

The status of the Technical Development of Hydrogen Refueling Station in Korea

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Introduction

In recent years, serious environmental concerns regarding pollution have emerged, while competition for energy resources has intensified. To solve these problems, the introduction of a fuel cell system to promote the hydrogen economy is important. Hydrogen has attracted as an ideal energy resources and is expected to be applied in a fuel cell. Especially hydrogen refueling station as a hydrogen supply system to hydrogen fuel cell vehicles is an important infrastructure to be necessary to carry out the hydrogen economy.

The demonstration and monitoring projects of hydrogen fuel cell vehicles and hydrogen infrastructure have successfully been accomplished the world-wide various nations using the hydrogen as the environment-friendly fuel of vehicles. The most important thing for the commercial business of hydrogen fuel cell vehicles is a hydrogen infrastructure. The number of operating hydrogen refueling stations in the respective countries for dissemination of the hydrogen fuel cell vehicles is very insufficiency. At the start of dissemination of hydrogen fuel cell vehicles, the number of hydrogen refueling stations is significant.

Well-to-wheel efficiency analysis shows that the energy- efficiency for hydrogen fuel cell vehicles is the most energy-efficiency among internal combustion engine cars such as gasoline and diesel, plug-in hybrids and electric vehicles over broader ranges of primary energy sources. Nowadays automobile companies such as Hyundai and Toyota etc. have signaled that they are ready to mass-produce hydrogen fuel cell vehicles. Many auto-car producers announced that hydrogen fuel cell vehicles are technologically ready and can be produced at much lower cost for an early commercial market over the few years. Toyota automobile company produces a sales strategy to sell hydrogen fuel cell vehicles over the next year.

In Korea, demonstration and monitoring projects of hydrogen fuel cell vehicles have

also been performed for the technical development of hydrogen fuel cell vehicles and hydrogen refueling stations as hydrogen infrastructures and for the preparation of the dissemination of hydrogen fuel cell vehicles.

This study is shown that the demonstration and monitoring projects are contributed for the technical development of hydrogen fuel cell vehicles and hydrogen refueling stations and promote to be constructed the hydrogen refueling stations for the dissemination of hydrogen fuel cell vehicles in Korea. And in this study, the demonstration and monitoring projects are suggested the best solution required for the dissemination of hydrogen fuel cell vehicles from hydrogen infrastructure viewpoint.

The Demonstration and monitoring projects in Korea

Table 1 is shown that 4 demonstration and monitoring projects of fuel cell vehicles and hydrogen refueling stations have been accomplished in Korea until now. The first demonstration project of hydrogen refueling stations was accomplished from September 2004 to August 2009. The purpose of this project is to construct and to operate 3 hydrogen refueling stations that use the different materials such as natural gas, LPG and naphtha to make hydrogen. These stations are on-site type stations. The results of this project are that 3 hydrogen stations using different materials were constructed and the fuel cell vehicles were fuelled hydrogen in each station.

The second project of fuel cell vehicles was accomplished from August 2006 to December 2010. The purpose of this project is to construct 4 hydrogen refueling stations and to drive 33 fuel cell vehicles and 4 FC buses that are produced by Hyundai motors co. all over the country. The results of this project are that 4 hydrogen stations that are 2 off-site types and 2 on-site types using electrolysis were constructed and 2 other hydrogen stations that are KOGAS' and GS Caltex' are involved in order to supply hydrogen to FCVs. And the fuel cell vehicles were fuelled hydrogen in each station.

The third project of fuel cell vehicles was accomplished from December 2009 to May 2013. The purpose of this project is to drive 100 fuel cell vehicles that are produced by Hyundai motors co. in 2 cities such as Seoul and Ulsan city. In this project, 2 other hydrogen stations that are Dongdeok Gas' and GS Caltex' are involved in order to supply hydrogen to FCVs.

The fourth project of fuel cell vehicles was accomplished from December 2011 to June 2014. The purpose of this project is to drive 2 FC buses that are produced by Hyundai motors co. in Incheon airport as a shuttle bus. KOGAS hydrogen station is participated in this project in order to supply hydrogen to FC buses.

