

# Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

**TEAM: Chevron Technology Ventures, Hyundai-Kia Motor Company & UTC Power**

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**Chevron Hydrogen**

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# Overview

## Timeline

- Start: January 15, 2004
- End: September 30, 2009
- 65% complete

## Budget

Total Project Funding	\$94.5 mil
DOE share	\$38.1 mil
Contractor share	\$56.4 mil
Prior Funding	\$22.6 mil
Funding FY08	\$ 5.8 mil

## Barriers

- Fuel Cell Vehicles
- H2 Refueling Infrastructure
- Hydrogen and Electricity Co-Production

## Team Members

- Hyundai-Kia Motor Companies
- UTC Power
- Hyundai Kia America Technical Center
- Alameda Contra Costa Transit
- Southern California Edison
- Tank Automotive Research, Development and Engineering Center (DOD)
- Gas Technology Institute

# Objectives

- Demonstrate complete systems of integrated hydrogen fuel cell technologies for transportation and hydrogen infrastructure under real-world operating conditions
- Validate DOE 2009 Performance Targets
  - 250 mile Vehicle Range
  - 2000 hr Fuel Cell Durability
  - \$3.00/gge production cost
  - Safe and convenient refueling by drivers

# Approach

- Public-Private Partnership
- Controlled fleet
- Limited access
- Third-party fuelings available
- Open during business hours
- Quiet and odorless



