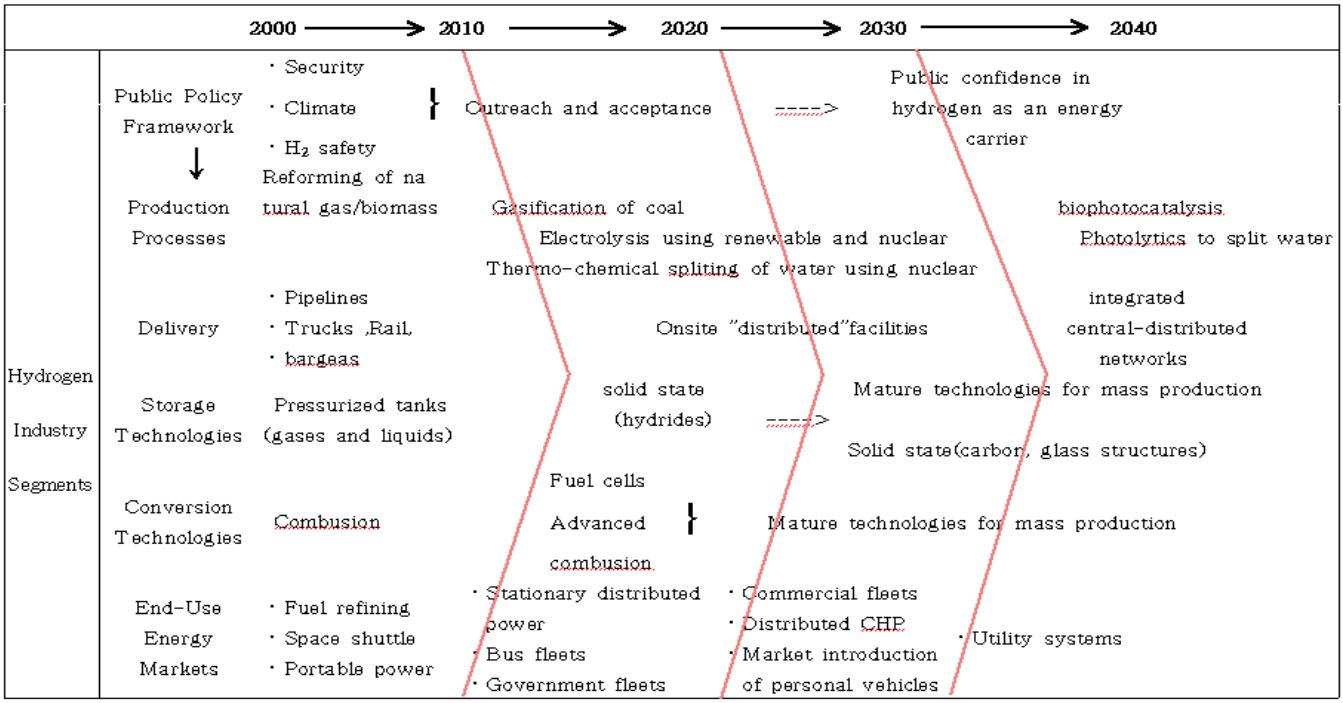
For storage issues current research and development efforts are insufficient and because of low demand cost is quite high. Regarding conversion, no single fuel cell technology has met all the basic criteria for

performance, durability, and cost. Fuel cells require enhanced materials, membranes, and catalysts to meet both engineering and cost criteria. Therefore, research is needed to fill in critical flame combustion. Market and institutional barriers hinder development of cost-competitive hydrogen conversion devices.(DOE, 2002) Application stage for transportation, stationary, and portable equipment require technological and engineering solutions.

III. Energy Policy in Developed Countries

In the U.S.A, hydrogen energy policy was derived by the several factors. Number one factor is linking to the national energy security issues. America's transportation sector relies exclusively on refined petroleum products; around 58% of the petroleum consumed in the United States is imported from outside, and that percentage is expected to rise steadily for the foreseeable future. Second reason is related to climate change problem. Although U.S.A had withdraw Kyoto Protocol, there is growing recognition that measures to reduce greenhouse gases are desperately needed, and many countries are adopting policies to accomplish that purposes.

<Figure 1.> Overview of the Transition to the Hydrogen Economy



References: DOE, "A Vision of America's Transition to a Hydrogen Economy – to 2030 and Beyond ," Paper discussed in the National Hydrogen Energy Roadmap workshop, Washington D.C 2002.4

Third factors is that developing countries and newly emerging countries like Korea, Brazil and Mexico are consuming lots of petroleum and energy supplies would have to increase enormously to meet demand. In the future, so they can make so called, Asian Premium.

Some automakers estimate that hydrogen based fuel automobiles would have to be available in at least thirty percent of the nation's fueling stations in year Private investment in such an transportation infrastructure is growing with supportive public policies in the U.S.A. Typical example is Freedom CAR(cooperate Automobile Research) Project. Many significant technology developments will have to occur in the automobile industry

In summary, America's hydrogen energy policy will be focus on 1) the state-of the-art energy production and distribution system 2) environmental protection, eco-product, and new technology, 3) energy security. In order to doing these , they are suggesting some ways : electricity connection , PUCHA(Public Utility Chart), energy efficiency, renewable energy, and bio fuel and ethanol. In Michigan State, 500 acres of land will be assigned for the renewable energy research complex.

<Table 4> 2010 Freedom CAR Technology Specific Goals

	Efficiency	Power	Energy	Cost**	Life	Weight
Fuel Cell System	60%(Hydrogen) 45%(W/reformer)	325 W/kg 220 W/L		$45/kW(2010) $30/kW(2015)		
Hydrogen Fuel/Storage/Infrastructure	70% well to pump		2 kW-h/kg 1.1 kW-h/L	$5/kW-h $1.25/gal(gas eqiv.)		
Electric ProPulsion		≥ 55kW 18s 30kW cont.		$12/kW peak	15 years	
Electric Energy Storage		25kW 18s	300W-h	$20/kW	15 years	
Material						50% less
Engine Powertrain System*	45% peak			$30/kW	15 years	

note: * Meets or exceeds emissions standards. ** Cost references based on CY2001 dollar values.

References: Sig Gronich," Hydrogen Program goals and outcomes," presented at 2000 hydrogen program annual meeting, 2000

Under the Sunshine project, and new sunshine project, Japan is trying to research on the critical technology for the hydrogen energy within the WE-Net program. Until 2020, 5million fuel cell based car will be operated and at the same time, try to make a fuel cell battery generating up to 10 million Kw of electric generating capacity. From 1997 Germany have invested 25 to 30 million German Marks in Munghen international airport..

<Table 5> Summary of Hydrogen Energy Policy

SCAQMD Pilot Project (U.S.A)	JAFC (Japan)	EU CUTE, ECTOS
▶ H_2 Fuel Cells & Infra-structure Tech. Develop. Freedom Car & Fuel ▶ Southern CA 20 fuel cell Bus and cars ▶ Liquefied H. storage NG, Bio Mass ▶ Chicago, Michigan, Nevada, Pen Sta. , Arizona	▶ **WE-NET Project (2002 end.) Tokyo, Yokohama, etc 10 Storage facility** ▶ **34 fuel cell car** ▶ **Naphtha, gasoline , LPG, NG etc – fuel combustion** ▶ **waste heat gas, mobile tube transportation**	► 10 cities ► 30 fuel cell bus ► use renewable energy ► electric use ► NG (3개) ► Liquefied Gas (2) – storage

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