



# ***Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project***

TEAM:

Chevron Technology Ventures

Hyundai-Kia Motor Company

UTC Power

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Dan Casey – Technical Director

**Chevron Hydrogen**

May 2007





## Timeline

- January 15, 2004
- September 30, 2009
- 45 % complete

## Budget

- Total project funding - \$93.9 mil
  - DOE share - \$37.8 mil
  - Contractor share - \$56.1 mil
- Prior Funding - \$16.1 mil
- Funding FY07 - \$ 0.5 mil







## Barriers

- Vehicles
- H2 Refueling Infrastructure
- Codes & Standards

## 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

<p>Overall</p> <p><b>FC Stack Durability: &gt;2000 hr</b></p> <p><b>Vehicle Range: &gt;250 miles</b></p> <p><b>Hydrogen Cost: &lt;\$3.00/gge</b></p>	<p><b>Obtain data to validate 2009 performance targets</b></p> <ul style="list-style-type: none"> <li>•Collect:             <ul style="list-style-type: none"> <li>– FC vehicle operating data</li> </ul> </li> <li>•Demonstrate:             <ul style="list-style-type: none"> <li>– Different methods of on-site hydrogen generation</li> </ul> </li> </ul>
<p>2006</p>	<ul style="list-style-type: none"> <li>•Hydrogen safe chassis dyno and Maintenance facility</li> <li>•Test different climatic conditions on FC vehicles</li> <li>•Three On-site Generators             <ul style="list-style-type: none"> <li>– Rosemead</li> <li>– Oakland</li> <li>– Orlando (not funded by DOE)</li> </ul> </li> </ul>
<p>2007</p>	<ul style="list-style-type: none"> <li>•Increase Vehicle availability and reliability</li> <li>•Improve Vehicle Performance with 2<sup>nd</sup> Gen. vehicles</li> <li>•Operate and report from 5 on-site generation stations</li> <li>•Construct and Operate Partial Oxidation Gas Turbine (POGT)</li> </ul>

 <b>Milestone 2</b>	<b>Demonstrate 50% higher fuel economy</b> <ul style="list-style-type: none"><li>➤ Conduct Dyno testing – initial testing complete</li><li>➤ Conduct on road testing – data reported to NREL monthly</li></ul>
 <b>Milestone 3</b>	<b>Demonstrate 2005 energy and mass density targets</b> <ul style="list-style-type: none"><li>➤ 350 bar vehicles on the road</li><li>➤ 700 bar vehicle to be tested</li></ul>
 <b>Milestone 5</b>	<b>Validate vehicle range of ~200 miles and 1000 hours</b> <ul style="list-style-type: none"><li>➤ On road testing data being reported to NREL monthly</li></ul>
 <b>Milestone 6</b>	<b>Validate refueling less than 5 minutes</b> <ul style="list-style-type: none"><li>➤ Work complete</li></ul>
 <b>Milestone 11</b>	<b>Validate \$3/gge production cost</b> <ul style="list-style-type: none"><li>➤ On-site hydrogen generation stations in operation</li></ul>
 <b>Milestone 12</b>	<b>Five station and two maintenance facilities constructed.</b> <ul style="list-style-type: none"><li>➤ Data reported to NREL from 2 stations</li><li>➤ Three additional stations on line 1Q 2007</li><li>➤ Maintenance facility operational in Chino</li></ul>

