ABSTRACT:

The Vancouver Fuel Cell Vehicle Program (VFCVP) is a five year, $8.7 million initiative designed to provide first hand experience to demonstrate, test and evaluate the performance, durability and reliability of five Ford Focus fuel cell vehicles in Vancouver and Victoria, British Columbia. The program is led by Fuel Cells Canada, Ford Motor Company, the Government of Canada and the Province of British Columbia. The five Ford Focus fuel cell vehicles were delivered in March 2005 and deployed for three years of operation until March 2008 where they will be driven in real-world conditions by employees of five selected companies. This paper provides an update of vehicle operations and an understanding of progress and issues for hydrogen and fuel cells for transportation based on first hand experience.

KEY WORDS: Ford Focus fuel Cell Vehicle Demonstration

1. Introduction

The Vancouver Fuel Cell Vehicle Program (VFCVP) is a five year, $8.7 million initiative designed to provide first hand experience to demonstrate, test and evaluate the performance, durability and reliability of five Ford Focus Fuel Cell Vehicles (FCV) in Vancouver and Victoria, British Columbia.

The program is the first of its kind in Canada and is led by Fuel Cells Canada, Ford Motor Company, the Government of Canada and the Province of British Columbia. The five Ford Focus FCV’s were delivered in March 2005 and deployed for three years of operation through to March 2008.

Over the course of the three years, the vehicles will be driven in real-world conditions by employees of five companies to help:
- generate data to determine the state of the technology and remaining challenges
- determine maintenance requirements
- provide driver comments and impressions
- examine fuelling and other hydrogen issues
- evaluate the reduction of greenhouse gas (GHG) emissions
- evaluate public acceptance and knowledge of hydrogen and fuel cell vehicles
- address associated codes and standards

In addition to affirming Canada's commitments to the environment and technology innovation, the VFCVP will create public awareness of the benefits to the environment and society by addressing air pollution, energy needs, and climate change issues:

- establish a better understanding of public opinion, attitudes and concerns regarding hydrogen and fuel cell vehicles and refueling stations
- educate and inform target audiences about hydrogen and fuel cell technology using tangible fuel cell vehicles
- increase public understanding of hydrogen and fuel cell technology through direct communication with target audiences and through the media
- increase acceptance of hydrogen and fuel cell vehicles as a viable future alternative to non-hydrogen internal combustion engine (ICE)
- provide target audiences with a clear understanding of the timelines and milestones required to deliver transportation fuel cell technology to the marketplace

This paper addresses the above after one year of vehicle operations. It will provide some understanding of progress and issues for hydrogen and fuel cells for transportation based on first hand experiences.

2. Ford Focus Fuel Cell Vehicle

The five Ford Focus FCV’s operating in Vancouver and Victoria are part of a thirty vehicle fleet delivered by Ford to Sacramento (California), Taylor (Michigan), Orlando (Florida) and Aachen (Germany) for similar evaluation programs. These vehicles are fuel cell-battery hybrids with the following features:

- Zero emissions
- Ballard Mark 902 PEM fuel cell system
- Ballard integrated power train, AC induction motor, front wheel drive
- Dynetek 350 bar hydrogen storage system
- Sanyo Ni-MH hybrid battery system
- Continental Teves Electro-hydraulic regenerative brake system
- 3-phase traction inverter module, 330 amps, 250/400 volts, 315 volts nominal
- 128+ kph maximum speed
- 260-320 driving range
- 65 kW peak power, 230 Nm peak torque, 91% peak efficiency
- Curb weight 1600 kg
3. Vehicle Operations in Vancouver and Victoria

To provide a variety of drive cycles and driver habits for evaluation and to maximize visibility in local communities, agreements were established with the following five organizations whose employees drive the vehicles during normal day to day activities:

- Fuel Cells Canada
- Ballard Power Systems
- British Columbia Hydro and Power Authority
- British Columbia Transit (Victoria)
- City of Vancouver

Generally, driving includes commutes of up to 30 km each way and/or local city driving, with targeted mileage accumulation of 12,000-15,000 km per year for each vehicle.

Until end-April 2006 the average mileage accumulated per vehicle was 4576 miles over an average of 240 hours of operation.

4. Fueling Stations

Three fueling stations provide hydrogen gas for the VFCVP vehicles:

- Three vehicles (Fuel Cells Canada, Ballard and the City of Vancouver) are fueled at the National Research Council’s Institute for Fuel Cell Innovation (NRC-IFCI), located at the University of BC campus. This station became operational in March 2005 and currently utilizes tube trailer gas provided by BOC. This station will be relocated in June 2006 with plans to install an electrolyzer for hydrogen supply. BOC also supplied the compressor and intermediate storage system. The storage and dispensing system was provided by General Hydrogen – eight 450 bar Dynetek storage tanks with approximately 67 kg capacity
- The BC Hydro vehicle is fueled at Powertech Labs, located in Surrey, BC, approximately 30 km southeast of Vancouver. This system utilizes a Stuart Energy/Hydrogenics electrolyzer and compression, with eleven 440 bar Dynetek storage tanks (60 kg capacity) and a FTI dispenser
- The BC Transit vehicle is fueled at their Langford maintenance facility from a temporary station provided by Powertech Labs with fuel also supplied from Powertech’s Surrey operation. There are nine 875 bar Dynetek tanks with 60 kg capacity and a FTI dispenser. A permanent station is currently being planned for installation summer 2006.
5. Emergency Response

One of the key elements in addressing stakeholder and public interests was the training of Emergency Response personnel, particularly local Fire and Rescue Services and British Columbia Ambulance Services.

