

# **R&D of a PEM Fuel Cell, Hydrogen Reformer, and Vehicle Refueling Facility (Las Vegas Energy Park)**

## **Project ID # TVP7**

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This presentation does not contain any proprietary or confidential information.

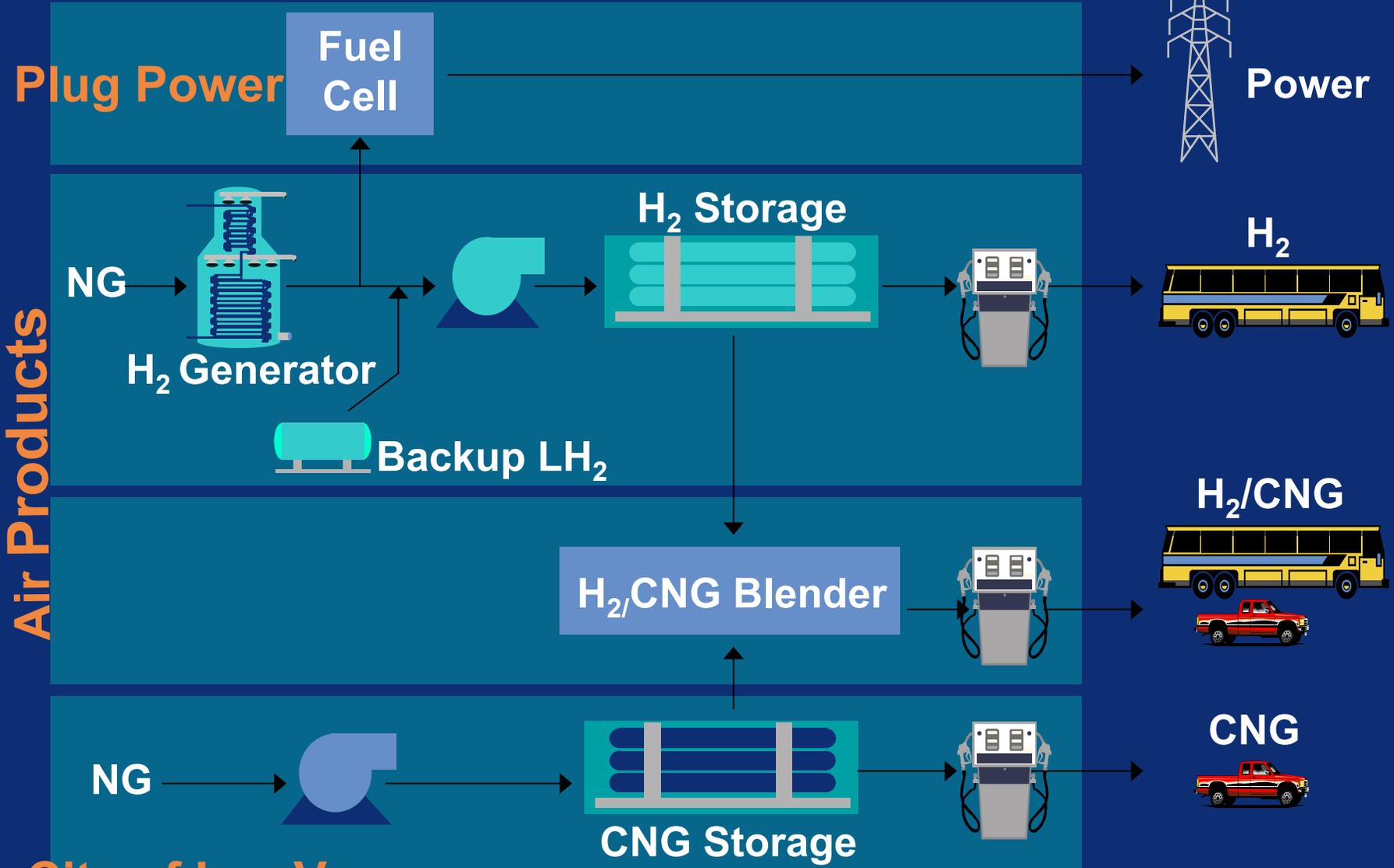
# Las Vegas Hydrogen Fueling and Energy Station – Compression, Storage and Fueling



# Las Vegas Hydrogen Fueling and Energy Station – Distributed Hydrogen Generation and PEM Fuel Cell Power Generation



# Nevada Hydrogen Project



Air Products

City of Las Vegas

# Program Objectives

- Done** ● Demonstrate small, on-site H<sub>2</sub> production for fuel cell power generation and H<sub>2</sub> fueling station
- Done** ● Demonstrate multipurpose vehicle refueling station to dispense H<sub>2</sub>/CNG blend and pure H<sub>2</sub>
- Done** ● Demonstrate H<sub>2</sub>-fueled stationary 50kW fuel cell
- Done** ● Evaluate operability/reliability/economic feasibility of integrated power generation and vehicle refueling designs
- Target 2006** ● Expand the current facility for 350 barg pressure filling to support vehicle needs.

