Hydrogen Hubs

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April 2022

1. Introduction

For roughly the last month or so, I've danced all around the subject / title of this brief paper with the posts referenced below. However, I've seemed to do this without bringing these together, as this post will do.

So what is a hydrogen hub? It is a major user of green hydrogen that will use renewable electricity from the grid to produce adequate supplies of green hydrogen via an electrolyzer and store this hydrogen in high pressure tanks. The storage might have several functions:

- The electrolyzer can be sized based on average demand rather than peak demand.
- Storage potentially disassociates production and use to allow the electrolyzer to use the least-cost renewable electricity for the former when it's available.
- Stored hydrogen can be used for backup when there is an electric outage.

The electrolyzer, storage and primary application will need to be co-optimized for the best economics.

In addition to satisfying the primary application of the major user, the hydrogen hub can supply hydrogen for applications of nearby smaller users and derive a profit from this supply.

2. Current and Future Major Users

We don't need the users below to actually produce the green hydrogen, but rather contract with an existing hydrogen producer to develop and manage the production and storage facility. Although it is likely that currently such companies produce gray hydrogen (by reforming geologically-sourced natural gas), they will need to evolve to producing green hydrogen over the next decade or two even without this new role. Furthermore, developing and managing green hydrogen hubs will be a seamless expansion of their current role, if not their current process. I would expect perspective hydrogen producers in California would be members of the organization linked below.

https://www.californiahydrogen.org/

One other comment: even if the major user just needs hydrogen, it would not be a major expansion of the production process to also produce oxygen, since electrolyzers produce both gases from water. I found one reference regarding a Siemens Silyzer 300 Electrolyzer that was used for both hydrogen and oxygen production.[1]

[1] Gerald Ondrey, Chemical Engineering, "Siemens to Build Large CO_2-Free Hydrogen Production Plant in Southern Germany," Sep 25, 2020, https://www.chemengonline.com/siemens-to-build-large-co2-free-hydrogen-production-plant-in-southern-germany/

The major users might include the following (with links to any related recent posts):

1. Rail-transit fueling depot

   https://energycentral.com/c/ec/hydrail

2. Hydrogen-fueled utility-scale generating plant

   https://energycentral.com/c/gn/reasonable-transition

3. Major cargo, warehouse, logistic or intermodal center

   Author's comment: These centers tend to cluster around the edge of major metropolitan areas. In the paper linked below, section 2.9, I describe one of these major areas near me. Each of these facilities will have many potential hydrogen users both for large trucks and trains in the future.

   https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-1-trucks

4. Major bus-transit depot that support a large number of hydrogen fueled buses. These would be mainly fleets of cross-country coaches rather than municipal transit and school buses. The latter would mainly be battery-electric buses.

   Note that there are many more battery-electric buses available than hydrogen fuel cell buses, but there are at least four of the latter available. Go through the link below, and then to section 3.1. In the specifications of each bus will either be "Battery Electric" or "Hydrogen Fuel Cell."

   https://energycentral.com/c/ec/electric-trucks-and-buses-california

5. Major industrial hydrogen (including for backup power) and/or oxygen user. For backup power see section 3 in the paper posted below:

   https://energycentral.com/c/ec/california-dreamin%E2%80%99-about-h2

6. Gas distribution pipeline hub (future, after and if a low percentage of hydrogen is allowed to be injected into the pipeline). See section 2 of the paper linked below:

   https://energycentral.com/c/cp/tech-race

3. Smaller Users

Smaller users include:

1. Fuel-cell road-vehicle filling (refueling) stations
2. Medium to heavy fuel-cell vehicle fleet depots with a limited number of fuel cell electric trucks or buses
3. Hospital or other medical oxygen users
4. Small or medium facilities with back-up generation based on fuel cells

4. Distribution of Hydrogen to Small Users

There are basically two methods for distribution:

1. At first distribution will use tanker / tube trucks to distribute hydrogen (and/or oxygen). Most small users will also each have their own local storage of hydrogen. The Energy.gov EERE site linked below has information on these

delivery trucks and hydrogen storage methods, including links to other related sites.

https://www.energy.gov/eere/fuelcells/hydrogen-delivery

2. Ultimately small users that are reasonably close to a hub may pay to have a small distribution pipeline extended from the hub to their facility. This would probably reduce the size of any local storage, or perhaps even eliminate it depending on the use-profile. The above linked site has a link to another site on hydrogen pipelines.