SunLine Transit Agency:
Hydrogen Commercialization for the 21st Century

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Abstract

Hydrogen technology will one day help solve pollution and resource consumption problems. It offers a clean, safe, reliable and locally produced source of fuel. Hydrogen fuel cell vehicles can replace those powered by hydrocarbon-based internal combustion engines (which emit greenhouse and smog-producing gases). Further environmental benefits can be realized when the hydrogen is generated using renewable resources, such as solar and wind. The result is a clean, renewably produced fuel that can be used to supply public and private transportation vehicles that emit only water.

To establish hydrogen as a commercial transportation fuel, refueling infrastructure and hydrogen vehicles must be designed, built, operated and maintained. Training and support services must be established and, above all, safety must be considered throughout. Successful projects build confidence in hydrogen systems and facilitate the transition of hydrogen technologies into the market place.

SunLine Transit Agency is leading one of the world's most complex integrated hydrogen demonstration projects. Both renewable- and fossil-based hydrogen production technologies are being evaluated, along with compressed gas storage. The hydrogen produced on site powers buildings and fuels a variety of transportation vehicles. The ongoing testing will pave the way for the complete transition of California's Coachella Valley public transit system to hydrogen fuel cell vehicles. The SunLine facility is truly today's model of tomorrow's world.

Introduction

In 1994, the SunLine Transit Agency, whose mission is to provide and expand the Coachella Valley's public transit service, became the first public transit fleet in the nation to park all of its diesel buses and switch overnight to a fleet operated 100 percent by compressed natural gas (CNG). Working with such manufacturers as Cummins Engine Company, Detroit Diesel, Engelhard Corporation and John Deere, SunLine has become a continuous beta test site for clean air equipment innovations.

Because of its experience with alternative fuel technology, SunLine was tapped by the U.S. Department of Energy to coordinate several projects designed to advance the commercialization of hydrogen as a transportation fuel. As part of this effort, SunLine was tasked with disassembling, relocating and integrating projects by Clean Air Now and the Schatz Energy Research Center at Humboldt State University into its transit fleet at the Thousand Palms headquarters. This mammoth undertaking culminated in the April 2000 grand opening of the world's first hydrogen generation/storage/fueling facility built by a public transit agency. The facility boasts two Hythane® buses (which use 80% CNG/20% hydrogen), the country's only XCELLSIS ZE-bus (zero-emission fuel cell bus), the nation's first street-legal hydrogen fuel cell mini-car (SunBug), three hydrogen fuel cell powered golf carts and a hydrogen powered internal combustion engine pickup. Since November 2000, SunLine has used hydrogen generated onsite to fill the vehicles, which are run regularly on Coachella Valley roads. SunLine is operating this "lab on wheels" to determine the supportability, reliability, maintainability and operability of a fleet of hydrogen-powered vehicles. Of particular interest are the public transit vehicles – the two Hythane® and the XCELLSIS ZE busses.

Background

SunLine is the umbrella organization for two joint power authorities, SunLine Transit Agency and SunLine Services Group, and a non-profit 501(c)3, Community Partnership of the Desert. All three entities serve the nine desert resort cities that comprise the Coachella Valley in California, including Palm Springs and areas of unincorporated Riverside County. All share a common board of directors, comprised of an elected official from each jurisdiction.

In 1992, the board members took a bold step and unanimously voted to replace SunLine's fleet with one powered exclusively by an alternative fuel as a major step towards preserving one of the desert's primary assets, its blue skies. They also included a resolution stating that all vehicles purchased in the future would be powered by alternative fuels.

SunLine staff researched alternative fuel technology and decided that compressed natural gas would be the short-term fuel choice, providing immediate air quality benefits and serving as a bridge to the longer-term target - hydrogen. Working with colleges and university to devise training curriculum, natural gas utility to build the infrastructure, government agencies to address policy and permitting issues, and manufacturers to procure the necessary equipment, in 1994 SunLine made the swift, successful transition to their fleet of CNG vehicles.

Hydrogen Headquarters

The first steps towards realizing a fleet of hydrogen-powered vehicles began in 1999. At the request of the U.S. Department of Energy and the Federal Transit Administration, the projects from Clean Air Now and Schatz Energy Research Center at Humboldt State University were disassembled, relocated and integrated into SunLine's facilities. This massive task began with SunLine being assured that no one in the region had the expertise to do what was needed. Like many other myths surrounding hydrogen, this proved to be untrue. With a good set of plans and close supervision, local contractors were able to complete the job and the facility was officially christened in April 2000.

