Hawai‘i Natural Energy Institute Research Highlights

Energy Policy & Analysis

Hawai‘i Hydrogen Integration Study

OBJECTIVE AND SIGNIFICANCE: HNEI initiated a study in 2022 that will evaluate the potential for hydrogen (H_2) production and grid integration in Hawai‘i, with expected completion in 2023. The objective of this study is twofold. Initially, it seeks to categorize the potential use cases for H_2 in Hawai‘i and quantify the power sector requirements for producing H_2 locally. Local H_2 production analysis can also be used for comparison against importing H_2 products. After H_2 needs are assessed, the integration of H_2 production into the electric grids across the state will be studied. The integration studies seek to determine the benefits and operational limitations of different H_2 electrolysis options and the power system requirements to satisfy Hawai‘i’s potential H_2 needs.

This study will also focus specifically on the power sector requirements for clean dispatchable resources and compare the H_2 integration for electric power use to other clean alternatives, such as long duration energy storage, geothermal, biodiesel, and other firm renewable technologies.

KEY RESULTS: While hydrogen may play an important role in long-term decarbonization, there exists uncertainty whether advancements in electrification will cut into potential hydrogen market shares. The round-trip efficiency differences between direct electrification and hydrogen use means that direct electrification is likely to be favorable if it is feasible for the end use. The following petroleum end uses in Hawai‘i may require hydrogen substitution of some form to fully decarbonize while other sectors will likely pursue electrification options:

- ***Aviation***: Opportunities for short-haul inter-island flights to be electrified;
- ***Medium/heavy duty vehicles***: Battery technology improvements could decrease fuel cell vehicle demand or replace them fully;
- ***Construction***: Heavy machinery, steel, cement, asphalt;
- ***Agriculture***: Remote locations may make grid charging difficult to manage; and
- ***Oil refining/chemical processes***: Residual petroleum for industrial products may require hydrogen.

BACKGROUND: In Hawai‘i, there is also continued interest in H_2 production and end use. During the most recent legislative session, multiple bills were proposed to encourage the development of an H_2 industry in Hawai‘i. HB1611 proposed a State Energy Plan that specifically addressed firm renewable options, including H_2, across Hawai‘i.

HB1937 required the Hawai‘i Natural Energy Institute to develop a H_2 Strategic Plan for Hawai‘i examining the State's ability to advance hydrogen production from local renewable energy resources. The study shall consider hydrogen availability and feasibility locally, water usage, costs/benefits, identification of end-use markets, permitting requirements, hydrogen for transportation and grid, techno-economic feasibility, and environmental benefits for resiliency, in comparison to imported hydrogen. The HNEI-Telos study, outlined in this document, is a first step of this Strategic Plan.

At a national level, the recent passage of both the infrastructure and jobs act (IIJA) and inflation reduction act (IRA) has created substantial momentum in the energy industry for producing clean hydrogen. Of most importance, is the ability for hydrogen to displace fossil fuel use in hard to abate sectors where electrification cannot meet all sector needs. Hard to abate sectors (e.g., aviation fuel) represent a significant portion of Hawai‘i’s current petroleum import needs and source of greenhouse gas emissions.

In addition, many prospective entities are developing hydrogen proposals for the U.S. Department of Energy (DOE) hydrogen hub grants around the country, including in Hawai‘i. Multiple stakeholders in Hawai‘i are pursuing DOE funding for a local “hydrogen hub” in the state. However, identification of the amount of useful hydrogen needed to decarbonize the economy, including an assessment of integrating hydrogen production in a high variable renewable energy grid has not yet been widely pursued. This study will serve as an initial basis for future hydrogen analysis in Hawai‘i as decarbonization goals progress.

PROJECT STATUS/RESULTS: A review of current petroleum and natural gas flows to end-use sectors is currently underway. Pre-COVID 2018 and 2019 petroleum use by end-use sector is available from the Hawai‘i State Energy Office (HSEO) and the U.S.