**Demonstrate practical hydrogen technologies in real-world settings**



# Progress – Infrastructure Locations



Oakland,  
California



Rosemead,  
California



Chino,  
California



Selfridge,  
Michigan

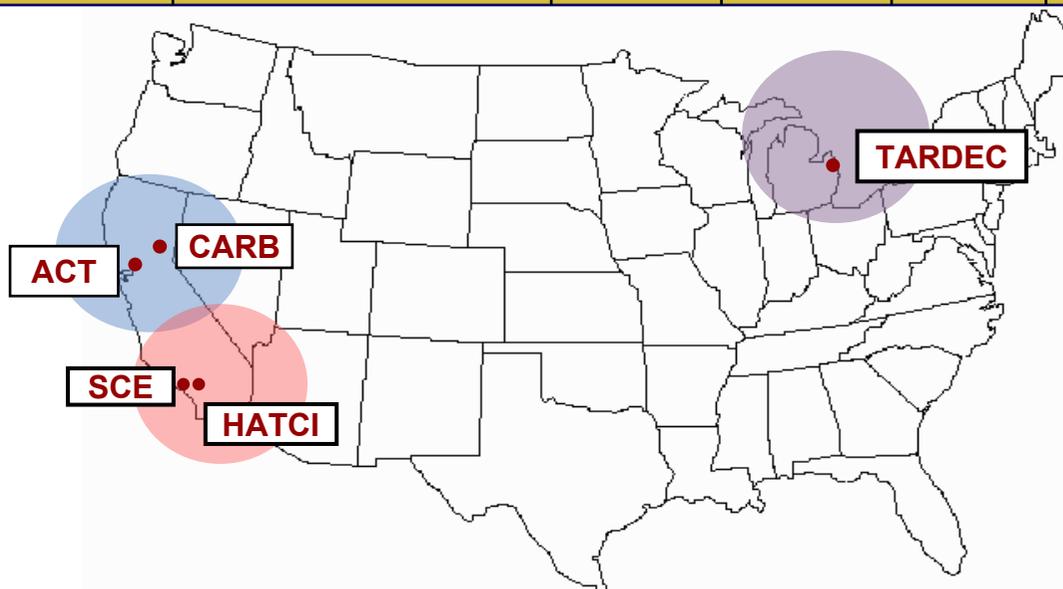


Orlando,  
Florida

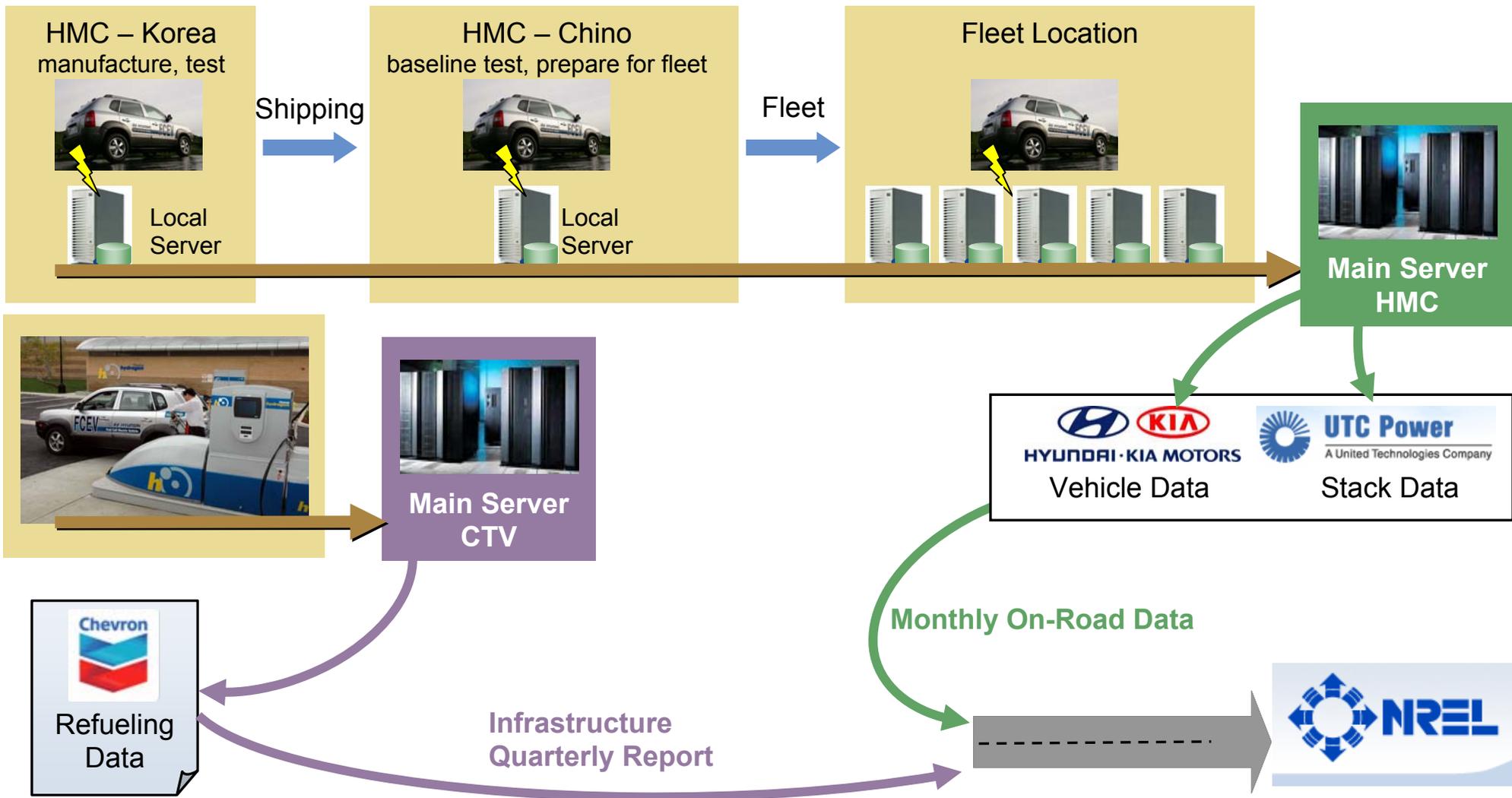
# Progress - Vehicle Deployment

Operation Area	Service Facility	Site Host Location	Operator	Total	2005	2006	2007	2008
Southern California	Chino	Chino	HATCI	6	3	2	0	1
		Rosemead	SC Edison	9	0	0	3	6
Northern California	Sacramento	Sacramento	CARB	2	0	0	1	1
		Oakland	AC Transit	10	1	6	1	2
Michigan	Ann Arbor	Selfridge	TARDEC	5	0	0	2	3
3 Regional Areas			5 Organizations	32	4	8	7	13

