



ALTERNATE FUEL TECHNOLOGY

The Race to Hydrogen – Who's Winning?

Editor's Note: In this installment, part 14 of a continuing series on Alternate Fuels, AFVs, and Advanced Vehicle Technology, author Bob Rodriguez looks at the alternate fuel winners in the race to a hydrogen economy.

In his 2003 State of the Union Address, President Bush announced that hydrogen would be America's alternative energy source for the future, and he challenged Congress to appropriate funding for research and development to get us there. Like a lightning rod, his announcement electrified the alternate fuels community and charted a course amid otherwise uncertain energy times. With unreliable petroleum imports now topping 65 percent, OEMs are competing in the race to put sustainable hydrogen-powered vehicles on the streets.

People are asking how soon we'll see hydrogen fuel-cell vehicles, and, more immediately, how do we make the transition from gasoline engines (ICE's) to fuel cells? It is taking a variety of alternate fuels to usher in the hydrogen economy, making the outlook for these fuels no less prom-

ising than for hydrogen. (See previous ASE Tech News articles.¹) For example, both natural gas pipelines and ethanol's fledgling distribution infrastructure will serve us. Liquid ethanol (and also methanol) is a good "energy carrier" for storing, transporting and reforming to hydrogen. Electricity, the cleanest alternative, is obviously used in both gasoline-electric hybrids and fuel cell vehicles and is used for electrolyzing water into hydrogen.

Let's take a closer look at some of these alternate fuels and vehicles in the context of who's competing and winning in the race to hydrogen.

Natural Gas (methane) is clean and plentiful (for now at least) and is certainly one of the winners among alternative fuel choices, thanks to a strong distribution (pipeline) infrastructure and strong trade support. Compressed natural gas (CNG) has found favor among federal fleets (USPS), municipal fleets (buses, police cruisers, etc.) and private fleets (taxicabs, etc.) for both light and medium duty vehicles. The population of registered natural gas vehicles (NGVs) has grown to an estimated 130,000 operating in the U.S. every day.² Some say growth has flattened, however, as fleet owners switch back and forth from gasoline/diesel to CNG, prompted by fluctuating fuel prices, equipment problems (due to poor fuel system

integration), and incremental costs. Installation costs for compressor and fill sites can be high as well.

On the other hand, operators of indoor vehicles have taken note of the clean air benefits of CNG, and some are switching over from propane. Liquefied natural gas (LNG) is successfully being used to power medium and heavy-duty vehicle applications like refuse haulers and line-haul trucks. Natural gas is also used for producing propane, for liquid fuels, and is itself a prime source for hydrogen.

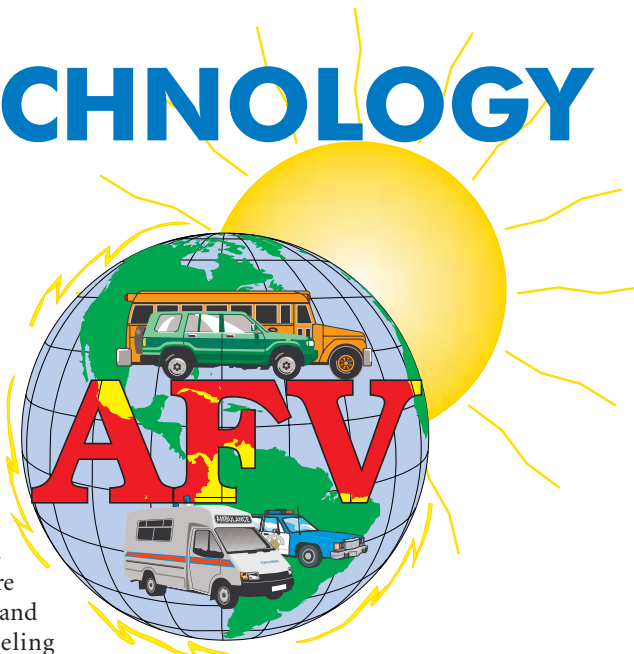
LPG/Propane could be a winner among motorfuel alternatives—if you can find the fuel, and at competitive motorfuel prices. Propane vehicles have been around for years, and propane is a favorite for bi-fuel or dedicated light and medium duty vehicles of all sorts, with just under 300,000 vehicles in service as of last year. Propane is also the fuel of choice for many non-road vehicles. An estimated 95 percent of the nearly 500,000 forklifts in use run on propane,³ not to mention tugs, ice sweepers, etc. The Propane Vehicle Council touts propane as the "Exceptional Energy" choice, and if a nation-wide propane vehicle-refueling infrastructure ever materializes, they could be right.

