

# Hydrogen Fuel Cell Power Generator Test and Demonstration Report

*Operational Observations for Zero-Emission (ZE)  
Portable Power Applications*



**California Air Resources Board**

Air Quality Planning and Science Division  
Mobile Source Analysis Branch

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## **California Air Resources Board**

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# **H2FC Generator Test and Demonstration Report**

### **Disclaimer**

To ensure transparency and neutrality, the following points apply to this report:

- This report presents factual observations and data collected under defined test conditions and does not constitute an endorsement, certification, or approval of any specific manufacturer, product, or technology by CARB.
- Brand names, model names, and specifications are included solely for transparency, technical identification and documentation purposes.
- The test results reflect performance under controlled demonstration conditions and should not be interpreted as representative of all in-use operating environments or duty cycles.
- The evaluated unit represents a specific model configuration (2022 version) of the EODev GEH2 80 kW generator; performance and design characteristics may differ in newer or updated versions.
- The test results do not fully represent real-world operation or the full range of system capabilities under varying field conditions.
- Economic and cost analysis and lifecycle assessment are outside the scope of this report.

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## **EXECUTIVE SUMMARY**

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This report presents the results of CARB's first in-house evaluation of a hydrogen fuel cell (H<sub>2</sub>FC) generator conducted at the Depot Park testing facility. The objective was to assess operational performance, energy efficiency, and fuel consumption using the steady-state test approach developed for diesel generators.

Eight independent 15-minute sessions were conducted at loads ranging from 20% to 90% of rated capacity. The H<sub>2</sub>FC generator demonstrated stable electrical output and consistent load tracking under all tested conditions.

Calculated global efficiency was highest at approximately 86% at 20% load and generally decreased at higher loads, reaching approximately 45% at 90% load. The 20% result was substantially influenced by the onboard battery and should not be interpreted as fuel-cell stack efficiency alone.

Hydrogen consumption generally increased with load and may support preliminary runtime estimates. The battery contribution was greatest during short, low-load operation, while its estimated relative contribution decreased with longer operating duration.

## **CHAPTER 1 – INTRODUCTION & BACKGROUND**

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### **Introduction**

Portable generators provide electricity in remote areas without grid access. The widespread installation of the power grid in the U.S. began in the early 20th century, and urban areas were electrified mainly between 1920 and 1930. Traditionally, access to electricity has depended on distance from the power grid, which makes location a key factor. The development of portable power generators has expanded access to electricity and enabled power use in off-grid environments such as construction sites, farms, outdoor events, and emergency operations.

The frequency of emergency power needs during wildfire-related outages and disaster recovery operations has increased demand for portable generator systems. Portable generators are a necessary component for emergency backup and disaster recovery during power outages or off-grid situations. According to [CARB's emissions inventory](#), the demand for portable generators is expected to continue growing through 2050, increasing demand for backup and distributed power systems.

CARB's latest Portable Engine emissions inventory includes generators equipped with engines certified to a range of emission standards, including older Tier 0 through Tier 3 standards. Given the continued use of older engines and projected growth in generator activity, zero-emission generator technologies are receiving increasing attention.

Today's generator market offers near zero- and zero-emission (ZE) options for diesel portable power generators. These include mobile hybrid generators that charge batteries using a small diesel engine, battery-powered units charged via the grid and supply electricity in remote areas, and hydrogen fuel cell (H2FC) generators that convert hydrogen into electricity. Among these, H2FC technology has advanced in recent years and provides electricity without combustion emissions.

To evaluate one such technology, CARB staff tested a commercially available 80 kW H2FC generator using the steady-state load approach developed for CARB's diesel-generator emissions testing program.

## Quick Overview of the Off-Road Diesel Surveillance Program

The California Air Resources Board (CARB)'s [Off-Road Diesel Equipment Surveillance Program](#) aims to improve the accuracy of its emissions inventories for diesel-powered equipment. In collaboration with the Off-Road Diesel Analysis Section (ORDAS) and the Measurement Assessment and Research Section (MARS), the current series of this program focuses on collecting in-use tailpipe emissions data from diesel portable power generators. Current emission rates in CARB's OFFROAD model rely on emission factors derived from engine-dynamometer certification testing, which may underestimate or overestimate in-use emissions under real-world operating conditions, especially at low-load operations. The surveillance program conducts emissions testing on power generators with various power ratings and generator models using a Portable Emissions Measurement System (PEMS). The refined emission data may support future updates to the Portable Equipment emissions inventory category.

