Hydrogen Production and Delivery

Overview

The production and transportation of hydrogen in a cost effective, environmentally friendly manner is one of the major challenges to the development of the hydrogen economy.

The production of hydrogen is an energy intensive process. The energy needed to produce hydrogen can be obtained from traditional fossil fuels, nuclear energy and renewable energy sources.

Hydrogen may be produced at large-scale central locations and then transported to multiple end use destinations. Alternatively, it can be produced on-site at small-scale decentralized locations closer to the point of use.

Hydrogen has the highest energy content per unit of weight of any known element. It is also the lightest element. As a result, it is characterized by low volume energy density, meaning that a given volume of hydrogen contains a small amount of energy. This presents significant challenges to transporting, delivering and storing the large quantities of hydrogen that will be necessary in the hydrogen energy economy.

How is Hydrogen Produced?

About 95% of the hydrogen we use today comes from processing natural gas. The remainder is produced using electrolysis – a process that splits water into its individual components, hydrogen and oxygen. Some of the specific technologies used to produce hydrogen include:

- **Steam reforming** converts methane (and other hydrocarbons in natural gas) into hydrogen and carbon monoxide by reaction with steam over a nickel catalyst. The carbon separated from the hydrogen in the reforming process may be captured and sequestered to avoid damage to the environment.
- **Electrolysis** uses direct electrical current to split water into hydrogen at the negative electrode and oxygen at the positive electrode.
- **Steam electrolysis** (a variation on conventional electrolysis) uses heat, instead of electricity, to provide some of the energy needed to split water, making the process more energy efficient.
- **Thermochemical** water splitting uses chemicals and heat in multiple steps to split water into its component parts.
- **Photocatalytic** systems use special materials to split water using only sunlight.
- **Photobiological** systems use microorganisms to split water in the presence of sunlight.
- **Biological** systems use microbes to break down a variety of biomass feedstocks into hydrogen.
- **Thermal water splitting** uses a very high temperature (approximately 1000°C) to split water.
- **Gasification** uses heat to break down biomass or coal into a gas from which pure hydrogen can be extracted.

In some countries, major industries such as steel production, petroleum refining and soda production produce excess hydrogen that may be used in the initial stages of the hydrogen economy.

How is Hydrogen Delivered?

Hydrogen is currently transported by pipeline or by road via cylinders, tube trailers, and cryogenic tankers, with a small amount shipped by rail or barge.

Due to the energy intensive nature and the cost associated with hydrogen distribution via high-pressure cylinders and tube trailers, this method of distribution has a range limited to approximately 200 km.

For longer distances of up to 1,600 km, hydrogen is usually transported as a liquid in super-insulated, cryogenic, over-the-road tankers, railcars, or barges, and then

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vaporized for use at the customer site. This is also an energy intensive and costly process.

Pipelines, which are owned by hydrogen producers, are limited to small areas where large hydrogen refineries and chemical plants are concentrated. A large pipeline system dedicated to transporting large volumes of hydrogen does not yet exist.

The Challenges

Due to its unique properties – high energy content per unit of weight coupled with low volumetric energy density – the production, transportation and storage of hydrogen presents unique challenges.

Two fundamental questions are how much energy is required to extract hydrogen from naturally occurring, stable hydrogen-rich compounds and whether hydrogen should be produced at large-scale central locations that will require the development of a dedicated infrastructure to store and transport it to end use destinations. Both of these questions demand close evaluation of the related social, economic, and environmental costs and benefits associated with developing a hydrogen production and transportation infrastructure.

In addition, breakthroughs are necessary in material science to reduce the cost of transporting hydrogen over long distances.

Another option is to produce hydrogen at decentralized locations closer to end use applications. This approach requires the examination of other technical and social questions related to the production and storage of hydrogen.

It is likely that hydrogen production, transportation, and storage will use both decentralized and centralized approaches. Developing the infrastructure necessary to produce, store and deliver the large quantities of hydrogen necessary for the future hydrogen economy is one of the major challenges addressed by the IPHE.

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The IPHE partners are working to develop the infrastructure necessary to produce, store and deliver the large quantities of hydrogen that will be essential to the future of the hydrogen economy. For more information, please visit the IPHE website at: www.iphe.net.