Green Hydrogen – an unlikely future

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Abstract and research questions

Hydrogen is a unique resource, one that has a long history with humanity. It is lightweight, energy-dense, and produces no pollutants or greenhouse gas emissions when burned. 'Green' hydrogen refers to how it is refined, in this case, electrolysis is used to crack water molecules into equal parts hydrogen and oxygen, most commonly using solar energy. Hydrogen can have other colors attached to its name; blue, grey, pink, and black most notably, all these different colors refer to different processes used to refine the hydrogen, most of these revolve around the use of fossil fuels like coal and methane.

In this research poster, we will attempt to answer the following interrogative: **What are the economic viability and scalability prospects of integrating green hydrogen production into existing power systems? A comparative analysis across different regions.** We'll discuss green hydrogen on a worldwide scale, then regional, and end with highlighting local hydrogen production. There are nuances to this, most notably the economic viability of green hydrogen and how efficacious it is concerning net-zero emissions, and energy sustainability in general.

Status of G H2:

World

Most of the GH2 infrastructure worldwide is either a concept, a demonstratable project, or a feasibility study. There are some operational facilities, centered mostly around Europe, although China currently has the largest operational production facility. The US, South America(multiple countries), and East Asia in general have other scattered facilities currently producing.
In terms of planned facilities under construction, or ones that fall under the conceptual or feasibility label, there are quite a few. These are centered around Europe, Australia, South America, East Asia (China), and the US.

USA

Here in the United States most of our projects are planned at seven different "hubs" across the country, one of which is centered around the Houston/Gulf Coast region.

Louisiana

The St. Gabriel Green Hydrogen plant (right outside of Baton Rouge), this plant operational and produces 15 tons/day. Another in Ascension Parish, the Louisiana Clean Energy Complex is expected to produce 750 million cubic feet per day of blue hydrogen. Because of the pre-existing energy infrastructure, the Gulf Coast hub is poised to be at the forefront of hydrogen production and transportation in the US.

What are the challenges?

Most challenges lie in the general cost of GH2 production. Supply chain operation is the main factor here. Building new hydrogen pipelines costs 110-150% more than traditional fossil fuel pipelines and converting pre-existing infrastructure to carry hydrogen also costs more. Another way to transport hydrogen is through liquefied hydrogen tanks and high-pressure tube trailers. With the cost of conversion and transportation still high it isn't economically viable to transport GH2.

-Alkaline electrolyser(AEL) is the production of hydrogen through water. Which is not efficient and will cause issues for regions with a lack of natural water.

-Another newer tech to produce hydrogen is called polymer electrolyte membrane electrolyser(PEMEL). This form of production is being investigated as it can produce more hydrogen than AEL by almost double. The issue is that it uses rare earth metals like iridium, platinum, and gold.

-The issue with transferring LNG into hydrogen lines is that it is highly expensive and takes the line to be temperature and pressure-controlled.

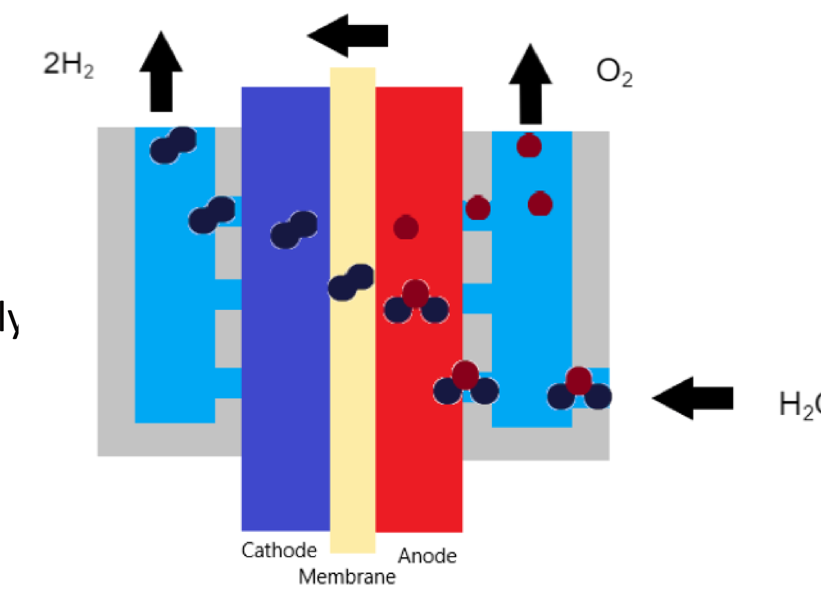
-America is primarily invested in carbon capture of hydrogen production rather than creating green hydrogen plants and facilities.

