Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

TEAM:
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Hyundai-Kia Motor Company
UTC Power

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This presentation does not contain any proprietary or confidential information

Overview

Timeline

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

Barriers

- Vehicles
- H2 Refueling Infrastructure
- Codes & Standards

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

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

Overall **FC Stack Durability: >2000 hr** **Vehicle Range: >250 miles** **Hydrogen Cost: <$3.00/gge**	**Obtain data** to validate **2009 performance targets** •Collect: – FC vehicle operating data •Demonstrate: – Different methods of on-site hydrogen generation
2006	•Hydrogen safe chassis dyno and Maintenance facility •Test different climatic conditions on FC vehicles •Three On-site Generators – Rosemead – Oakland – Orlando (not funded by DOE)
2007	•Increase Vehicle availability and reliability •Improve Vehicle Performance with 2nd Gen. vehicles •Operate and report from 5 on-site generation stations •Construct and Operate Partial Oxidation Gas Turbine (POGT)

Approach

Milestone 2	**Demonstrate 50% higher fuel economy** ➢ Conduct Dyno testing – initial testing complete ➢ Conduct on road testing – data reported to NREL monthly
Milestone 3	**Demonstrate 2005 energy and mass density targets** ➢ 350 bar vehicles on the road ➢ 700 bar vehicle to be tested
Milestone 5	**Validate vehicle range of ~200 miles and 1000 hours** ➢ On road testing data being reported to NREL monthly
Milestone 6	**Validate refueling less than 5 minutes** ➢ Work complete
Milestone 11	**Validate $3/gge production cost** ➢ On-site hydrogen generation stations in operation
Milestone 12	**Five station and two maintenance facilities constructed.** ➢ Data reported to NREL from 2 stations ➢ Three additional stations on line 1Q 2007 ➢ Maintenance facility operational in Chino

Approach – Infrastructure

Approach – Vehicle Deployment

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

Status – GTI Program POGT

Design	Construction
• Process Flow Diagram, Equipment Layout, and Piping & Instrumentation Drawings Completed	➢ Partial Oxidation Gas Turbine (POGT) and Partial Oxidation Reactor (POR) Integration in Progress
• HazOp Review Completed	➢ Water Gas Shift (WGS) Slipstream Unit Fabricated
• PSA System and Gas Analysis Available	➢ Compressor and Buffer Tank Received

Vehicles – Progress/Results
Safe Operations

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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

Infrastructure – Selfridge Energy Station

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

Infrastructure – Orlando Energy Station

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

Infrastructure – GTI POGT

Slipstream Water-Gas-Shift Reactor (shown uninsulated)

Partial Oxidation Gas Turbine System

Partial Oxidation Reactor (POR)

Partial Oxidation Gas Turbine (POGT)

Hot Weather performance

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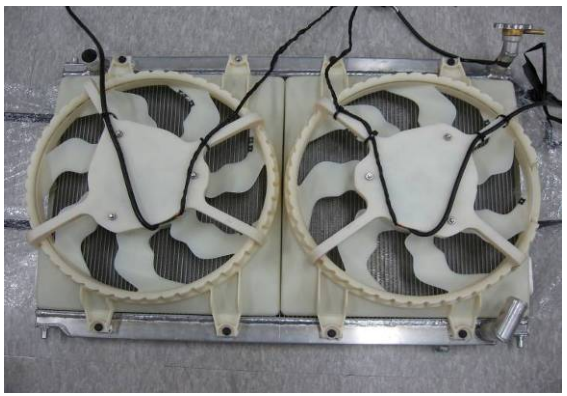
➢ Hot test performed at Death Valley on Jul. 2006

