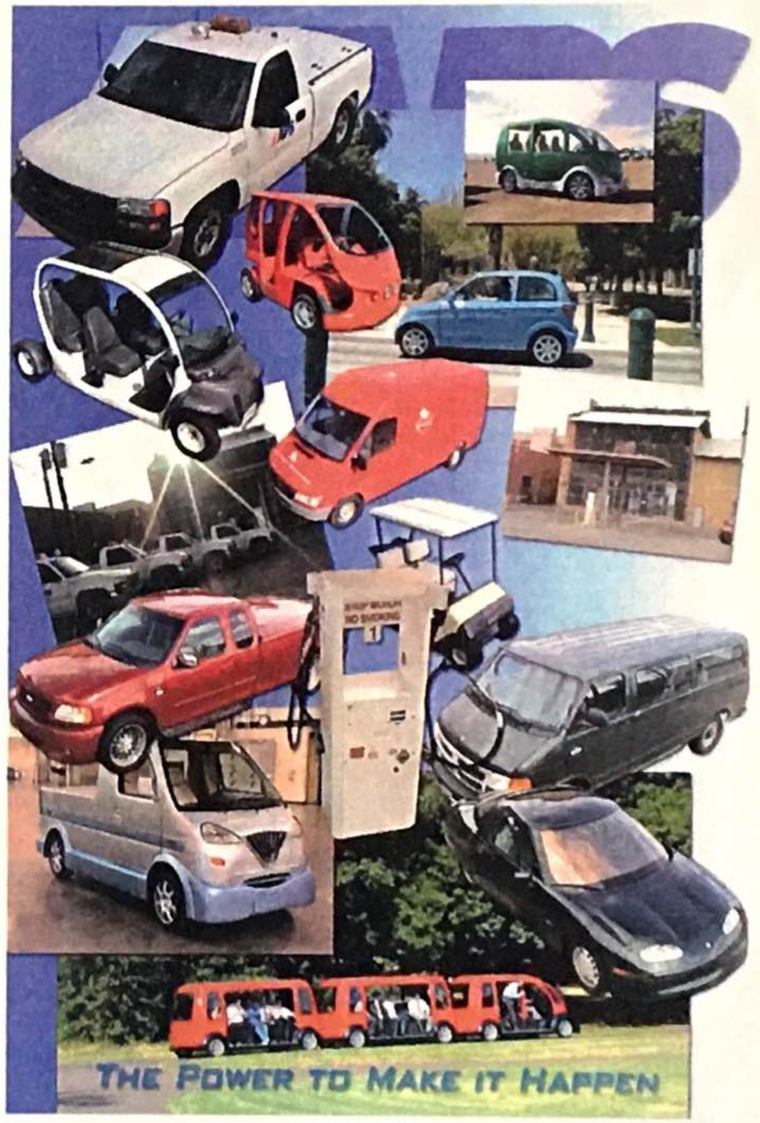
## Pilot Refueling Station


The APS Hydrogen Park was the first commercial hydrogen motor vehicle refueling station in Arizona. The Park, permitted to fuel hydrogen motor vehicles in March 2002 and located in downtown the Phoenix historic district, provides an example of modern fueling infrastructure integrated with urban architecture. The APS Hydrogen Park is part of the US Department of Energy Hydrogen & Fuel Program and Freedom Car. Since going into operation, more than 6,000 kilograms (equivalent to gallons of gasoline) of hydrogen has been produced. Hydrogen is priced at $2.25 per kilogram or $2.25 per gallon of gasoline equipvalent Hydrogen, CNG (compressed natural gas), and CHyNG (blends of hydrogen and CNG) motor vehicle fueling are all available at the Hydrogen Park fuel dispensers. Customers can use their credit cards to purchase these clean fuels during daylight hours. Hydrogen is also used to produce electricity at the Park. Both fuel cells and internal combustion engine driven generators produce elctricity from hydrogen. When hydrogen is used as a fuel, water and water vapor are exhausted into the air we breathe. Hydrogen is made from City of Phoenix tap water and electricity in a device called an electrolyzer. Some of the electricity to produce hydrogen comes from a solar PV array at the Park. About 2.3 gallons of water is required to make 1 gallon equivalent or kilogram of hydrogen. During the process both hydrogen and oxygen are produce. Since the Park began operation more, than 1 million cubic feet of pure oxygen has been release into the downtown Phoenix air from the Park's electrolyzer, almost like having a one acre park with 36 turn of the 19th century mature trees. More than 4,000 vehicle fueling events have occurred and there have been no safety incidents since the Park began operation. Hydrogen system availability has been above 99%. The hydrogen produced from water has been 99.9997% pure, and the station has released 1,242,000 scf of oxygen.