# Budget

- Total Project Budget:
  - \$13,118,282
  
- FY2005 Funding
  - Total = \$641,078
    - DOE = \$320,539
    - APCI = \$320,539

# DOE Technical Barriers

## DOE HFCIT Multi-Year Plan

- Technology Validation
  - B. Storage – Cost, Performance, Structural Integrity
  - C. Hydrogen Refueling Infrastructure – Cost of Hydrogen, Low Availability, Safe Systems
  - D. Maintenance & Training Facilities – Operating and Maintenance Requirements, Personnel Training
  - E. Codes & Standards – Lack of Adopted Codes and Standards
  - I. Hydrogen and Electricity Co-production – Cost and Durability, Permitting, Safety Procedures

# DOE Technical Targets

## DOE HFCIT Multi-Year Plan

- Technical Targets
  - Reformer Efficiency, 2003, %(LHV) – 70%
    - Vegas Result, 2000 design – 68% (Current test data)
    - Test data collected while producing < 1 ppm CO purity
    - Vegas has capability to meet target; additional operation to demonstrate capability
    - PSU Program will deliver improvements to 2005 targets
  - Cost of Hydrogen, 2003, \$/kg - \$5.00
    - Vegas Result - < \$5.00
    - Based on evaluation of Las Vegas Energy Station performance using HFCIT MYPP assumptions
    - PSU Program will deliver improvements to 2005 targets

# Technical Approach

- **Design, Build, Test**
  - Scaled extension of research
  - Real-world performance and durability testing
  - Site selection, permitting, safety, operability, reliability, maintenance experience clarifies research and development gaps
  
- **Severe Test Environment – Las Vegas**
  - Desert climate – high summer temps, occasional freezing temps in winter
  - 2000 feet above sea level
  - CO2 Non-attainment (Clark County)



# Technical Approach

- **Phase 1**
  - **Define System Requirements**
  - **Finalize System Definition to Requirements**
  - **System Engineering and Design**
- **Phase 2**
  - **Equipment Manufacturing**
  - **Detailed Design for Integrated System Installation**
  - **Installation, Commissioning and Start-up**
- **Phase 3**
  - **Demonstration Operation and Maintenance**
  - **Data Collection and Analysis**
  - **Feedback to Future Designs**
  - **Select Existing System Improvements**

**Current Status: Test Report Being Prepared. Phase 4  
Expansion for higher pressure approved by DOE HQ**

# Project Timeline

ID	Task Name	2000				2001				2002				2003				2004					
		Q3	Q4	Q1	Q2	Q3	Q4																
1	Phase 1 - Engineering and Design																						
2	Phase 2 - Manufacture, Install, Start-up																						
3	Phase 3 - Operation Period																						

- Hydrogen Generator Start-up at Site Achieved August 2002
- Site Opening Dedication in November 2002
- Completed 2 year demonstration operating period
- Operating Demonstration Extended

# Project Safety

- **Safety Evaluated by DOE Safety Panel in Mar 04**
  - No major issues, some areas of interest:
    - Hydrogen fill rates
    - Underground piping
    - Mechanical joints
    - Pressurized Storage Vessel MIP
- **Site Safety Performance to Date Validates Design**
  - No safety incidents for site over 18 months of operation
  - >200 fuel fills conducted without station incident
  - Inherently safe systems with safety instrumented controls
- **Vegas Energy Station Safety Efforts**
  - Hazop, MOC, Quantitative Risk as required
  - Use of applicable industry codes
  - Operational Readiness Inspection (ORI)
  - Trained Operating Personnel
  - Safety Performance Measured



# Technical Accomplishments – Hydrogen Generator

## ● Status Overview

- Over 4800 hours operation
- Satisfactory process operation and product purity capability
- One button start, load following, additional features
- Remote monitoring from Allentown, PA & Sacramento, CA

