Recent developmental status and prospects of hydrogen refueling stations

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Abstract

Hydrogen refueling infrastructure to support the introduction of fuel cell and other hydrogen(and hydrogen mixture)-fueled vehicles is seen as one of the key factors for the transition to the hydrogen economy. Basically, hydrogen station can be configured by any combination of six modules : hydrogen generator, purifier, compression, storage, dispenser and power generator. And there can be several ways in hydrogen delivery for use at refueling stations.

In the early demonstration phase, the use of distributed hydrogen refueling system(cryogenic liquid hydrogen, compressed hydrogen, reforming of hydrocarbon feedstocks such as natural, gas, LPG and naphtha, electrolysis of water) may be a intermediate pathways to infrastructure development with future development of hydrogen pipeline delivery. The understanding of the implications of each system as well as comparisons between the choices of generation methods for use is essential in developing the refueling infrastructure.

In this session, we present the recent developmental status and prospects of hydrogen refueling stations in advanced countries such as America, Japan, and Europe. Especially, national demonstration programs to promote early introduction of hydrogen fueled vehicles are reviewed.

Keywords : hydrogen refueling station, developmental status, national program

Introduction

Within the next decade, concern about global climate changes will become greater, forcing society to move toward energy sources that will minimize the emission of greenhouse gases such as carbon dioxide and methane having detrimental effects on the global climate. Also, because of a potential major impact on our future energy supply, cost-effective production of hydrogen from sustainable energy(mid- and long-term) as well as from fossil fuels(short term) with carbon sequestration has been a goal of each country to achieve energy independence and environmental security.

Early establishment of a hydrogen-based fueling infrastructure depends on hydrogen vehicle (fuel cell or engine-based demand) and fueling infrastructure (supply) advancements. There can be two broad applicable process for hydrogen production : hydrocarbon based (steam reforming, partial oxidation, and autothermal reforming(combination of steam reforming and partial oxidation) and non-hydrocarbon based processes(water electrolysis and thermochemical water decomposition).

In this review, we present the recent developmental status and prospects of hydrogen refueling stations in advanced countries such as America, Japan, and Europe. Especially, national demonstration programs to promote early introduction of hydrogen fueled vehicles are presented.

National Programs

CUTE(Clean Urban Transportation for Europe)

9 European cities : Amsterdam(Netherlands), Barcelona(Spain), Hamburg(Germany), London(United Kingdom), Luxemburg, Madrid(Spain), Porto(Portugal), Stockholm(Sweden) and Stuttgart(Germany), have committed to the CUTE demonstration project, in introducing fuelcell powered buses with hydrogen as fuel into their public transport system. These 9 cities are convinced that the combination of hydrogen and fuel cells will lead towards the most sustainable urban transport system.

Amsterdam : Using renewable energy, which together with water is the basis for hydrogen production on-site, a pressurized electrolyser produces high quality hydrogen.

Barcelona : hydrogen is produced by water electrolysis. Electrical power is partly obtained by means of solar energy.

Hamburg : A pressurized electrolyser produces high quality hydrogen. Wind power is connected to the grid.

London : liquid hydrogen is transported directly to the site through a third party supplier.

Luxemburg : trailer is connected to the filling station.

Madrid : hydrogen is produced on-site through a compact methane steam reformer with a rated capacity slightly below the maximum demand. Complementary and back-up supply are provided by trucked hydrogen from a central production plant, mainly as a by-product from industrial processes

Porto : on-site steam reformer based on natural gas as fuel is chosen.

Stockholm : hydrogen is produced using water electrolysis, with eco-labelled electricity from hydrogpower.

Stuttgart : steam reformer is designed for small production of hydrogen. In case the reformer is not in operation, there is a connection available for external hydrogen supplies by trailer.

WE-NET(world energy network)

This project aims at establishing technologies to construct a hydrogen energy network based on renewable energy sources and administrated by NEDO under the METI of Japan. In the 2nd stage(1999-2002) of R&D of WE-NET program, hydrogen filling stations with three different hydrogen sources(natural gas steam reforming, water electrolysis, and by-product hydrogen) have been developed. The former two processes are called on-site system . On the other hand, in by-product hydrogen system, hydrogen is carried from outside into stations and it is referred to as an off-site system

JHFC(Japan Hydrogen & Fuel Cell Demonstration Program)

This project is intended for the establishment of technologies for 1) constructing the hydrogen filling facilities for fuel cell vehicles(FCV), 2) the data collection for preparing standards, regulations, and criteria related to energy-saving effect(reduction of CO2m efficiency) and safety and 3) clarification of challenges for improving cost effectiveness and promoting widespread use of FCVs during the periods of FY2002-2004. Five hydrogen refueling stations from various sources(desulfurized gasoline, naphtha, liquid hydrogen, LPG, methanol) has been constructed. And a station from WE-NET project(by-product hydrogen) is joined in this program.

US DOE hydrogen program

Hydrogen research at the U.S Department of Energy(DOE) is being led by the Office of Energy Efficiency and Renewable Energy(EERE). Other DOE Office carrying out portions of the Initiative are Fossil Energy, Nuclear Energy, and Science. Within EERE, hydrogen and fuel cell technologies are being managed by the Office of Hydrogen, Fuel Cells, and Infrastructure Technologies. Hybrid and other advanced vehicle technologies are being developed within the Office of FreedomCAR and Vehicle Technologies.

The Hydrogen, Fuel Cells and Infrastructure Technologies Program funds research, development, and validation activities linked to public-private partnerships. And the hydrogen production and delivery technologies solicitation incluses the following topics : biomass gasification and pyrolysis, photolytic processes, distributed natural gas reforming technologies, separtion and purification technologies, advanced slectrolysis systems, high temperature thermochemical water splitting, hydrogen production infrastructure analysis and advanced hydrogen delivery technologies. This program responds to recommendations in the President's National Energy Policy, the DOE Strategic Plan, and the National Hydrogen Energy Vision and Roadmap.

Hydrogen production goal is to research and develop low cost, highly efficient hydrogen production technologies from diverse domestic sources, including fossil,

nuclear, and renewable sources. Also, the main objectives for the delivery of hydrogen are to define a cost effective and energy efficient fuel delivery infrastructure for the introduction and long-term use of hydrogen for transportation and stationary power by 2006 and to develop enabling technologies to reduce the cost of hydrogen fuel delivery from the point of production to the point of use in vehicles or stationary power units to <$1.00/kg in total by 2015.

References

1. http://www.fuel-cell-bus-club.com
2. FY 2003 Progress report for hydrogen, fuel cells, and infrastructure technologies program, EERRE, office of hydrogen, fuel cells, and infrastructure technologies, Oct. 2003
3. http://www.enaa.or.jp/WE-NET/
4. http://www.hydrogen.org
5. http://www.eren.doe.gov/hydrogen
6. http://www.nrel.gov
7. National hydrogen roadmap, based on the results of the national hydrogen energy roadmap workshop, Washington, DC, April 2-3, 2002, US DOE