



# WestStart-CALSTART's Hydrogen Bus Source

THE source for information on buses powered by hydrogen and fuel cells

Taking The Initiative To Make Fuel Cell Buses a Reality

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## Hydrogen Bus Source

*This is a quarterly electronic publication on hydrogen buses, produced by WestStart-CALSTART in partnership with, and funded by, the Federal Transit Administration.*

*The mission of the Hydrogen Bus Source is to inform stakeholders on the progress and activities of fuel cell and hydrogen buses, in the U.S. and abroad.*

*We dedicate Hydrogen Bus Source to be THE source for information on buses powered by fuel cells and hydrogen internal combustion engines.*

## SIDE-STEPPING THE POULTRY PROBLEM DIALOG ON HICE

You have heard about the poultry debate! Which comes first, the hydrogen infrastructure or the hydrogen fueled vehicle? Rather than taking this debate head-on, WestStart-CALSTART together with the Federal Transit Administration suggests 'let's talk about it (in a Symposium)!' The intent is not to resolve the debate but rather to explore the role that the internal combustion engine (ICE) may possibly play during the transition to hydrogen as a transportation fuel.

WestStart-CALSTART and the FTA plan to encourage that dialog at a one-day Symposium, titled "Bridging the Transition... Hydrogen Internal Combustion Engines." The meeting will be held Wednesday, February 22, 2006 in conjunction with the Clean Heavy Duty Vehicle Conference 2006 at the San Diego Hilton in San Diego, California. The Symposium will bring government and the private sector together to highlight the breadth and depth of accomplishments to date in the development, testing and validation of hydrogen or hydrogen-enriched natural gas fueled internal combustion engine technology, referred to as (HICE or HCNG-ICE) respectively.

The backdrop for this Symposium, the Clean Heavy Duty Vehicle (CHDV) Conference 2006, is jointly hosted by WestStart-CALSTART and the U.S. Army National Automotive Center. The CHDV Conference has become recognized as the leading national conference on the subject of clean and efficient heavy-duty vehicle technology.

Why consider internal combustion engines as a transition technology? After over 100 years of service with continued refinements and over 30 years of alternative fuels experience, the ICE may offer some advantages in the transition especially for heavy-duty vehicles. Some manufacturers are convinced that efficiencies achieved in a hydrogen ICE can exceed the best achieved with diesel and certainly gasoline. With careful design, emissions can also be lowered.

Achieving such performance with lower emissions involves both hardware and software design modifications in areas such as cylinder heads, injectors, engine controls and fuel system relative to a conventional ICE. Extensive Modeling and combustion research experience for ICE exists already to help with these design modifications. As a pragmatic note, an ICE operating on hydrogen may provide a familiar performing product for the general driving public during this transition.

Cost of the ICE certainly can win in the short term, during the transition. And both the fuel cell vehicles and ICE

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FORD 2.3-L SUPERCHARGED HICE

## A Mini-Hydrogen Economy

A Canadian vision for a future hydrogen economy – production, storage, distribution, dispensing of hydrogen and use in vehicles, public transit and stationary power generation – was launched in September of 2005. Planned to showcase the entire value chain of hydrogen technology, the Integrated Waste Hydrogen Utilization Project (IWHUP) will develop and demonstrate innovative clean energy elements for a hydrogen economy that make use of an existing but currently untapped source of hydrogen fuel: hydrogen emitted as the by-product of sodium chlorate manufacturing in North Vancouver.

Making hydrogen fuel takes energy and current methods that manufacture hydrogen from fossil fuels require a companion carbon capture process. Renewable forms of energy allow hydrogen fuel production and can avoid greenhouse gas (GHG) emission concerns. In IWHUP, the hydrogen, a normal byproduct of a chemical manufacturing process usually vented to the atmosphere, will be captured for use in vehicles to reduce emissions and for a stationary fuel cell. Up to 600 kg per hour of hydrogen are released, which when properly captured could power up to 20,000 fuel cell vehicles. Worldwide there are over 1,000 similar opportunities to capture co-product hydrogen from manufacturing operations.