## APS EV History

The original interest in electric vehicles dates back to 1967 when APS purchased a "MARS II" battery-powered car, which was driven from Detroit to Phoenix in a publicized cross-country odyssey. Under the Energy Conservation Program, APS was one of ten test sites chosen by the Department of Energy in 1979 for electric and hybrid electric vehicle testing. APS first began using electric vehicles in its fleet in the early 1980's, purchasing 2 vehicles manufactures by Unique Mobility and 27 Dodge vehicles that were converted to battery-powered electric by Jet Industries of Texas. Beginning in 1991, APS supported electric vehicle racing as an education program for the media, general public, secondary education schools and major universities. Four competitive (race) vehicles were developed with partnerships from numerous other organizations. The educational portion of the APS racing effort was supported by the U.S. Department of Energy and grew to include some 42 Arizona high schools, along with several other schools across the U.S. In 1994, APS lead the efforts to create a market lead initiative named EV America which grew to include the U.S. government, the state of California and 188 electric utilities in the United States. The original goal for the APS EV Program was finally realized in 1997 when GM offered its EV1 for retail sale in California.


# Future Fuels Program




APS

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## LSV-100 EV Opportunity Charger

A compact fast charger was developed in 2002, which provides opportunity refueling for low voltage (36-volt thru 96-volt) battery electric vehicles. Vehicles may include neighborhood electric vehicles, golf carts and utility carts that are used in applications such as commercial fleets, university campuses, golf resorts and military bases.


Features include:

- Less than 30 minutes charge time (30-80% SSOC)
- BIW 9-pin connector
- Sealed and flooded lead-acid batteries
- Vehicle conversion kits available (not included)
- Standard discrete output voltage options include 36V, 48V, 72V and 96V

| OUTPUT | |
|---|---|
| Output Power | 10kW |
| Maximum Output Current | 100 Amps |
| **INPUT** | |
| 208 VAC, 3-PH / 48 Amps Max. (60A Breaker) | |
| 240 VAC, 1-PH / 50 Amps Max. (70A Breaker) | |
| 60Hz Input Frequency | |
| **GENERAL** | |
| Dimensions (H/W/D) | 24" / 20" / 12" |
| Weight | 250 Lbs. |
| Operating Temperature | -25° C to 50° C |
| Mounting | Wall or Pedestal |

## Alternative Fuel Vehicle Summary

In 2004, the APS alternative fuel fleet managed by the Technology Development Future Fuels Program accumulated 150,027miles. Emissions reductions from these vehicles were estimated at 13 tons of $CO_2$, 12 pounds of NOx and 10 pounds of NMHC. There was 2,076 fuel transactions for a total of 8,691 GGE of clean fuel. Major credit cards are now accepted at the refueling station and include Visa, MasterCard, Voyager and Wright Express. The fleet includes 56 vehicles with fuel types ranging from bi-fuel to dedicated hydrogen to low speed battery electric neighborhood vehicles. Vehicle usages included Meter Reading operations, downtown/metro carpool, education programs and community relations events. A CNG vehicle driver's training program was developed and more than 120 employees have been trained since program inception. A NEV carpool program also operates for employees commuting in the downtown area.

*Ford F150 "ZEROOUT"*
*50/50 Blend of Hydrogen & CNG*

*Mercedes Sprinter*
*100% Hydrogen*

*4-Passenger GEM*
*Low-speed neighborhood electric vehicle*

*Dodge Ram*
*15/85 Blend of Hydrogen & CNG*

## Supercharge Stations

APS has installed 15 SuperChargers in Arizona…this one for public access in Fountain Hills. Other installations include a 33kW supercharger at SunCor locations of Sun Ridge Canyon and Palm Valley, and at the City of Palm Springs. APS has also worked with Southwest Airlines in electrification of their ground support equipment in six locations including Phoenix, Ontario, Tulsa, San Diego, Sacramento and Burbank. EV charging services were also provided to DaimlerChrysler at the Arizona Proving Grounds, Michigan and California. SuperChargers are to batteries what the gasoline pumps are to cars. Battery-powered electric vehicles can be charged quickly…some in as little as 6 minutes…others may take as long as 45 minutes.

## EV Outreach

The APS alternative fuel fleet participates in Energy Fairs, parades, high school homecoming events, school education events, scout events, dedications and other community events such as "Sunday on Central". Community interest is very high in clean alternatives for personal mobility. The vehicles participated in more than 75 events from Phoenix to Wickenburg, from Prescott to Flagstaff.

