DR. ROGER H. BEZDEK, CONTRIBUTING EDITOR, WASHINGTON

Whatever happened to the hydrogen economy?

The hydrogen economy has the distinction of vying with nuclear fusion as the energy technology that is always a "constant XX years" away from fruition. Consider:

- In 1960, a reputable engineering magazine predicted widespread military use of hydrogen fuel cells and industrial use in five years.
- In the mid 1970's, the U.S. Energy Research and Development Administration predicted the imminent arrival of the hydrogen economy.
- In 1998, Iceland announced a 10-year plan to create a hydrogen economy and convert all transportation vehicles to fuel cell power.
- A decade ago, the world was "on the cusp of a fuel-cell revolution" and hydrogen fuel cell–powered cars were poised to dominate the market

Of course, none of this happened. Why not? While the hydrogen economy has not arrived, hydrogen is nevertheless a big business and is growing rapidly. As an industrial gas, hydrogen is already a huge global industry, with strong fundamentals and good prospects. The global hydrogen market is forecast to increase $33 billion over the next four years, from $122 billion in 2018 to $155 billion in 2022. This is a compound annual growth rate of over 6%/year. The world market is expected to grow rapidly, due to government regulations for desulfurization of petroleum products and increasing demand for hydrogen as a transportation fuel.

During petroleum refining, hydrogen is used for desulfurization, and thus the requirement for hydrogen in refineries depends on the sulfur level present in petroleum products. Governments are regulating sulfur content in final petroleum products, and the demand for hydrogen in refineries is increasing rapidly.

Hydrogen is used in large quantities for chemical product synthesis and as an agricultural fertilizer. It is also used in metal production, food processing and for energy storage. About 55% of the global hydro¬gen demand is for ammonia synthesis, 25% in refineries ($31 billion/year.), and 10% for methanol production.

There will likely be further increases in hydrogen demand in refineries. One reason is the need to achieve greater processing depths for each bbl of crude oil. Another is increasing worldwide quality requirements for fuels, especially in emerging markets. In addition, higher-quality fuels are needed to comply with more stringent engine standards and stricter exhaust gas regulations.

Two hydrogen markets. "Merchant" hydrogen is sold to consumers by pipeline, bulk tank, or cylinder truck delivery, and "captive" hydrogen is produced by the consumer for internal use at the point of consumption. Captive hydrogen comprises about 95% of the market. However, the U.S. market for merchant hydrogen exceeds $4 billion annually and is growing about 7%/year, while the U.S. market for hydrogen power systems is about $3.5 billion and growing 10% annually.

Captive hydrogen production is expected to dominate the market until 2021. However, merchant production is forecast to increase in market share, because of the effective technologies used by manufacturers in the market – the most common technologies used worldwide include electrolysis (water) and reformation (methane). North America is the largest market for merchant hydrogen.

At present, nearly all industrial hydrogen is produced from methane in fossil energy, primarily from natural gas. The relatively low price and increasing availability of natural gas implies that it will be increasingly used to meet the growing world demand for hydrogen. It thus appears that hydrogen production will be an increasingly important driver of natural gas demand.

However, there is a major problem for both the oil and natural gas sectors. As noted, much of the future increase in demand for hydrogen is based on the growing demand for clean transportation fuels, strict government regulations, and the focus on reducing CO_2 in the atmosphere. It is true that at point-of-use, hydrogen is a clean-burning fuel whose only byproduct is water. But since more than 95% of hydrogen is produced using fossil fuels, hydrogen is not really green, and electrolysis–the major hydrogen source other than reformation—is exceedingly inefficient and energy-intensive. Experimental methods involving, wind, solar and biomass are still far from being economic or commercially cost-competitive.

CO_2 emissions are limiting factor. The elephant in the room is that the hydrogen economy is hitting a brick wall that will severely limit its growth potential. All the hype over hydrogen fuel cells, hydrogen vehicles, distributed power, and clean fuels is meaningless, until a method can be found to efficiently produce large quantities of hydrogen in a sustainable manner that does not increase CO_2 emissions. Experimental methods involving bio-hydrogen production and renewable electrolysis (et al) are not technically feasible, much less economic or commercially cost competitive. More recently, sustainable hydrogen is being produced from scrap aluminum, and this represents a promising solution to the major problem confronting the hydrogen economy.

Nevertheless, there are two major concerns for oil and gas. First, it will be increasingly difficult and expensive to meet the growing demand for hydrogen in oil refineries. Second, the increasing demand for natural gas driven by requirements for hydrogen may be short-lived.

Inevitable truth. Regulatory pressures to reduce CO_2 will limit, and likely prohibit, the use of natural gas to produce hydrogen. Until a solution is found to the problem of hydrogen production CO_2 emissions, the hydrogen economy will remain with nuclear fusion as being "always in the future." WO

DR. ROGER BEZDEK is an internationally recognized energy analyst and president of MISI, in Washington, D.C. He has over 30 years' experience in the energy, utility, environmental, and regulatory areas. He has served as senior adviser in the U.S. Treasury Department and as U.S. energy delegate to the EU and NATO.