Renewable Electrolysis in Texas: Pipelines versus Power Lines

Using wind and solar generation to power electrolysis facilities and produce "green" hydrogen at scale would require infrastructure investment. Using current technology, we identify at least one situation in which producing hydrogen at the point of electricity generation and transporting it to the point of use via pipeline costs about one third that of transmitting the electricity and generating hydrogen at the point of use. This raises the possibility that hydrogen pipelines might provide an alternative to high voltage transmission lines for connecting renewable generation with demand. In this white paper, we explore the tradeoffs of those two options.

Texas produces one-third of the United States' hydrogen—roughly 9 million kg per day[1,2] equivalent to 300 GWh of energy. Texas also has abundant undeveloped renewable resources—approximately 40% of the United States' economically-viable wind resources and 50% of its economically-viable solar resources[3] – much more than needed to meet its electricity demand. Using electrolysis to produce hydrogen via electricity could provide an opportunity to harness these excess renewable resources. Recent announcements of wind-powered electrolysis projects indicate that there is a burgeoning market for such clean hydrogen.[4]

Texas' best wind and solar resources, however, are located far from hydrogen consumers. This analysis reviews two options for connecting those renewable resources with hydrogen consumers: 1) use power lines to move the renewable electricity to electrolysis units near the hydrogen demand, or 2) locate the electrolysis facilities near the electricity source and move the hydrogen to its final consumers via pipeline.

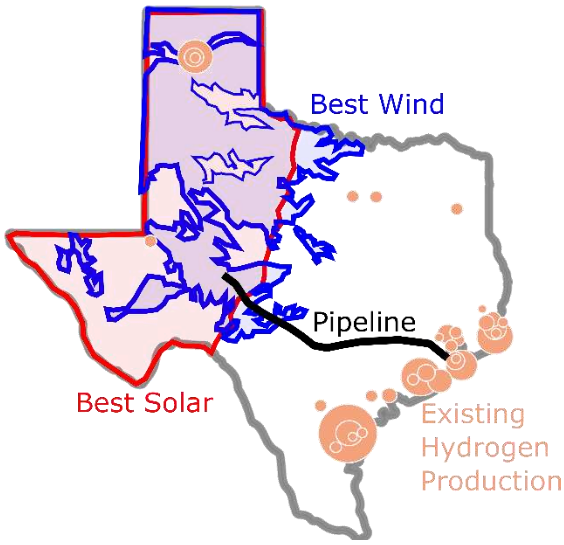

Figure 1: West Texas contains the best wind and solar resources . The Houston coast contains the greatest amount of existing hydrogen production and infrastructure . Here, a 400-mile long pipeline or transmission line connects them.

[1] https://www.energy.gov/eere/fuelcells/fact-month-may-2018-10-million-metric-tons-hydrogen-produced-annually-united-states
[2] Deetjen et al., "Market Competitive Electrolysis in ERCOT" (2021) https://sites.utexas.edu/h2/h2ut-white-papers/
[3] Brown et al. "Estimating Renewable Energy Economic Potential in the United States: Methodology and Initial Results" National Renewable Energy Laboratory (2016) NREL/TP-6A20-64503
[4] https://www.utilitydive.com/news/developers-enter-largest-green-hydrogen-ppa-in-us-with-345-mw-of-wind-to-po/603366/

Using a case study of West Texas wind and solar resources along with Houston hydrogen demand, this paper explores key considerations for comparing these two energy transmission pathways. The conclusions show that hydrogen pipelines provide cost, energy storage, and other benefits when compared to power lines.

Scenario Comparisons

This section compares the delivery of renewable (green) hydrogen to hydrogen consumers in the Houston region using electricity generated in West Texas, where the best of Texas' wind and solar resources are. This analysis will use the existing Houston hydrogen demand as the baseline for the analysis, but additional future demands—including clean hydrogen exports—could further drive the development of these resources. Because both the pipeline and power line scenario utilize electrolysis, it was assumed that the bulk of their electricity needs would be similar.[5,6]

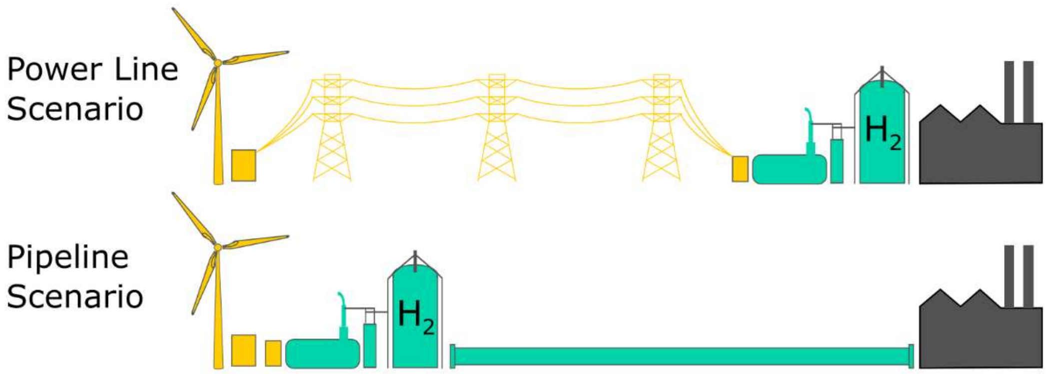

Figure 2: The two scenarios analyzed in this study. The Power Line scenario sites electrolysis near hydrogen consumers. The Pipeline scenario sites electrolysis near renewable electricity generators.

