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Hydrogen Blending in Texas Natural Gas Power Plants at Scale

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Introduction

Hydrogen is a potential solution to help decarbonize the economy, including electricity. Once hydrogen is produced, it can be used in industrial processes or to produce electricity from fuel cells and gas turbines. Hydrogen can also be a long-term storage solution for excess electricity produced by other clean sources. Multiple studies have derived deep decarbonization pathways by integrating large amounts of hydrogen into many sectors of the economy.[1,2] These studies generally require large amounts of new capital expenditures and a significant reworking of the energy and transportation sectors to achieve their carbon reductions.

This study sought to assess the carbon emissions reduction value, if any, in utilizing low levels of hydrogen blending in *existing* power plants. This study finds that blending even relatively small amounts of hydrogen in the fuel streams of existing natural gas power plants can reduce carbon emissions. Furthermore, the results suggest that the levels of tax credits currently being considered at the federal level are likely necessary and sufficient to make hydrogen blending economically competitive in the short term.

Significant strides have been made in the development of new power plants, particularly natural gas turbines and combined cycle systems, that have the ability to utilize hydrogen fuel blends.[3] For example, the proposed Orange County Advanced Power Station in Texas is a 1.2 GW natural gas power plant with the ability to blend up to 30% hydrogen.[4] In addition, El Paso Electric is planning to install a similar unit to support its energy grid as part of its decarbonization efforts.[5] Outside the borders of Texas, the power industry also sees growth in hydrogen consumption utilizing gas turbines to help accelerate decarbonization efforts, including the Intermountain Power Project[6] in Utah and the Magnolia project[7] under development in Louisiana.

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[1] https://www.sciencedirect.com/science/article/abs/pii/S2542435121004426
[2] https://www.fchea.org/us-hydrogen-study
[3] https://www.powermag.com/high-volume-hydrogen-gas-turbines-take-shape/
[4] https://www.powermag.com/1-2-gw-dedicated-hydrogen-fired-power-plant-starts-taking-shape-in-texas/
[5] https://pv-magazine-usa.com/2021/10/21/el-paso-electric-looks-to-hydrogen-for-future-electric-power-generation/
[6] https://www.ipautah.com/ipp-renewed/
[7] https://kindle-energy.com/about-us/about-kindle-energy/

However, power plant fleet turnover is on the order of decades. While new gas turbines with the ability to consume high hydrogen blends are likely to be deployed in the future, existing power plants (that do not have this ability) will likely outnumber these new technologies in the short term. There are currently about 464 GW of natural gas turbine-driven[8] power plants in the US. About 13% (59 GW) of those power plants are in Texas and many are located in the energy-intensive Texas Gulf Coast region.

The Gulf Coast region is also home to the largest hydrogen hub in the US. Within this regional hydrogen hub, Texas alone consumes about 9 million kg of hydrogen per day, or about 1/3 of the total US consumption. Currently, almost all this hydrogen is used as feedstocks for the chemicals and oil and gas industries and is produced via steam methane reforming (SMR). The Texas Gulf Coast is also home to the most extensive hydrogen pipeline networks in the country, with over 715 km (~440 miles) of pipelines (in Texas) moving hydrogen throughout the region including to and from Louisiana.[9]

This investigation focused on a potential area for early adoption of hydrogen, based on co-located critical infrastructure. The analysis sought to accomplish two goals: 1) determine the spatial relationship between the existing hydrogen pipeline network and the local natural gas power plant fleet and 2) assess the implications for connecting the two. Utilizing historical energy generation and spatial data analysis techniques, the team assesses the suitability of the local natural gas power plant fleet to consume hydrogen, its impacts on power plant economics and emissions, as well as the increased demand for hydrogen in the Gulf Coast region of Texas.

Methods

Data

The initial area of study included power plants that were within 5 km of the existing hydrogen network. EIA 860[10] and EIA 923[11] (2020) were used as the basis for the set of power plants, and data from the Texas Railroad Commission (RRC)[12] for the locations of hydrogen pipelines.