Ethanol/E85 could become a real winner, too, being well promoted by trade associations and seen as a viable alternative to gasoline in the agricultural corn belt of America. Ethanol markets have grown tenfold (about 10 million gallons a year) during the past five years; admittedly 98 percent of the ethanol presently produced is used as the additive in E10 (Gasohol). Ethanol is a good energy carrier for reforming into hydrogen, once fuel cell vehicles arrive.

Ethanol flexible-fuel vehicles (FFVs), which are conventional ICE vehicles with provisions for alcohol use, will play a winning role in dis-

placing petroleum until hydrogen arrives.^{4 & 5}

As of January 2003, there were more than three million FFVs on the road, and more are coming. Reportedly there are about 300 public and private E85 refueling



What are Hybrids?

In the hybrid, electricity is generated and stored in battery modules, or ultra-capacitors, which serve as "electric superchargers" to augment ICE power under load. Hybrid electric vehicles (HEVs) typically get 25–40 percent (or more) better economy and lower emissions thanks to engines that are "super tuned" for peak volumetric efficiency and clean performance. Atkinson Cycle variable intake valve timing (Toyota – VVTi) technology and continuously variable transmissions (CVTs) help keep engines running at their most efficient speeds to achieve super-low emissions (SULEV). Regenerative coasting and braking add to already impressive MPG, vehicle performance, and range.

Various HEV drive configurations are possible—series, parallel, full, partial, through-the-road, etc. (See ASE Tech News, Summer 2001 and Fall 2001 for greater detail. Visit www.ase.com to view or download the articles.) In a "full hybrid" vehicle like the Toyota Prius and the Ford Escape, the engine shuts off at low vehicle speeds for zero emissions (or for stealth operation in military vehicles.) Full hybrids qualify as SULEV and P-ZEV vehicles. Partial hybrid vehicle engines, as used in the Honda Insight or Civic, don't shut off when under way. The OEs will be offering increasing numbers of hybrids soon, but so-called "plug-in hybrids" being tested in Europe are not likely here for some time.

stations in the U.S. The Department of Energy (DOE) and original equipment manufacturers (OEs) have joined forces to develop E85 markets in six major areas including Denver, Chicago, and Minneapolis. Many more motorists would likely opt for using ethanol if refueling stations were accessible and cost-per-mile prices were made more competitive with gasoline.

Biodiesel, made principally from soybeans or recycled vegetable oils and fats, has more recently been rec-

ognized as meeting federal EPA mandates when used as B20 (20 percent splash blended) or neat (100 percent). Bio is a winning alternative fuel for diesel engines, although older engines may require fuel system modifications, since bio could cause seals to deteriorate. OE warranties generally accept up to five percent biodiesel blended with petrodiesel. The market for biodiesel is now small, and bio prices are about 30 percent more ex-

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Hybrids' Presence Grows

Environmentally friendly vehicles are gaining in popularity, seeing a 54-fold increase in popularity in the past five years, according to an R. L. Polk & Co. study done in 2003. Gasoline-electric hybrid-electric vehicles (HEVs) accounted for nearly 83 percent of green vehicles registered in 2002. Toyota's Prius led with approximately 17,500 registrations, and Honda's hybrid Civic had nearly 10,000. Hybrid-electric vehicle sales are expected to grow by over 2000% over the next ten years.