Technical analysis

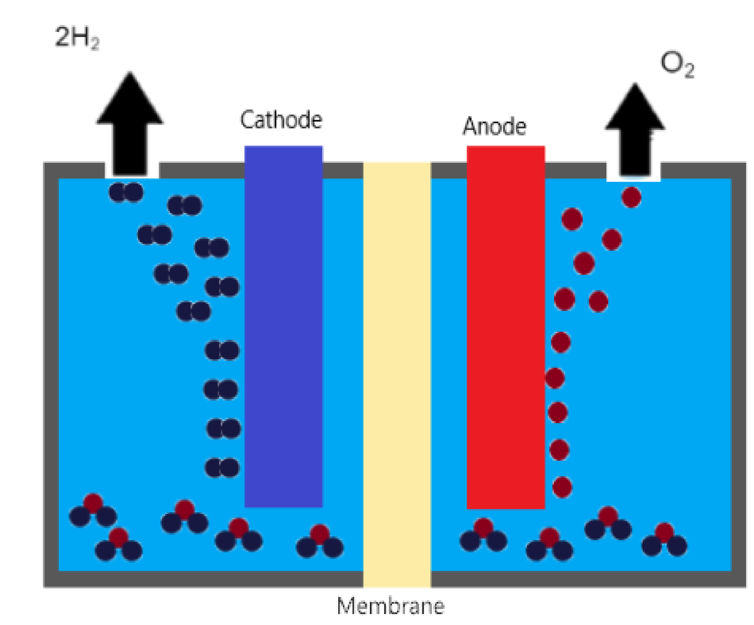
Hydrogen production by electrolysis is done by applying a specific DC current, supplied by PV-EL processes, to water molecules (H2O) which split into hydrogen and oxygen. Other carbon-neutral energy sources include wind, geothermal, and hydro. In this process, eight times more oxygen is produced than hydrogen. Specifically, for 9kg of water and approximately 50 kWh of electricity, 1kg of hydrogen and 8kg of oxygen are produced. All of these are net zero carbon emissions. The majority of green hydrogen infrastructure uses renewable energy sources, predominantly solar, to perform the electrolytic conversion which leads to a unique problem: the intermittency of solar power sources and the availability of solar power in general. We will provide more detail on this in the 'Challenges' section of this presentation.

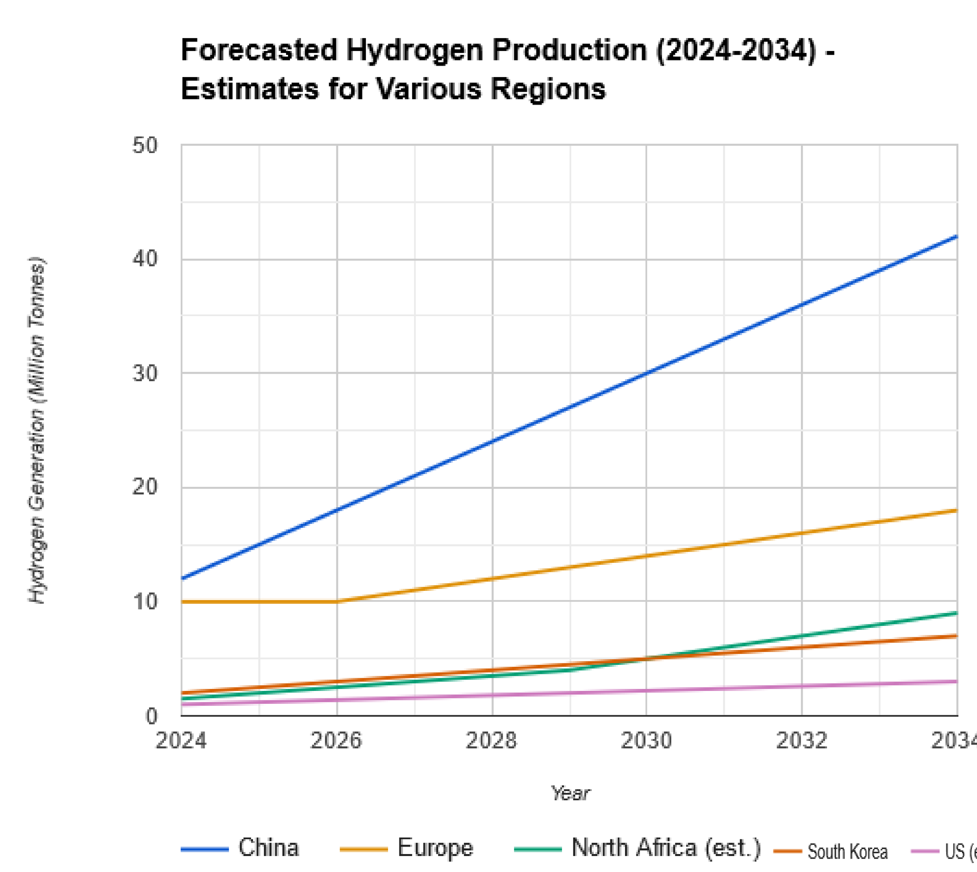
Hydrogen is a good energy carrier in its pressurized form, as it has a high level of energy per unit of mass (120 MJ/kg). There are two main ways to store hydrogen, physical-based methods and material-based methods. Physical methods, such as liquifying and compressing it as a gas, are most common. Material methods such as using a liquid organic carrier, using an organic compound that absorbs the hydrogen, and metal hydride (metal that absorbs hydrogen) are also options but carry excessive costs. The economic and widespread method of storage is as a compressed gas. In this form, the gas is stored at a pressure range of 350-700 bar, that is approximately 5000-10000 psi, extremely high pressure.