The three-year IWHUP collaboration of an industry group led by North Vancouver-based Sacré-Davey Innovations involves coordinated implementations and demonstrations. Sacré-Davey Engineering, Hydrogen Technology & Energy Corporation and QuestAir Technologies are engineering facilities to capture, purify and store the supply of hydrogen. Although up to 600 kg per hour may be available from a single manufacturing source, the initial phase pegs the delivery rate at 20 kg/hour of hydrogen that has been scrubbed of trace contaminants yielding 99.995% pure hydrogen.

Sacré-Davey Innovations and Dynetek Industries will develop and demonstrate a compressed hydrogen storage system based on 450 bar, aluminum lined, carbon-fiber wrapped cylinders. The cylinders will be assembled into “PowerCubes” containing a total of 90 kg hydrogen. Transport trailers will carry six PowerCubes to distribute the captured hydrogen to light-duty and heavy-duty vehicle fueling stations as well as a stationary fuel cell resulting in lighter-weight, higher pressure distribution than with conventional transport trailer systems.

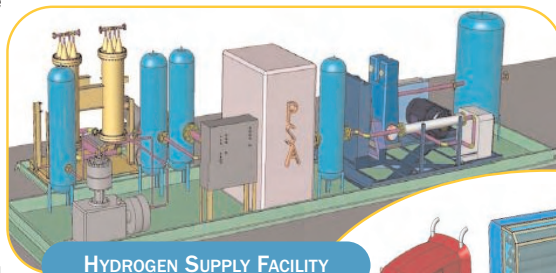
Sacré-Davey Innovations and Powertech Labs will team to demonstrate a self-serve, fast-fill hydrogen fueling station supplied by the PowerCubes. The light-duty vehicle fueling station will dispense hydrogen at 350 bar to a fleet of eight GMC Sierra 1500HD trucks converted to run on pure hydrogen. Fleet operations data including GHG emissions will be captured.

Clean Energy Fuels and Translink, the British Columbia (BC) transit operator, will site a hydrogen-compressed natural gas (HCNG) blending and fueling facility for heavy-duty vehicles. The heavy-duty HCNG facility will use hydrogen delivered by PowerCube to blend with CNG on-site. The HCNG fast fill dispensing facility will be located at Translink’s Port Coquitlam property.

Westport Innovations plans to convert four Translink CNG buses to operate on the blend of hydrogen and natural gas fuels using its patented CWI lean burn technology. Translink will operate the HCNG fueled buses in revenue service.

A stationary power generation system rounds out the elements of IWHUP with Sacré-Davey Innovations, Nuvera Fuel Cells and Easywash, a ‘green’ carwash company, teaming to demonstrate a 150 kW stationary fuel cell system fueled with hydrogen from the PowerCubes. The fuel cell will be installed at the carwash location, integrated with the local electrical grid to supply power for the carwash. Heat recovered from the fuel cell cooling system will heat water for use in the carwash, providing for the combined heat and power (CHP) fuel system demonstration.

Hydrogen offers the potential to significantly reduce emissions of greenhouse gases and other pollutants in Canada and around the world. By tapping an available fuel source, this project will demonstrate the viability of using hydrogen captured as a by-product for use in a transition to a hydrogen economy and opening the door to future opportunities. Highlighting the project outreach value, the IWHUP North Vancouver light-duty, hydrogen fuel station is one of the key stops on the BC Hydrogen Highway™ that will play a role in sustainable transportation demonstrations for the Vancouver/Whistler 2010 Olympic and Paralympic Winter Games.



