Hawai‘i Natural Energy Institute Research Highlights

Alternative Fuels; Electrochemical Power Systems

NELHA & MTA Hydrogen Stations and Fuel Cell Electric Buses

OBJECTIVE AND SIGNIFICANCE: HNEI has installed a 65kg/day hydrogen production and dispensing station on the Island of Hawai‘i at the Natural Energy Laboratory Hawai‘i Authority (NELHA) (Figure 1). The objective of the project is to evaluate the technical and financial performance, and durability of the equipment, and support a fleet of three hydrogen Fuel Cell Electric Buses (FCEB) operated by the County of Hawai‘i Mass Transit Agency (MTA). The knowledge gained in this project will inform the MTA on benefits and issues associated with transitioning from a diesel bus fleet to a zero emissions FCEB fleet in support of the State of Hawai‘i’s and the County of Hawai‘i’s clean transportation goals. The knowledge will also be transferred to other counties to assist them in evaluating the deployment of zero emission buses for their public transportation fleets.

Figure 1. HNEI’s NELHA Hydrogen Station.

BACKGROUND: Development of hydrogen-based transportation systems requires infrastructure to produce, compress, store, and deliver the hydrogen; a means to dispense the fuel; and vehicles to use the hydrogen. The HNEI hydrogen station at NELHA has been designed to dispense hydrogen at 350 bar (5,000 psi). In place of ground-mounted tank storage, HNEI will demonstrate centralized hydrogen production and distributed dispensing with a fleet of three hydrogen transport trailers (HTT). High purity hydrogen produced at NELHA will be delivered to the MTA base yard in Hilo to support heavy-duty FCEBs operated by the MTA Hele-On public bus service. This concept is illustrated in Figure 2.

In additon to the technical and cost analysis, HNEI is developing implementation plans to support the introduction of zero emission transportation systems. HNEI is coordinating with the University of Hawai‘i’s Hawai‘i Community College and the County of Hawai‘i MTA to support the introduction of workforce development programs to train technicians to service the FCEBs and other battery electric vehicles.

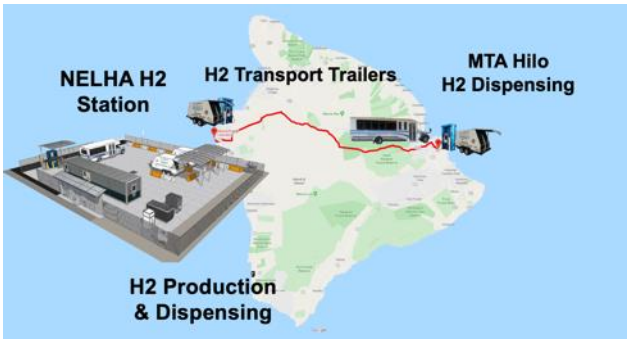

Figure 2. Hydrogen Transport Concept.

PROJECT STATUS/RESULTS:

Hydrogen Station: The site infrastructure, as well as the hydrogen production and compression systems equipment, have been installed at NELHA (Figure 3). In 2021, the station was fully commissioned by HNEI and Powertech, the equipment supplier.

Figure 3. HNEI Hydrogen Station

The station uses a Proton Onsite (now Nel) electrolyzer to produce 65 kg of hydrogen per day at an outlet pressure of 30 bar (440) psi. A HydroPak compressor (Figure 4) compresses the hydrogen to 450 bar (6,600 psi).

Figure 4. HydroPac Compressor.

The system is powered by the Hawai‘i Electric Light Company (HELCO) grid which includes a substantial fraction of renewable energy including solar, wind, and geothermal.

Hydrogen Transport Trailers: Three trailers (Figure 5) are available for transport between the production and fueling site are certified by the Federal Transit Administration for use on U.S. public roads. The hydrogen cylinders must be recertified every five years.

Figure 5. Hydrogen Transport Trailers.

Hydrogen Dispensing System: The dispensing system consists of a dispenser (Figure 6) connected to a fueling trailer through a fueling post interface that is connected to the dispenser via an underground hydrogen piping distribution system. The hydrogen dispenser is fully automated and programmed to “fail safe” for unattended operation.