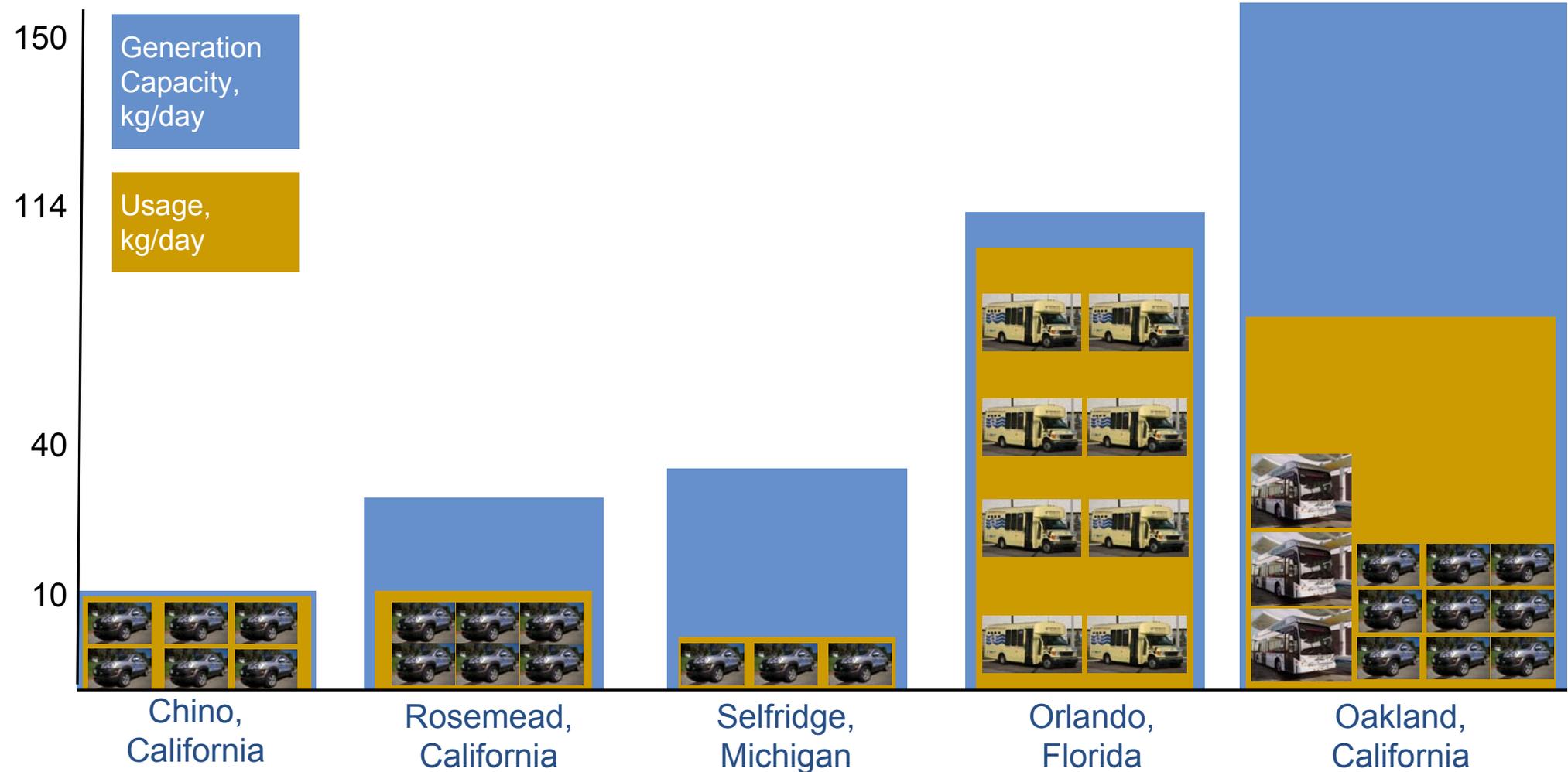
- **Twenty-five vehicles deployed** by end of March 2008
- Seven more vehicles deployed in 2008