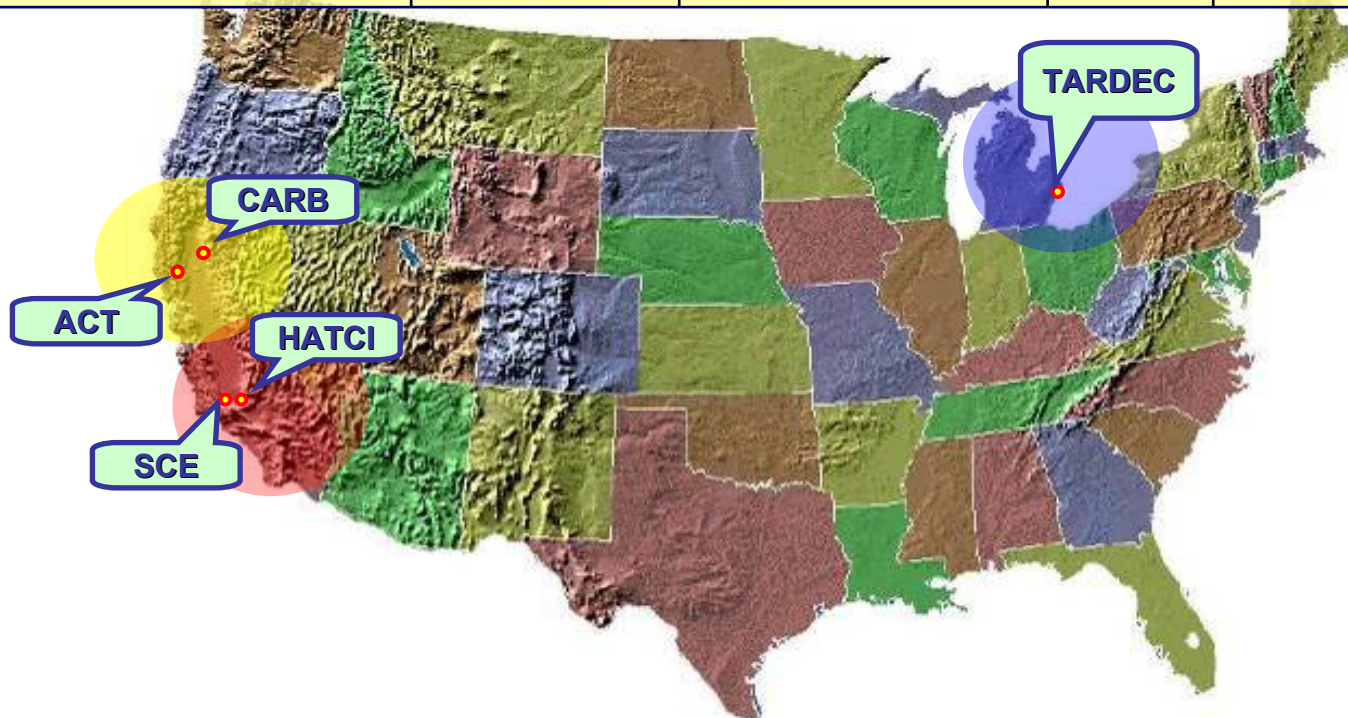
# Approach – Infrastructure



# Approach – Vehicle Deployment



Operation Area	Service Facility	Site Host Location	Operator	Total	2005	2006	2007
Southern California	Chino	Chino	HATCI	6	3	2	1
		Rosemead	SC Edison	9	0	0	9
Northern California	Sacramento	Sacramento	CARB	1	0	0	1
		Oakland	AC Transit	11	1	6	4
Michigan	Ann Arbor	Selfridge	TARDEC	5	0	0	5
3 Regional Areas			5 Organizations	32	4	8	20



<h2>Design</h2>	<h2>Construction</h2>
<ul style="list-style-type: none"><li>• <b>Process Flow Diagram, Equipment Layout, and Piping &amp; Instrumentation Drawings Completed</b></li></ul>	<ul style="list-style-type: none"><li>➤ <b>Partial Oxidation Gas Turbine (POGT) and Partial Oxidation Reactor (POR) Integration in Progress</b></li></ul>
<ul style="list-style-type: none"><li>• <b>HazOp Review Completed</b></li></ul>	<ul style="list-style-type: none"><li>➤ <b>Water Gas Shift (WGS) Slipstream Unit Fabricated</b></li></ul>
<ul style="list-style-type: none"><li>• <b>PSA System and Gas Analysis Available</b></li></ul>	<ul style="list-style-type: none"><li>➤ <b>Compressor and Buffer Tank Received</b></li></ul>

### **Alameda County Transit (ACT)**

- 30 more employees have been trained in vehicle operation since last review for a total of 50
- ACT performed maintenance and light repair of 3 of their fleet vehicles
- HATCI has provided an updated Routine Maintenance Check sheet along with photos

### **Southern California Edison (SCE)**

- 5 employees have been trained in vehicle operation at Southern California Edison
- 3 employees have been trained in vehicle maintenance at Southern California Edison

