ISSUE PAPER

Hydrogen Technology Options

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Hydrogen is a key technology solution to the climate change issues facing the world today. In order for the world to realize a clean energy future, hydrogen will need to play a significant role to decarbonize the energy sector. While hydrogen is currently largely dominated by uses in industry, such as oil refining, chemical production, and steel production, there are a number of power and energy applications for hydrogen as well.

Currently, the US is investigating a number of various hydrogen technology options including the production of hydrogen through alkaline, solid oxide, and PEM electrolyzers; storage and delivery of hydrogen through pipelines, compressed gas containers, and tanks; and the blending of hydrogen in natural gas pipelines. The blending of hydrogen in natural gas pipelines is an intermediary step that the US hopes to realize as a stepping-stone to creating demand for a hydrogen market, as currently, there is a large lack of hydrogen delivery infrastructure in the US. The use of natural gas pipelines can increase the demand for hydrogen without significant capital investment into dedicated hydrogen pipeline infrastructure. Areas of potential cooperation between the US and Korea for hydrogen research include electrolyzer technology R&D, hydrogen storage, and hydrogen infrastructure.

The U.S. DOE has made significant financial investments into developing hydrogen technology through R&D, but a majority of the work in hydrogen R&D currently takes place through competitive projects awarded through Funding Opportunity Announcements with academia and the private sector. Currently, the US DOE and national labs are focusing on the early stage R&D to find technical solutions to some of the barriers that have yet to been overcome. R&D efforts at DOE and National Labs are focused primarily on reducing the cost of hydrogen technologies and improving the performance of hydrogen technologies in three main areas: Fuel Cell R&D, Hydrogen Fuel R&D, and Hydrogen Infrastructure R&D.

Fuel Cell R&D is focused on early-stage R&D for transportation applications beyond light-duty passenger vehicles (i.e. heavy-duty trucks, marine, rail, air) through investigation of catalysts, membranes, electrodes, etc. Activities in 2020 under the Fuel Cell R&D are focused on cost reductions of catalysts and electrodes through the removal of platinum group metals and improving the performance of fuel cells to reach the target vehicle performance and cost metrics set out by DOE.

Hydrogen Fuel R&D is focused on early stage R&D to advance viable options for hydrogen production and storage. A key goal of this subprogram is to develop hydrogen production from domestic resources at a production cost of less than $2/gge, which is the target at which hydrogen fuel for fuel cell electric vehicles will be cost competitive with conventional fuels. Another goal for this subprogram in 2020 is to achieve a hydrogen storage energy density twice that of 700 bar energy density.

Hydrogen Infrastructure R&D is focused on early stage R&D efforts to support innovations to generate hydrogen as an energy carrier across multiple sectors. The R&D efforts conducted under this subprogram directly support the H2@Scale program at DOE. One significant objective under this program is to investigate innovations in hydrogen delivery technologies and stations components that can enable the hydrogen industry to reduce delivery costs to a cost-competitive rate of $2/gge by 2030 at high volumes. R&D efforts are focused on advanced characterization of hydrogen release behavior, safety, and materials compatibility R&D in order to find materials and technologies that can more efficiently and cost-effectively deliver hydrogen. Chemical carriers are also being investigated at DOE, but ammonia research is not a significant area of investigation under the chemical carriers R&D unlike many other countries.

KIER is also focusing efforts on hydrogen research under two research areas: Hydrogen R&D and Fuel Cell R&D. Under Hydrogen R&D, KIER is investigating hydrogen production and storage including hydrocarbon reforming, electrolysis, and system development. Fuel Cell R&D is focused on the development of core material technology to improve the performance and durability of fuel cell technologies while maintaining opportunities for technology integration. Three main R&D projects for KIER include electrolyzer innovation, P2G hydrogen production units, and chemical storage of hydrogen via ammonia.

KIER has been focused on cost reduction and performance improvement of alkaline electrolyzers. KIER found the ability to reduce the stack cost of these alkaline electrolyzers by increasing the operation's current density from 0.2-0.6 Amperes/cm2. Furthermore, KIER has identified opportunities to scale up the capacity from 10 kW to 100 kW.

KIER has also developed an on-site hydrogen production unit with a capacity of producing 500kg of hydrogen per day that can be supplied to commercial vehicle fueling stations. The hope of this project is to scale up to 2,000 kg/ day hydrogen production with the goal of commercializing this medium-sized hydrogen production unit within 10 years. The unit will be able to take a flexible feedstock including biogas and LPG.

The third area of KIER's interest in hydrogen technology R&D is through the delivery and storage of hydrogen via ammonia. Storage of hydrogen through ammonia has shown to have the highest gravimetric and volumetric density, with the capability of easily liquefying ammonia. Furthermore, KIER hopes to develop this technology as a means to utilize the world's already existing and well-developed ammonia infrastructure in order to minimize the cost and barrier for hydrogen to be traded internationally.

Of the many R&D areas between KIER and the US, it remains very clear that there is a shared interest in the cost reduction of hydrogen generation through electrolyzer technology. KIER has made innovations in the alkaline electrolyzer to improve the cost through altering operational current density, and the US is investigating methods to reduce cost through the removal of platinum group metals and other expensive elements. The US takes a technology neutral stance on their electrolyzer technology, so there can be significant opportunity for KIER to cooperate with the US on cost reductions of electrolyzers.

Another R&D opportunity is in the chemical storage of hydrogen. Currently, the US is not making significant investments towards the investigation of chemical carriers as the US infrastructure, while KIER is looking to develop ammonia as a chemical storage option for hydrogen. While the US is not looking into chemical carriers as a storage option, the US has significant attention towards the on-board storage of hydrogen in vehicles for transportation fuel. Because ammonia can serve as a transition fuel that can be used to power ICE vehicles, there can be an opportunity for collaboration for KIER to share its chemical storage R&D with the US's on-board vehicle storage efforts.

A third area of R&D cooperation opportunity between the US and Korea can be highlighted through KIER's efforts in the P2G hydrogen production unit. KIER has demonstrated that it can produce 500kg of hydrogen per day to be used in commercial fueling stations. However, there may be an opportunity for KIER to cooperate with the US on its hydrogen-natural gas blending research to find additional uses for hydrogen and available infrastructure for hydrogen delivery. The US currently blends up to 15% hydrogen into natural gas to be used in end-use systems without significantly increased risk. Furthermore, blended hydrogen and gas can be separated closer to the end-use system as a way to extract pure hydrogen. Korea imports a significant amount of LNG for its own domestic energy needs, and there may be potential for Korea to utilize hydrogen and natural gas blending to both reduce the emissions of LNG use and increase the market share of hydrogen in the energy mix as a way to create a market demand for hydrogen.