This was started through early dialogue to create awareness of the program, hydrogen and the FCV technologies and involved over 35 fire departments in the Greater Vancouver and Greater Victoria regions plus the ambulance services. The process was carried out as follows:
- Initial meetings and discussions with training officers to present details of the program and to solicit input for required training and response materials
- Workshops to present details of the program, the vehicles and hydrogen safety and emergency response
- Provision of training and reference materials
  - Emergency Response Guide
  - Interactive training CD
  - Plastic-coated detail sheets for all emergency response vehicles
- Follow-on meetings at fire halls to view the vehicles and address any specific concerns or issues raised by automobile extrication personnel

6. Underground Parking

There are currently no local regulations or codes that permit or restrict parking of hydrogen fuel cell vehicles in multi-level garages in British Columbia. The Vancouver Fuel Cell Vehicle Program is addressing this with a long term view, so that local authorities understand any associated safety issues. The local authorities include the BC Safety Authority (Gas Division) and the Vancouver Fire and Rescue Services. Building owners have also been engaged in this process so that any insurance issues can be addressed.

The program is taking a two-step approval approach from the authorities for parking FCV's:
- Initially, to allow parking in two selected underground garages representing typical configurations for office towers and malls
- In 3-6 months, assess the possibility of extending this to all garages in the Vancouver area

Approval from authorities has been based on Computational Fluid Dynamics (CFD) modeling to simulate the dispersion of hydrogen from the vehicle tailpipe (most likely source of hydrogen). The CFD modeling considered the dispersion characteristics based on two ventilation scenarios – actual mechanical ventilation with intermittent operation and no mechanical ventilation based on SAE J7528, 0.18 air changes per hour.
7. Vehicle Availability and Vehicle Maintenance

The vehicles are maintained by technicians that have had no previous experience with hydrogen, fuel cell or electric drive technologies. These technicians normally work on maintenance of cars, heavy trucks and transit buses. Training for the Ford Focus FCV maintenance included two weeks of hands-on training by Ford engineers and FCV technicians at Ford’s facility in Sacramento, California (located at the California Fuel Cell Partnership).

To date, all maintenance has been performed by the local technicians, with remote assistance from Ford, facilitated by a wireless vehicle data collection and internet and mobile telephone based transfer systems.

With this maintenance program, vehicle availability has been excellent as shown in the charts below.

Regularly scheduled maintenance is carried out in 90 day, 6 month and 1 year intervals and includes:

90 day
- Basic vehicle maintenance – inspect brakes, tire wear, tire pressure, fluid levels, wipers, lamps, check filters, check coolant conductivity, lubricate door hinges and latches, inspect hydrogen tanks and lines
- Perform 90-day high voltage battery reconditioning

6 month
- Change filters, rotate tires

1 year
- Change particulate filter and system module oil

Component reliability has been excellent. Since April 2005, there have been a very limited number of parts changed out on these vehicles. The following parts changes are the totals for all five vehicles:

- Fuel cell/power train 3
- Fuel system 5
- High voltage battery system 5
- Other vehicle components 8

In January 2006, updated software was installed to address the following:
- General operating systems update
- Cold weather operation
- High voltage battery re-conditioning frequency

For cold weather conditions, operation was initially restricted to ambient temperatures above +5C. However, this created too great a restriction on vehicle usage in Vancouver and Victoria from November through to March and restricted the ability to deliver the mileage targets required by Ford. The updated software resolved this issue by relaxing the ambient temperature parameters to provide more flexibility in vehicle operations:

- Operation of vehicles permitted down to -15C
- Once the vehicle system temperature reaches warm condition indicated by the temperature gauges on the dash (5-10 minutes driving), parking of vehicles outside:
  - Ambient above +3C Indefinite
  - Ambient +3C to -5C 6 hours
  - Ambient -5C to -15C 3 hours

Fueling of vehicles must be performed when the ambient temperature is above -5C.
AVERAGE DAYS AVAILABLE TO CUSTOMER

Chart 1. Vehicle Availability - Days

AVERAGE % AVAILABLE TO CUSTOMERS

Chart 2. Vehicle Availability - Percentage
8. Driver Impressions

Eighty-two drivers have been trained by Ford or Fuel Cells Canada that are permitted to drive the vehicles on their own, a requirement established by Ford and the Insurance Corporation of British Columbia. A survey of all drivers was carried out to provide valuable feedback to Ford to address required improvements.

In general, the vehicles were rated by the drivers as very good (see charts below) with the only area of concern being range and restrictions imposed by Ford on ambient temperature operations.

The following charts summarize the driver ratings and provide valuable input to Ford on improvements that need to be addressed. The Vancouver/Victoria results were comparable those from the other Ford sites in the United States.

![Driver Performance Ratings - Vancouver](chart3.png)

**Chart 3. Driver Performance Ratings - VFCVP**
9. Summary

To date, for the first year of vehicle operations the VFCVP has been successful in meeting its objectives. The vehicles are performing with high reliability and availability to drivers. Communications and public outreach is getting the message out regarding the benefits and safety of hydrogen and fuel cells in transportation. The program and the vehicles have a high level of awareness in Vancouver and Victoria and the VFCVP is making solid contributions to Ford’s engineering efforts in the development of its FCV design.