The hydrogen pipeline data were down sampled from RRC county-level GIS files that contained pipeline data of all types. The pipelines that mentioned hydrogen in their description were taken from each of the 254 county files and combined into one pipeline dataset.

The EIA data include, among other things, the type of power plant, the amount of fuel it consumed, the amount of energy it generated, and its latitude and longitude. The locational

[8] Natural gas combustion turbines and combined cycles.
[9] This analysis only considered Texas power plants and pipelines, more pipelines an potentially near power plants also exist in Louisiana.
[10] https://www.eia.gov/electricity/data/eia860/
[11] https://www.eia.gov/electricity/data/eia923/
[12] https://mft.rrc.texas.gov/link/d4eda8c4-9ff0-43b7-8f19-da0a57f10fd2

values were used to convert the dataset into a spatial dataset that could be put into reference with the pipeline data using custom Python GeoPandas scripts.[13]

Hydrogen Substitution

Blending hydrogen with natural gas reduces the volumetric energy density of the mixed gas. Thus, a higher volume of hydrogen-blended natural gas is required to deliver the same amount of energy to a power plant. For reference, a 5% volumetric blending of hydrogen with natural gas would only displace about 2% of the natural gas if the blended gas stream is to deliver the same level of energy (MMBTU) to a power plant.

Figure 1 shows a schematic of two methods of delivering hydrogen to power plants. One path is to blend hydrogen into the existing network before reaching the power plant. A different near-term possible pathway would be to deliver hydrogen directly to power plants via dedicated infrastructure. Due to the presumably small, but unknown cost differential, the second pathway, blending onsite at the power plant, was chosen for this study.

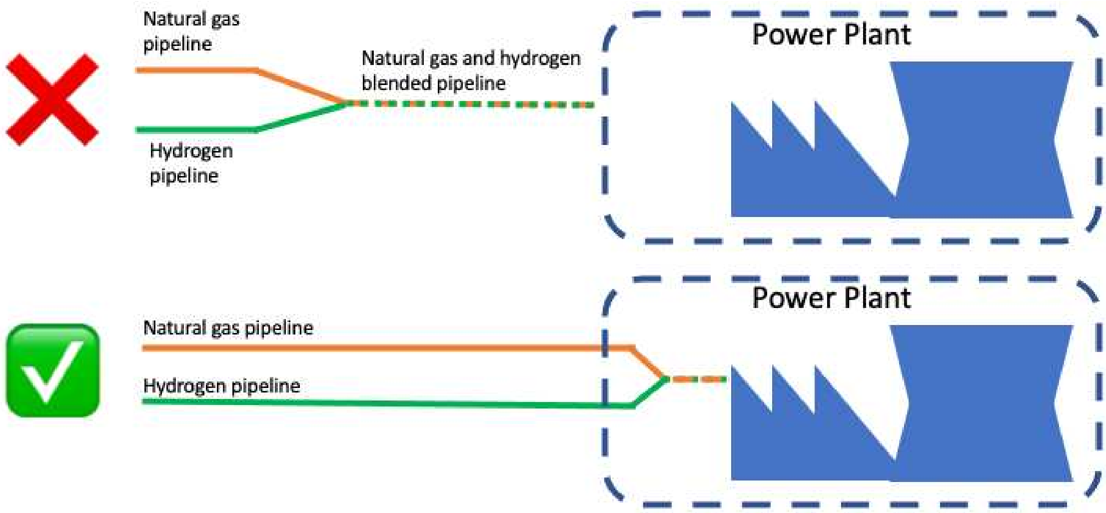

Figure 1: Figure showing the method of getting hydrogen to power plants considered in this analysis. The analysis DID NOT consider blending hydrogen into the bulk natural gas grid (top), but instead utilizing a separate pipeline to deliver pure hydrogen directly to the power plant to be mixed into the fuel stream immediately before combustion (bottom).

Case Study Area

This analysis focused on the Gulf Coast region of Texas, including the counties of Texas that border the Houston (Harris County) region and touch the Gulf of Mexico. This area of Texas is home to most of the existing hydrogen infrastructure in the state.

Results

[13] https://geopandas.org/en/stable/