Hydrogen – the "Green Fuel"?

Virtually all thermal energy we use today is produced by the reaction between hydrogen and oxygen. The result is H2O and heat. The "carrier" of hydrogen to yield that energy is carbon (hydrocarbons such as coal, oil or natural gas). The problem is that the carbon "carrier" also burns, producing byproduct - CO2.

The idea behind hydrogen as a "green fuel" is to extract hydrogen from water using renewables as the power source to break the bond between hydrogen and oxygen. The hydrogen can be stored and then used as a fuel for stationary or transport applications. The ultimate vision is to displace hydrocarbons in the highest polluting sector – transportation – with renewable electricity that is either (a) stored in batteries or (b) electrochemically converted to hydrogen and then turned back into electricity via fuel cells. Why the interest in fuel cells?

A Brief History of Fuel Cells (and Electrolysis)

Technology evolved from submarine (electrolyzer) and space (fuel cell) applications. Developed by GE in 50's and 60's; acquired by United Technologies where it evolved gradually into the 90's. VERY high cost applications limited to aerospace and defense. The Apollo 13 movie chronicled a leak in the hydrogen storage tank that reduced fuel cell performance to bare requirements.

California stimulated a surge in technology development in early-1990's with a mandate that every car maker selling in the state must offer a zero emission model by the year 2000.

> Batteries were then evaluated as woefully inadequate (remember EV-1?)
> Commercial fuel cell programs started at GM, Chrysler/Daimler, Toyota, UTC, others

In the late 1990's, California relaxed its mandate. Fuel cell development slowed dramatically, while battery technology development accelerated, driven not by automotive demand but by the proliferation of small electronic devices. These devices embodied a high value proposition for batteries, and spawned an extraordinary wave of technology advances. These advances, have changed the game for the practical use of batteries in automotive applications. Especially important: Power to Weight Ratio, Energy (range) capacity, recharge cycling time.

Batteries will capture a huge part of the market for storing (and thereby increasing the value of) renewably-generated electricity. But battery architecture contains a basic limiting feature: the electrolyte and electrode are bound together in a single container. If you need "deep energy" -- that is more electrolyte but not necessarily more electrode, you get more electrode anyway. The electrolyte is stored energy; the electrode is the conductor that delivers the power. Depending on the field of use, battery power imposes inherent tradeoffs and limitations. You simply can’t make a battery big enough to power a large truck or a train or a ship. These heavy and long haul transport markets are immutably off limits to batteries (as even Elon Musk is now admitting). For the same reason, bulk storage of utility-scale electricity with traditional battery architecture is also unlikely to be cost effective in comparison to systems comprised of electrolysis (hydrogen stored in a virtually infinite variety of tank sizes) and fuel cells.

Exhibit 1: Batteries vs Fuel Cells

Because batteries cannot be cost effective for large scale and long haul, energy policy makers are calling out a new energy mantra: GREEN FUEL – Hydrogen from electrolysis powered by renewables. Europe and China have adopted meaningful, ambitious incentives to address an enormous range of market applications including

Heavy Duty Vehicles (displacing gasoline or diesel)
Pipelines (displacing natural gas)
Power Plants (displacing coal, oil or natural gas)

Dramatic reductions in the cost of solar and wind energy are significantly increasing the commercial feasibility of electrolysis, opening the path to these huge hydrogen-supplied fields of use. And because renewables are inherently intermittent, there must be a way to store or convert excess renewable power. These are the forces driving the Green Fuel phenomenon.

Exhibit 2: Visualizing Proton Exchange Electrolysis

Exhibit 3: View of Typical Membrane/Electrode Assemblies (MEA)

Retail brokerages are getting into the story; a great “retail-everyman” theme.
E.g. Goldman: Investment in Green Fuel will be 10 Trillion Euros; 20% of which will be In Europe. Demand for electrolysis will lead to 650 x supply growth
Bank of America: $ 11 Trillion
Most major houses have bought into the hydrogen story (quite literally in the case of Ballard Power (Canadian) in recent days
These are numbers worth our attention.

The list of companies mentioned include

1. technology developers such as NEL (from Norsk Hydro), Siemens, Cummins, AREVA (Fr), Toshiba, Proton on-site, Suzhou (China), PLUG, BLDP, Bloom Energy and others
2. Incumbents
   a. Virtually every vehicle manufacturer
   b. Service Providers such as industrial gas companies
   c. Utilities
3. New users of hydrogen and fuel cells
   a. Trucks (Nikola)
   b. Buses (Chinese manufacturer)
   c. Trains (GE)

Check out the stock prices of the “pure plays”

PLUG, BLDP, BE, FCEL

Note especially BLDP’s $375 MM “bought deal” last week

PLUG: commercializing fork lift niche, aiming at other motive markets
BLDP deepest IP of the group, strategic focus on buses and ships

Investment thesis: Demand/Supply

Who doesn’t want green hydrogen applications? Everyone does. Investors and executives are backing away from fossil fuels.

The number of companies that make the most critical component (Membrane Electrode Assembly -MEA) are very few. BLDP and PLUG (and BE) are uniquely positioned, each stand-alone with $100’s of MM of Intellectual Property.

Both are on a lot of radar screens
Both are take-out candidates. Oil companies?

YEAR 2000 – the first fuel cell investment concept wave. Will there be another 20 years later? Momentum in the group was building even under Trump; it should do just as well or better under the new Administration. Strong forces from Europe and Asia.

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