## Purpose of This Report

This report documents the results of CARB's first in-house evaluation of an H2FC generator, conducted at the Depot Park testing facility in Sacramento. The evaluation used the load bank and related testing resources available through the Off-Road Diesel Equipment Surveillance Program to better understand the operational characteristics and energy performance of a commercially available zero-emission generator technology.

While the surveillance program primarily focuses on collecting in-use emissions data from diesel portable generators, the availability of an H2FC generator during the July 2025 ZE demonstration event provided an opportunity for CARB staff to examine how this emerging technology performs under the same steady-state test conditions used for diesel generator testing. The objective was not to conduct a full technology certification assessment, but rather to collect practical operational data and document field observations.

In addition to the measured test results, the report summarizes several observations made during system setup and operation, including deployment requirements, hydrogen supply logistics, startup procedures, and general operational behavior.

## Contribution of Portable Equipment and Power Generators

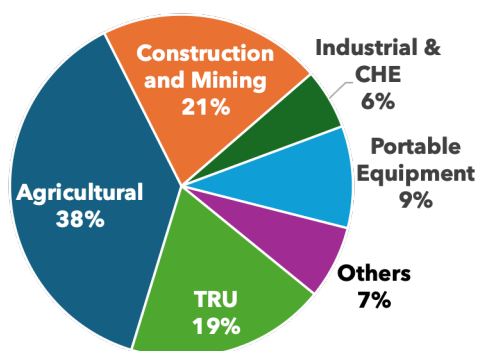
The [Portable Equipment \(PE\) category](#) includes generators, compressors, pumps, and similar equipment. CARB's current PE inventory methodology was last updated in 2017. As shown in **Figure 1**, PE accounts for approximately 9 percent

of NOx emissions and 7 percent of PM emissions among the land-based off-road sectors included in the comparison. Ocean-going vessels, locomotives, aircraft, and other primarily federally regulated sources are excluded.

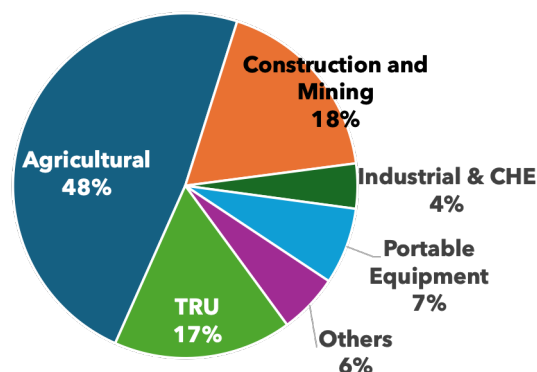
Within the PE category, generators rated at 50 horsepower (hp) or greater were the largest subcategory in calendar year 2024. Their estimated population was 13,367 units, representing approximately 50 percent of the total PE population. These generators emitted an estimated 10.4 tons per day (tpd) of NOx and 0.35 tpd of PM. Portable diesel engines rated at 50 horsepower (HP) or greater are subject to the Airborne Toxic Control Measure ([ATCM](#)) for Diesel Particulate Matter from Portable Engines.

Given their population and emissions contribution, generators represent a potential application for zero-emission portable-power technologies, including hydrogen fuel-cell systems.

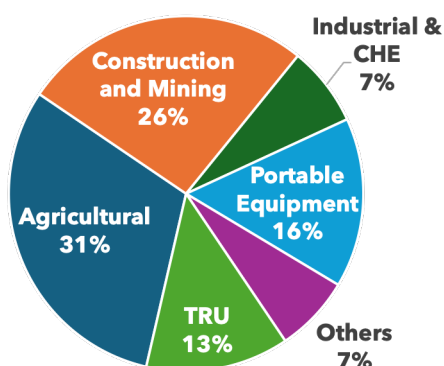
NOx Emission Contributions



PM Emission Contributions



Fuel Consumption Contributions



Population Allocations

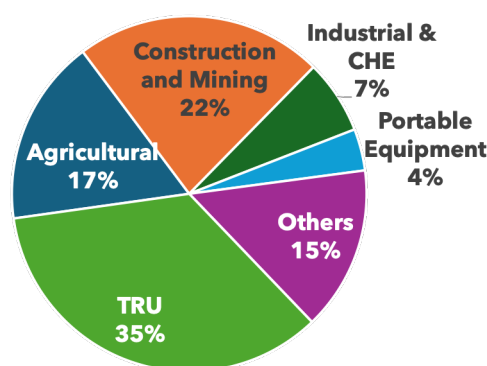


**Figure 1. Contribution of Portable Equipment in California Off-Road Sectors (2024)<sup>1</sup>**

<sup>1</sup> CHE: Cargo Handling Equipment, TRU: Transport Refrigeration Unit

## CHAPTER 2 - HYDROGEN FUEL CELL GENERATOR TECHNOLOGY OVERVIEW

### H2FC Generator / Mobile Power & Charging OEM Examples

**Table 1** provides examples of commercially available hydrogen fuel cell generator systems and mobile power platforms, including representative applications, power classes, and system architecture characteristics.