- 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

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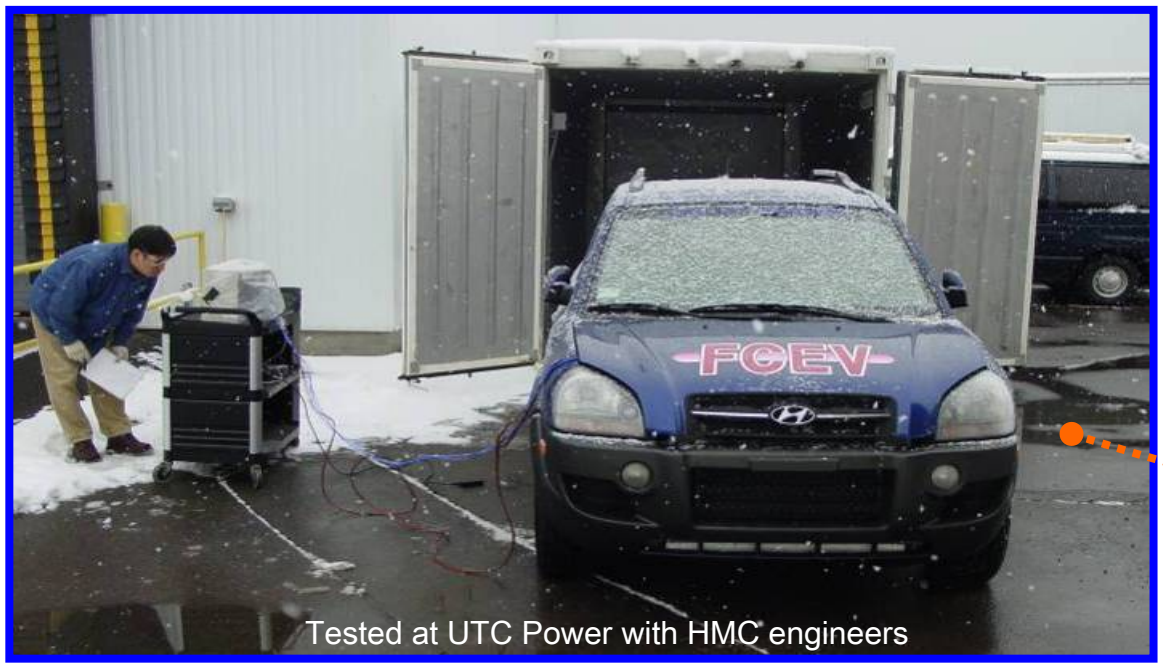
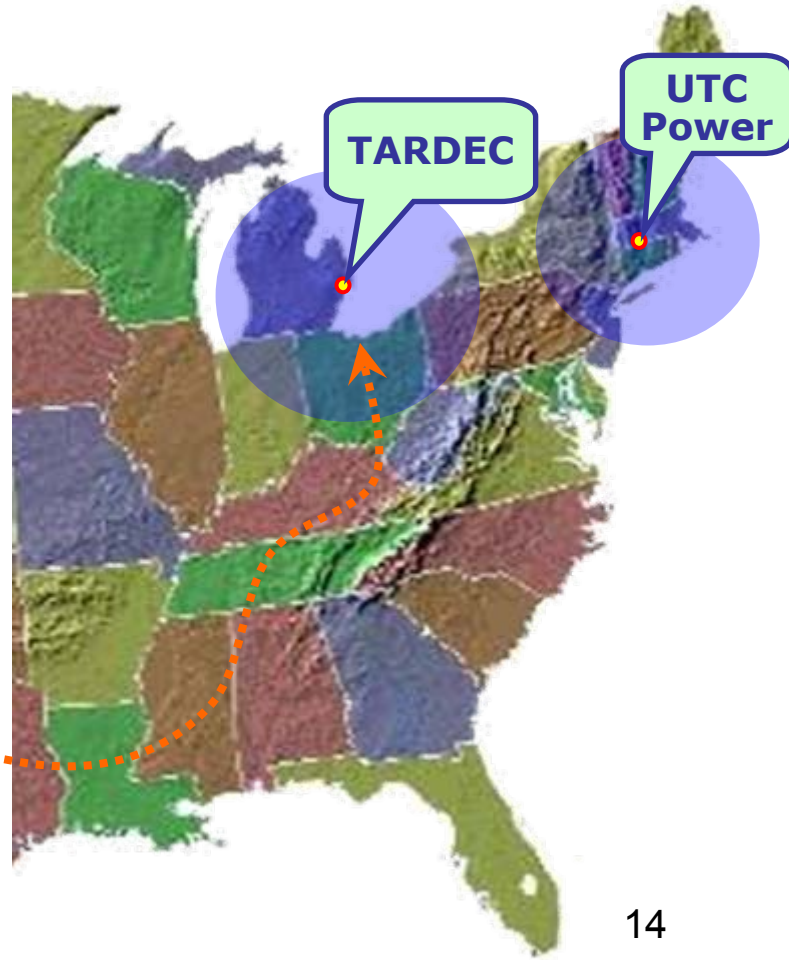
➢ Cold start up test successfully performed on Feb. 2007