HYDROGEN SUPPLY FACILITY



H2 STORAGE AND TRANSPORT SYSTEM



TRANSLINK BUS



CARWASH WITH CHP FUEL CELL SYSTEM



## IN THE NEWS! FUEL CELL BUS INDUSTRY LEADERS MEET IN VANCOUVER

Industry and government representatives from fuel cell bus demonstration activities worldwide met for three days in Vancouver in December for the Third International Fuel Cell Bus Workshop. Sixty-four people from nine countries attended the Vancouver event, previous workshops were held in Long Beach in 2003 and Porto in 2004. These workshops are a unique opportunity for stakeholders to meet, share information and lessons learned, and work together to help advance fuel cell (and hydrogen ICE) bus demonstration efforts. The workshop was organized by the Electric Drive Transportation Association with funding from the Federal Transit Administration, and an organizing committee of representatives from the FTA, the European Commission, Premia, National Renewable Energy Laboratory and the Northeast Advanced Vehicle Consortium.

Building on the success of the past two workshops, which established the value of an annual venue for face-to-face discussions and information exchanges, this year's program took a new direction, featuring breakout sessions where small groups discussed three critical issues the industry faces:

**Sensitivities in Data Sharing:** Attendees first heard a progress report on the past year's collection of "characteristic" data from current fuel cell and hydrogen ICE bus demonstrations, sharing basic information about the vehicle, the propulsion system, demonstration particulars and infrastructure. Most of this data is public, but only demonstration sites that participate in this effort will have access to any non-public data. Twenty demonstration sites have been asked to participate, with half responding to date.

**Attendees brainstormed the next phase:** Attendees contribute collecting operational and performance data. The results were a preliminary list of data vital to understanding the development of the technology, and ideas about how to present sensitive data without revealing competitive information. This data collection effort will continue in 2006.

**Business/Policy Case for Fuel Cells:** Attendees brainstormed arguments to convince industry, transit, and policymakers of the value that fuel cell bus demonstrations provide, as these players are asked to invest considerable resources. Attendees also discussed barriers to advancement of the technology, and how to address these barriers through policy.

**Hydrogen Infrastructure:** Attendees discussed and debated the lessons learned thus far on permitting, safety, production, supply, storage, and dispensing hydrogen for fuel cell buses, and what needs to be addressed as fuel cell bus deployments expand. Attendees agreed that an on-going international forum to exchange lessons learned would be valuable.

The presentations, project posters, and results from the breakout sessions are available online at: <http://www.electricdrive.org/index.php?tg=articles&idx=More&opics=17&article=736>.

The next international fuel cell bus workshop will be held in conjunction with EVS-22 in late October 2006 in Yokohama, Japan. For more information, contact the EDTA at [info@electricdrive.org](mailto:info@electricdrive.org).

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vehicles can benefit from the progress in on-board hydrogen storage advances during the transitional period. By then, too, the dispensing capability and the infrastructure proliferation may be there or right around the corner.

In researching the activities in North America and abroad WestStart-CALSTART has found in researching the activities in North America and abroad not only significant interest but considerable experience that may make this a timely symposium as we seek to establish HICE dialog in support of the FTA. This one-day event brings together experts to spotlight the technology that can benefit both light-duty vehicles and heavy duty vehicles for tomorrow's hydrogen-based vision.

Invited Departments of Energy, Defense, Transportation (FTA), the Environmental Protection Agency and the National Science Foundation managers and invited experts will discuss program goals and project objectives, explore

technical challenges in selected vocations and delve into tools and promising research that are important to HICE development. Invited industry leaders add the private sector perspective on the use of hydrogen and hydrogen-blends in internal combustion engines and the possible roles in the hydrogen vision.

Poster presentations will also provide another avenue for attendees to review project status and technical details. Papers, also in poster format, will be presented by specialists and authors as well as posters on commercial private sector activities. A delegation of federal, state and local organizations will tour the posters to discuss project content and results with authors. Judging from the initial response it should be an interesting and informative Symposium. For more information visit: [www.calstart.org](http://www.calstart.org) or [www.calstart.org/programs/chdvc/2006CHDV/HICE\\_AGENDA.php](http://www.calstart.org/programs/chdvc/2006CHDV/HICE_AGENDA.php) or contact Lawrence Wnuk Ph.D. at [lw nuk@calstart.org](mailto:lw nuk@calstart.org).