**Table 1. Hydrogen Fuel Cell Generator Technology Overview – Market Examples**

| OEM / Brand    | Product / System                   | Application                                          | Power output                                                                                  | Key Features                                                                                                                                                                 |
|----------------|------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EODev          | GEH2                               | Mobile/temporary power and diesel genset replacement | <ul style="list-style-type: none"> <li>80 kW</li> </ul>                                       | <ul style="list-style-type: none"> <li>Toyota PEM fuel cell<sup>2</sup> + LiFePO<sub>4</sub> battery (44–62 kWh cited by OEM); low-noise; zero tailpipe emissions</li> </ul> |
| Nuvera         | HydroCharge <sup>TM</sup>          | Off-grid EV charging and on-site AC power            | <ul style="list-style-type: none"> <li>50 kW DC fast charging</li> </ul>                      | <ul style="list-style-type: none"> <li>Integrated H2FC system combining EV fast charging and AC generation; designed for temporary/remote sites</li> </ul>                   |
| Hyundai (HTWO) | Fuel Cell Power Generator / System | Stationary/grid-connected power generation           | <ul style="list-style-type: none"> <li>100 kW peak / 70 kW rated (platform spec)</li> </ul>   | <ul style="list-style-type: none"> <li>PEMFC system platform</li> <li>Grid-connection operation</li> <li>Max efficiency up to 61.7%</li> </ul>                               |
| GeoPura        | Hydrogen Power Unit (HPU)          | Temporary power / backup power / off-grid deployment | <ul style="list-style-type: none"> <li>250 kVA, including battery buffer (216 kWh)</li> </ul> | <ul style="list-style-type: none"> <li>Fuel-cell powered generator with integrated battery buffer; delivered as managed power service</li> </ul>                             |

### H2FC Powertrain Manufacturers

**Table 2** summarizes hydrogen fuel cell stack, module, and power system manufacturers relevant to portable power and mobile energy applications. This table includes representative product lines and typical power classes referenced in publicly available technical materials. The list is intended for illustrative purposes and is not exhaustive.

<sup>2</sup> PEM: Proton-exchange membrane

**Table 2. Examples of Commercial Hydrogen Fuel Cell Powertrain and Fuel Cell System Manufacturers**

| Company                               | Product line / System                                         | Power Output                                                                             |
|---------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------------------------------|
| <a href="#">Ballard Power Systems</a> | FCmove®                                                       | • 70 kW module class (mobility)                                                          |
| <a href="#">Cummins (Hydrogenics)</a> | HyPM™ <a href="#">HD90</a>                                    | • 99 kW continuous class (scalable)                                                      |
| <a href="#">Toyota</a>                | Toyota fuel cell system                                       | • 60–80 kW class modules (scalable)                                                      |
| <a href="#">Hyundai</a>               | HTWO                                                          | • 100 kW peak / 70 kW rated class                                                        |
| <a href="#">Honda</a>                 | <a href="#">Next-Generation Fuel Cell Module</a>              | • 150 kW module class; also integrated into Honda Fuel Cell Power Generator applications |
| <a href="#">Bosch</a>                 | Fuel cell power modules                                       | • 300kW                                                                                  |
| <a href="#">cellcentric</a>           | Scalable fuel cell system                                     | • 150 kW system class (scalable)                                                         |
| <a href="#">PowerCell Group</a>       | Heavy-Duty System 100                                         | • Up to 100 kW system class                                                              |
| <a href="#">Symbio</a>                | StackPack™ 150                                                | • Up to 150 kW system class                                                              |
| Horizon Fuel Cell Technologies        | <a href="#">VLS II</a> Pro series / <a href="#">VL series</a> | • VLS II: 100 kW / 135 kW / VL: 150kW                                                    |

## Regulation/Code/Policy relevant to the hydrogen refueling process and logistics

**Table 3** summarizes selected hydrogen safety codes, engineering standards, and regulatory frameworks related to hydrogen storage, handling, transportation, fueling, and pressure vessel design that are relevant to portable hydrogen fuel cell generator applications. The list is intended to provide representative examples and is not exhaustive.