- Toyota reportedly has plans to offer six different hybrid engines using two or three versions of their hybrid-drive system in the next two or three years; models include a mini van, a luxury sedan, and an SUV.
- Honda has aggressively marketed both its Insight and Civic gasoline-electric hybrid vehicles and was the first OE to certify a (hybrid) hydrogen fuel-cell vehicle with both EPA and CARB. The FCX is powered by gaseous hydrogen and uses ultra-capacitors (rather than battery modules) to store electrical energy.
- Ford plans the release of a hybrid SUV in July 2004.
- GM will offer hybrid trucks in 2004; a hybrid version of the Saturn VUE sport utility vehicle begins in 2005; the Chevy Equinox SUV appears in 2006; and the Chevy Malibu Sedan comes on line in 2007.
- Hybrid electric trucks and buses are proving popular for urban and suburban use. In May 2003, FedEx Express introduced a hybrid medium-duty delivery truck (see photo) using Eaton's electric powertrain. Hybrid trucks are expected to account for 39 percent of HEV sales by 2005.
- For non-road use, Deere and Co. has taken delivery of a hybrid version of their Gator® Utility Vehicle using wheel motors. Also, a hybrid 7000 series farm tractor and a 300 series lawn and garden tractor have been demonstrated.
- For military use, hybrids offer superior fuel economy and electric-only stealth capability. The U.S. Army is purchasing a militarized diesel-electric hybrid version of Chevy's Silverado crew cab (see picture) complete with a 5 KW fuel-cell APU. A diesel-electric hybrid Humvee is also being tested.

Hybrids best serve our needs when used for stop-and-go driving, in smaller-lighter passenger vehicles, and where stealth operation is needed.



Urban transit companies and city dwellers alike benefit from buses like these New York City diesel powered hybrid buses made by Orion and using BAE drive systems.



FedEx partnered with Environmental Defense and Eaton to build this diesel powered hybrid-electric step-van which achieves remarkably low emissions and excellent fuel economy.



This GM Silverado-based DuraMax diesel parallel hybrid military crew-cab can operate on batteries only for covert "stealth" operation, reportedly gets 25–40% better fuel economy, and includes a fuel-cell auxiliary power unit.

Part of a continuing series on alternate fuel vehicles and advanced vehicle technology. If you have comments or questions, contact ASE's Bob Rodriguez at 703-669-6634 or brodriguez@asecert.org.



AUTO TRAINING RESOURCES



Changes in Gasoline Manual Now Available for Free Download

As ethanol use expands and enters new markets, it's bound to trigger some questions you may have about ethanol and other fuel quality issues. The Changes in Gasoline manual series has achieved a circulation in excess of a half million copies, making it the most widely circulated gasoline reference manual used by the auto service and repair community. Containing information on new fuels and gasoline quality, vehicle performance and driveability, along with information on power equipment and recreational engines, Changes in Gasoline covers a wide spectrum of topics that impact you directly as a service technician.

"Changes in Gasoline" is available for a free download from the Renewable Fuels Association at www.ethanolrfa.org.

Click on the link marked "Auto Mechanics."



Renewable Fuels Association

Once there, you will also find other related documents covering different topics on gasoline and its uses.

La versión en Español ahora está disponible para que usted la obtenga libre de cargo.

IAPA Offers Career Training Online

IAPA, through its Automotive Service Professionals (ASP) program offers two new training opportunities via the Internet: The Elite Parts Force Training Program and the eTech network.

Designed as "basic training" for counterpeople, service advisors and entry-level technicians, the Elite Parts Force Training Program provides a better understanding of automotive systems and increased customer service skills.

The program, divided into technical and non-technical training, brings counterpeople and service advisors up to speed on systems and components they'll sell and install. Entry-level technicians receive instruction in merchandising, customer service and selling skills. Participants receive a 19-chapter manual; each section concludes with a test that can be mailed to IAPA headquarters or taken online. Cost for this training, which includes an insignia leather jacket and diploma upon course completion, is \$99.00 for ASP member shops.

ASP's online eTech Network enables technicians to assess their skills, sign up for local classes, and track their training progress any hour of the day or night. 'Core Services,' 'Drivability,' and 'Emissions' assessments direct techs to the courses best suited to their skill level. The eTech Network is included at no additional cost with a basic ASP membership.

Information on the Elite Parts Force Training Program, the eTech Network, and other ASP educational opportunities, in-

cluding Enhanced ASP Technical Assessment/ Training, National Manufacturer Programs, Technical Support, and Specialized Pro Training Clinics, is available online at www.autoservicepro.com or by calling 1-888-505-1364.