Table 1. Demonstration and monitoring projects in Korea

<ul style="list-style-type: none">◆ Demonstration of Hydrogen station(2004.9 ~ 2009.8)<ul style="list-style-type: none">◆ Company : Hyundai motors, KOGAS, SK, GS Caltex etc.◆ Purpose : to construct and operate hydrogen stations ◆ Monitoring project of HFCVs(2006.8 ~ 2010.12.)<ul style="list-style-type: none">◆ Company : Hyundai motors, KOGAS, GS Caltex , Dongdeok Gas, SPG chemical◆ Purpose : to construct 4 hydrogen stations , to drive 30 FCVs and 4 FC buses ◆ Social Demonstration of HFCVs(2009.12 ~ 2013.5)<ul style="list-style-type: none">◆ Company : Hyundai motors, GS Caltex , Dongdeok Gas◆ Purpose : to drive 100 FCVs ◆ Demonstration of Hydrogen FC Bus(2011.12 ~ 2014.6)<ul style="list-style-type: none">◆ Company : Hyundai motors, KOGAS◆ Purpose : to drive 2 FC buses in Incheon airport

Figure 1 shows the state of hydrogen refueling stations in Korea. Until now hydrogen refueling stations of 16 places were constructed, the stations of 1 place are constructing. 16 hydrogen refueling stations have been constructed from 2001, 2 hydrogen refueling stations of all stations have been cancelled and 14 hydrogen refueling stations of all hydrogen stations have been operated and are operating. The 8 hydrogen refueling stations of all stations are off-site type and 8 hydrogen refueling stations of all stations are on-site type. 8 on-site type hydrogen stations consist of 5 reforming generator types and 3 electrolysis types. 5 reforming generator type hydrogen stations comprises 2 natural gas reforming generator types and 1 naphtha reforming type and 1 LPG reforming type and 1 land fill gas reforming type. Steam reforming of hydrocarbons is probably the most common and economical method for producing hydrogen in industrial scale. In particular natural gas is the most economical material.

Most of all hydrogen stations except 15th and 16th hydrogen station are supplied at 35MPa to FVHs. 15th and 16th hydrogen station are supplied 35MPa and 70MPa to FCVs.

If fuel cell vehicles are disseminated in Korea from 2015, few hydrogen stations are effectively used now. Because most of hydrogen refueling stations are located inside each companies and are not operated. So those hydrogen stations can't supply hydrogen to consumer' FCVs and we can't use there.

17th hydrogen station is constructing in Kwangju city. The station which is an off-site type station will be completed September 2014.