## ● Performance

- 68% LHV Efficiency achieved w/ year 2000 design basis equipment , < 1 ppm CO purity control
- Sound process technology implementation
- Interim inspection of equipment showed equipment in good mechanical condition



# Technical Accomplishments – Hydrogen Generator (Cont)

## ● Operating Experience Information

- Severe diurnal cycling affects ambient conditions, influencing process dynamics
- Seasonal ambient changes influence process dynamics
- Steam system dynamics and control
- More than sufficient instrumentation for safe and reliable control system
- Lessons Learned fed to APCI Penn State and Power Park (Hydrogen Energy Station) Project Teams

## ● Operating Test Campaign

- Added primary air flow measurement
- Added steam flow measurement
- Added additional thermocouples along reformer tube to monitor thermal stratification
- 2000 hour on-purpose test run successfully completed. Performance test data collected.

# City of Las Vegas H2 / CNG Bus



# Responses to Reviewers' Comments

- **Educational Benefits**

- Significant international and national visitor traffic
- International Energy Agency
- DOE Safety Panel
- Numerous conference tours (PowerGen, APTA, etc.)
- Permit experiences shared

- **Vehicles**

- Support given to CLV blend bus with Collier Technologies
- Pickup truck
- Assisted with CLV lease of 2 Honda fuel cell vehicles.

- **Expanding Operations**

- Upgrading to 350 barg gaseous H2 fueling
- Potential to add Liquid H2 refueling as part of DOE CHIP

- **“Overlap” with Other Projects (Penn State Station)**

- LV is first of a kind prototype station
- Lessons learned fed to Penn State and Power Park development teams. The Penn State station team is working to demonstrate reduced cost of H2, reduced footprint, improved aesthetics, higher pressure refueling, higher efficiency.

# Future Work

- **Conclude current operating period**
  - Analyze data collected during 2000 hour run for final report
    - Incorporation of lessons learned into PSU
      - H2 Generator Packaging
      - H2 Generator Process and Control Improvements
      - System Design, Costs and Economics
  - Support CLV fleet expansion
- **Planning for continued DOE support of site beyond current operating period**
  - Upgrade of fueling systems for 350 Bar / 5000 psig fueling ( systems mechanically rated for 5000 psig)
  - Potential for upgrade of fueling systems for communication based fill
  - Continued use of Vegas asset as a R&D test bed facility
  - Support Vegas Fleet Build-out
    - City currently has 1 bus, 1 pickup truck, and is leasing 2 Honda fuel cell vehicles
    - Current fleet of 268 CNG vehicles
    - Progressive in testing / adopting alternative fuels

# Collaborations

- DOE HQ and Golden Field Office
- Dan Hyde, City of Las Vegas Fleet Site Mgr
- Plug Power – Rob Dross, Dave Parry, Bob Sinuc
- Sandia National Laboratory – Andrew Lutz
- International Energy Agency
- DOE Safety Panel

Thank you.

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# Publications / Presentations

- DOE Annual Review Meeting – 2000-2004
- Mentioned in Presentations at:
  - DOE Regional Meeting in Annapolis, MD - 2004
  - NHA Annual Meeting – March 2005
  - SAE Annual Meeting – 2004

# Hydrogen Safety

- The most significant hydrogen hazard associated with this project is:
  - *This is a comprehensive project which includes the operating demonstration of an integrated hydrogen generation, hydrogen refueling, and CNG/hydrogen refueling station. As such, several potentially hazardous situations are possible and are covered in Air Products' safety and design reviews. The detailed HAZOP identifies the hazards and the safety measures taken to mitigate them.*

# Hydrogen Safety - Approach

- Our approach to safety issues is comprehensive and is based upon a tremendous experience base:
- **Safety**
  - APCI has >40 years experience in safe design, construction, & operation of H<sub>2</sub> plants.
    - > 12,000 H<sub>2</sub> fuel fills complete to date (>75-120 per week now)
    - Leader in Management of Change, Near Miss Reporting, and Quantified Risk Assessment Procedures
  - PHR: Phase 1
  - HAZOP: Phases 2 & 3
  - All applicable industry codes are followed
  - APCI participates in SAE, ICC, ISO, HFPA, IETC, and EIHP2 committees.
- **Site Selection and Personnel Training**
  - Site concurrent with CLV fleet garage
  - Personnel are trained in H<sub>2</sub> handling and maintenance of H<sub>2</sub>-related equipment