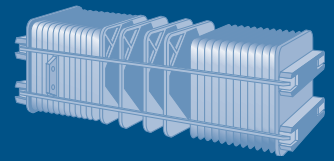


# FUEL CELL BUS DEMONSTRATION PROJECTS

Hydrogen, Fuel Cells & Infrastructure Technologies Program



U.S. Department of Energy  
**Energy Efficiency and Renewable Energy**  
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable



## VTA, SamTrans Look into Future with Bus Demo

### SANTA CLARA VALLEY TRANSPORTATION AUTHORITY (VTA)

is a multi-modal transportation organization based in San Jose, California. VTA provides bus and light rail service in Santa Clara County, as well as congestion mitigation, highway improvement projects, and countywide transportation planning. VTA operates an active bus fleet of 423 buses on 69 routes throughout the urbanized area of Santa Clara County.

In February 2000, the California Air Resources Board (CARB) adopted new regulations for transit buses to reduce oxides of nitrogen and particulate matter emissions. As a result, VTA adopted a clean fuels strategy, which includes a zero-emission bus program. The fleet entered into contract with Gillig Corporation and Ballard Power Systems to procure three low-floor fuel cell buses, which were delivered in 2004. VTA is working with the San Mateo County Transit District (SamTrans) to demonstrate these fuel cell buses in revenue service. In addition to complying with the CARB regulations, VTA's goals include testing the viability of emerging clean-fuels technology.

VTA is currently collaborating with the U.S. Department of Energy's (DOE) Hydrogen, Fuel Cells & Infrastructure Technologies (HFCIT) Program on the evaluation of the three fuel cell buses developed by Ballard and Gillig. VTA will operate the buses in revenue service as part of the two-year demonstration program. During this time, DOE's National Renewable Energy Laboratory (NREL) will collect and analyze performance and operations data.

This evaluation is one of several DOE projects that support the research and development of low- or zero-emission fuel cell power systems and is consistent with the HFCIT Program goal of an industry commercialization decision by 2015. Information gathered during the demonstration will help researchers assess the status of the technology and aid fleets in making informed purchase decisions. Results will also be fed back into the R&D process to focus future resources, as appropriate.

**THE GILLIG BUSES BEING TESTED** by VTA/SamTrans are typical in every way—standard seating capacity, wheelchair lift, air conditioning—but they are fueled with hydrogen and propelled by a fuel cell electric drive. Ballard Power Systems supplies the two 150 kW (300 kW per bus) proton-exchange membrane (PEM) fuel cells, as well as one three-phase



The Gillig buses in demonstration at VTA feature Ballard fuel cell systems.

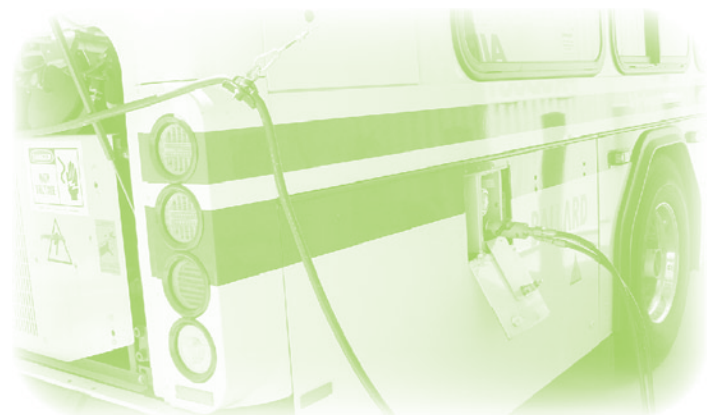
NREL/PIX 14077

induction motor for propulsion. Although there are several fuel cell chemistries and configurations, PEM is generally recognized as the best combination of electrochemistry, operating temperature, and weight for transportation applications.

The fuel cell supplies electric current via an inverter to the propulsion motor, which is a proprietary design. This chassis-

mounted, three-phase, induction motor is rated at 225 kW (369 horsepower). Hydrogen is stored onboard in eleven 5,000-psi cylinders that are located on the roof. These Dynetek Dynecell carbon fiber-wrapped tanks are equipped with many safety features, including pressure release devices, which safely vent the hydrogen in the unlikely event of an accident or fire.