# Progress – Upgraded Data Transfer System



# Progress – Infrastructure On-site Generation / Usage



# Progress – Diverse Driving Patterns

## Hydrogen Energy

- Security Patrol
- Fire Chief
- Mail Delivery
- Road Supervisors
- Commuting
- Driver Fueling

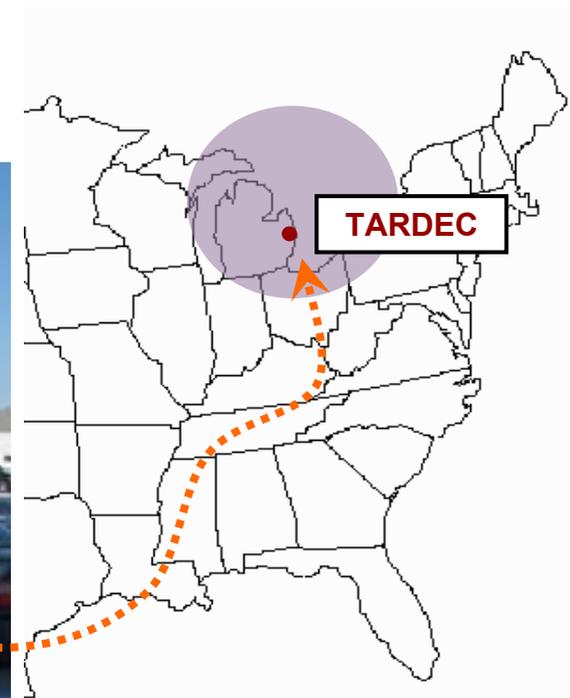


## Human Energy

# Technical Accomplishments

## Cold Area Fleet Operation -> Cold Start-up Test

- Fleet region: Michigan (TARDEC, HATCI Ann Arbor)
- Cold weather sub zero soaking time more than 48hrs

