

### **VIII.A.3 Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project**

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*Contract Number: DE-FC36-04GO14286*

#### *Subcontractors:*

*Hyundai Motor Company (HMC) - Seoul, South Korea*

*Kia Motors Corporation (KMC) - Seoul South Korea*

*Hyundai-KIA America Technical Center Inc. (HATCI) - Ann Arbor, MI.*

*UTF Fuel Cells (UTC) - South Windsor, CT.*

*Alameda Contra Costa Transit (ACT) – Oakland, CA.*

*Southern California Edison (SCE) – Rosemead, CA.*

*Start Date: January 15, 2004*

*Projected End Date: September 30, 2009*

#### **Objectives:**

Record, collect, report, and analyze data from fuel cell vehicles (FCVs) and hydrogen fueling operations.

Validate certain 2009 performance targets:

- Fuel cell stack durability: >2000 hours
- Vehicle range: >250 miles
- Hydrogen cost: <\$3.00/gge

Demonstrate an integrated project of hydrogen energy station and fuel cell vehicle construction, operation, and maintenance. Chevron Technology Ventures LLC (CTV) shall demonstrate a variety of hydrogen generation technologies including both auto-thermal and steam reformation of natural gas, and the electrolysis of water. A renewable energy source, such as ethanol, is also being considered for one of the stations. The information generated using these different technologies is needed to evaluate the commercial viability of achieving future hydrogen costs of <\$3.00/gge.

In addition, CTV is investigating the inclusion of an electricity generation component (e.g. fuel cell or gas turbine) at one of their stations in order to provide data on co-production and small scale electricity load-balancing.

Together, Hyundai Motor Company, Kia Motors Corporation and UTC Fuel Cells shall demonstrate vehicle improvements such as increased on-board gas storage to improve the vehicle driving range and improved manufacturing processes for the production of fuel cell components in order to lower the overall cost of fuel cell vehicles. Both of these activities are necessary in order to evaluate the commercial viability of meeting the two fuel cell related performance targets.

### **Technical Barriers**

This project addresses the technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A. Vehicles
- B. Storage
- C. Hydrogen Refueling Infrastructure
- D. Maintenance and Training Facilities
- E. Codes and Standards
- H. Hydrogen from Renewable Sources
- I. Hydrogen and Electricity from Co-production

### **Contribution to Achievement of DOE Technology Validation Milestones**

This project will contribute to achievement of the following DOE technology validation milestones from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

#### ***Milestone 1: Make awards to start fuel cell vehicle/infrastructure demonstration activity and for hydrogen co-production infrastructure facilities***

After the execution of the DOE award, Chevron Technology Ventures LLC negotiated and executed contracts with its current and near term technology providers and site hosts. Other contracts will be put in place as needed.

#### ***Milestone 2: Demonstrate FCVs that achieve 50% higher fuel economy than gasoline vehicles***

Hyundai and UTC Fuel Cells worked together to manufacture and assemble the first four of the 32 Hyundai / Kia FCVs which will participate in the DOE demonstration project. Tuning has been completed on two vehicles and tuning is in process on the remaining two vehicles. These FCVs are based on UTC Fuel Cells PEM stack technology and Hyundai's advanced drive systems and balance of plant. By the end of 2005, it is expected that four Hyundai/Kia FCVs will have been introduced into the project. The introduction of the remainder of the vehicles is timed to coincide with the commissioning of the various hydrogen energy stations that Chevron Technology Ventures LLC will build.

Due to the late start of the program (late award) our project has not yet been able to begin the collection of data and validation of increased fuel economy. However, procedures are being developed and tested that allow the transfer and extraction of data that will be ultimately provided to NREL. Alpha testing of the data transfer and extraction has been completed. Modifications to the process are being made as a result of this testing. Data collection is expected to begin late in the third quarter 2005.

***Milestone 3: Demonstrate (on a vehicle) compressed and cryogenic storage tanks achieving the 2005 energy and mass density targets***

The compressed hydrogen storage tanks that will be used in both the HMC Tuscon and KMC Sportage fuel cell vehicles has been designed to realize an energy density which allows extended range. Fleet operations starting late in the third quarter of 2005 shall provide the data supporting the drive toward the 2005 energy and mass density targets.

This team is not planning on-board cryogenic storage tanks.