Figure 6. Hydrogen Dispenser.

The fueling dispensers located at NELHA and at MTA are identical except for the addition of a boost compressor at the MTA site integrated into the MTA fueling post (Figure 7). The boost compressor system was developed by HNEI and Powertech to dispense up to 90% of the hydrogen stored in the HTT in order to reduce transportation costs by not having to return half-filled trailers to be refilled at NELHA.

Figure 7. MTA Boost Compressor Fueling Post.

Hele-On 29-Passenger Fuel Cell Electric Bus: The Hele-On 29-passenger FCEB (Figure 8) was purchased with funds from the Energy Systems Development Special Fund. This bus, manufactured by Eldorado National, and converted to a hydrogen-electric drive train by U.S. Hybrid is ADA-compliant. During this reporting period, the fuel cell power system was upgraded by replacing the original 30 kW Hydrogenics fuel cell with a new state-of-the-art 40 kW U.S. Hybrid fuel cell. During commissioning the fuel cell produced 46kW, a 15% improvement.

Figure 8. Hele-On 29-Passenger FCEB.

Onboard hydrogen is stored in composite carbon fiber cylinders located under the bus with a capacity of 20kg. The fuel cell power system is integrated with two 11 kWh A123 Lithium-ion battery packs to provide motive power to a 200 kW electric drive system. U.S. Hybrid also replaced batteries with the new technology A123 batteries using U.S. Hybrid internal funding. At cruising speed, the fuel cell maintains the battery state of charge within a range that supports the long-term health of the battery.

During deceleration, the electric motor acts as a generator sending power back into the battery ("regenerative braking"). This contributes to overall system energy efficiency and improves bus mileage. The bus has a range of approximately 200 miles depending on the route topography and driver skills.

A 10 kW export power system (Figure 9) was installed in the 29-passenger bus to enable the bus to provide 110/220VAC electric power at full power for up to 30 hours as emergency power for civil defense resilience operations when the grid power is down. The bus can be refueled in 10 minutes providing an additional 30 hours of emergency power.

Figure 9. Bus Export Power Unit.

Hele-On 19-Passenger Fuel Cell Electric Buses: Two 19-passenger FCEBs (Figure 10) were also acquired by the MTA from Hawai'i Volanoes National Park (HAVO). These buses were converted by U.S. Hybrid and are of similar design to the 29-passenger FCEB. Onboard hydrogen capacity is 10 kg giving a projected range of 100 miles. These buses are being upgraded with 40kW U.S. Hybrid fuel cells and A123 Lithium-ion batteries using funding provided by the County of Hawai'i.


Figure 10. HAVO 19-Passenger FCEB.

Figure 11 is a conceptual design of the hydrogen fueling dispensing system located at the MTA base yard in Hilo which is comprised of repurposed, new equipment that was originally intended to support the two HAVO buses.

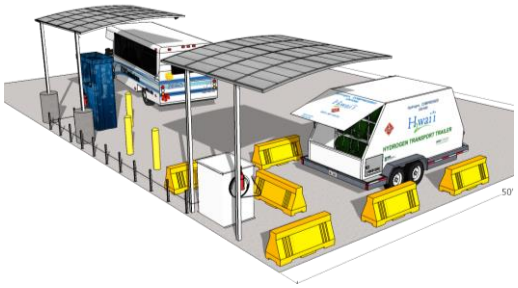
Figure 11. MTA Fueling Dispensing Station.

HNEI consulted with the MTA to select the location illustrated in Figure 12 for the hydrogen dispensing system. This single dispenser can support approximately 22 buses (illustrated) over a 6-hour period at a 16-minute fueling interval.


Figure 12. MTA Site with Fueling Dispenser.

This project has produced the following papers:

- 2020, A. Headley, et al., **Valuation and cost reduction of behind-the-meter hydrogen production in Hawai'i**, MRS Energy & Sustainability, Vol. 7, Paper E26.
- 2020, M. Virji, et al., **Analyses of hydrogen energy system as a grid management tool for the Hawaiian Isles**, International Journal of Hydrogen Energy, Vol. 45, Issue 15, pp. 8052-8066.

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