Market Competitive Electrolysis in ERCOT

Across US and global markets, demand for hydrogen is increasing. Simultaneously, the cost of producing hydrogen via electrolysis using electricity is decreasing, creating new market opportunities for this low-carbon hydrogen production process. To assess this opportunity, three key cost factors for hydrogen production using an electrolyzer need to be considered: capital, operating, and electricity cost. Of these three, the electricity cost can be assumed to vary most widely by location due to local availability of generating sources and local market rate structures. Although conventional wisdom holds that electrolyzers can only operate profitably if given very low electricity prices, this paper highlights an existing electricity market where electrolysis could be an attractive and profitable option for hydrogen production today.

Since electricity prices vary over time, an electrolysis facility can choose when and to what extent to adjust its hydrogen production to target lower electricity prices and consequently reduce its hydrogen production costs. This white paper uses historical electricity price data from the Electric Reliability Council of Texas (ERCOT), the grid that serves 90% of Texas, coupled with a basic techno-economic model of electrolysis to explore the costs and benefits of flexible electrolysis operation considering variable wholesale electricity prices. With strategic operating schedules, cost reductions, and efficiency improvements, electrolysis shows promise as a low-carbon, cross-sector, market competitive, and flexible source of hydrogen.

Electrolysis techno-economic model

To explore the cost and benefits of flexible electrolysis operation, we use a general model of a PEM electrolysis facility. The facility[1] has fixed costs—including amortized capital costs and fixed annual operating costs—and purchases electricity via a monthly demand charge ($/kW) applied to the facility's peak electricity consumption plus an hourly energy price ($/kWh). We assume the facility has access to potable water, is connected to the Houston hydrogen pipeline network, and operates at an energy efficiency of 60% (55.6 MWh-electricity/tonne-H2).[2]

We assume the electrolysis facility's hourly energy price ($/kWh) equals the wholesale electricity price at ERCOT's Houston price hub[3]. These prices change every 15-minutes due to their dependence on the supply and demand in the ERCOT electricity market.

This energy price variation has a direct impact on the cost of hydrogen production, and thus profitability, at any particular location. The ten-year average cost variation at the Houston hub is summarized in Figure 1. For example, this chart shows that about 80% of the time, the wholesale price of electricity was less than $30/MWh. These data provide the total electrical energy cost if one decides to only operate the electrolyzer when the cost of electricity is below a preselected threshold

[1] Data from the NREL H2A model (version 3.2) for centralized electrolysis facilities: < https://www.nrel.gov/hydrogen/h2a-production-models.html>
[2] For more information on capital costs, fixed costs, efficiency, financing, and demand charges, see the Appendix.
[3] Data from ERCOT: "Historical RTM Load Zone and Hub Prices" < http://www.ercot.com/mktinfo/prices>

level. To explore the benefit of electricity price optimization in this market, we assume the electrolysis facility can turn on and off throughout the day to make use of advantageous prices. This behavior is captured using a simple heuristic: whenever prices exceed a specific "threshold electricity price," the electrolysis unit does not produce hydrogen.