Although many of these standards were originally developed for hydrogen vehicle fueling or stationary hydrogen systems, the underlying principles for pressure vessel design, hydrogen handling, and fueling safety are also relevant to portable H2FC generator applications.

**Table 3. Examples of Hydrogen Safety Codes, Standards, and Regulatory Frameworks Relevant to Portable H2FC Systems**

| Regulation / Code / Policy                         | Description                                                                                                                                                                                                      |
|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ASME BPVC Section VIII, Division 3 (Article KD-10) | • Provides design requirements for high-pressure vessels used to transport and store gaseous hydrogen. Relevant to hydrogen storage cylinders and pressure systems used in portable H2FC generator applications. |
| ISO 19880-1: Gaseous Hydrogen Fueling Stations     | • International standard providing safety and design requirements for gaseous hydrogen fueling stations and                                                                                                      |

| Regulation / Code / Policy                                            | Description                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                       | fueling equipment. Relevant to hydrogen refueling infrastructure and portable fueling applications.                                                                                                                                                               |
| SAE J2601: Fueling Protocols for Light-Duty Gaseous Hydrogen Vehicles | <ul style="list-style-type: none"> <li>Defines fueling protocols and communication requirements for hydrogen dispensing systems to support safe and consistent hydrogen fueling.</li> </ul>                                                                       |
| NFPA 2: Hydrogen Technologies Code                                    | <ul style="list-style-type: none"> <li>Provides safety requirements for producing, storing, transporting, and using hydrogen in stationary, portable, and vehicle applications. Widely recognized as the primary U.S. hydrogen safety code.</li> </ul>            |
| U.S. Department of Energy (DOE) Safety, Codes & Standards Program     | <ul style="list-style-type: none"> <li>Supports research that improves hydrogen safety, engineering standards, and codes through studies of hydrogen behavior, storage, and fueling technologies.</li> </ul>                                                      |
| California Adoption of NFPA 2                                         | <ul style="list-style-type: none"> <li>California incorporates NFPA 2 into its fire and building codes. Hydrogen fueling stations, storage systems, and related infrastructure must comply with these requirements during permitting and construction.</li> </ul> |
| California SB 1418 (Expedited Permitting for H2 Fueling Stations)     | <ul style="list-style-type: none"> <li>Streamlines local permitting process for hydrogen fueling stations to support faster deployment of hydrogen infrastructure.</li> </ul>                                                                                     |
| California AB 716 (Statewide Hydrogen Safety Standards proposed)      | <ul style="list-style-type: none"> <li>Would establish consistent statewide hydrogen safety requirements and provide additional technical support and training for local agencies.</li> </ul>                                                                     |

## CHAPTER 3 – TEST PLAN AND METHODS

The H2FC genset test, conducted in partnership with [EODev](#), allowed CARB staff to evaluate the energy efficiency and operational behavior of an 80 kW H2FC genset using the same steady-state framework applied to [Tier 4 final diesel generators](#). This report summarizes the test results and lessons learned from the demonstration and documents operational observations from evaluating a commercially available H2FC generator.

### Test location and test equipment setup

- Test Location: CARB's emission test facility in Depot Park, Sacramento
- Test Setup: The test article, a hydrogen fuel cell generator, was located outside of the test facility, and the test engineers located the hydrogen tanks 15 feet away from the generator.