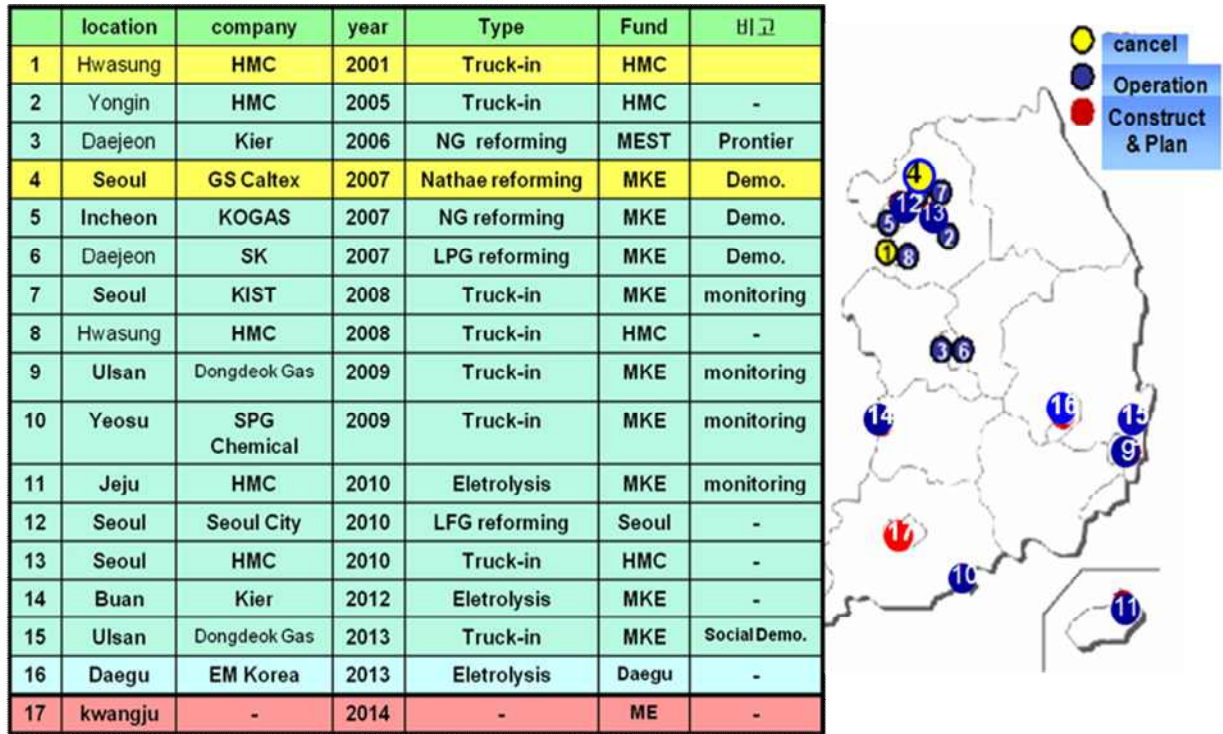


Figure 1. The state of hydrogen refueling stations in Korea.

Especially in the monitoring project, table 2 shows the states of fuel cell vehicles operation organization. The hydrogen fuel cell vehicles were driven over 20,000km and 2 years respectively. The results of this project are that the manufacturing technologies of fuel cell vehicles are verified up to 70% of localization. And the target of equivalent gasoline efficiency of a fuel cell vehicle is a 24 km/L but the real equivalent gasoline efficiency is a 27.2km/L. And the target of total mileage of 30 FCVs is 960,000km but the total mileage is 1,104,645km.

4 hydrogen stations are participated in this project to supply hydrogen into fuel cell vehicles. The weight of filling hydrogen for Dongdeok Gas' hydrogen station is 488kg from July 2009 to December 2010. And the weight of filling hydrogen for SPG Chemical' hydrogen station is 389kg from August 2009 to December 2010. The weight of filling hydrogen for KOGAS' hydrogen station is 401kg from April 2009 to December 2010. The weight of filling hydrogen for GS Caltex' hydrogen station is 900kg from January 2009 to December 2010. The total weight of filling hydrogen in this project is 2,278kg from April 2009 to December 2010.

Table 2. The states of fuel cell vehicles operation organization

		Vehicle Operation Organization
FC Car (30)	HMC (17)	1 st 4 Vehicles 2 nd 4 Vehicles 3 rd 9 Vehicles
	Others (11)	Seoul City : 2 Vehicles Younsei Univ. : 2 Vehicles KETEP : 1 Vehicle KIST : 1 Vehicle KATECH : 1 Vehicle KEMCO : 1 Vehicle KOGAS : 1 Vehicle Yeosu City : 1 Vehicle SPG Chemical : 1 Vehicle Ulsan City : 2 Vehicles
FC Bus (4)		Government Building Shuttle Bus

Figure 2 is shown that the hydrogen is charged into hydrogen fuel cell vehicles and buses in KOGAS hydrogen refueling station. We are charging hydrogen into hydrogen fuel cell vehicles and buses with and without communication method between vehicles and a dispenser in a station respectively. There are quantitative differences between dispenser measurements and real values in hydrogen charging without communication. The measuring values of dispenser are larger than real values in hydrogen charging with communication. The quantitative difference in communication fill is larger than that in non-communication fill.

The demonstration project of fuel cell buses has been accomplished in an Incheon airport parking area as a shuttle bus. Fuel cell buses are charging hydrogen in KOGAS hydrogen refueling station. The weight of filling hydrogen into hydrogen fuel cell bus is 3,983kg in this project. In this project, the catalysts of reformer and water shift reactor in the station are changed for improving the thermal efficiency of hydrogen generator. And the adsorbent of pressure swing adsorption in the station is also changed for improving the recovery rate of PSA.



Figure 2. Hydrogen charging in hydrogen fuel cell vehicle and bus

The plan of construction of hydrogen stations in Korea

Figure 3 is shown that the plan of construction of hydrogen refueling stations in Korea was announced by a government in December 2010. The target number of hydrogen refueling stations is 43 stations until 2015 and 168 stations to 2020. However the target stations weren't constructed now and can't be constructed for the initial dissemination of fuel cell vehicles until 2015.