### **Safety and ER Training**

- HATCI has participated in First Responder Training in both Northern and Southern California
- Zero Vehicle Accidents





# Infrastructure – Rosemead Energy Station



- 20 kg/day generation capacity
- 60 kg storage
- Single dispenser
- 5000 psig
- Fill rate – up to 3.6 kg/min



- 40 kg/day generation
- 312 kg storage
- Single Dispenser
- 5000 psig
- Fill rate – up to 3.6 kg/min



- 114 kg/day generation
- 312 kg storage
- Single Dispenser
- 5000 psig

**Slipstream  
Water-  
Gas-Shift  
Reactor**  
(shown  
uninsulated)



**Partial  
Oxidation  
Gas  
Turbine  
System**

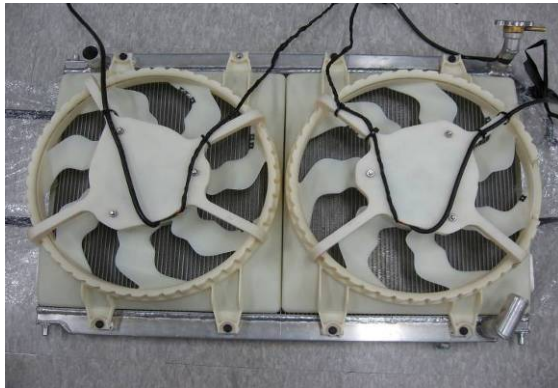
Partial  
Oxidation  
Reactor  
(POR)

Partial  
Oxidation  
Gas  
Turbine  
(POGT)



## ➤ Hot test performed at Death Valley on Jul. 2006

- Test region : Death Valley & Mojave PG(HMC)
- Test modified cooling module



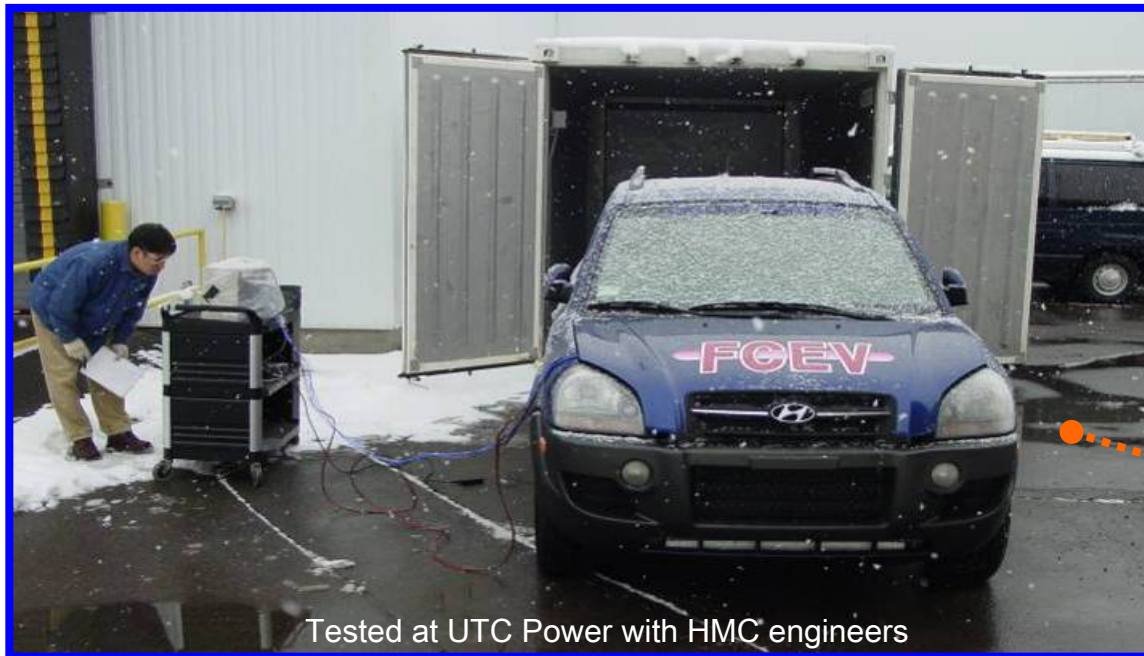
July '06 @ Death Valley

- Achieved improved cooling performance
  - No power degradation
  - Positive water balance at Daylight and Towne pass

