



## SunLine Test Drives Hydrogen Bus

**IN FALL 2002, SUNLINE TRANSIT AGENCY** became the first transit agency to put a hybrid fuel cell bus into routine passenger service. From November 2002 to February 2003, the prototype advanced technology bus served Palm Springs, California, which is not far from SunLine's hometown of Thousand Palms.

SunLine collaborated with the U.S. Department of Energy's (DOE) Hydrogen, Fuel Cells & Infrastructure Technologies (HFC&IT) Program on the evaluation of the 30-foot hybrid fuel cell bus that was developed by ThunderPower LLC, a joint venture by Thor Industries and ISE Research. The data gathered during the ThunderPower bus demonstration will help fleets make informed purchasing decisions and help researchers assess whether fuel cell vehicles can meet commercialization requirements.

This evaluation is one of several DOE projects that support the research and development of highly efficient, low- or zero-emission fuel cell power systems, which serve as an alternative to internal combustion engines. The demonstration is consistent with the HFC&IT goal of having advanced technology vehicles enter the marketplace by 2010.

**THE PRINCIPLE BEHIND FUEL CELLS** was discovered in 1839 but wasn't used in practical applications until the 1960s when fuel cells were selected to produce electricity for rockets during the Gemini and Apollo space programs. Fuel cells are favorable in transportation applications because they produce little noise, have no moving parts, and can increase a vehicle's operating efficiency by 20% to 30%.

The ThunderPower fuel cell bus has a compact but powerful 60-kilowatt fuel cell power plant to provide the required power. The propulsion system is efficient, quiet, and reliable and can triple the fuel economy of a conventional bus. Plus, the only emissions the system produces are water and air, making the bus a zero emissions vehicle.

The hydrogen fuel cell system in the ThunderPower bus works like this:

- A heavy-duty fuel cell uses hydrogen, which can be made from renewable sources (such as wind or solar power), and air to produce enough electricity to power the bus.
- The fuel cell produces electricity through a chemical process using hydrogen and oxygen from the air.

- The electricity is routed to electric motors that turn the wheels.
- On-board battery packs store energy to propel the bus and absorb energy during braking. This is known as "regenerative braking."



SunLine Transit Agency/PIX12451

**THE THUNDERPOWER BUS** looks like a standard bus but is able to cover 11 miles on an energy equivalent gallon of hydrogen, nearly triple the fuel economy of a 30-foot conventional bus. It accommodates up to 26 riders and has a range of 175 to 200 city miles.

ISE Research (ISE-TVI) integrated the electric propulsion with the drive system power plant in collaboration with UTC Fuel Cells, which installed its newest technology proton-exchange membrane (PEM) fuel cell in the bus. The PEM combines a thin plastic film and a substance—called electrolyte—that increases the conduction of electricity.

Manufactured by Thor/EIDorado National, the bus chassis uses a drive system by ISE-TVI ThunderVolt™ and includes hybrid propulsion components of Siemens' ELFA™ propulsion system. A motive drive hybrid subsystem is based on a dual motor and controller set from Siemens. This includes a combining gearbox that directly couples to the two motors and provides a flange for a drive shaft to the differential.

The dual motor/controller set has a continuous power rating of 170 kilowatts and a peak power rating of 288 kilowatts. ISE-TVI also developed a communication system integrating the fuel cell, drive system, energy storage system, operator controls, accessory drives, and standard bus controls.

**ACCORDING TO RESEARCHERS,** the commercial use of fuel cell buses may be 10 years away, but SunLine is off to a good start and is a recognized leader in selecting and using alternative fuels.

### SunLine's Partners

In addition to DOE, SunLine benefits from the support of several partners. They include:

- **Demonstration partners:** Sacramento Municipal Utility District, the U.S. Department of Transportation, and South Coast Air Quality Management District
- **Technology partners:** ISE Research Corp. (systems integration), UTC (fuel cell), Siemens (propulsion system), Thor/EIDorado National (bus chassis)
- **Evaluation partner:** National Renewable Energy Laboratory

## THUNDERPOWER BUS FACTS

Bus Chassis	Precommercial ElDorado National EZ Rider 2
Model Year	2002
Length/Width/Height	30 ft./102 in./137.5 in.
GVWR/Curb Weight	34,000 lbs./25,180 lbs.
Seats	26 (with no wheel chair spaces) 20 (with two wheel chair spaces)
Wheel Base	160 in.
Service	Transit service (Line 50)
Drive System	High voltage electrical system
Engine	Two electric motors; inverters; combining gearbox; pre-commercial, zero emission fuel cell
Batteries	48 Panasonic
Transmission	Automatic
Vehicle Controls	Multiplexing system controlling all operations (driver controls, air, hydraulic, cooling system, energy management)
Brakes	Regenerative with air support
Hydrogen Storage	On-board, pressurized tanks
Propulsion	UTC fuel cell (60 kW continuous), electric AC induction motors
Drive System	Siemens ELFA™ electric propulsion
Nominal Output	2 x 85 kW @ 600 VDC
Peak Output	2 x 140 kW
Rated Speed	9,000 rpm
Storage Device	Battery (under floor in rear)
Battery Pack	600V, 48 12 V batteries
Emissions Equipment	Zero emissions
Fuel	Hydrogen fuel cells



SunLine Transit Agency/PIX 12739

In 1994, SunLine became the first U.S. public transit agency to abandon its diesel buses and switch overnight to an entire fleet of clean-burning compressed natural gas buses. Before the prototype fuel cell bus arrived at SunLine in 2002, the agency began generating hydrogen on site from solar power and reformed natural gas.

When the demonstration of the prototype fuel cell bus ended at SunLine, the transit agency began looking at options to acquire additional fuel cell buses. SunLine managers believe DOE's evaluation will be useful in establishing parameters, conducting environmental testing in extreme heat conditions, and transferring technology to the agency. SunLine looks forward to continuing its role as a test site for new fuel cells and systems.

The ThunderPower bus left SunLine for Chula Vista Transit to complete further testing and operation. Chula Vista is located just south of San Diego and is near ISE Research's home offices.



SunLine Transit Agency/PIX 12737

### For More Information

Read about SunLine's experience with the ThunderPower bus in "ThunderPower Fuel Cell Bus Evaluation at Sun Transit Agency," a more detailed report that will be available in September 2003 on Alternative Fuels Data Center Web site ([www.afdc.doe.gov](http://www.afdc.doe.gov)). The publication will feature details on the buses' performance during its six months of operation at SunLine, including its three months of revenue service.

### For More Information

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SunLine Transit Agency: [www.sunline.org](http://www.sunline.org)  
Thor Industries: [www.thorindustries.com](http://www.thorindustries.com)  
UTC Fuel Cells: [www.utcfuelcells.com](http://www.utcfuelcells.com)

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