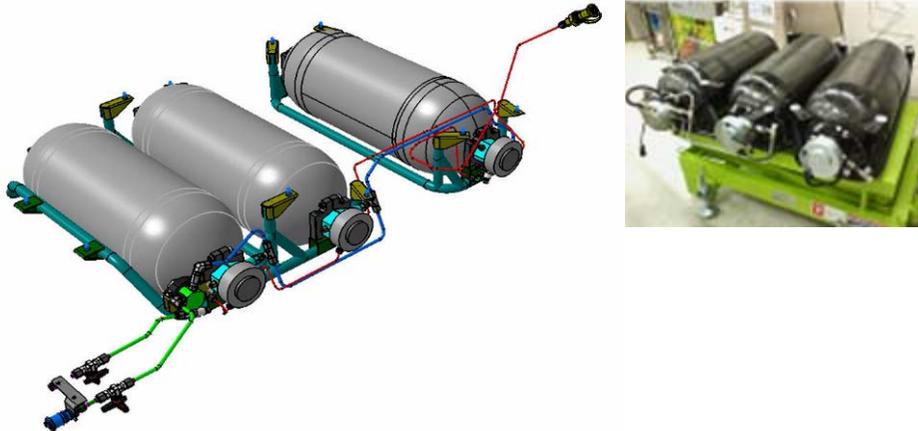


Fleet Vehicle Operation in Michigan

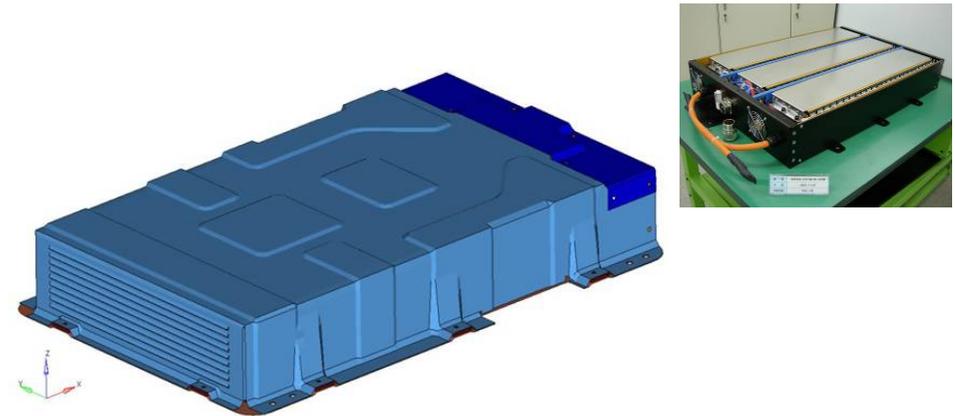
# Technical Accomplishments

## 2nd Generation Vehicle Function

- **700bar H<sub>2</sub> tank:** Increased vehicle range more than 33%



- **Super-capacitor:** Increased vehicle performance

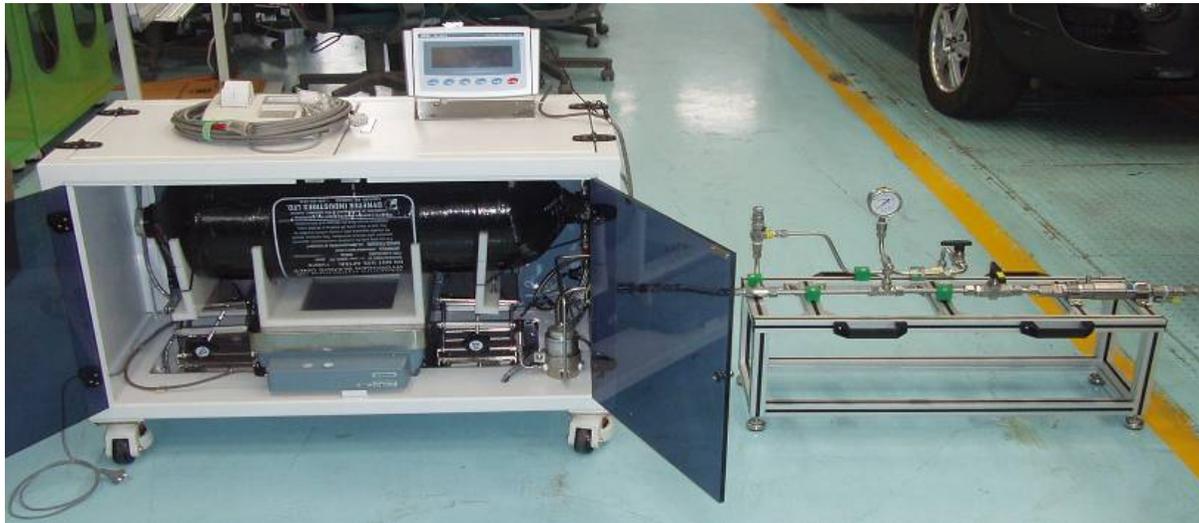


- Improved Vehicle **Software logic and controller**
- Improved **BOP** component
- **New stack** with 2nd generation function (from 2007 model year)

# Technical Accomplishments

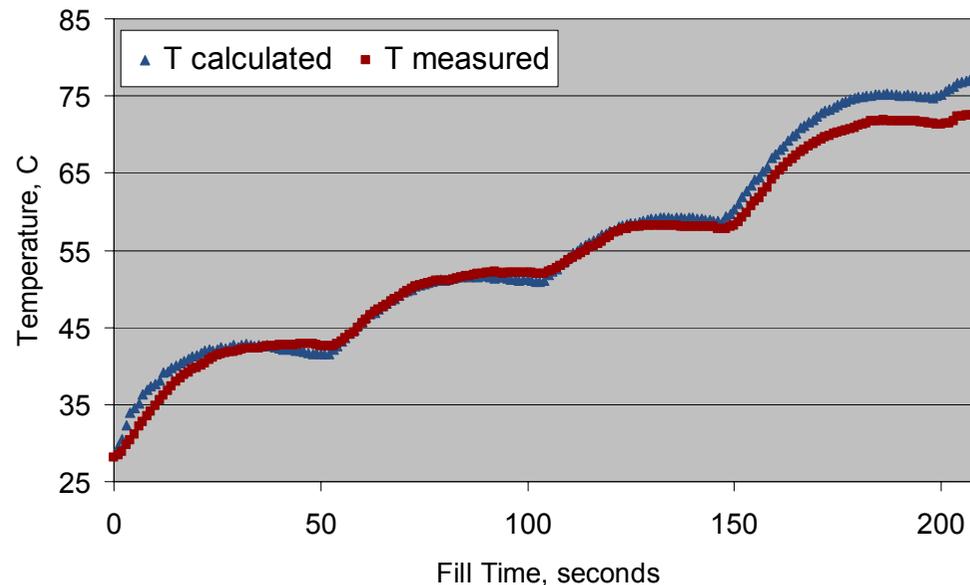
## Introduction to New Fuel Economy Test Equipment