**Figure 2. H2FC Generator and Load Bank Installed at the Test Site**



**Figure 3. Hydrogen Storage Cylinders and Pressure Regulation System Connected to the H2FC Generator**



**Figure 4. Water Byproduct Observed During H2FC Generator Operation**



**Figure 6. Typical transportation configuration for a portable diesel power generator during field deployment.**

**Figure 5. Physical Size Comparison Between the Diesel Generator and the H2FC Generator**



**Figure 7. H2FC generator demonstration powering an electric vehicle**

## H2FC Generator System Architecture

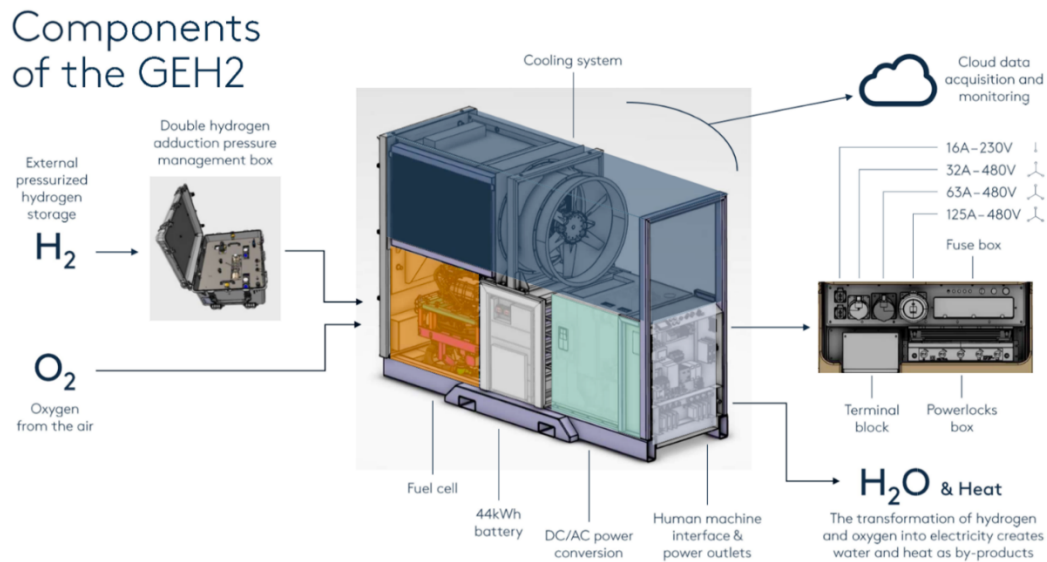


**Figure 8. OEM-Provided Architecture of the H2FC Power Generator System**

The overall configuration of the tested H2FC generator is illustrated in **Figure 8**, based on the OEM-provided system architecture. The unit is a containerized, integrated power system that combines fuel cell generation, energy storage, power conditioning, and control components within a single enclosure, while hydrogen storage and primary pressure regulation are provided by external systems.

The system includes the following key modules.

- H2 Fuel Cell: The PEM stack generates electricity from hydrogen and oxygen. Water, vapor, and heat are produced as byproducts.
- External Hydrogen Tanks: Hydrogen is supplied from external tanks and passes through an external pressure regulator before entering the generator.
- On-board Battery Energy Storage (OBES): A built-in battery (about 44 kWh) helps handle short load changes and keeps the output stable.

## **Generator emission test cycle**

- To compare energy consumption and operating characteristics, CARB staff evaluated the diesel and H2FC generators under controlled steady-state loads using the test approach developed for the Off-Road Diesel Equipment Surveillance Program.
- Power generation activity is generally predictable and less dynamically variable compared to on-road vehicles or mobile off-road equipment. Diesel portable generators typically operate under relatively stable and sustained load conditions to meet site-specific electricity demand. As a result, the steady-state cycle provides a consistent framework for evaluating generator performance under controlled constant-load conditions that may occur during portable generator operation.
- CARB staff conducted eight independent 15-minute steady-state test sessions at loads ranging from 20% to 90% of rated capacity, in 10-percentage-point increments. Each session began with the onboard battery at or near 100% state of charge and was conducted under stabilized operating conditions using the same hydrogen-supply configuration. The load levels were evaluated as separate sessions rather than as a continuous ramp.
- The eight analyzed sessions represent 120 minutes, or 2.0 hours, of measured steady-state operation. Values presented for 45-minute and 1-hour operation were extrapolated from the measured 15-minute results and do not represent separately conducted extended-duration tests. The 2.0-hour total includes only the steady-state periods used in the analysis and excludes setup, startup, stabilization, shutdown, and demonstration activities.
- The original test plan also included a 10% load condition. However, this condition was excluded from the analysis because the onboard battery supplied a substantial portion of the electrical energy, making the result unrepresentative of sustained steady-state fuel-cell operation. Accordingly, the 10% condition is not included in the eight analyzed sessions or the reported 2.0 hours of steady-state testing.

## Chapter 4 – RESULTS AND OPERATIONAL OBSERVATIONS

This chapter presents the measured energy-performance results and operational observations from the independently conducted steady-state load sessions.

**Table 4** summarizes calculated global efficiency, hydrogen consumption, and onboard battery contribution across the evaluated load conditions. Subsequent sections discuss each performance metric and its implications for operation and deployment.