VTA fuels these advanced technology buses at the VTA Cerone Operations Division using a hydrogen fueling station constructed and operated by Air Products & Chemicals, Inc. The fueling station, which is leased to VTA, consists of a tank that receives and stores hydrogen in liquid form. Hydrogen is compressed to 6,000 psi and vaporized for secondary storage in a pressurized tank cascade. Air Product's unique liquid compression system enables fast filling of fuel cell buses. A fueling island dispenses pressurized gaseous hydrogen to the fuel cell buses. This facility is monitored remotely by Air Products and is equipped with a variety of sensors and alarms.



NREL/PIX 14075

The fuel cell buses are powered by compressed gaseous hydrogen dispensed onsite.

## VTA FUEL CELL BUS FACTS

Bus Chassis	Gillig, low-floor
Model Year	2004
Length/Width/Height	40 ft/102 in/144 in
GVWR/Curb Weight	40,600 lb/34,100 lb
Seats	37 passenger seats 29 seats with two wheelchair spaces
Wheel Base	284 in
Service	Extra revenue transit service
Drive System	Fuel cell powerplant, inverter, one electric propulsion motor, six-speed transmission
Powerplant	Two Ballard Power Systems PEM fuel cells, 150 kW each
Propulsion Motor	Reuland Electric three-phase induction motor rated at 225 kW
Transmission	Six-speed automatic
Fuel	Gaseous hydrogen
Hydrogen Storage	Eleven on-board, Dynetek Dynecell carbon fiber-wrapped tanks
Emissions Equipment	Zero emissions

A specialized maintenance structure was built at VTA's Cerone Operations Division, where the buses are based. This facility is equipped with an array of sensors and alarms, as well as specialized doors and heating. Like compressed natural gas buses, hydrogen buses require a maintenance facility with adequate ventilation and other safeguards.

**NOW THAT THE BUSES ARE IN REVENUE SERVICE,** the evaluation is underway. NREL is currently collecting performance and operational data on the fuel cell and base-line diesel buses. The objective of the DOE/NREL evaluation is to provide comprehensive, unbiased results of advanced technology vehicle development and operations, including economic, technical, and safety analyses. It will also assess hydrogen infrastructure development and operation and provide descriptions of facility modifications required for the safe operation of the fuel cell vehicles. Decision makers, including transit operators considering the use of these advanced technology vehicles, are the primary audience for this information.

## Zero-Emission Bus Program Partners

Company	Role
VTA	Demonstration partner and funding
SamTrans	Demonstration partner and funding
Gillig	Bus manufacturer
Ballard	Fuel cell and propulsion system manufacturer
Air Products	Fuel and fueling facility supplier
Federal Transit Administration	Funding
California Energy Commission	Funding
Bay Area Air Quality Management District (BAAQMD)	Funding
California Fuel Cell Partnership (CaFCP)	Support
CARB	Support and regulations
DOE/NREL	Technical evaluation



NREL/PIX 14074

VTA's Cerone Operations Division is home to a liquid hydrogen station operated by Air Products & Chemicals, Inc.

### Contacts

**Santa Clara Valley Transportation Authority**  
Art Douwes  
Phone: 408-321-7027  
douwes@vta.org

**National Renewable Energy Laboratory**  
Leslie Eudy  
Phone: 303-275-4412  
E-mail: leslie\_eudy@nrel.gov

**Produced by the National Renewable Energy Laboratory (NREL)**  
NREL is a U.S. Department of Energy National Laboratory  
Operated by Midwest Research Institute • Battelle

### Web Sites

VTA: [www.vta.org](http://www.vta.org)  
SamTrans: [www.samtrans.com](http://www.samtrans.com)  
Ballard: [www.ballard.com](http://www.ballard.com)  
Gillig: [www.gillig.com](http://www.gillig.com)  
Air Products: [www.airproducts.com](http://www.airproducts.com)  
DOE: [www.eere.energy.gov/hydrogenandfuelcells](http://www.eere.energy.gov/hydrogenandfuelcells)  
NREL: [www.nrel.gov/vehiclesandfuels/fleettest](http://www.nrel.gov/vehiclesandfuels/fleettest)  
CaFCP: [www.caftp.org](http://www.caftp.org)  
Federal Transit Administration: [www.fta.dot.gov](http://www.fta.dot.gov)  
BAAQMD: [www.baaqmd.gov](http://www.baaqmd.gov)  
CARB: [www.arb.ca.gov](http://www.arb.ca.gov)

### For more information contact:

**EERE Information Center**  
1-877-EERE-INF (1-877-337-3463)  
[www.eere.energy.gov](http://www.eere.energy.gov)

### A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

DOE/GO-102005-2147 ■ September 2005

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste.

Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.