# Arizona Public Service Alternative Fuel Pilot Plant and Hydrogen ICE Vehicle Testing

*The Idaho National Engineering and Environmental Laboratory manages the light-duty vehicle testing activities of the U.S. Department of Energy's Advanced Vehicle Testing Activity (AVTA). As part of this activity, the INEEL and the AVTA teamed with Electric Transportation Applications and Arizona Public Service (APS) to develop the APS Alternative Fuel Pilot Plant, which produces and dispenses hydrogen on site. The hydrogen is produced through electrolysis, by operating a PEM fuel cell in reverse. The Pilot Plant also compresses natural gas on site. The Pilot Plant is used to fuel internal combustion engine test vehicles that operate on 100% hydrogen, and blends of 15 to 50% hydrogen and compressed natural gas.*

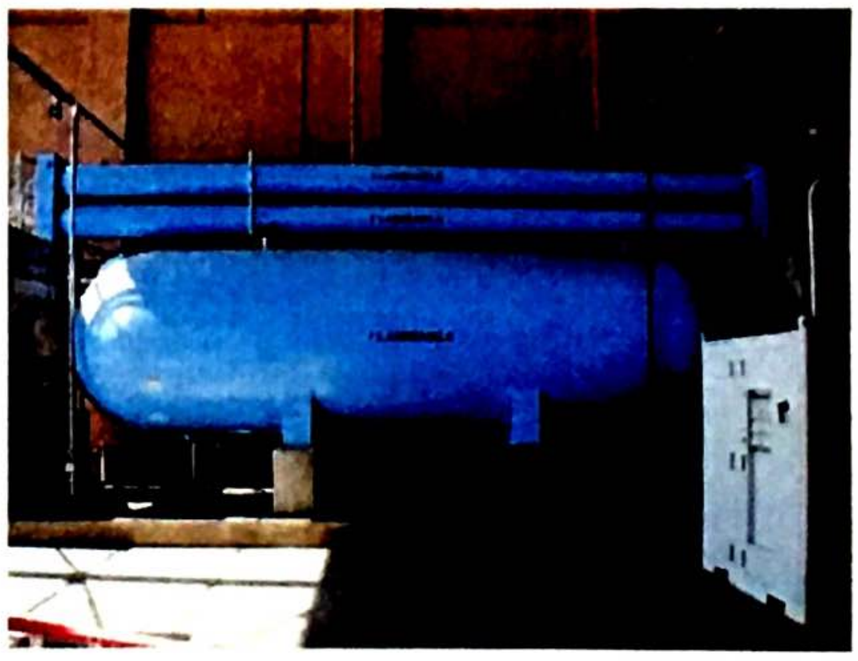
## *APS Alternative Fuel Pilot Plant*

The APS Alternative Fuel Pilot Plant is a model alternative fuel refueling system, dispensing hydrogen, compressed natural gas (CNG), and hydrogen/CNG blends (HCNG). The plant is used daily to fuel vehicles operated in Arizona Public Service's fleet.

***APS Alternative Fuel Pilot Plant and fueling island.***

**Hydrogen Subsystem** - The plant's hydrogen system consists of production, compression, storage, and dispensing. The hydrogen produced is suitable for use in fuel cell-powered vehicles, for which the minimum hydrogen purity goal is 99.999%. Hydrogen is produced using an electrolysis process that separates water into hydrogen and oxygen.

At present, the hydrogen is compressed and stored at a maximum operating working pressure of 6,100 psig. The facility has over 17,000 scf of high-pressure hydrogen storage capacity and 9,000 scf of low-pressure hydrogen storage capacity. The dispenser can fuel vehicles at pressures, up to 5,000 psi.



***Hydrogen low-pressure storage tank, two high-pressure storage tanks, and PEM electrolyzer on right.***

**Compressed Natural Gas Subsystem** - In addition to producing hydrogen, the plant also compresses natural gas for use as a motor fuel. CNG vehicles typically have 3,600 psi storage tanks. However, to fill a vehicle's onboard tanks, storage pressures must be higher. The APS system compresses natural gas to pressures up to 5,000 psi, using a three-stage cascade pressure arrangement.