**Table 4. Summary of Energy Production, Hydrogen Consumption, Battery Contribution, and Global Efficiency Across Discrete Steady-State Load Conditions<sup>3</sup>**

| Load (%) | Global Efficiency (%) <sup>4</sup> | Hydrogen Consumption by Duration (kg) |                       |                       | On-board Battery Energy Storage (OBES) Contribution to Total Energy Demand (%) |                       |                       |
|----------|------------------------------------|---------------------------------------|-----------------------|-----------------------|--------------------------------------------------------------------------------|-----------------------|-----------------------|
|          |                                    | 15-min H <sub>2</sub>                 | 45-min H <sub>2</sub> | 1-hour H <sub>2</sub> | 15-min OBES Share (%)                                                          | 45-min OBES Share (%) | 1-hour OBES Share (%) |
| 20%      | 86.0                               | 0.15                                  | 0.39                  | 0.54                  | 43                                                                             | 15                    | 11                    |
| 30%      | 67.6                               | 0.26                                  | 0.71                  | 0.97                  | 26                                                                             | 11                    | 8                     |
| 40%      | 60.2                               | 0.39                                  | 1.08                  | 1.48                  | 20                                                                             | 8                     | 6                     |
| 50%      | 66.1                               | 0.44                                  | 1.23                  | 1.67                  | 28                                                                             | 7                     | 5                     |
| 60%      | 55.5                               | 0.60                                  | 1.75                  | 2.37                  | 16                                                                             | 6                     | 4                     |
| 70%      | 52.6                               | 0.75                                  | 2.17                  | 2.93                  | 15                                                                             | 5                     | 4                     |
| 80%      | 51.7                               | 0.83                                  | 2.52                  | 3.40                  | 15                                                                             | 4                     | 3                     |
| 90%      | 44.7                               | 2.17                                  | 3.20                  | 4.32                  | 5                                                                              | 4                     | 3                     |

### Electricity Output and Load Tracking Performance

Across the independently conducted steady-state sessions, the H<sub>2</sub>FC generator maintained electrical output corresponding to the loads applied by the load bank. Measured AC output remained generally consistent with the commanded load throughout the evaluated range of 20% to 90% of rated capacity, and no output instability was observed.

<sup>3</sup> Hydrogen consumption values for 45-minute and 1-hour durations were estimated from measured steady-state performance and should be interpreted as indicative rather than directly measured.

<sup>4</sup> Global efficiency is defined as the ratio of AC electrical energy delivered by the generator to the lower heating value (LHV) energy content of the hydrogen consumed, including the contribution of the onboard battery during each test. Because the calculation includes electrical energy contributed by the initially charged onboard battery, the reported global efficiency represents the performance of the integrated generator system under the defined test conditions and should not be interpreted as fuel-cell stack efficiency.

## Global Efficiency Trends Across Load Levels

Calculated global efficiency generally decreased as load increased. Efficiency was approximately 86% at 20% load, 68% at 30% load, and 60% at 40% load. Between 60% and 80% load, efficiency ranged from approximately 52% to 56%, with some variation among individual load points. At 90% load, efficiency decreased to approximately 45%. The unusually high calculated efficiency at 20% load reflects the substantial contribution of the onboard battery; therefore, this value represents integrated system performance and should not be interpreted as the fuel-cell stack efficiency alone.

Excluding the battery-influenced result at 20% load, the overall decline in efficiency with increasing load is qualitatively consistent with proton-exchange membrane fuel-cell behavior described in the literature<sup>5,6</sup>.

## Hydrogen Consumption

Hydrogen consumption was calculated from the measured pressure decrease in the storage cylinders using the manufacturer-specified cylinder volume and recorded temperature conditions. As shown in **Table 4** and **Figure 9**, hydrogen consumption generally increased with electrical load. Based on the measured 15-minute steady-state consumption rates, estimated one-hour hydrogen consumption increased from approximately 0.54 kg at 20% load to 3.40 kg at 80% load and 4.32 kg at 90% load. These one-hour values were extrapolated and do not represent separately conducted one-hour tests.

The estimated consumption rates may support preliminary runtime calculations based on anticipated electrical load and available hydrogen-storage capacity. Actual field consumption and runtime would also depend on the operating profile, storage configuration, ambient conditions, system efficiency, and operating procedures.