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



Tested at UTC Power with HMC engineers



Vehicle Service Facilities

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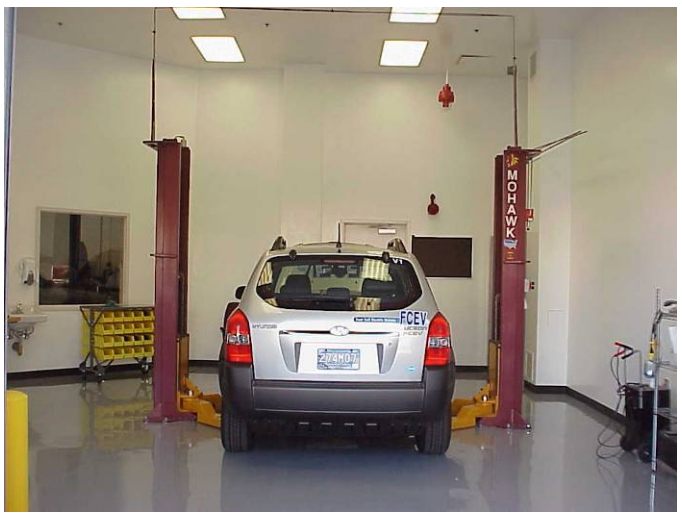
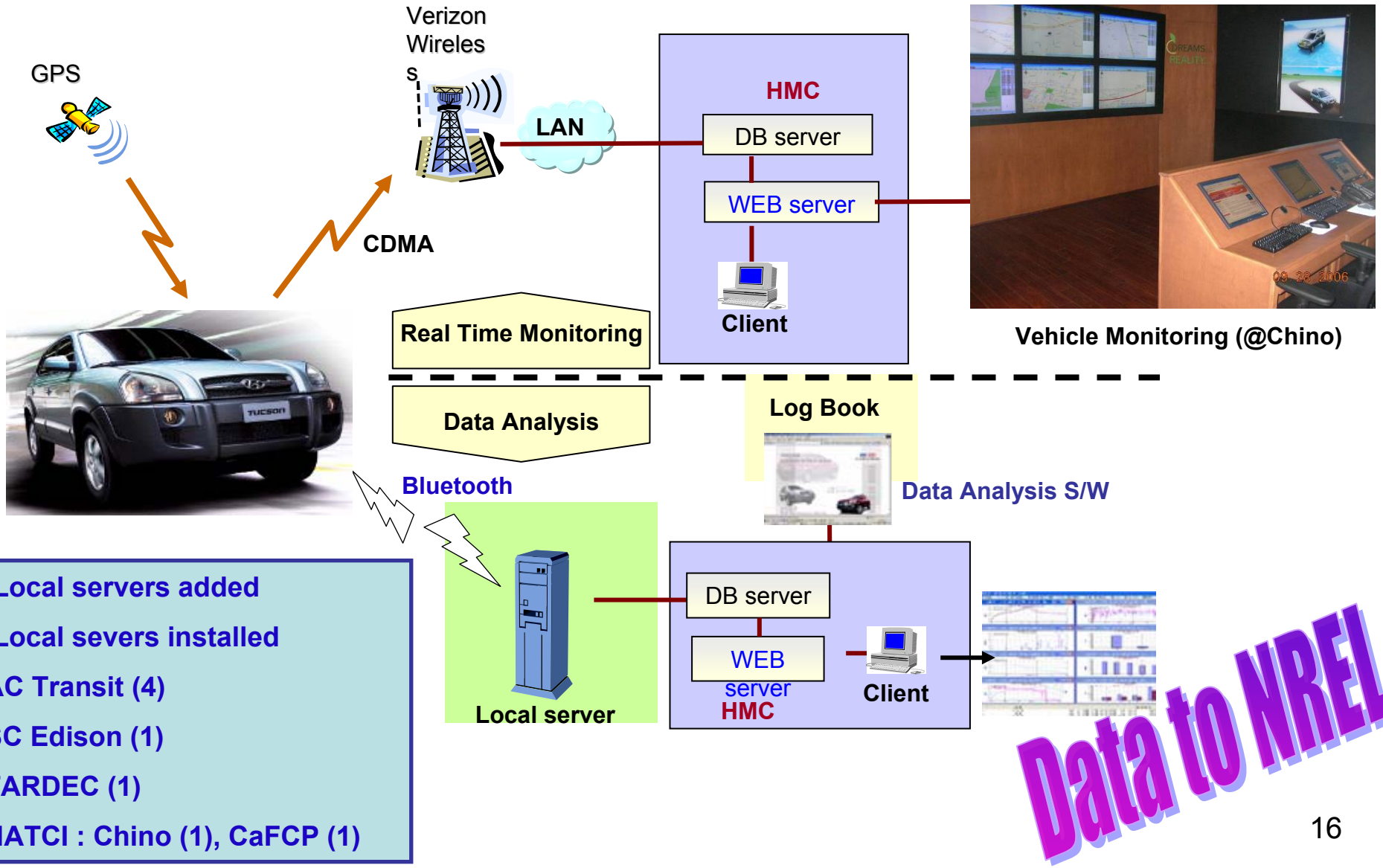
➢ Hydrogen Safe Dyno Bay (Chino)