# Hydrogen Bus Source

## TECH CORNER

### BERLIN TO LAUNCH HYFLEET HICE BUS FLEET TO FOLLOW CUTE PROGRAM



Berlin is preparing to launch a fleet of 14 Hydrogen Internal Combustion Engine buses starting this summer to coincide with the FIFA World Cup hosted by Berlin in June and July. The buses will be developed and produced by MAN Nutzfahrzeuge AG and operated by the BVG, the Berlin public transit agency. TOTAL France will provide the hydrogen refueling infrastructure as part of a public filling station in Berlin. The infrastructure will have a daily hydrogen filling capacity of at least 20 buses and will feature innovative elements aiming at operation reliability, CO2 reduction and energy efficiency.

The HyFleet program follows Europe's recently-completed 9-city CUTE fuel cell bus demonstration program. Reykjavik and Perth also participated in parallel demonstrations. In total the 33 fuel cell buses in 11 cities accumulated about 660,000 miles, ranging from 24,000 miles in Barcelona to 88,000 miles in Luxembourg. The buses accumulated 75,000 operating hours, ranging from 1,200 to 3,000 hours per bus. On an average day the buses carry up to 10,000 passengers. Overall availability of the buses was 88%. But the reliability of the fueling infrastructure used in each city varied widely. Transit operators were mostly pleased with the reliability of the fuel cell systems, but in some cities the fueling infrastructure problems caused significant down time for the bus operations.

Through the follow-on HyFleet program, the European Commission plans to extend the demonstration of the fuel cell buses for an additional 12 months in seven European and two non-European cities. There are also plans to develop a next generation pre-prototype hybrid-electric fuel cell bus that targets a 10-20% improvement in energy efficiency compared to a diesel bus.

The HyFleet program will also launch demonstration buses that use internal combustion engines (ICE) rather than fuel cells to power the hydrogen-fueled buses. There will be several different configurations of the 14 buses for Berlin. Four buses scheduled to roll out in June will use naturally aspirated, 200-hp hydrogen engines, nine buses scheduled to roll out in March 2007 will use turbocharged/direct injection 270-hp hydrogen engines, and one bus scheduled to roll out in March 2007 will use a turbocharged/direct injection 270-hp hydrogen engine with energy management and a fuel cell APU.

In Berlin the new hydrogen infrastructure will use on-site production through reforming LPG, which can be substituted by Bio-DME. New generations of dispensers and compressors will use ionic fluids and re-liquefaction equipment. Two stationary fuel cells will be used to use the surplus hydrogen produced on-site.

## UP COMING EVENTS ....

EVENTS..

### 2005 Clean Heavy Duty Vehicle Conference .....February 22-24, 2006

This event is a nationally-recognized and attended conference on clean technologies and fuels for heavy-duty vehicles. It is the only national conference that focuses on clean advanced technologies and fuels for these vehicles and will be held in San Diego CA. For more information visit [www.weststart.org](http://www.weststart.org).

### NHA Annual Hydrogen Conference.....March 12-16, 2006

The Forum offers you an opportunity to hear and meet with a competitively selected group of promising hydrogen companies seeking capital and strategic partnerships to accelerate their growth. For more information visit <http://www.hydrogenconference.org/index.asp>

## NewsLinks

### January 12, 2006: AC Transit to Use Hyundai Fuel Cells for Demo

Hyundai has delivered the first of 10 fuel cell vehicles to the Alameda-Contra Costa Transit District (AC Transit) for a five-year demonstration and validation project...

### December 19, 2005: BC Transit Issues Request Re Hydrogen Fueling Stations

BC Transit has issued request for interested in supporting its purchase of 20 hybrid hydrogen fuel cell buses...

### November 21, 2005: Fuel Cell Bus Unveiled at SunLine Transit

Palm Springs, Calif. - SunLine Transit Agency officials recently unveiled their new zero-emission fuel cell bus at the 2005 Fuel Cell Seminar...

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