## APS Alternative Fuel Pilot Plant – Facts:

- Location – Downtown Phoenix, Arizona
- Objectives:
  - Evaluate the safety and reliability of operating internal combustion engine (ICE) vehicles on hydrogen and blended HCNG fuels
  - Quantify ICE hydrogen and HCNG vehicle costs, performance and emissions
  - Ascertain the safety issues for a hydrogen production operation in a commercial setting
  - Develop a working model of a refueling system for ICE and fuel cell vehicles, and evaluate the vehicle fueling infrastructure and vehicle-to-infrastructure interface
- Hydrogen generator – PEM fuel cell, 57 kW, 300 scfh hydrogen output
- Hydrogen compressor – Oil free, three stage, diaphragm compressor, 99.9997% purity
- Hydrogen dispenser – dispenses hydrogen up to 5,000 psi
- HCNG and CNG dispenser – dispenses HCNG and CNG up to 3,600 psi
- CNG Boot compressor – 300 SCFM @ 60 psi
- CNG Main compressor – 350 SCFM @ 4500 psi
- High Pressure CNG Storage – 50,000 @ 4,000 psi
- Fuel Dispenser – Pure hydrogen or CNG and HCNG blended fuels, with metering and electronic billing interface

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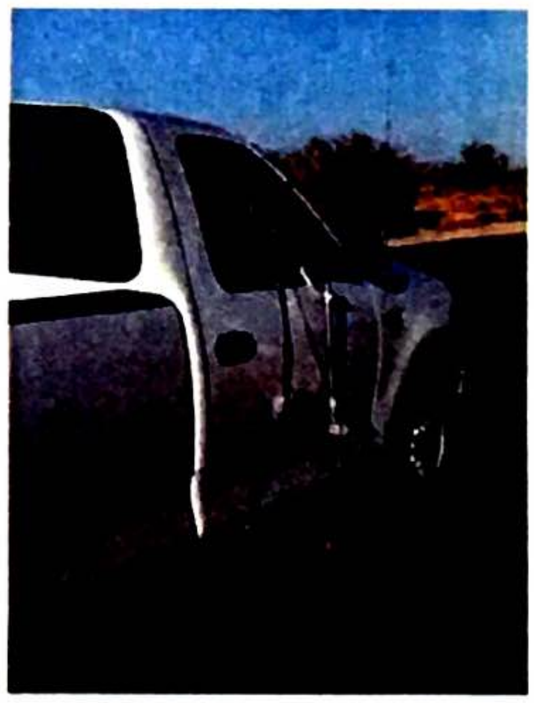
## Hydrogen and Hydrogen/CNG (HCNG) Internal Combustion Engine (ICE) Vehicle Testing

The U.S. Department of Energy's Advanced Vehicle Testing Activity (AVTA) is evaluating hydrogen and HCNG ICE vehicles in closed-track and laboratory environments (baseline performance testing), as well as in real-world applications, including fleet testing and accelerated reliability testing (accumulating life-cycle vehicle mile and operational knowledge within 1 to 1.5 years). Emissions testing has also being conducted on several vehicles.

***Arizona Public Service's 50% HCNG test vehicle.***

In addition to reducing the use of petroleum, using hydrogen and HCNG as a fuel in ICE vehicles provides air emissions benefits. Testing hydrogen ICE vehicles also supports development of the hydrogen infrastructure needed for fuel cell vehicles.

The AVTA, along with its testing partners APS and Electric Transportation Applications, is operating several 100% hydrogen ICE vehicles, with Ford and Mercedes Benz engines, as well as a dozen ICE vehicles (including Daimler Chrysler, Ford and General Motors vehicles) that operate on 15 to 50% HCNG blends. Various fuel blends have also been tested in a Ford F-150 to allow the comparison of performance and emissions impacts.



***Ford F-150 instrumented for acceleration testing.***

Additional information about the APS Alternative Fuel Pilot Plant and the hydrogen ICE vehicle testing can be found at:

***http://avt.inel.gov/hydrogen.html***

*January 2004*

# TECHNOLOGY DEVELOPMENT PROJECT FACT SHEET

## NO. 013 H2 VEHICLES – MERCEDES SPRINTER

The 1998 Mercedes Sprinter originally was equipped with a 2.4L gasoline engine, but was converted to pure hydrogen by the German government as part of the hydrogen demonstration program in Hamburg. Modifications to the vehicle included adding three hydrogen tanks (115L), CV injection and a spark ignition. APS received the vehicle in January 2002 to test the APS pilot refueling station.

During the almost three years of operation in the APS fleet, the Sprinter van has had only minor mechanical problems, resulting in an operating cost of $0.099 per mile. As of December 2003, the Mercedes Sprinter had operated 9,300 kilometers (15,000 miles) in the APS fleet with no safety problems encountered, and an average fuel efficiency of approximately 25 mpg.

The vehicle has been demonstrated and exhibited in numerous events throughout America. The logo on the sides of the vehicle are the original logo from the City of Hamburg. Translation is "*we drive with hydrogen for a cleaner world*."

| Operation Range | H2 GGE (kg) | Efficiency (mpg) | Emissions | CO2 Emissions |
|---|---|---|---|---|
| 100 | 4 | 25 | $H_20$ Vapor | 0.00% |

APS

PINNACLE WEST