

The Potential of Hydrogen as a Fuel Source and as Fossil Fuel Investment Alternative

Overview:

Over the past two years Winthrop Partners has been reviewing investment alternatives to the Fossil Fuel Industry. Whether one approaches the topic of energy on an ideological basis or on an economic basis it is becoming clear that the fossil fuel industry, as currently configured, has likely reached its peak.

We believe the fossil fuels will be major energy contributors for the foreseeable future. However alternative energy sources will first contribute the growth component of the energy market and then over the next two decades increasingly take market share from the traditional fossil fuel industry. More emphasis is now being placed on alternative sources of energy from new and old energy producers (including the big oil companies). The hydro, solar, wind and battery industries were the first movers in the alternative energy market. Now Hydrogen appears poised to become a substantial energy source particularly for high energy consuming applications and industries.

Should the Biden Administration's multi Trillion Dollar Infrastructure Bill be approved, the cash infusion into Hydrogen Technology and infrastructure, along with substantial European Public and Private investment in Hydrogen will vastly accelerate the production and use of Hydrogen. Should the Biden Infrastructure Bill be rejected, we believe the US adoption of Hydrogen will be substantially delayed and its initial scope reduced. Relying on funding by government fiat is a dangerous strategy. Because of this funding variable, Winthrop believes the more viable alternative is to focus on large, diversified companies that have a foothold in the Hydrogen Market, but where Hydrogen is only a small part of their product array. These companies will be at the forefront of the Hydrogen industry if it materializes and will maintain profitable Hydrogen submarkets if Hydrogen does not live up to its potential.

A review of this type during periods of rapid technological advancement, is at best, bound to be partially incorrect as new technologies emerge and change the course of the market.

What Is Hydrogen and why is it emerging as an energy source:

What: Hydrogen is the lightest, and most common element in the universe and is believed to comprise 75% of all matter. It is also highly combustible; however, it rarely exists on its own, instead it bonds with other chemical elements such as oxygen to form water. When isolated it exists as a gas, but it needs to be condensed into liquid form to achieve the energy density required to be used as a fuel for most applications.

Why: When Hydrogen combusts, it does not emit CO₂ like Fossil Fuels instead it produces water.

Issues, Hurdles and Limitations: While Hydrogen is a clean fuel, 95% of present-day Hydrogen is produced using the Steam Reforming Method that strips Hydrogen from Natural Gas and releases large amounts of greenhouse gas in the process. This process is akin to using an electric car run on electricity produced from fossil fuel fired plants. At present there are a number of emerging Hydrogen production processes that are less or non-polluting (see Colored Hydrogen Chart). For Hydrogen to be used as a liquid it needs to be compressed and cooled to -252 Degrees Celsius, which presents a number of storage and transportation challenges. Hydrogen is highly volatile and explodes easily (remember the

Hindenburg) it also corrodes metal welds and plastic parts making typical container materials brittle and unusable. New technologies are addressing the above captioned hurdles, but substantial investment will be required to commercialize these technologies.

Hydrogen Production:

Hydrogen can be produced using a variety of processes from highly polluting processes to purely green processes. Unfortunately, today the least expensive (and most polluting) processes are being used to produce 95% of the world’s Hydrogen. The Europeans are focused on an interim “Blue” solution used to sequester underground the waste greenhouse gas produced by the existing Gray process. America appears to be more focused on green processes like Electrolysis of water and Pyrolysis of methane. At present it requires much more energy to produce hydrogen from water than what is contained in the hydrogen produced although there are many advances in the electrolysis process that are driving costs down. The pyrolysis of methane is still in the laboratory stage and has not been scaled up to commercial production levels. At present green Hydrogen costs about four times as much to produce as gray hydrogen and possibly two times as much as blue hydrogen. Wind, Solar and Hydro producers who cannot efficiently store excess electric production in batteries during peak production periods are beginning to direct the excess energy to Hydrogen Electrolysis plants. They reason its preferable to produce hydrogen inefficiently rather allowing the excess electricity to escape the system.

