Hydrogen Fuel Cells in Transit

November Tech Talk

November 3, 2022

CALSTART Overview

- Nonprofit organization based in Pasadena, CA
- International presence with offices in California, Colorado, Michigan, New York, and Europe
- Advances the clean transportation industry

CALSTART Members



Introduction to Fuel Cells

- Fuel electric vehicles (FCEVs) are similar to EVs. FCEVs has on-board electricity generation to continue charging the battery to power the traction battery.
- FCEVs produce electricity using a fuel cell powered by hydrogen rather than drawing electricity from only a battery
- The amount of energy stored onboard is determined by the size of the hydrogen fuel tank. This differs from an all-electric vehicle, where the amount of power and energy available is closely related to the battery's size.



Transit FCEBs

- Major FCEB OEMs:
 - New Flyer
 - ElDorado National
- 40' and 60' models
- Most FCEBs have 30 50 kg of onboard hydrogen storage
- Can store more energy than batteries
- Similar refueling operational schedule as a diesel or CNG bus
- Typically used on longer routes



ZEB Grid Impacts



Size of ZEB Fleet 2021

Hydrogen Refueling Infrastructure

- Hydrogen Production Pathways:
 - Steam Methane Reforming of Natural Gas
 - Steam Methane Reforming of Renewable Natural Gas/Biogas
 - Electrolysis
- Hydrogen Supply:
 - Delivered Hydrogen
 - Onsite Production
- Hydrogen Storage:
 - Gaseous
 - Cryogenic Liquid
- Fueling Dispenser:
 - 350 bar
 - 700 bar



Dispenser

ZEB Deployments





CALSTART

4000



Zero Emission Bus Deployments

■ BEB ■ FCEBs

FCEB Market



FCEB Deployments Number of Buses 00 08 00 00 00 Year

Small FC Buses

- Cutaway buses and transit vans are typically used for microtransit and paratransit service
- Rural transit agencies interested in small FC buses
- Currently, small FC buses are at a lower technology readiness than transit FC buses
- US Hybrid has developed a FC transit van
- California has provided funding to develop a FC cutaway bus (A-1 Alternative Fuel Systems)





Drivers of ZEB Deployments

- FTA Low-No Program and Bus & Bus Facilities Grant Program (\$5.25 billion over five years)
- California HVIP program
- California Innovative Clean Transit (ICT) Regulation
- Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding
- Statewide Procurement Contracts

Impact on the Clean Transportation Industry



Similar drivetrain and
component sizing can scale to
early near applicationsExpanded supply chain capabilities
and price reductions enable
additional applications

Steadily increasing volumes and infrastructure strengthen business case and performance confidence

Questions?

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SARTA Key Facts

- Transport 2.8 million passengers
- 212 employees
- \$23 million budget
- Operates express routes to Akron and Cleveland (the longest route in Ohio)
- 30 routes and countywide paratransit

National Fuel Cell Bus Program

- Part of a \$90 million Federal Transit Administration program
- Goal is to demonstrate fuel cell buses
- Set goals for performance and demonstration of vehicles
- Deployed vehicles IN NY, CA, MA, and SC
- 2 fuel cell buses will be in Canton
- Total federal funding is \$5.54 million

Bus at the Statehouse





System Layout





Hydrogen compressors





Compressor Pad





Station Controls





Operations

- Range 220 miles
- Operate every day
- 15 minute fill
- Getting about 7 mpg compared to 4 for diesel
- Program evaluated by NREL

Efforts of Midwest Center

May 5, 2017 Green on the Green – Worthington, OH - Hydrogen bus demonstration

Apr 17-19 2017 OPTA Conference - Columbus, OH – Booth and Hydrogen bus demonstration Jul 25-26, 2017 – 2 day Hydrogen Workshop at Stark State College/ SARTA

Aug 2017 EcoFest - Grove City, OH - Hydrogen bus demonstration

Sep 13-14, 2017 – 2 day Hydrogen Workshop at Stark State College/ SARTA

Jul 26- Aug 6 2017 Ohio State Fair – Columbus, OH - Booth and Hydrogen bus demonstration – Blue Ribbon Award of Merit – Technology Education

Data loggers installed Jul 2018 for CTE study completed and published Jul 22, 2020 (Using the Birmingham NFCBP Bus for Regional Outreach in Ohio)



Experiment



OSU President Drake @ Horseshoe





The Prince





Walking Behind the Prince



Infrastructure the Near Term Challenge for ZEBs Peak Loads Considerations for Battery Electric Buses



Assumptions: the Chevy Volt charging rate is 3.3 kW, the medium-duty E-Truck charging rate is 15 kW and the E-Bus charging rate is 60 kW.