Therefore the minimum number of hydrogen refueling stations for initial dissemination of fuel cell vehicles has to be constructed in a short space of time in Korea. Of course, dozens of hydrogen refueling stations can be constructed in several focus cities like Japan.

However we can't know the exact necessary number of hydrogen refueling stations for initial dissemination of fuel cell vehicles. So we need to know the necessary number and locations of hydrogen refueling stations all over the country when fuel cell vehicles are expected to spread over the whole country. And we need to know the information of distances between hydrogen stations and hydrogen production facilities. It is necessary to make a suitable construction plan of hydrogen refueling stations that should be constructed on each district using geographic information system.

Hence, the plan of construction of hydrogen refueling stations in shown figure 3 is changed for smooth dissemination of fuel cell vehicles at this point.

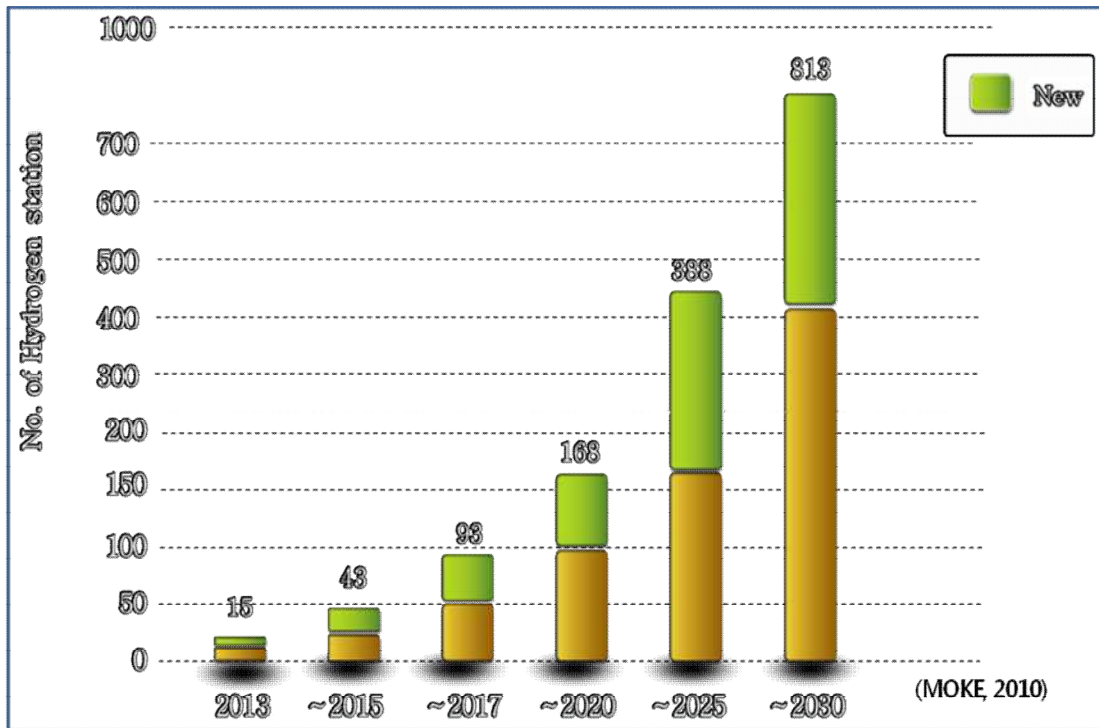


Figure 3. The plan of construction of hydrogen refueling stations in Korea.

Conclusions

The demonstration and monitoring projects have been performed for initial dissemination of hydrogen fuel cell vehicles since 2015 in Korea. Hyundai motor company announced to make the small plant for the manufacture of fuel cell vehicles in February 2013. The main equipments such as reformer, shift reactor, hydrogen high pressure compressor, hydrogen storage vessel and dispenser continuously have been developed for the durability, accuracy and safety of the station.

And in order to promote the dissemination of fuel cell vehicles since 2015, the deregulation of construction of station is established and the dissemination policy of government is setting up strongly.

So to speak the suitable construction plan of hydrogen refueling stations, initially an off-site type station is constructed and gradually an on-site type station is constructed.

It is easy and economical to construct an on-site type hydrogen refueling station using natural gas as raw materials in Korea.

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