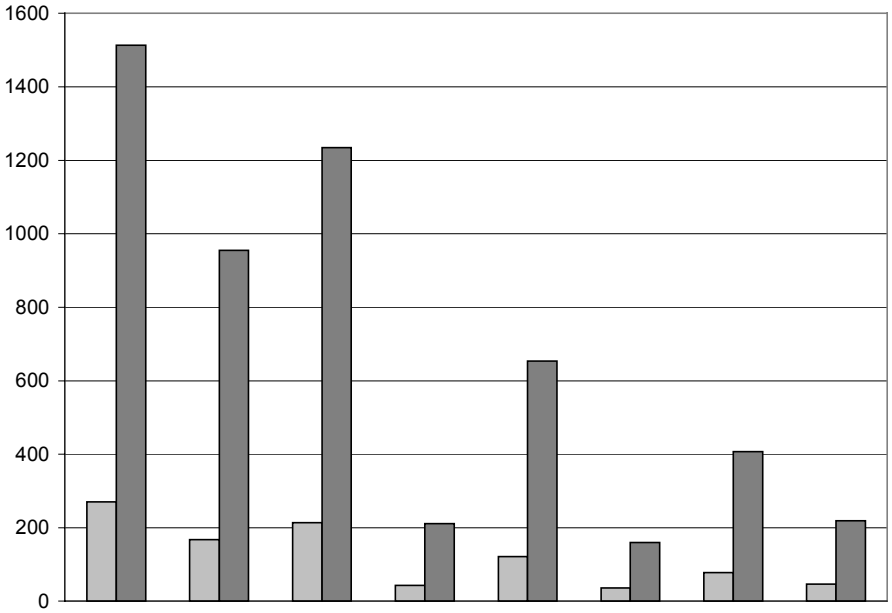
On-site hydrogen production began in November 2000 using two electrolyzers and a Hydrogen Burner Technology (HBT) natural gas reformer. The first electrolyzer, a Teledyne Brown unit, not only has the task of producing 40 standard cubic feet of hydrogen per hour, it is also testing the viability of using solar power. The hydrogen is separated from water, piped and then compressed into mobile low-pressure storage tanks, then used to fill the golf carts and SunBug. These vehicles, built by Schatz Energy Research Center, and jointly owned by SunLine and the City of Palm Dessert, require a total of 360 standard cubic feet of hydrogen per day.

The Teledyne Brown electrolyzer requires 7.5 kilowatts of electricity to produce the hydrogen. This power is supplied by 480 feet of raised photovoltaic panels and 200 Siemens solar panels. Combined, the panels have the capacity to produce 37 kilowatts of electricity. When available, the excess electricity is used to support the second electrolyzer, the on-site Zweig Education Center and the Schatz Hydrogen Generation Building (houses the Teledyne Brown electrolyzer and a visual education display on electrolysis). On cloudy days, the electrolyzer may use power from the grid. Hydrogen production by this electrolyzer is shown in Figure 1, for an 8-month period beginning in June 2000. The solar panel power production for 4 months in 2001 is shown in Figure 2.

The second electrolyzer is a self-contained Phase 3 (P3) Stuart Energy unit that produces and compresses 1,400 standard cubic feet of hydrogen per hour. The hydrogen production by this electrolyzer for 9 months, also beginning in July 2001, is shown in Figure 3. The hydrogen is piped to a high-volume high-pressure storage facility. The FIBA Technologies storage system is comprised of a 16-tube Department of Transportation (DOT) storage trailer and two high-pressure ASME tube tanks. The DOT trailer can store up to 104,000 standard cubic feet of hydrogen at 3130 psi. The ASME tube tanks can store an additional 12,500 standard cubic feet at 4000 psi. These tanks are attached to a cascade control panel used to fill hydrogen buses and pickups at the public fueling island, located across from SunLine's on-site compressed natural gas station in Thousand Palms.

The public access fueling island was incorporated from the Clean Air Now project. The station utilizes equipment from Stuart Energy and Fueling Technology and features two hose dispensers, one for pure hydrogen and one for Hythane®. The Hythane® dispenser was specially designed to allow the hydrogen and natural gas to be mixed as they are being pumped. The station currently provides fuel for the two Hythane® buses, the XCELLSIS ZE-bus, the hydrogen pickup and a hydrogen-powered Shelby Cobra racing car that is privately owned by an engineer from the

University of California, Riverside College of Engineering-Center for Environmental Research Technology (CE-CERT). Data related to fuel usage and miles driven by the Hythane® buses are shown in Figure 4.