- Purpose: Dynamometer fuel economy test
- New method: H<sub>2</sub> weight measurement equipment: Based on SAE J2572
- Test and review completed
- Equipment testing at Chino Lab



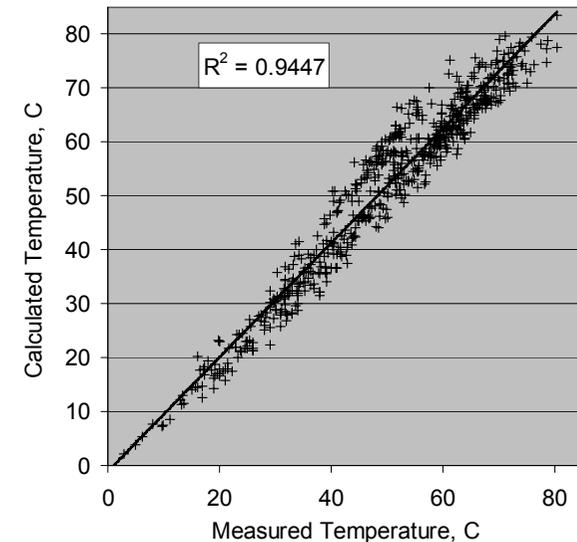
# Accomplishment - Fueling Temperature Increase Calculation

- Equation developed to calculate on board storage tank temperature based on signals at the dispenser
- No communications cable required
- Calculated temperature compares well with measured temperatures



## Equation compared for fuelings

- 382 fills of 152 liter vehicles
- 117 fills of 1228 liter vehicles
- 132 fills of 2100 liter vehicles
- 0.945 Correlation coefficient



# Progress – GTI POGT



**Partial Oxidation Gas Turbine (POGT) & Reactor**

## Co-Production of Hydrogen and Electricity

Partial Oxidation Gas Turbine (POGT) and Partial Oxidation Reactor (POR) integration complete

Achieved nine (9) successful start/stops of POGT with Stable Run Durations of 7 to 95 minutes

Process variables of interest were controlled, data collected, and being analyzed

Interconnection of WGS, compressor, PSA and Balance of Plant underway



**Slipstream Water-Gas-Shift Reactor**

# Lessons Learned

## Vehicle Accident & Safety

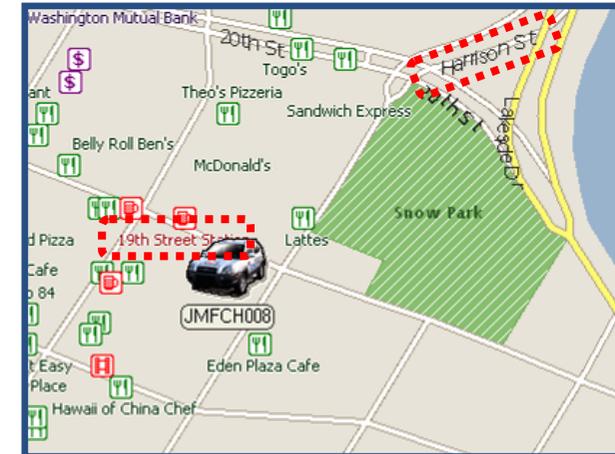
- All Safety Devices worked as designed (ESD function)
- Case Study → First FCV accident
- Vehicle: ACT fleet vehicle
- Location: Oakland, CA