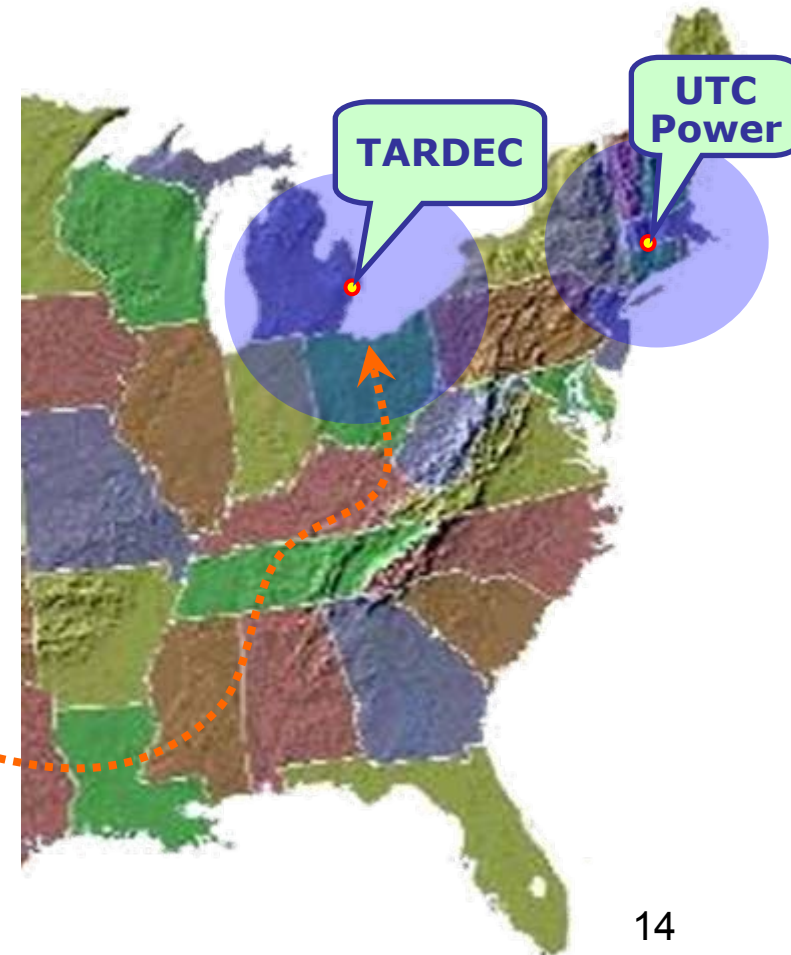
# Sub-zero start up performance

➤ Cold start up test successfully performed on Feb. 2007

- Test region : UTC Power (Hartford, CT)
- Cold climate soaking time : more than 3 days