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5 Barbir, F. (2006). PEM Fuel Cells. In: Sammes, N. (eds) Fuel Cell Technology. Engineering Materials and Processes. Springer, London. [https://doi.org/10.1007/1-84628-207-1\\_2](https://doi.org/10.1007/1-84628-207-1_2)

6 <https://www.netl.doe.gov/sites/default/files/netl-file/FCHandbook7.pdf>

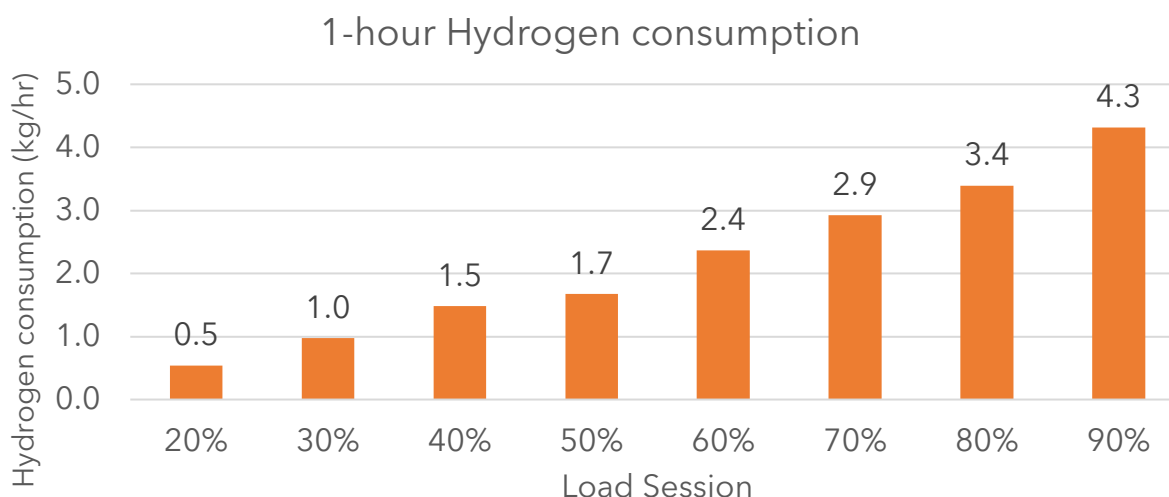


**Figure 9. Estimated one-hour hydrogen consumption by load level**

## Contribution of Onboard Battery Energy Storage (OBES)

The tested H<sub>2</sub>FC generator incorporates an onboard battery that primarily buffers short-duration changes in power demand and helps maintain stable fuel-cell system operation. The battery contribution was greatest during short, low-load operation. During the measured 15-minute session at 20% load, the battery supplied approximately 43% of the total electrical energy delivered. Battery contributions across the evaluated load levels are summarized in **Table 4**.

For the extrapolated one-hour values, we assumed the battery contribution remained at approximately 1.9 kWh while total delivered energy increased with operating duration. Under this assumption, the estimated battery share decreased to approximately 11% at 20% load and 3%–4% at loads of 60% and above. These results indicate that the battery primarily supports short-duration and low-load operation, while the fuel-cell system supplies most of the energy during sustained operation.

## Low-Load Operational Implications

At the evaluated partial-load conditions of 20% and 30%, the H<sub>2</sub>FC generator maintained stable electrical output without observed operational instability. During the measured 15-minute sessions, however, the onboard battery supplied a relatively large share of the delivered electrical energy, approximately 43% at 20% load and 26% at 30% load. The calculated global-efficiency values at these conditions therefore represent the performance of the integrated battery and fuel-cell system and should not be interpreted as fuel-cell stack efficiency alone.

Unlike diesel generators, the H2FC system does not use combustion-based exhaust aftertreatment and therefore is not subject to the exhaust-temperature requirements needed to maintain aftertreatment performance. This distinction may be relevant for applications involving sustained partial-load operation. However, the observations are limited to the controlled steady-state conditions evaluated during this demonstration.

## Operational Observations: Noise and Emissions

During the demonstration, CARB staff observed that the H2FC generator was subjectively quieter than diesel generators of similar power ratings typically encountered during generator testing. No direct sound-level comparison was conducted as part of this evaluation.

CARB staff subjectively observed that the H2FC generator was quieter than diesel generators of similar power ratings encountered during prior generator testing. However, this evaluation did not measure sound levels. Published sources report sound levels of approximately 55 dB(A) for some fuel-cell systems, compared with approximately 70–90 dB(A) for diesel generators of similar size<sup>7,8,9</sup>. **Figure 10** presents these literature values for context; they do not represent a direct comparison measured during this evaluation.

No visible exhaust emissions were observed during operation. The electrochemical reaction within the fuel-cell system produces water and water vapor during operation.

