Hawai‘i Natural Energy Institute Research Highlights

Alternative Fuels

Hydrogen to Meet Firm Power Needs in Hawai‘i

OBJECTIVE AND SIGNIFICANCE: In December 2023, HNEI provided a report to the legislature on the potential production and use of renewable hydrogen in Hawai‘i to inform the H_2 Strategic Plan. The study identified several potential use cases for hydrogen to meet Hawai‘i’s decarbonization goals, including using hydrogen for firm power generation.

Previous HNEI work and long-term utility planning has determined there will be a need for firm dispatchable power generation to support a 100% renewable energy system. To assess hydrogen’s ability to serve this need, HNEI evaluated the energy, and infrastructure needs to produce hydrogen using water electrolysis, store it, and convert it back to electricity to meet long-term firm power needs by supplying 5% of Hawai‘i’s 2045 annual electricity demand.

KEY RESULTS: Results of this analysis show that while it is technically feasible for hydrogen to provide firm power needs, there are substantial energy and storage infrastructure hurdles that are unique to the islands. Producing hydrogen using electrolysis is extremely energy intensive.

Results indicate that under optimistic technology performance, meeting 5% of statewide electricity demand using hydrogen would require annual electricity generation to increase by 21-27% when accounting for energy to enable storage. Whether produced by solar, wind, or geothermal, O‘ahu would be land constrained. Providing hydrogen to O‘ahu would require production and transport from one of the neighbor islands.

While hydrogen may have niche applications in Hawai‘i’s energy future, high production costs, the need for seasonal storage challenges, and shipping and transportation challenges/needs make it impractical for widespread use for firm power.

BACKGROUND: Hydrogen has received significant attention as a potential solution for decarbonizing various sectors in Hawai‘i’s economy. Legislative initiatives such as HB 1611 and HB 1937 reflect a strong interest in exploring hydrogen’s potential. HB 1611 proposed a State Energy Plan emphasizing firm renewable energy options, including hydrogen, while HB 1937 tasked the Hawai‘i Natural Energy Institute (HNEI) with evaluating hydrogen production from local renewable resources. This analysis included considerations, such as water usage, system costs, feasibility of end-use applications, and hydrogen's role in the grid. These issues are addressed in HNEI’s 2023 “Report on the Potential Production and Use of Renewable Hydrogen in Hawai‘i.”

National interest in hydrogen has surged following the passage of the Inflation Reduction Act (IRA), which introduced incentives for clean hydrogen hubs, intended to connect hydrogen consumers and producers. While Hawai‘i did not receive hydrogen hub funding, recent federal funding announcements continue to signal interest in hydrogen development in the state. A $56.7 million award to the Hawai‘i Department of Transportation was recently announced by the EPA to support hydrogen cargo handling equipment and associated storage and fueling infrastructure at Honolulu Harbor.

With the ongoing state interest in hydrogen, the HNEI-Telos team has continued to monitor developments to assess viability for Hawai‘i.

PROJECT STATUS/RESULTS: Deploying hydrogen for firm power generation in Hawai‘i presents three primary challenges:

1. **Energy Intensity of Production**: Producing hydrogen via electrolysis requires substantial amounts of energy, adding to the already significant demand for renewable electricity.
2. **Seasonal Storage Requirements**: Hydrogen storage would need to shift large amounts of energy from renewable-rich periods (spring/summer) to low-renewable, high-demand periods (fall/winter) – necessitating costly infrastructure.
3. **Inter-Island Transportation**: O‘ahu is unlikely to have the land availability to produce hydrogen at scale on its island. Transporting hydrogen between islands would further increase logistical complexity and costs.

Due to limited local resources, alternative hydrogen production methods, such as from crops or waste streams, are infeasible to meet firm power needs in Hawai‘i.

Approximately 54 million kilograms (kg) of hydrogen would need to be produced annually to meet 5% of Hawai‘i’s projected 2045 electricity demand (700 GWh/year). Electrolyzing this volume of hydrogen and converting it back into electricity would require 3,000 GWh/year of clean energy – representing a 27% increase in clean energy generation over the current estimated electricity demand. The low efficiency (24% round-trip) stems from losses in electrolysis (60%) and hydrogen combustion for electricity generation (40%), with additional losses due to needing liquid hydrogen for bulk storage.

Producing this amount of hydrogen using clean energy would require:

- 1,500 MW of solar PV (2x existing capacity, including rooftop solar);
- 860 MW of wind (4x existing capacity); or
- 360 MW of geothermal (10x existing capacity).

While Hawai‘i is blessed with a good year-round solar resource, there is significant seasonal variability. The use of hydrogen for firm power would result in a net production in the summer and a net consumption in the winter. Figure 1 shows weekly net hydrogen production (blue) and consumption (red) over a single year. A clear seasonal shift of energy from summer and spring months to fall and winter months is shown.

The mismatch between production and consumption shown above drives the need to consider hydrogen storage when assessing the use of hydrogen for firm power generation. In this example, O‘ahu requires peak hydrogen storage of 18,000 metric tons, equivalent to approximately 54 of NASA’s largest 330 metric ton liquid hydrogen storage tanks. Hawai‘i does not possess the type of geologic storage that some regions on the mainland may benefit from to reduce bulk storage costs and gaseous hydrogen storage is impractical at the scale discussed here.

This study will continue to inform economic and energy planners on the impact that integrating hydrogen production will have on Hawai‘i’s grid.

REFERENCES:

[1] HNEI, Report on the Potential Production and Use of Renewable Hydrogen in Hawai‘i, under Act 140, SLH 2022 and SB 2283, December 2023

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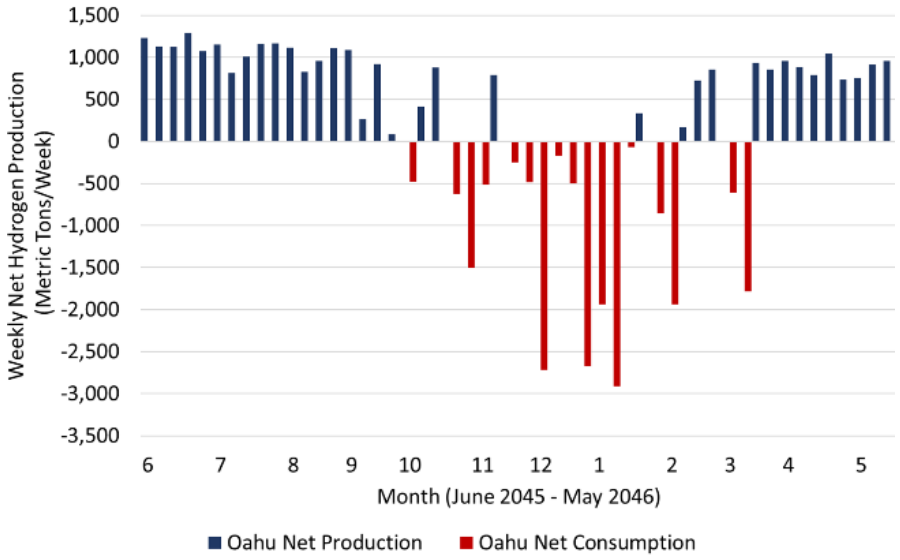

Figure 1. Weekly net hydrogen production for delivering 5% of O‘ahu electricity in 2045.