**LH Front-side Impact**



**Air Bag Activated**

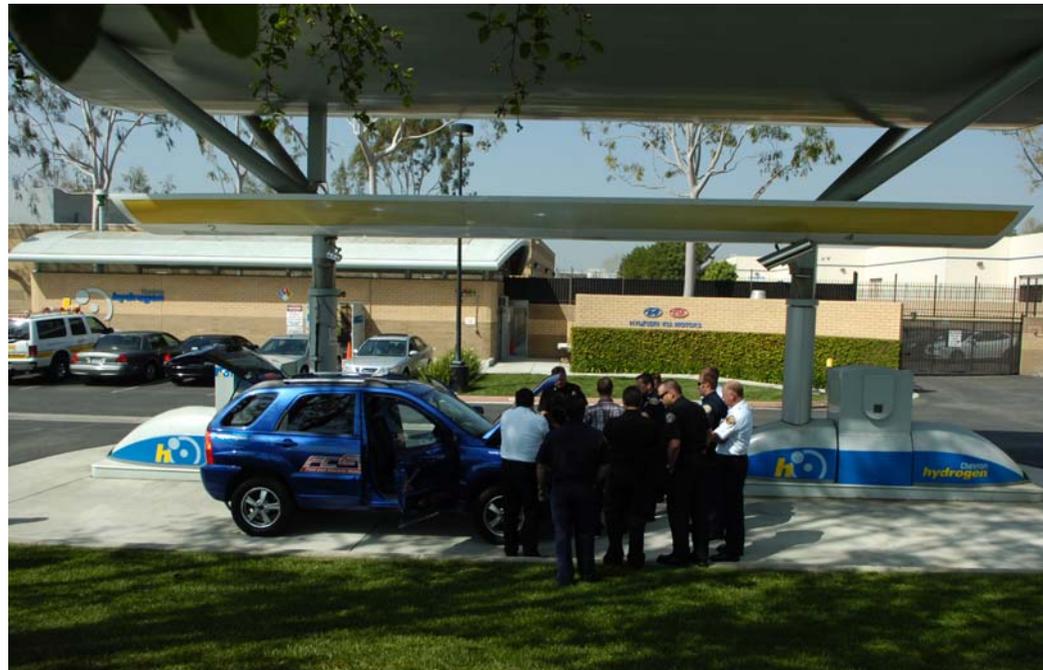


**Accident Location**

# Results - First Responder Retraining Sessions

## Lessons Learned: First Responders Can Rotate Between Local Stations

- Initial training completed at end of station construction
- Additional yearly refresher training added at all stations



# Lessons Learned – Station Permitting

## Station Permitting Durations

Location	Permitting Authority	Duration (months)
Chino, CA	City of Chino	6
Oakland, CA	City of Oakland	7
Rosemead, CA	Los Angeles County, California	10
Orlando, FL	City of Orlando	7
Selfridge, MI	Selfridge Air National Guard Base, Michigan	1

## Permitting Differences

### FACP Design

- Design of flame and gas detection system
  - Flame and gas sensors part of SIS
  - Flame sensors part of FACP, gas sensors part of SIS
  - Flame and gas sensors as separate system