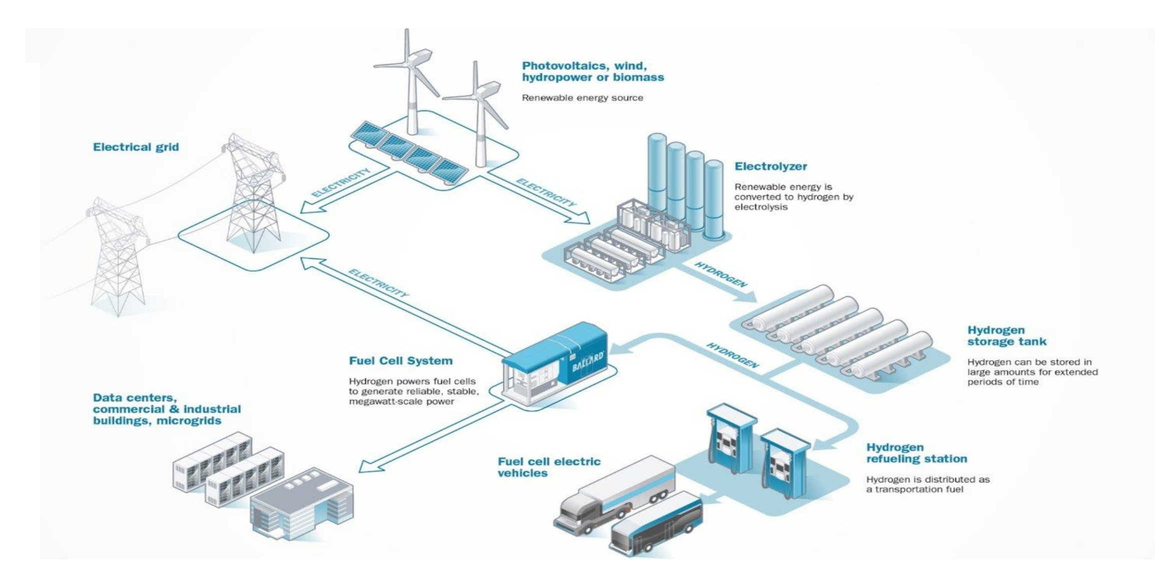
Alkaline Electrolyser

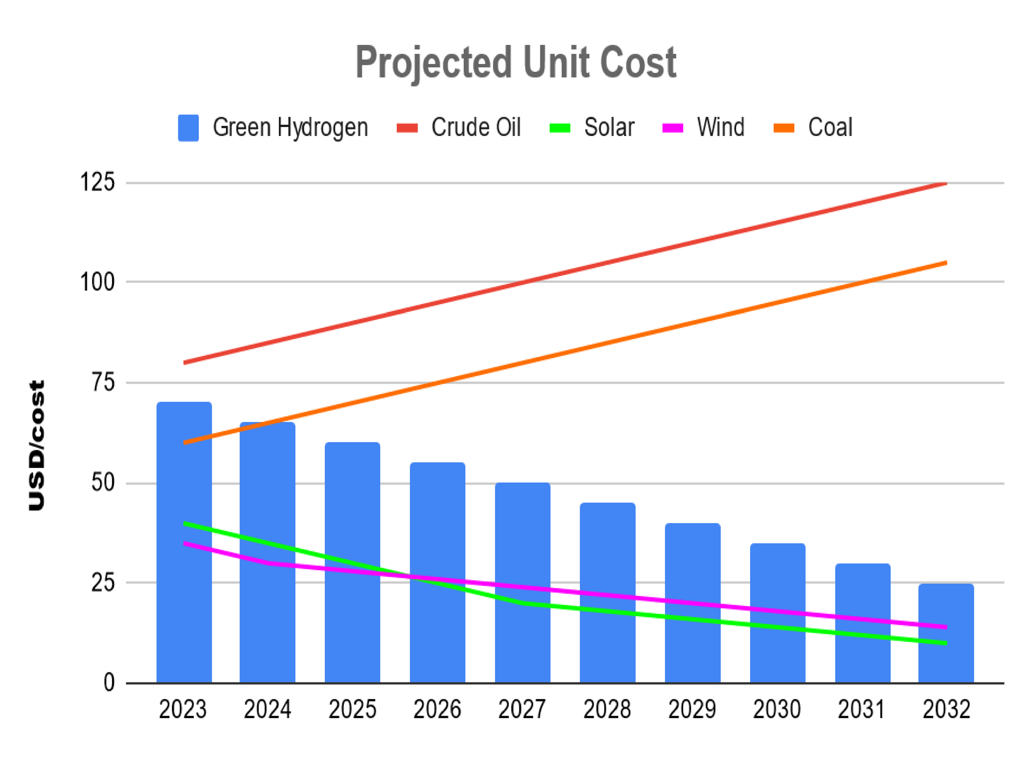


Polymer Electrolyte Membrane Electrolyser









Economics

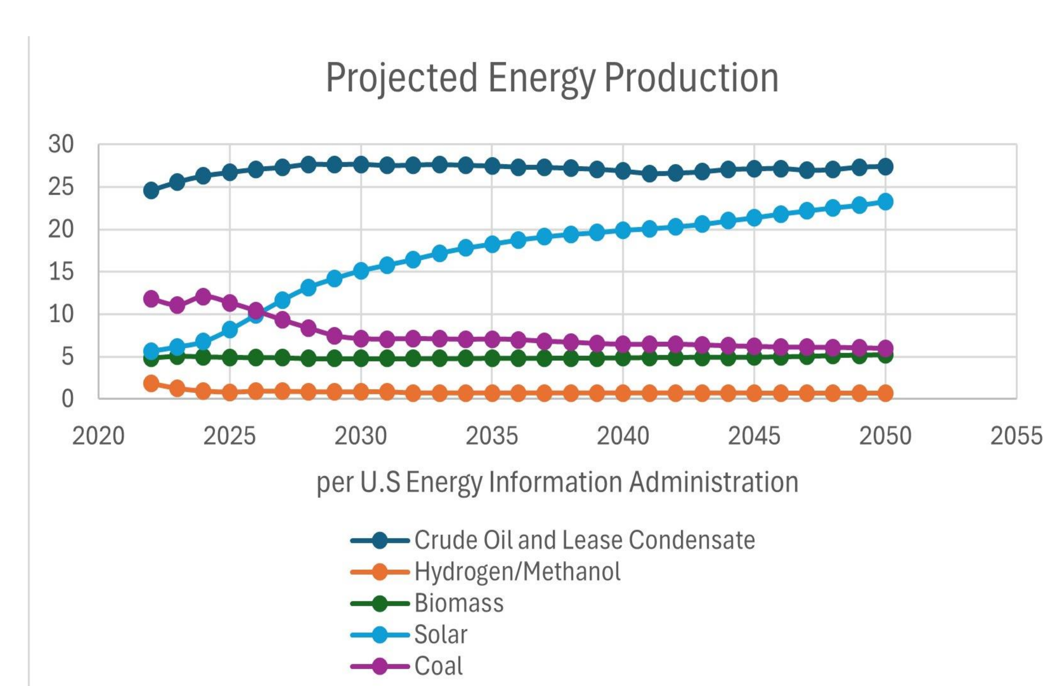
European natural gas prices
-In 2019 the price was $0.6-0.7/barrel
-In 2021 the price was $5/barrel

Storage cost per kW for
-AEL is 1000-2000 Eur/kW
-And PEMEL is 2000-300 Euro/kW

Main uses of hydrogen in the US
-57% is for Petroleum
-20% ammonia
-10% methane

AEL production loses 30% of the initial amount of energy.

Overall Hydrogen is not economically viable in its current state. However, countries that are lacking in natural resources are investing in green hydrogen production to become energy independent.



Forecasting (the future of G H2)

The future of GH2 will encompass integration into transportation methods as an alternative fuel source.
-Integrating into existing transportation/large-scale grid management
-Energy storage as alternative fuel(H-cells) and energy storage
-The largest developments in the research and funding are occurring in the EU as they plan to integrate green hydrogen tech to become carbon-neutral
-A large issue that needs to be addressed is large-scale investment to produce innovation in the infrastructure for hydrogen which is slowly happening.
-The major future use of green hydrogen is in the replacement and reusing of light natural gas lines as countries move to use green energy on a larger scale

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