Auto Manufacturer OEM Service Websites Launched

The National Automotive Service Task Force (NASTF) has announced a posting on its website (www.nastf.org) that summarizes OEM service website access charges. All automakers now make service information available online, notes NASTF. This includes service manuals, technical service bulletins, training materials, reprogramming information and other related information.

The access charges for the OEM service websites vary by manufacturer. To view the summary of access charges, go to www.nastf.org and select "Summary of OEM Service Website Access Charges."

According to NASTF, most automakers currently offer subscription rates for information on all their models based on daily, monthly, or yearly access. Some offer other subscription options, such as on a per-document basis, single-model basis, etc. Several websites are available free of charge.

To access the automaker sites, log onto www.nastf.org and click on "OEM Service websites."

NASTF was established in 2000 to facilitate: (1) the identification and correction of gaps in the availability and accessibility of OEM automotive service information; (2) technology training for technicians;

(3) availability of both OEM and generic diagnostic tools and equipment; and (4) communication outreach to automotive service professionals.

Go to www.nastf.org for details or contact NASTF's John Cabaniss at jcabaniss@aiaam.org or call him at 703-247-2107.



Listing of OEM Service Websites

- Acura – www.ServiceExpress.Honda.com
- Audi – <http://erwin.audi.de>
- BMW – www.bmwtechinfo.com
- Chrysler/Dodge/Eagle/Jeep/Plymouth – www.techauthority.com
- Ford/Lincoln/Mercury – www.motorcraft.com
- General Motors – Buick/Cadillac/Chevrolet/Geo/GMC/Hummer/Oldsmobile/Pontiac/Saturn – www.gmtechinfo.com
- Honda – www.ServiceExpress.Honda.com
- Hyundai – www.hmaservice.com
- Infiniti – www.infinititechinfo.com
- Isuzu – www.isuzutechinfo.com
- Jaguar – www.jaguartechinfo.com
- Kia – www.kiatechinfo.com
- Land Rover – www.landrovertchinfo.com
- Lexus – www.techinfo.lexus.com
- Mazda – www.mazdatechinfo.com
- Mercedes Benz – www.startechinfo.com
- Mini – www.minitechinfo.com
- Mitsubishi – www.mitsubishitechinfo.com
- Nissan – www.nissantechinfo.com
- Porsche – <http://techinfo.porsche.com>
- Saab – www.saabtechinfo.com
- Subaru – www.subaru.com Click on "home" and then "technical information"
- Suzuki – www.suzukitechinfo.com
- Toyota – <http://techinfo.toyota.com>
- Volkswagen – www.erwin.vw.com
- Volvo – www.volvotechinfo.com

Source: National Automotive Service Task Force, www.nastf.org

Alt Fuels

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ensive than petrodiesel. Biodiesel markets are expected to grow to over 40 million gallons this year. Presently over 100 major fleets use biodiesel; many are federal government agencies like NASA, the National Park Service, and the military. However, municipalities using biodiesel realize benefits because bio offers an inexpensive way to meet their EPAct mandates (and help clean the air).

Electricity is an excellent clean and sustainable energy carrier. Emissions are low as fossil fuel emissions are scrubbed at the source, or even zero when solar, wind, or hydro (river or tidal) power is used to generate it. But electricity is expensive to transport (via the "grid") and even more difficult to store. It serves as an auxiliary power source when used with gasoline in hybrids (see below).

Battery Electric Vehicles (BEVs) have evolved greatly from simple DC motor golf carts, but high vehicle costs and limited battery capacity still limit BEVs to a range of 100 miles or so. Making things worse, advanced-battery problems like heating/cooling issues forced some OEs to revert to heavier lead-acid batteries, which adds more weight and reduces vehicle range further. The 10 percent zero-emission-vehicle mandates in California that cham-

Hybrid Training

With increasing numbers of gasoline-electric hybrid vehicles on the highways, perhaps you're wondering where to get training on servicing these vehicles. Along with OE factory schools for dealer personnel, here are some training sources. Also, check the Internet for the latest, keyword search on "Hybrid Electric Vehicle Training."