	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01
Electrolyzer Power (kW)	270	168	214	43	121	36	78	46
Standard Cubic Feet H2	1513	955	1234	211	654	160	407	219

Figure 1: Teledyne Energy Systems electrolyzer power usage and hydrogen production.

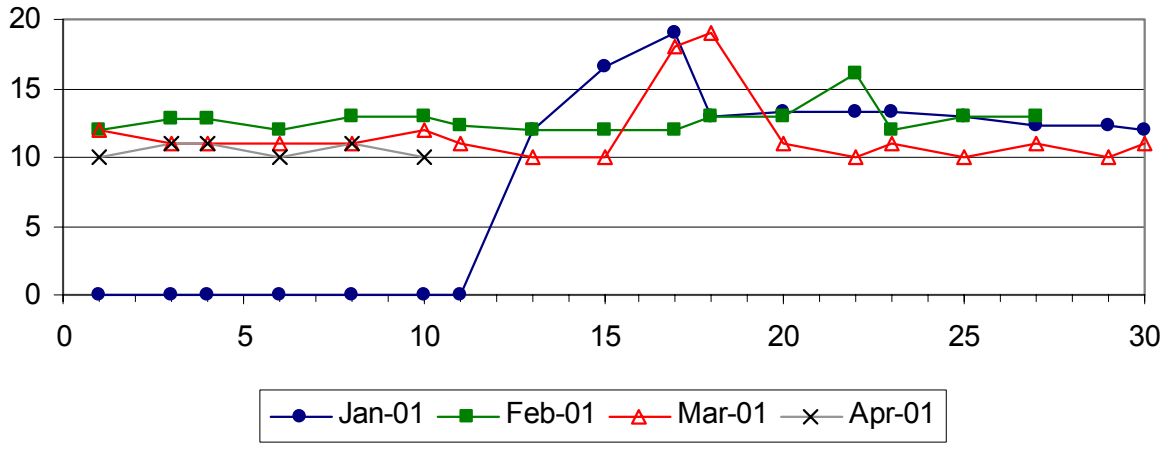
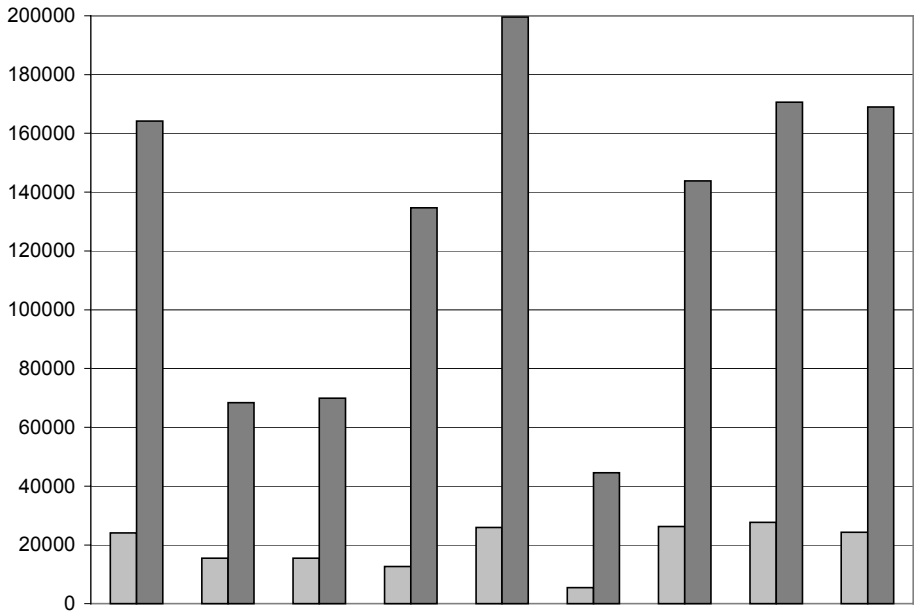
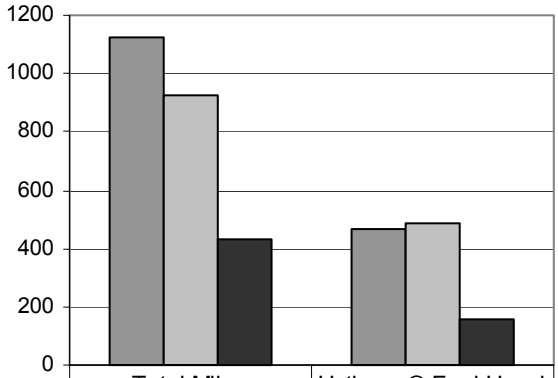


Figure 2: Solar power profile at SunLine.