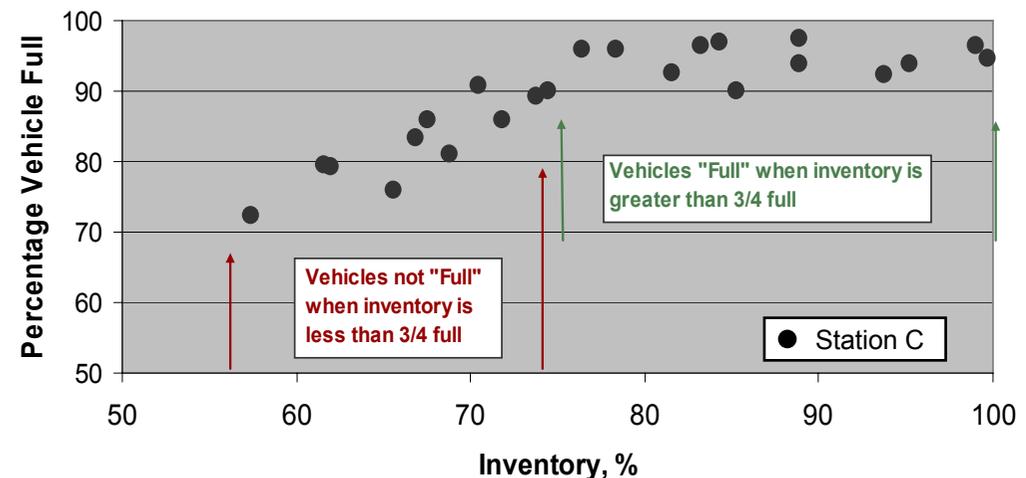
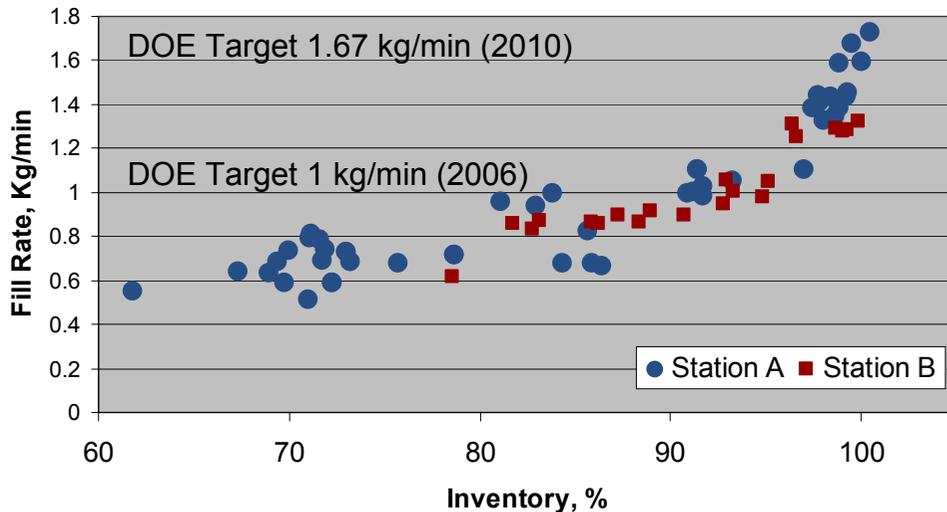
### Fire Suppression Systems

- Not required at Chino, Orlando, Oakland
- Required at LA County, SANGB

# Results - Vehicle Percentage Full vs. Storage Inventory

- Storage Inventory % – kg H2 (kg H2 when full)
- Fill Rates and Percentage Full is dependent on storage inventory – at less than 85% inventory flow rates can drop below 1 kg/min
- Differential Pressure is used to drive the gas from storage to the vehicle

- Storage density at 15C 28.4 kg/m<sup>3</sup>
- Vehicle density at 350 bar 24.1 kg/m<sup>3</sup>
- For every cubic meter of storage
  - 4.3 kg of “useable” hydrogen
  - 24.1 kg of stranded gas
- At less than 75% inventory – customer does not receive “full” fill



## Future Work

- Collect operating data from generators at various operating capacities in:
  - Chino, CA
  - Oakland, CA
  - Rosemead, CO
  - Selfridge, MI
  - Orlando, FL
- Field 32 vehicles in program
- Continue POGT testing and integrate balance of plant by end of 2Q



# Program Summary

## Relevance

- FC vehicle real world operating data
- On-site hydrogen generation demonstration

## Approach

- Fleet testing of 32 FC vehicles
- Operation of six on-site hydrogen generators

## Technology Transfer

- Lessons learned included in merit review

## Technical Accomplishments and Progress

- Range and durability reported to NREL
- Five stations reported to NREL
- Technical capability developed to meet 7% to 10% of a conventional gasoline station's daily fuel dispensing requirement using on-site hydrogen production

## Proposed Future Work

- Continue demonstration of vehicles and infrastructure data reporting to NREL