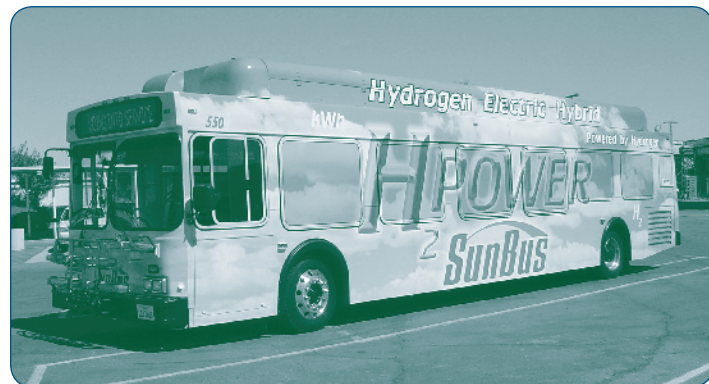


SunLine Tests HHICE Bus in Desert Climate

SUNLINE TRANSIT AGENCY provides public transit and community services to California's Coachella Valley. Headquartered in Thousand Palms, California, SunLine's service area encompasses more than 1,100 square miles and includes nine member cities, as well as Riverside County. SunLine has more than 10 years experience with alternative fuels for bus operations. In 1994, it replaced its entire fleet with compressed natural gas (CNG) buses. In addition to CNG, the agency has experimented with many advanced technologies designed to reduce or eliminate emissions. These technologies include buses that run on a blend of hydrogen and CNG, battery electric power, and fuel cells.

SunLine has become a prime location for testing advanced technology buses. Much of the experience gained with gaseous fuels, such as CNG, carries over to hydrogen. SunLine has had hydrogen infrastructure in place since early 2000 and was one of the first transit agencies to test fuel cell buses. In addition, SunLine's maintenance staff is proficient in troubleshooting problems with prototype technologies. This experience has proved invaluable in helping manufacturers develop and optimize technologies for transit applications.

IN DECEMBER 2004, SUNLINE BECAME the first transit agency to operate a hybrid hydrogen internal combustion engine (HHICE) bus. Fund-



NREL/PIX 14393

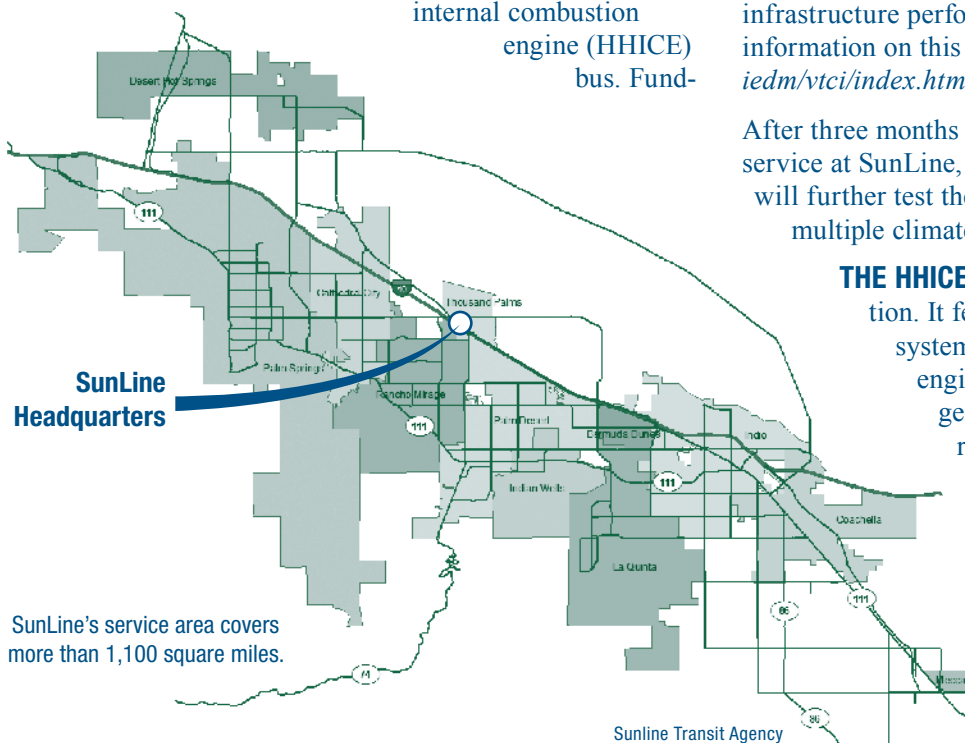
The HHICE bus features an ISE ThunderVolt hybrid drive system and a Ford Motor Company Triton V10 engine optimized to run on hydrogen.

ed as part of an international collaboration, the HHICE bus spent several weeks in SunLine revenue service in early 2005 before being sent to Manitoba, Canada, for cold-weather testing in the City of Winnipeg Transit fleet.