Energy Information Agency (EIA). This data serves as the basis for determining the proportion of primary energy input that can either be electrified or require H_2 conversion.

Table 1. 2018 Petroleum Use by End Use Sector (from HSEO 2020 HI Energy Facts and Figures).

HSEO End-Use Sector	Total 2018 Petroleum Usage (%)
Transportation	65%
Electric Power	24%
Industrial	8%
Commercial	3%
Residential	0.3%

Of the end-use sectors referenced in Table 1, Transportation and Electric Power make up the bulk of petroleum usage, but also present significant electrification potential. Disaggregating the end-use sectors into granular energy uses, such as light versus heavy duty vehicle input is required to assess electrification potential versus H_2 potential. This is the current state of phase one for the H_2 integration study. Analysis of available HSEO, Hawai‘i Department of Business, Economic Development & Tourism (DBEDT), and the EIA State Energy Data System (SEDS) energy use data will be used to disaggregate sectors (Figure 1).

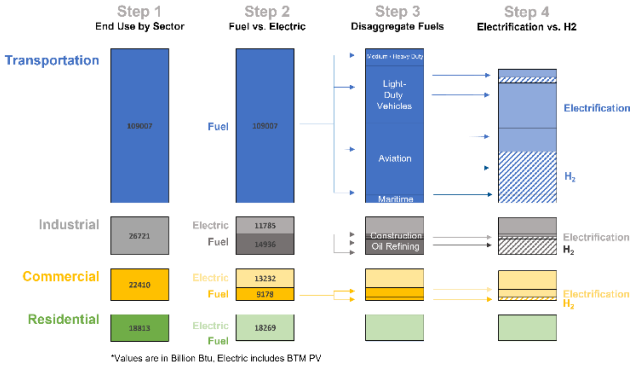

Figure 1. Example of the disaggregation of end use sector energy input into electrification versus H_2.

Building off the statewide review of potential H_2 end-uses, future electricity demand profiles will be developed. These profiles will reflect different electrification futures with different splits between electricity and molecules (hydrogen) for energy inputs. An example of this could be a future where electrification potential increases beyond electric power and light-duty vehicle needs, translating to lower H_2 demand.

For each electrification/H_2 scenario developed, the amount of H_2 production needed on a yearly and monthly basis will be used to characterize electrolyzer and electric power needs. The H_2 needs for each scenario will be modeled using production cost software to assess three hydrogen integration pathways to meet each future scenarios H_2 need.

The following hydrogen integration pathways present different grid integration and production challenges for H_2 to serve industrial and electric power needs. Electrolysis production factors kept consistent between H_2 configurations will be electrolyzer efficiencies, minimum operating durations, load flexibility, and H_2 storage configurations including the impact on round trip efficiency of the H_2 systems.

- **Baseload**, high capacity factor, low capacity (small electrolyzer size) which curtails only during extreme electric power shortages. This configuration maximizes electrolyzer utilization.
- **Self-supply**, electrolyzer load brings a separate portfolio of renewable energy resources but still operates with grid energy.
- **Grid-supply**, low capacity factor, high capacity (large electrolyzer size) targeting surplus renewable energy periods. This configuration is more price sensitive and grid buildout heavily influences hydrogen production load.

The H_2 integration study will inform the operational requirements for future H_2 load to serve multiple purposes in a decarbonized Hawai‘i economy. The study will focus on several important integration questions; key questions are included below for context:

- How much H_2 storage is required to meet multiple H_2 end-use demands? How much is strictly for long duration energy storage?
- What impact does H_2 load have on statewide electricity curtailments?
- What amount of load flexibility is useful from H_2 electrolyzers?
- What are the system losses and roundtrip efficiency of the H_2 system, inclusive of production, transportation, and storage of H_2 within the island?

This study is a first step in developing Hawai‘i’s hydrogen economy. It will inform economic and energy planners on the impact that integrating hydrogen production will have on Hawai‘i’s grid.

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