Tested at UTC Power with HMC engineers



# Vehicle Service Facilities

## ➤ Hydrogen Safe Dyno Bay (Chino)

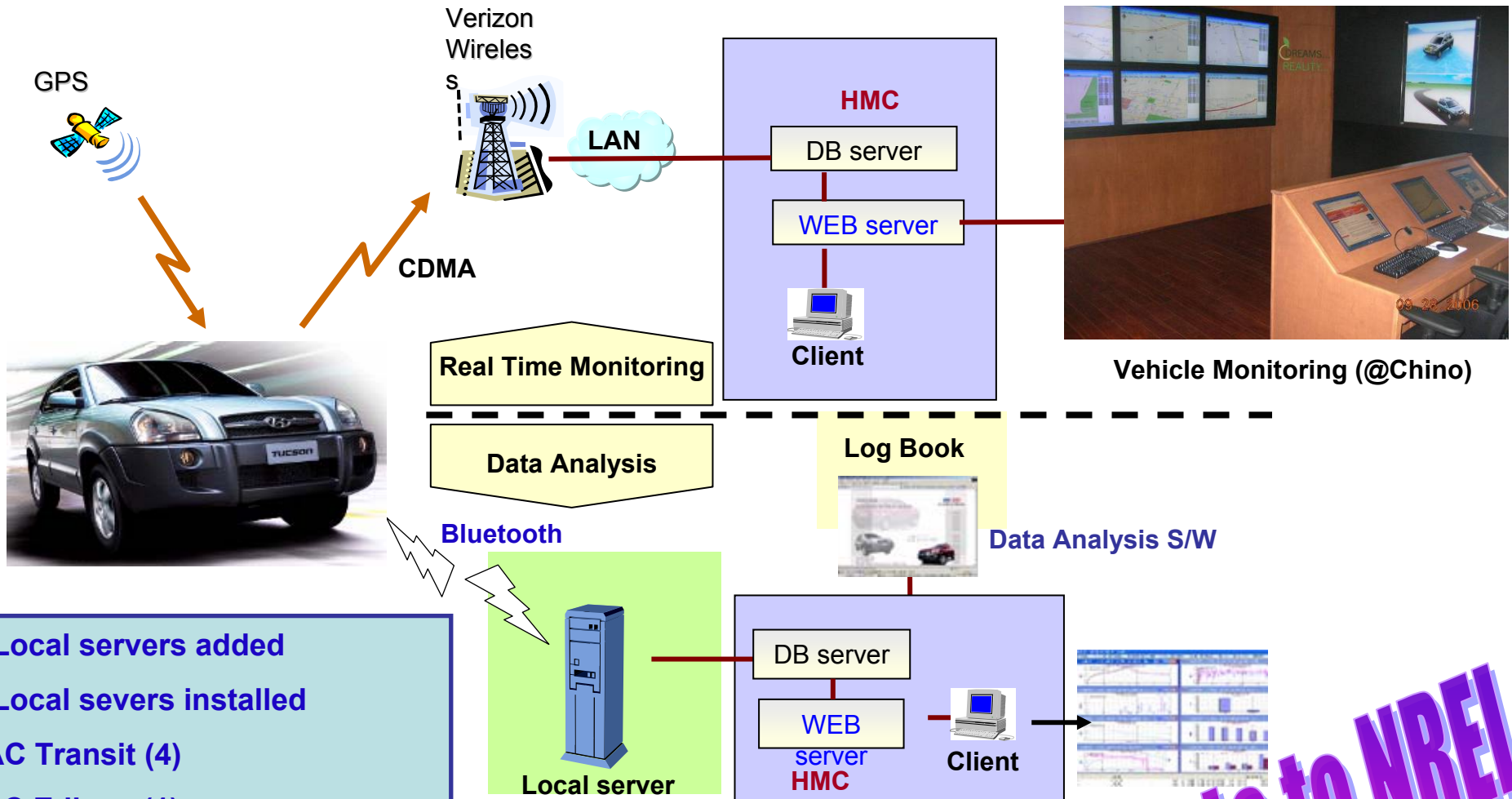


- H2 Safety Dyno Cell :  
Chino, CA ('07. 3)
- H2 Safety Work Bay :
  - CaFCP (5 vehicle bay )
  - Chino, CA (1 vehicle bay)
  - Selfridge, MI (Under Construction)
  - Seminary, CA(1 veh. Tent)
  - Pomona, CA (1 veh. Bay)

## ➤ Hydrogen Safe Work Bay (Chino)



# Fleet Monitoring and Data Collection



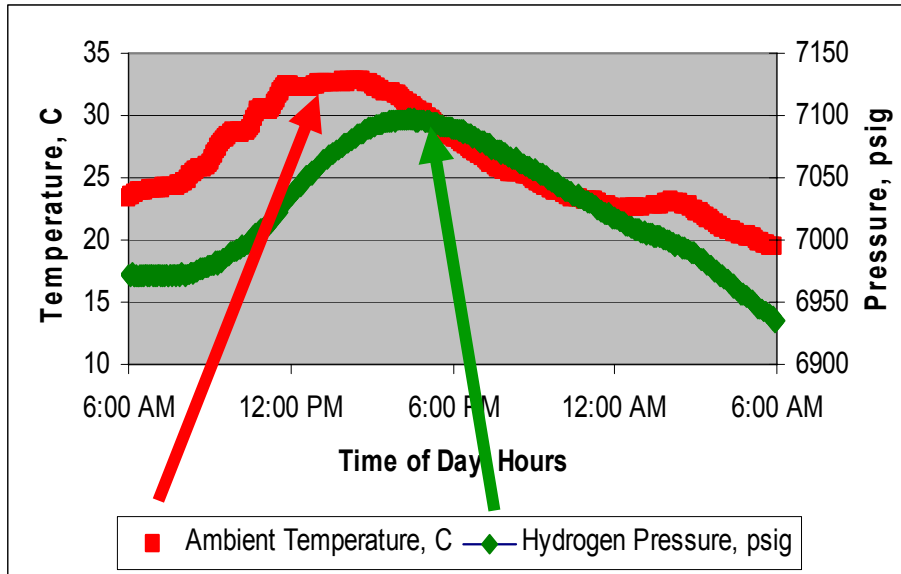
- 5 Local servers added
- 8 Local servers installed
- AC Transit (4)
- SC Edison (1)
- TARDEC (1)
- HATCI : Chino (1), CaFCP (1)