The Importance of Hydrogen's Various Colors	
<p>BROWN HYDROGEN Produced From Coal Gaisification a Process developed in the 1890s to produce "City Gas", a gas used to light city streets. An inexpensive, but highly polluting method of Hyrogen production. The Japanese are using this process in Australia to produce Clean burning Hydrogen to be consumed in energy starved Japan.</p>	<p>GRAY HYDROGEN Gray Hydrogen is produced from fossil fuels primarily natural gas. About 95% of Hydrogen is produced in this manner which uses a Steam Methane Reforming Process which generates subsantial CO2 that is released into the atmosphere. Presently industrial gas companies like AIQUY, LIN and APD are the largest producers.</p>
<p>BLUE HYDROGEN Like Gray Hydrogen Blue Hydrogen is produced using the Steam Methane Reforming Process, but instead of releasing CO2 into the atmosphere, the aim is to sequester the CO2 into underground caverns. The sequestration process is not yet perfected, but major european oil companies and governments are on the cusp of commercialization.</p>	<p>GREEN HYDOGEN Green Hydrogen is generally made by seperating water into its compoent elements using electrolosis a process that consumes more electricity (from wind and solar) than what is supplied by the Hydrogen produced. Advances in Green Hydrogen Electrolysis and Methane Pyrolysis are reducing its cost . NEE and PLUG are BASF are the largest producers.</p>

Excel Hydrogen Colors

Hydrogen Distribution:

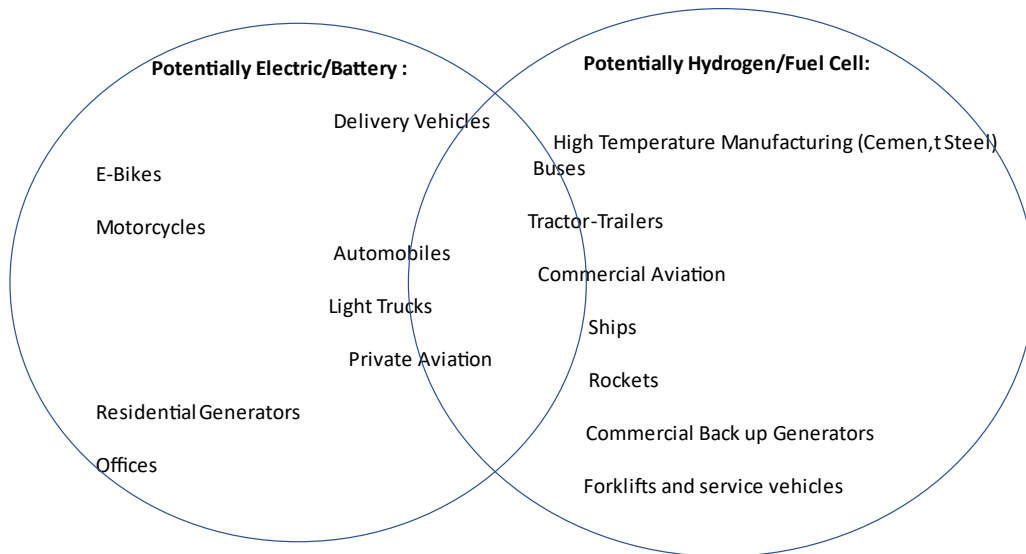
Liquid Hydrogen is a very volatile substance that must be compressed and kept at temperatures below -252 degrees Celsius and has a corrosive effect on many piping and storage materials. Because of these factors that limit its transportation, Hydrogen is first being used in fixed base operations such as for the fuel in forklifts in warehouses and back up generation in server farms. It is also being introduced in point-to-point transportation vehicles like buses (many European countries use Hydrogen buses) where elaborate distribution infrastructure for the liquid is not required. Other areas that share similar hub characteristics include airports, shipping ports and well-defined truck routes. In these locations Hydrogen can be trucked in much like propane. The distribution infrastructure is being investigated at three levels: 1) Onsite manufacturing at Hubs, 2) building a high-tech distribution and storage network and 3) Converting Liquid Hydrogen into Ammonia by adding Nitrogen. Ammonia is a stable liquid at room temperature and is currently distributed through the nation's pipeline. Advances are being made that allow for the removal of nitrogen close to the areas of consumption in an efficient manner. If efficient methods of producing, transporting, and storage can be found, Hydrogen will become a major green fuel source.