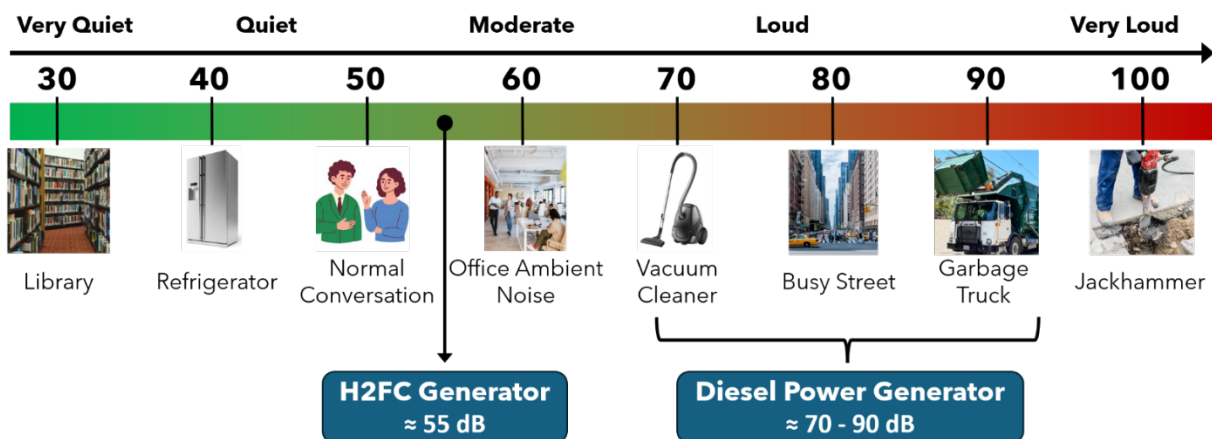


**Figure 10. Comparison of Typical Noise Levels for Hydrogen Fuel Cell and Diesel Power Generators with Common Everyday Sounds**

<sup>7</sup> <https://www.sciencedirect.com/science/article/abs/pii/S0360319924007225>

<sup>8</sup> <https://www.energy.gov/cmei/fuels/fuel-cell-basics>

<sup>9</sup> [https://woodstockpower.com/blog/generator-noise-sound-attenuation/?utm\\_source=chatgpt.com](https://woodstockpower.com/blog/generator-noise-sound-attenuation/?utm_source=chatgpt.com)

## **Deployment Considerations**

The controlled steady-state tests did not evaluate the full range of conditions that may affect field deployment. Additional considerations include hydrogen availability, storage capacity, refueling logistics, site conditions, and operating procedures such as system startup and purge sequences.

Available hydrogen storage capacity would be a primary determinant of operating duration. Actual runtime would also depend on the equipment load profile, system efficiency, ambient conditions, and hydrogen-storage configuration. Deployment planning should therefore match hydrogen supply and refueling schedules to anticipated electrical demand and required operating duration.

Unlike diesel fuel, hydrogen is stored and handled as a compressed gas and requires specialized equipment and procedures for transportation, on-site storage, pressure regulation, and system connection. Site planning should address ventilation, separation distances, potential ignition sources, equipment access, and emergency procedures. Operators should follow the manufacturer's instructions and applicable hydrogen-safety requirements, including relevant provisions of NFPA 2 and requirements established by the local authority having jurisdiction. These field-deployment and safety considerations were not independently evaluated as part of this controlled demonstration.

## **Chapter 5 – LESSONS LEARNED AND RECOMMENDATIONS**

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Under the controlled steady-state conditions evaluated in this demonstration, the H2FC generator maintained stable electrical output across loads ranging from 20% to 90% of rated capacity. The onboard battery contributed a larger share of electrical energy during short, low-load operation, while the fuel-cell system supplied most of the estimated energy demand over longer operating durations. Hydrogen consumption generally increased with electrical load.

The generator produced electricity without a grid connection during the evaluated sessions using an external compressed-hydrogen supply. For field deployment, operating duration would depend on the load profile, hydrogen-storage capacity, and refueling availability. Deployment planning would also need to address cylinder transportation and storage, site conditions, startup and purge procedures, and applicable safety requirements.

These results are based on one generator configuration tested during eight independent 15-minute steady-state sessions. The evaluation did not examine long-duration operation, dynamic load cycles, repeated startup and shutdown events, varying environmental conditions, or performance at an operating site. The findings therefore should not be interpreted as representative of all H2FC generator systems, duty cycles, or field applications.

Future evaluations should include longer-duration testing, transient load profiles, different initial battery states of charge, and operation under representative field conditions. Additional testing could also examine hydrogen-refueling requirements, direct sound-level measurements, and performance across different H2FC generator designs and power ratings.