**Data to NREL**

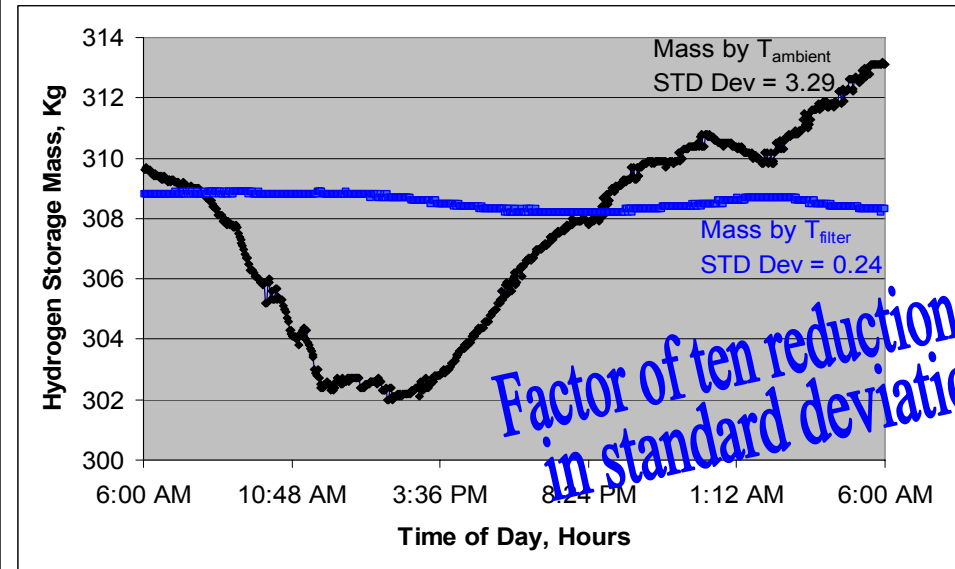


# Lesson Learned Storage Inventory Calculation Use First Order Filter on Temperature Measurement

Peak Pressure Lags Peak Ambient Temperature



"Constant" Mass calculation varies with time of day



- Ambient temperature external of storage is used for mass calculation
  - Eliminates electrical equipment in C1D2GB electrical area
  - Eliminates penetration into high pressure storage vessel
- However, Peak pressure does not coincide with peak daily temperature
  - Delay is due to heat transfer from ambient to massive steel vessels
- Mismatch leads to error and variation in "constant" mass calculation
- First order filter reduces standard deviation of calculated mass by a factor of 10

- Field 32 Vehicles
  - by the end of 2007
- Collect operating data from Stations in:
  - Rosemead, CA
  - Selfridge, MI
  - Orlando, FL\*
- POGT Testing 2<sup>nd</sup> quarter



\*not in DOE program but data to be shared with DOE

## **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**
  - **Reformers CSA 5.99 US Certified**

## **Technical Accomplishments and Progress**

- **Range and Durability reported to NREL**
- **Two stations reported to NREL**
- **Third Party fuelings conducted at stations**

## **Technology Transfer**

- **Lessons learned included in merit review**

## **Proposed Future Work**

- **Continue testing of vehicles and data reporting to NREL**

# Fleet Monitoring and Data Collection

**Strategy**

- 1) Provide safe and delightful driving to partners
- 2) Provide quick maintenance
- 3) Monitor the route and encourage usage