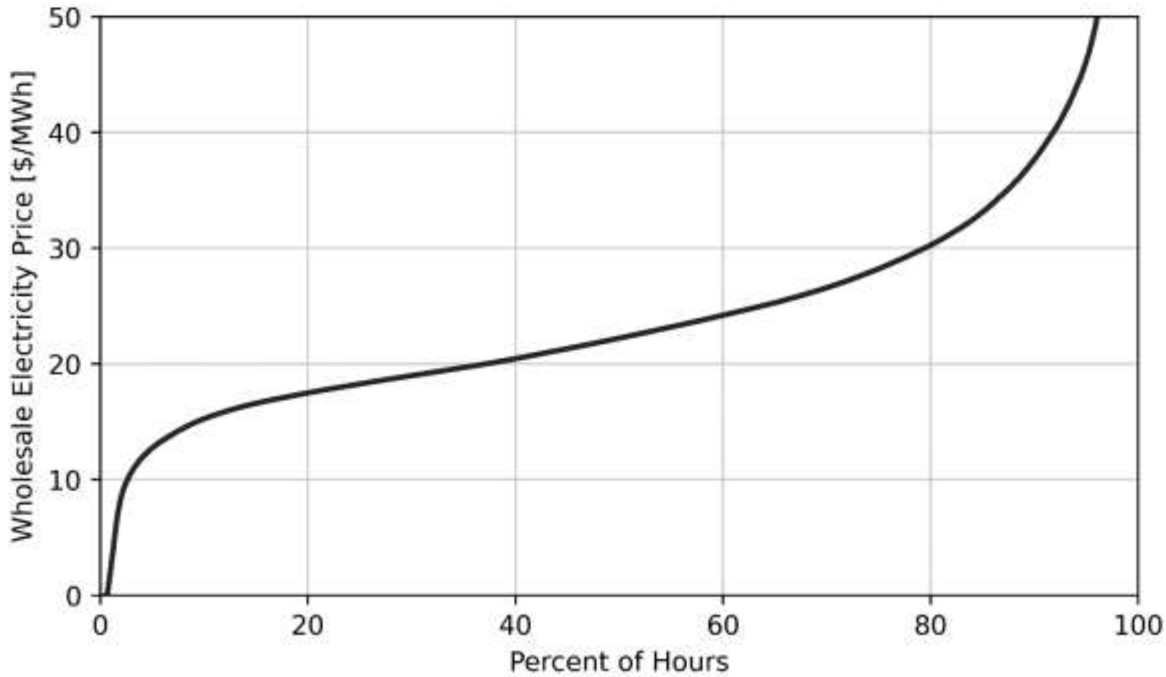

Figure 1: Wholesale electricity prices at the ERCOT Houston price hub from 2011-2020, arranged from lowest to highest. The data show, for example, that 80% of the time, the wholesale price of electricity was less than $30/MWh.

Flat production costs at utilization rates above 65%

Figure 2 shows the tradeoffs between fixed production costs, electric demand charge, and electrical energy cost in terms of the threshold electricity price. A noteworthy trend is that there is little benefit in this particular market to curtail production when electricity prices exceed a predetermined threshold, at least up to a threshold of $50/MWh. This is because, at threshold electricity prices above $26 /MWh—i.e., full load hours above 65%—the electrolysis facility's production cost remains relatively constant: ranging from $1.83-1.90 /kg-$H_2$.

On the other hand, at threshold electricity prices below $26 /MWh, the production cost ($/kg-$H_2$) of the electrolysis facility increases exponentially. Here, variable electrical energy costs are low, but the facility produces too little hydrogen to cover its other costs.

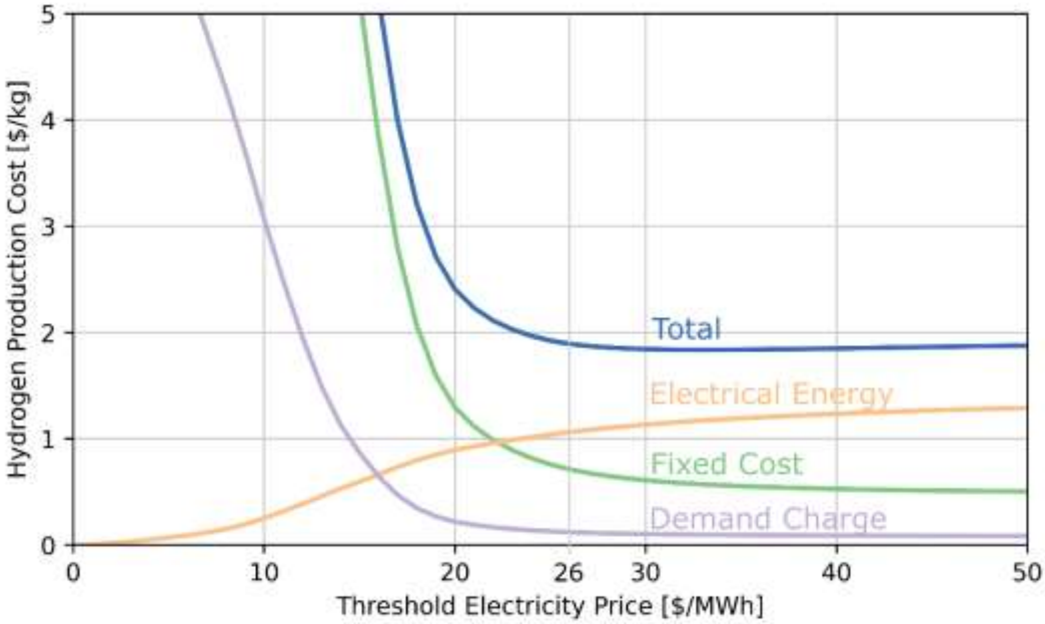

Figure 2: Average production costs ($/kg-$H_2$) and full load hours depend on the threshold electricity price. Whenever prices exceed the threshold electricity price, the electrolysis unit does not produce hydrogen. At threshold prices above 26 $/MWh, higher electrical energy costs are balanced by lower average fixed costs and demand costs. This yields a relatively flat average total production cost curve whenever full load hours exceed 65%.

Technology improvement impacts the production cost curve

Figure 3 shows how increased energy efficiency and reduced fixed costs would impact the electrolysis facility's production cost curve.

By raising the electrolysis facility's efficiency from 60% to 70%, the production cost curve shifts down and to the right. Higher efficiency electrolyzers can achieve lower production costs, but if they have higher fixed costs may require more operating hours to generate revenue to compensate for the fixed cost.

By reducing the electrolysis facility's fixed cost by 50%, the production cost curve shifts down and to the left. Lower cost electrolyzers with the same performance can achieve lower production costs and can operate at fewer full load hours without sacrificing production cost.

A combination of increased efficiency (70%) and reduced costs (-50%) brings total production costs down to 1.40 $/kg-H2.