HYDROGEN

The grass may not be greener on the GREEN side, for now

By Yang Han, PhD

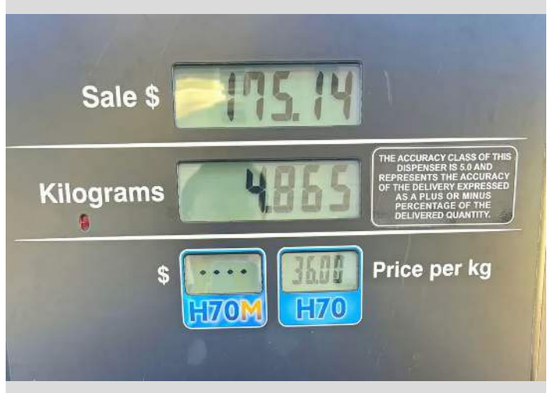
A paradigm shift in energy and transportation, a gradual move away from fossils to renewables, has taken place. The Biden Administration has unveiled plans to invest $3.1 billion to address the country's battery shortage by supporting domestic manufacturers in increasing battery production within the US. Meanwhile, oil and gas behemoth ExxonMobil drilled the first lithium well in Arkansas and aims to be the leading supplier for electric vehicles in 2030. However, the long-term decarbonization vision cannot be achieved overnight. The nation's power grid, designed for a fossil-fuel world, will strain under an 18% increase in electricity demand by 2030. California currently has the largest number of EVs in the United States and apparently its power shortage may be more than 18% by 2030, not to mention the growing demand from data farms and new AI chips and servers that will push the state's electricity grid to its limit. Therefore, in addition to EV, the hydrogen fuel cell electric vehicles (such as Toyota's Mirai and Honda's CR-V e) in California can also enjoy government (Clean Vehicle Rebate Project) subsidies to alleviate electricity usage pressure.

Obviously, hydrogen gas has been considered another option (in addition to electrification) to achieve the ambitious carbon neutral goal since it can be used to generate electricity via fuel cell where water is the only product in this process. The main issue about hydrogen is that most of it is currently produced from natural gas (also known as steam reforming hydrogen or gray hydrogen). Since natural gas is indeed a fossil fuel, gray hydrogen is not sustainable in the long term.

Green hydrogen (also known as renewable hydrogen, or CO2-free hydrogen)—which is derived from water electrolysis by renewable energy—attracted attention worldwide as an option for curbing CO2 emissions with the production of hydrogen. Helen, an electricity company in Finland, will build its first green hydrogen production and filling plant. The 3MW project will cover four different sectors: electricity, transportation (heavy transport), heat, and hydrogen. In Switzerland, Axpo said it has signed a cooperation agreement with French energy investor ENEGO to study the feasibility of a 100 MW green hydrogen plant in Sicily, Italy. In Minnesota, 3M said it has invested in EVOLOH, a cleantech company that's working to scale up manufacturing of its electrolyzers to make green hydrogen affordable and efficient. At DIG, I am happy to say that we can distinguish green hydrogen from gray hydrogen using isotope analysis. Stable isotopes of hydrogen ($^2H/^1H$) carry fingerprints of produced hydrogen from varying origins. In addition to fingerprinting hydrogen, DIG also provides services for the continuously evolving carbon storage monitoring and leakage detection for carbon storage operations.

However, unlike these promising visions for green hydrogen, hydrogen appears to have a longer way to go when it comes to hydrogen FCEV use. Let's go back to California, the state with the most hydrogen vehicles and hydrogen refueling stations in the United States. Shell permanently closed 7 light-duty hydrogen fueling stations earlier this year "due to hydrogen supply complications and other external market factors".

Although green hydrogen can be electrolyzed from water with renewable energy sources, why don't we just store solar and wind power in batteries and use it directly in electric vehicles? Moreover, just as electric vehicles have



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Unlike promising visions for *green* hydrogen, hydrogen appears to have a longer way to go when it comes to FCEV use

the problem of aging batteries year by year and battery recycling at the end of the battery life, a hydrogen FCEV also has the problem of cathode catalyst degradation during its start-up and shut-down events. Of course, another factor is pricing: hydrogen isn't sold in gallons, and it is not a liquid. Hydrogen in California now costs $36/kg. A Toyota Mirai FCEV can store 5.5 kg of hydrogen. So, that's $198 for a fill up and it can travel 312 miles according to Toyota's estimate. So that's 63 cents per mile. In comparison, a Tesla Model Y (3.3-3.8 mile/kWh) charged on grid power at prices of ~0.35/kWh costs roughly 10 cents per mile.

The future of clean transportation remains to be seen. It is hoped that with the development of technology, the price of green hydrogen energy can be brought down, and more car manufactures are willing to jump on board to make FCEV a viable option. ■