Power Line Scenario: Siting electrolysis near Houston hydrogen demand

If 25% of the daily Houston hydrogen demand—about 2.3 million kg—were met by local electrolysis, it would require an average of 4,000 MW[7] of *additional* electrical demand[8] in the region. This new electrical demand would increase the ERCOT Houston Load Zone's 2020 *peak* demand (19,700 MW) by 20% and increase its average demand (11,800 MW) by about 35%.

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[5] Note that if brackish groundwater is used, there is an additional energy need to treat the water to a potable water standard assumed for the electrolysis. We quantify this cost later in the Qualitative Comparison section.
[6] Note that system-wide efficiency may increase by co-locating electrolysis with wind and solar facilities and feeding DC power directly from the generator to the electrolyzer, thus avoiding AC/DC conversion losses.
[7] Peak demand may actually be higher than this 4,000 MW, depending on the capacity of the electrolysis facilities. If the electrolysis facilities ramp up and down with wind and solar output, for example, their utilization would be lower than 100%, and a peak demand of greater than 4,000 MW would be required.
[8] Not including compression costs as it is assumed approximately the same amount would be needed for SMR as electrolysis.

Given the large increase in the amount of electricity demand for this scenario in the Houston region, it is likely that the transmission capacity into the region would need to substantially increase given the current levels of congestion.[9] If all of the excess power came from outside of the region, then approximately the same capacity of new high-voltage power lines—4,000 MW—would be required.[10,11]

The majority of high-voltage transmission lines in Texas are 345 kV lines, of which, a double circuit can move about 800 MW, depending on length and operating conditions. If all of the power necessary for this electrolysis were brought in via new lines, roughly 5 new transmission corridors of double-circuit 345 kV lines would be required[12].

Pipeline Scenario: Siting electrolysis near west Texas renewables

Alternatively, the electrolysis could be sited in West Texas and the renewable hydrogen transmitted to Houston via pipeline. A 36-inch diameter pipe operating at 600 psi can transmit about 2.1 million kg of hydrogen per day[13]—enough capacity to provide 25% of Houston's current hydrogen demand. This analysis assumes that such a pipeline would be constructed as a new-build. However, it could be possible to reuse some existing pipeline rights-of-way or repurpose natural gas pipelines for hydrogen transport.[14]

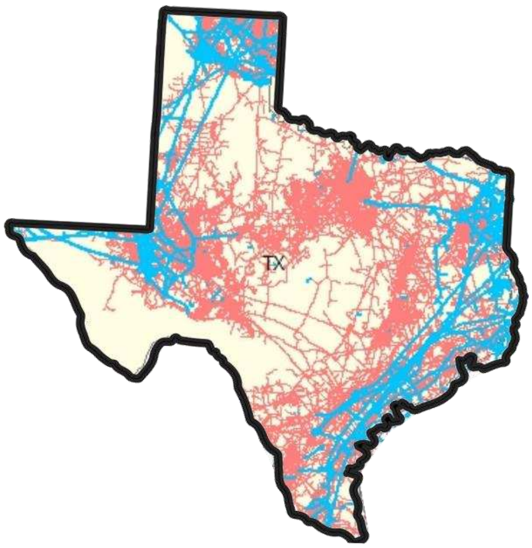

Figure 3: The natural gas infrastructure in 2013 (red=intrastate, blue=interstate)[1]. Existing pipeline right-of-way corridors may be useful for a potential hydrogen pipeline project.

[9] ERCOT "Report on Existing and Potential Electric System Constrains and Needs" (December 2020)
[10] It is also likely that some distribution system upgrades would be required, but we assumed that the electrolysis systems would be large and directly connected to the transmission network.
[11] Because wind and solar capacity factors are less than 100%, it is assumed that the renewable electricity would be purchased through a Power Purchase Agreement on an annual volumetric basis and that there would be times where the power consumed by the constant electrolysis load would be provided by other types of generation resources.
[12] It is possible that the new electrolysis load could be operated flexibility and thus not require as many new lines, but that is beyond the scope of this white paper.
[13] https://www.energy.gov/sites/prod/files/2014/03/f11/delivery_infrastructure_analysis.pdf#page10
[14] https://www.siemens-energy.com/global/en/news/magazine/2020/repurposing-natural-gas-infrastructure-for-hydrogen.html

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