With temperatures dipping as low as -27°C (-16°F), the HHICE bus was operated during Winnipeg's coldest months. It performed well—accumulating over 300 miles and carrying more than 1,000 passengers. The test results offer valuable insight on how the hydrogen bus and its supporting infrastructure perform in harsh winter conditions. For more information on this cold weather trial, visit www.gov.mb.ca/iedm/vtci/index.html.

After three months in Canada, the HHICE bus is back in service at SunLine, where the hot, dry desert climate will further test the performance of hydrogen buses in multiple climates.

THE HHICE BUS WAS DEVELOPED by ISE Corporation. It features ISE's ThunderVolt hybrid drive system and Ford Motor Company's Triton V10 engine, which is optimized to run on hydrogen. ISE's hybrid system is a series configuration, meaning that the powerplant is not mechanically coupled to the drive axle. The powerplant and energy storage system work together to provide electricity to two electric drive motors that are connected to the driveline through a combining gearbox.



SUNLINE HHICE BUS FACTS

Bus Chassis/Model	New Flyer/TB-40HICE
Model Year	2005
Length/Width/Height	40 ft/102 in/137 in
GVWR	40,000 lb
Seats	39
Service	Revenue service
Drive System	ISE Thundervolt Hybrid Drive System
Powerplant	Ford 6.8 liter V10 hydrogen internal combustion engine, 190 hp
Propulsion Motor	Two Siemens AC induction motors, 85 kW each (170 kW total)
Energy Storage	Maxwell ultracapacitors, two packs, maximum total energy stored: 0.6 kWh
Accessories	Electrically driven
Fuel	Gaseous hydrogen, 58 kg at 5,000 psi
Hydrogen Storage	Eight on-board, type III tanks by Structural Composites Industries

The hybrid system is capable of regenerative braking, a process that captures the energy typically expended during braking and uses it to recharge the energy storage system. Each component of the propulsion system is carefully controlled through an ISE-developed operating system. ISE designed the system to be flexible, allowing for a variety of powerplants and energy storage options.

Using hydrogen in a well-established engine technology is a potential pathway for transitioning to a hydrogen society. Hydrogen-fueled internal combustion engines (ICEs) such as the engine in the HHICE bus, will help build demand and support for hydrogen infrastructure while fuel cell technology is being perfected. The HHICE bus can be a good candidate for transit agencies because fleet mechanics are familiar with the workings of combustion engines. This innate knowledge, therefore, frees up maintenance workers to focus on the nuances of using a new gaseous fuel.

Project Participants

The HHICE bus in demonstration at SunLine was developed through an international partnership, which included funding and support from the following U.S. and Canadian organizations.

- **Partners:** U.S. Federal Transit Administration (FTA), California Energy Commission, South Coast Air Quality Management District (SCAQMD); Natural Resources Canada; Province of Manitoba, Manitoba Energy Science, and Technology (MEST); WestStart/CALSTART
- **Fleets:** SunLine, City of Winnipeg Transit, Chula Vista Transit
- **Manufacturers:** ISE Corporation (hybrid system and integration), Ford (engine), New Flyer (bus chassis)

Hydrogen ICEs also have the potential for near-zero emissions. Because the fuel contains no carbon, the engine does not produce carbon dioxide or any other carbon compounds. The only undesirable emission is oxides of nitrogen (NO_x). However, operating at ultra-lean conditions keeps the combustion temperature low enough to nearly eliminate NO_x without using any aftertreatment device.

SUNLINE IS CURRENTLY COLLABORATING with the U.S. Department of Energy's (DOE) Hydrogen, Fuel Cells & Infrastructure Technologies (HFCIT) Program on the evaluation of the HHICE bus. The agency will continue to run the bus in revenue service. DOE's National Renewable Energy Laboratory (NREL) will collect and analyze performance and operations data on the bus for at least one year.

This evaluation is one of several DOE projects that support the research and development of highly efficient, low- or zero-emission systems that will reduce our dependence on imported petroleum. The results are important in understanding the state of the technology and the work that still needs to be done. 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 research and development process to focus future resources, as appropriate.

Contacts

Sunline Transit Agency
Tommy Edwards
760-343-3456, ext. 312
tedwards@sunline.org

National Renewable Energy Laboratory
Leslie Eudy
Senior Project Leader
303-275-4412
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

SunLine: www.sunline.org
ISE: www.isecorp.com
Ford: www.ford.com
FTA: www.fta.dot.gov
SCAQMD Technology Advancement Office:
www.aqmd.gov/tao/about.html
Province of Manitoba, MEST:
www.gov.mb.ca/est/energy/
DOE: www.eere.energy.gov/hydrogenandfuelcells
NREL: www.nrel.gov/hydrogen/proj_tech_validation.html


For more information contact:

EERE Information Center
1-877-EERE-INF (1-877-337-3463)
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-102006-2333 ■ October 2006

 Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% 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.