	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01
Electrolyzer Power (kW)	24168	15487	15487	12674	25994	5528	26283	27652	24273
Standard Cubic Feet	164200	68400	70000	134700	199500	44600	143800	170600	169000

Figure 3: Hydrogen produced using Stuart Energy Systems P3 Unit.



	Total Miles	Hythane® Fuel Used
Jan-01	1123	468.6
Feb-01	926	485.6
Mar-01	431	159.3

Figure 4: Hythane® Bus Miles Driven and Hythane® Usage.

In addition to the two electrolyzers, SunLine is reforming hydrogen from natural gas. The HBT stationary reformer utilizes under-oxidized burner (UOB™) technology and a QuestAir purification system to produce 4,200 standard cubic feet of hydrogen per hour. The hydrogen is 99.999% pure and is enough to fuel five buses a day. Currently, the project generates more hydrogen than it can store or utilize in its existing fleet, so the hydrogen from the HBT reformer is temporarily being flared. However, SunLine is investigating additional storage options and potential customers for the excess hydrogen.

SunLine is poised to begin testing Hythane® in an unmodified CNG engine. If the testing proves successful, the CNG fleet will be converted to Hythane®. Plans also continue towards the long-term goal of replacing the entire fleet (buses, trucks and passenger vehicles) with zero emission fuel cell vehicles. The first installment of fuel cell vehicles is scheduled for 2003. If all goes according to plan, SunLine and AC Transit in Northern California will each receive 10 fuel cell buses as part of the California Fuel Cell Partnership Bus Demonstration Project.

Outreach

An important aspect of any hydrogen demonstration project is outreach. SunLine is committed to educating the public on the benefits of clean fuels technology and mass transportation. Since SunLine is currently the only site in the world where hydrogen generated on site from solar energy is used to power buildings and Hythane® and zero-emission fuel cell vehicles, and will, in the near future, demonstrate hydrogen generation from wind power, it is ideally positioned to educate as it demonstrates.

SunLine built and operates the world's first Clean Fuels Mall where compressed natural gas, liquefied natural gas, hydrogen and Hythane® are available to the public 24 hours a day. Additionally, global shoppers for electrolyzers, reformers and other equipment that generates, stores and dispenses alternative fuels can visit SunLine to see prototype and product-development units in operation. SunLine has worked with the equipment manufacturers to develop educational displays and kiosks located throughout its facilities.

SunLine has produced an educational video series entitled "Energy Matters." Thirteen, two-minute videos are available on the Web at www.sunline.com and cover such topics as alternative fuels, electricity and the grid, fuel cells, microturbines and new car technologies. The videos are also available to teachers and administrators for use in classrooms. SunLine is also working with local schools to develop activity books and workbooks for third to sixth graders that will correspond to the video series.

When SunLine converted its bus fleet to CNG they partnered with the College of the Dessert, the local community college, to devise training curriculum. College of the Dessert, located in Palm Dessert, California, now offers a unique Advanced Transportation Technologies program that teaches students about clean fuel vehicles, electronics and systems that will run the vehicles of the future. Students who complete the 2-year program earn an Automotive Technologies Associate of Arts Degree and acquire in-demand job skills repairing and maintaining clean fuel vehicles.

Finally, representatives of SunLine are traveling throughout the region and around the world to share its experiences and the opportunities of clean fuel vehicles. Audiences include the technical hydrogen community, policy makers, financial officers, community groups and schools.

Summary

The Coachella Valley of California has become the world's leading test bed for alternative fuels technologies. Environmental stewardship, leadership, technology advancement, strategic thinking and partnership development are the fundamentals on which the Coachella Valley public transit system has been built. Now with seven years of experience in CNG vehicle technology and the knowledge gained in hydrogen production, storage and utilization, SunLine Transit Agency is poised to begin transitioning the Coachella public transit fleet to zero-emission hydrogen fuel cell vehicles.

In the coming years, SunLine will continue testing its Hythane® and hydrogen vehicles. Once feasibility has been established, the entire fleet of CNG vehicles will be converted to Hythane®. SunLine will also continue to produce hydrogen on-site and will incorporate wind into its power supply infrastructure. As early as 2003, conversion of the transit fleet to hydrogen fuel cell vehicles will begin. SunLine will work with its partners to incorporate the latest technology developments and to publicize the opportunities hydrogen technologies present. By continually demonstrating the safety and reliability of hydrogen technologies, SunLine will help lead the way to our hydrogen future. SunLine is truly today's model for tomorrow's world.