***Milestone 5: Validate fuel cell demonstration vehicle range of ~200 miles and durability of ~1,000 hours***

Hyundai has embarked on an upgrade of their dynamometer facility and begun the process of obtaining DOE acceptance of the facility by hosting a contingent from the National Renewable Energy Laboratory. One of the project team's challenges is to effectively obtain a 'start of test baseline' on vehicles coming into the program during the period of HATCI's facility upgrade. After the NREL session, the project team discussed various options to facilitate the collection of this 'start of test' data including commissioning at the EPA Ann Arbor facility or use of another acceptable facility.

As indicated under progress toward Milestone 3, due to the fact that that project has not yet fully commissioned FCVs, we have not yet begun collecting this data from program vehicles.

***Milestone 6: Validate vehicle refueling time of 5 minutes or less***

The Chino station is currently fueling two on-site vehicles at an average refueling time of < 15 minutes through an analog communication fill based on manual regulation of vehicle storage tank temperature and pressure. When fully commissioned, the station will have the capability to fuel a suitably equipped FCV using an automatic digital system in <5 minutes.

***Milestone 11: Validate cost of producing hydrogen in quantity of \$3.00/gge untaxed***

CTV has plans move toward the 2009 hydrogen cost target through the evaluation of various hydrogen production technologies including on-site autothermal reformation of natural gas and (possibly) ethanol, steam reformation of natural gas, electrolysis of water, and central plant hydrogen production (dispensed through compressed storage at a hydrogen fueling station).

The following is a list of some of the technologies reviewed to date: Chevron's own natural gas autothermal and steam reforming technologies and Hydrogenics' (formerly Stuart Energy) electrolyzer technology. CTV is also evaluating other vendors' reforming technologies, a variety of gas cleanup technologies, high pressure compressors, and different storage vessels in order to determine the best durability/cost profile.

In addition, Chevron Corporation, is conducting its own basic research into alternative fuels and continuing its efforts toward evaluation and refinement of the various generation technologies. These activities, along with its work toward understanding the implications, costs, and commercial viability of the implementation of a hydrogen fueling infrastructure to support a hydrogen economy, are moving in a practical direction in support of the DOE targets. It is too soon to tell if the targets can be practically reached.

***Milestone 12: Five stations and two maintenance facilities constructed with advanced sensor systems and operating procedures***

In mid-2004, CTV began construction of their first hydrogen energy station at the Hyundai-Kia America Technical Center in Chino, California. When fully commissioned (expected in late 2005) this station will demonstrate the auto-thermal reformation of natural gas and may later demonstrate reformation of a renewable feedstock such as ethanol. This Chino site will serve as the commissioning site for all future project vehicles as well as also serving as one of the project's fleet operators. It will provide real-world construction and operating expense data, as well as serves as a location from which community outreach can stem.

The station's compression, storage and dispensing modules are fully commissioned and the station is currently dispensing hydrogen to two HMC FCVs, one which is being commissioned for entry into the project and another older generation non-project FCV. CTV is presently finishing the commissioning of the purified hydrogen generation module.

The station was designed to utilize state-of-the art remote monitoring and operation systems and incorporates advanced hydrogen and fire sensors. It has received the approval of the local Fire Marshal. After the completion of commissioning and a short period of attended operation, the station shall operate in an unattended mode, with the exception of the fueling procedure, which requires a hydrogen-safety trained attendant.

CTV intends to complete the construction of at least four additional hydrogen energy stations, one in each of the three climatic regions, hot, moderate and cold, including locations in Northern California, Southern California, and Michigan. Mobile refueling apparatus shall be employed to supply central plant gas during periods of station maintenance, extend vehicle range and provide opportunities to operate the FCVs under very hot conditions, such as those in Palm Desert, California.

***Milestone 15: Validate co-production system using 50kW PEM fuel cell; hydrogen produced at \$3.60/gge and electricity at 8 cents/kWhr***

CTV hopes to incorporate a fuel cell or other electricity generation technology into one of the stations to be built under this project in order to study the costs and benefits of co-production. CTV has held preliminary discussions with manufacturers of such technologies including UTC Fuel Cells and the Gas Technology Institute, but has not finalized its recommendation at this time.

## **Approach**

CTV and its project team of HMC, HATCI, UTC and the site hosts intend to operate a fully integrated fueling and fleet operation consisting of 32 FCVs, (including two different generations) with the aim of developing a database of operational experience under a wide variety of conditions including, for the stations, different technology and feedstocks, and for the vehicles, differing driving patterns and ambient temperatures. This data will also be collected in a manner that allows "consumer" (including station operators, fuelers, drivers and maintenance workers) feedback to be recognized and incorporated into lessons learned.

It is hoped that the learnings from the early phases of this project can be incorporated into later phases in a way that allows performance improving technologies to be tested in the most cost effective and efficacious manner.