➢ Hydrogen Safe Work 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)

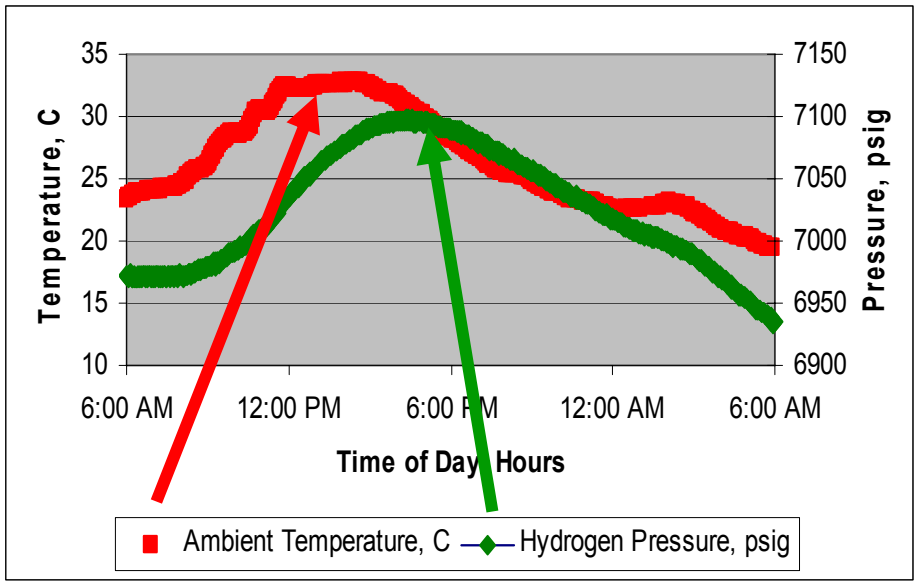
Fleet Monitoring and Data Collection



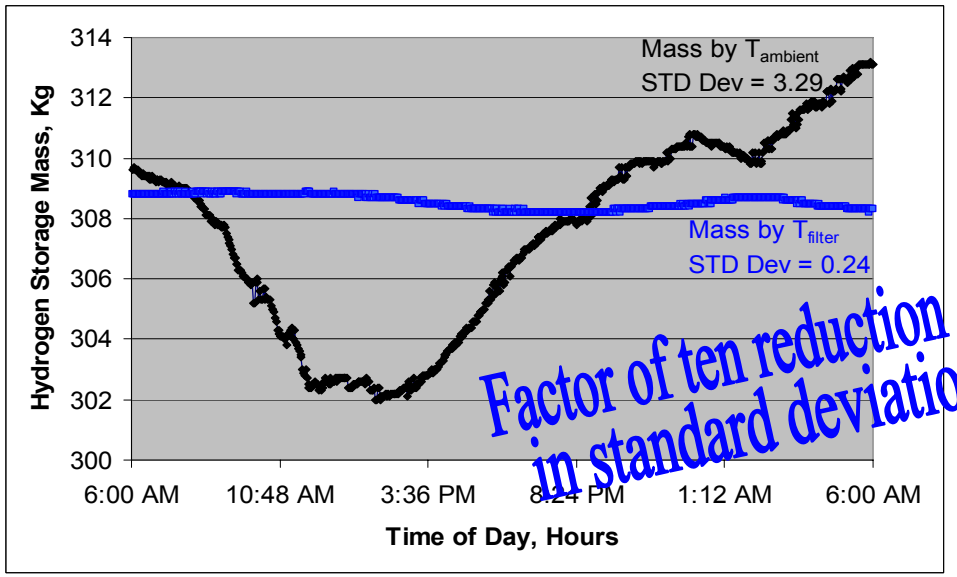
- 5 Local servers added
- 8 Local severs installed
  - AC Transit (4)
  - SC Edison (1)
  - TARDEC (1)
  - HATCI : Chino (1), CaFCP (1)

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

Peak Pressure Lags Peak Ambient Temperature



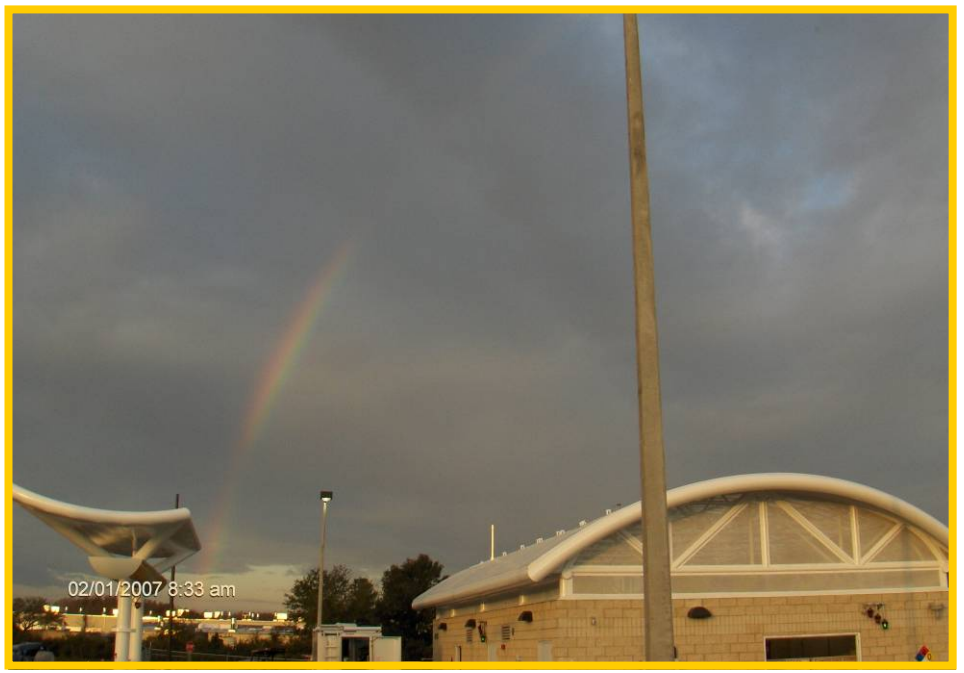
"Constant" Mass calculation varies with time of day



- 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

Future Work

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



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

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
  - 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

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Strategy

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