Hydrogen Usage and The Potential Segmentation of Energy Markets:

Full adoption of alternative energy sources is decades away and it is anticipated fossil fuel will continue to play a significant role. At present, there are energy consuming applications that appear to be better served by Hydrogen/Fuel Cell technologies and others that are better served by Green Electricity/Battery technology. In general, the anticipated breakout of Electric/Battery versus Hydrogen/Fuel cell resembles the existing use of Gasoline versus Diesel fuel. Although there will be several areas of overlap lighter vehicles or devices carrying smaller payloads will tend to be electrified. Heavy-duty vehicles and high temperature processing industries will gravitate toward Hydrogen.

Hydrogen combustion creates the high temperatures required for many heavy industries including steel and cement that cannot be reached by electricity. In payload industries like trucking, busing, shipping and aerospace the weight of batteries reduce payload capacities and battery performance declines in cold and saltwater environments. Hydrogen Fuel cells are also better suited to replace diesel generators as back up industrial generators. Turbine engines that run on Hydrogen are being introduced to the electrical generation market and will eventually be made available to the aviation market. For the above reasons Hydrogen will likely become the preferred fuel for these applications. Automobiles, small delivery vehicles, private aviation and residential applications are better suited for green electricity and battery pairings

Presently these applications predominantly utilize Fossil Fuel. Within the next 25 Years its estimated Electric and Hydrogen will be the predominant energy source for these applications



Companies Exclusively Focused on Hydrogen:

(These companies are small and will either succeed or fail based upon the prospects for Hydrogen).

Ballard Power (BLDP) Ballard designs, develops and manufactures fuel cell products for marine systems, Backup power systems and fuel cells for the locomotive, truck, bus and automotive applications.

Plug Power (PLUG) Plug Power Inc. provides hydrogen fuel cell turnkey solutions for the electric mobility and stationary power markets in North America and Europe.

Itm Power (ITM) (LSE) Produces PEM Electrolyzers to produce Hydrogen.

Bloom Energy (BE) The company offers Bloom Energy Server, a power generation platform that converts standard low-pressure natural gas, biogas, or hydrogen into electricity through an electrochemical process without combustion.

Large, Diversified Companies with Interests in Hydrogen

(These companies are S&P 500 or equivalent sized companies who have a significant and profitable Hydrogen Operations).

Hydrogen Turbine and Fuel Cell Manufacturers

General Electric (GE) Within GE's Power Segment GE Produces gas turbines including the world's only turbine engine that runs on Hydrogen.

Cummins, Inc (CMI) Cummins operates through five segments: Engine, Distribution, Components, Power Systems, and New Power including battery, fuel cell, and hydrogen production technologies

Industrial Gas Producers and Plant Constructors

L Air Liquide (AIQUY) L'Air Liquide S.A. provides gases, technologies, and services for the industrial and health sectors in Europe, the Americas, the Asia Pacific, the Middle East, and Africa. The Engineering & Construction segment invests in biomethane production units, as well as develops stations for distributing natural bio-gas for vehicles and hydrogen to support clean mobility

Linde PLC(LIN) Linde plc operates as an industrial gas company in North and South America, Europe, the Middle East, Africa, and the Asia Pacific. It offers oxygen, nitrogen, argon, rare gases, carbon dioxide, hydrogen, helium, electronic and specialty gases, acetylene, and carbon monoxide. The company also designs and constructs turnkey process plants, such as olefin, natural gas, air separation, hydrogen and synthesis gas, and other plants

Air Products (APD) Air Products and Chemicals, Inc. provides atmospheric gases, process and specialty gases (including Hydrogen) , equipment, and services worldwide. It also designs and manufactures equipment for air separation, hydrocarbon recovery and purification, natural gas liquefaction, and liquid helium and liquid hydrogen transport and storage. Air Products and Chemicals, Inc. has a strategic collaboration with Baker Hughes Company to develop hydrogen compression systems

Hydro Wind Solar and Green Hydrogen Producer

Next Era Energy (NEE) The company is the largest producer of alternative energy in The US. It generates electricity through wind, solar, nuclear, and fossil fuel, such as coal and natural gas facilities. The company has also launched industrial scale electrolysis plants using excess solar and wind energy.

Conclusion:

Hydrogen has been the clean energy for tomorrow for a long time, but only recently have advances in production distribution and storage created an environment where commercial scale use of Hydrogen is occurring and scalable. Never-the-less, the road from Hydrogen producing less than 1% of the worlds energy to it creating 30% or more of the world's energy will be long and arduous even under the most optimal circumstances

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Word: Hydrogen