AR&D – Sterling Heights, Mich.

Text books and courses on HEVs, etc. Contact Chris Bina at (586) 615-3834, or arandd@ix.netcom.com for information on training courses.

Mid-Del Technology Center – Midwest City, Okla.

Courses on BEVs, HEVs, FVCs, and EMS/First Responder training. Contact Sandy Stephens at (405) 672-6665.

National Alternative Fuels Training Program – Morgantown, W.Va.

Twenty-plus training locations around the country. Contact Al Ebron at (304) 293-7882.

Veejer Enterprises – Garland, Texas.

New publication *Essential AC Electric Theory and Basic Circuits of Hybrid/Electric Drive Vehicle*; training courses. Contact Vince Fischelli at (972) 276-9642; www.veejer.com.

York Technical College – Rock Hill, S.C.

Contact Director Bob Kosak at (803) 325-2865 for details about their EV, HEV, FCV training curricula and programs.

pioned BEVs have since been rewritten, and OEs have been canceling leasing programs. The good news? BEVs have proven themselves in "niche markets" serving municipalities, gated communities, stop-and-go delivery fleets and as commuter cars. Plus, BEV technology transfers readily to hybrid-electric vehicles (HEVs).

And The Winner Is... Hybrid Electric Vehicles!

Today's HEVs are early models for tomorrow's hydrogen-electric fuel

cell vehicles, and clearly lead the race as the most practical near-term answer for reducing and eliminating petroleum use. Today's gasoline-electric hybrids have a miserly fuel appetite and are rated super ultra low emission (SULEV) and partial zero emission (P-ZEV) for their ultra clean emissions. Smaller passenger vehicles benefit most from being "hybridized" as do urban stop-and-go transit buses, refuse haulers, and other such vehicles. These heavier hybrid applications use ethanol, clean diesel, natural gas and

propane powered ICEs, or even propane micro-turbines, in conjunction with a variety of innovative electric drivetrain configurations. Biomass-ethanol FFV hybrids are proposed by some⁶ as the best way to turn off the oil-importation spigot, but we haven't seen any of these on the OE horizon. Nonetheless, expect to see a large variety and number of gasoline-electric hybrids to enter markets soon in the race to hydrogen (see sidebar).

The race for advanced transportation technologies and hydrogen is definitely on and the course is clearly defined. Edward B. Cohen,

Honda's VP of Government and Industry Relations, describes it best when he cites Honda's three-fold vision for R&D and marketing: 1) Maximize efficiency of internal combustion engines; 2) Expand the market for gasoline-hybrids, and; 3) Advance alternate fuel and fuel cell technology.⁷

Clearly these are exciting times: automotive history is being written before our eyes. As the alternatives to petroleum jockey for market position, we as technicians can do our part by supporting the leaders in the race to fuel cell vehicles and, ultimately, a hydrogen economy.

Footnotes:

1. *Thirteen previous ASE TechNews alternate fuels and advanced technology vehicles articles describe in greater detail developments and market forces affecting the industry. Visit our website at www.ase.com to view and download past articles in this series.*
2. *According to the Natural Gas Vehicle Coalition's 2003 Purchasing Guide, available from the NGVC in Washington, D.C. Visit www.ngvc.org ("Tools and Resources").*
3. *Bill McGlinchey, "Teaching Forklift Maintenance is Vital," LP Gas Magazine, May 2003.*
4. *Contact the Alt Fuels Data Center at 1-800-42301363 to obtain a VHS or DVD copy of John Davis' informative MotorWeek cable TV presentation about ethanol-burning FFVs.*
5. *To regain lost vehicle range when burning lower BTU ethanol in FFVs, compression ratios could be raised (to take advantage of ethanol's higher-than-gasoline 100 octane) by employing variable valve timing principles, as used by Toyota (VVT-I) and Mazda (S-VT).*
6. *Former CIA Director James Woolsey and Sen. Richard D. Lugar, "The New Petroleum," published in Foreign Affairs. Visit www.foreignaffairs.org for the full text.*
7. *From a presentation delivered June 18, 2003, at the Advanced Transportation Technology Forum, Hart Senate Office Building, Washington, D.C.*