Validation of an Integrated Hydrogen Energy Station

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Air Products and Chemicals, Inc.

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Project ID
#TV006

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Overview

Timeline

- Start – 30 Sept. 2001
- End – 31 Dec. 2011
- 100% Complete

Barriers

- H_2 Fueling Infrastructure
- H_2 & Power Coproduction

Budget

- Total project funding
  - DOE share: $5.95 million
  - APCI + Partners share: $6.59 million
- Funding received in FY11: $0
- Funding for FY12: $0

Partners

- FuelCell Energy®
  - MCFC, Fuel Prep, WGS
- OCSD – Host Site (CA)
- CA – ARB, AQMD
  - UC Irvine

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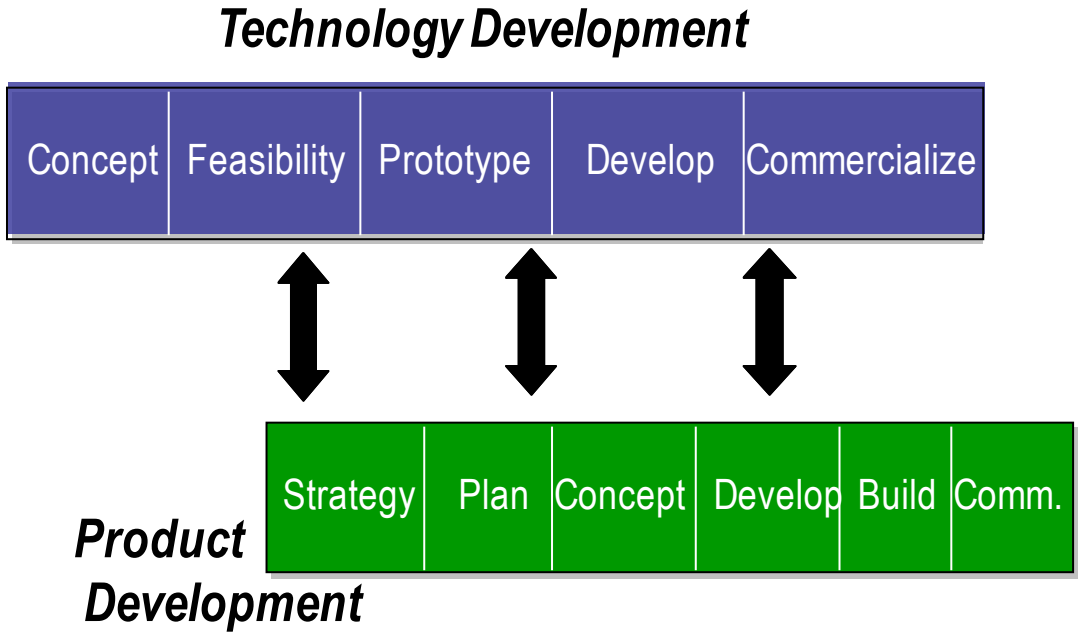
Objectives - Relevance

- **Determine the economic and technical viability of a hydrogen energy station designed to co-produce power and hydrogen**

Utilize technology development roadmap to provide deliverables and go/no-go decision points



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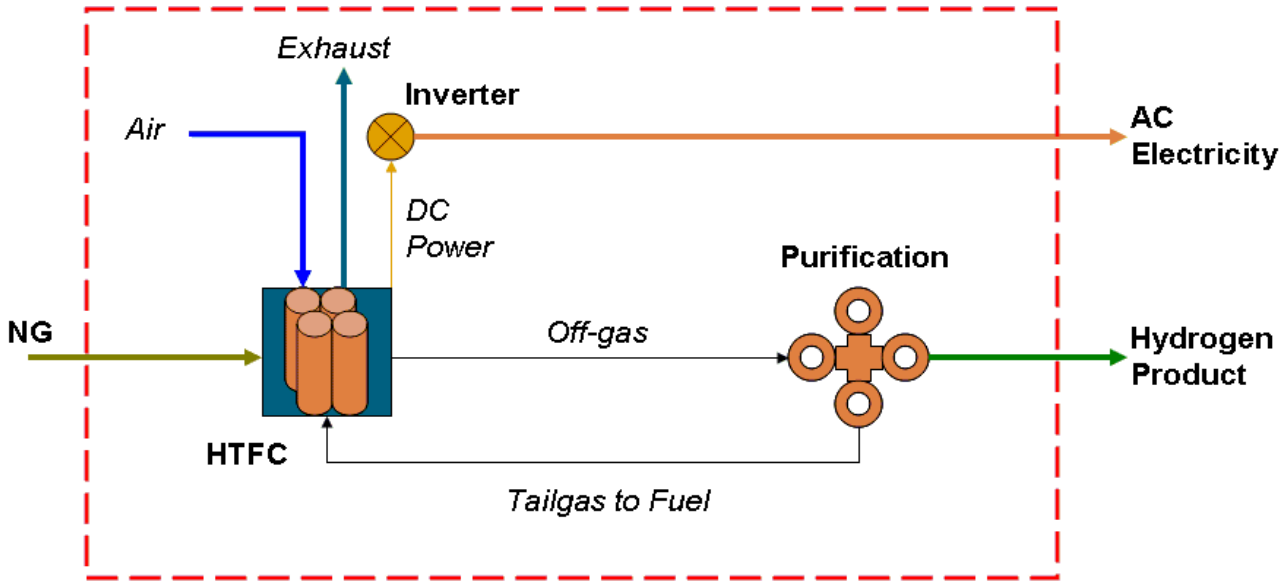
Hydrogen Energy Station Concept



Potential Co-Production Efficiency (LHV): 55 - 60%

Fuel Cell Outlet at High Temperature and Low Pressure

- H_2 : 10%
- H_2O: 40%
- CO: 5%
- CO_2: 45%

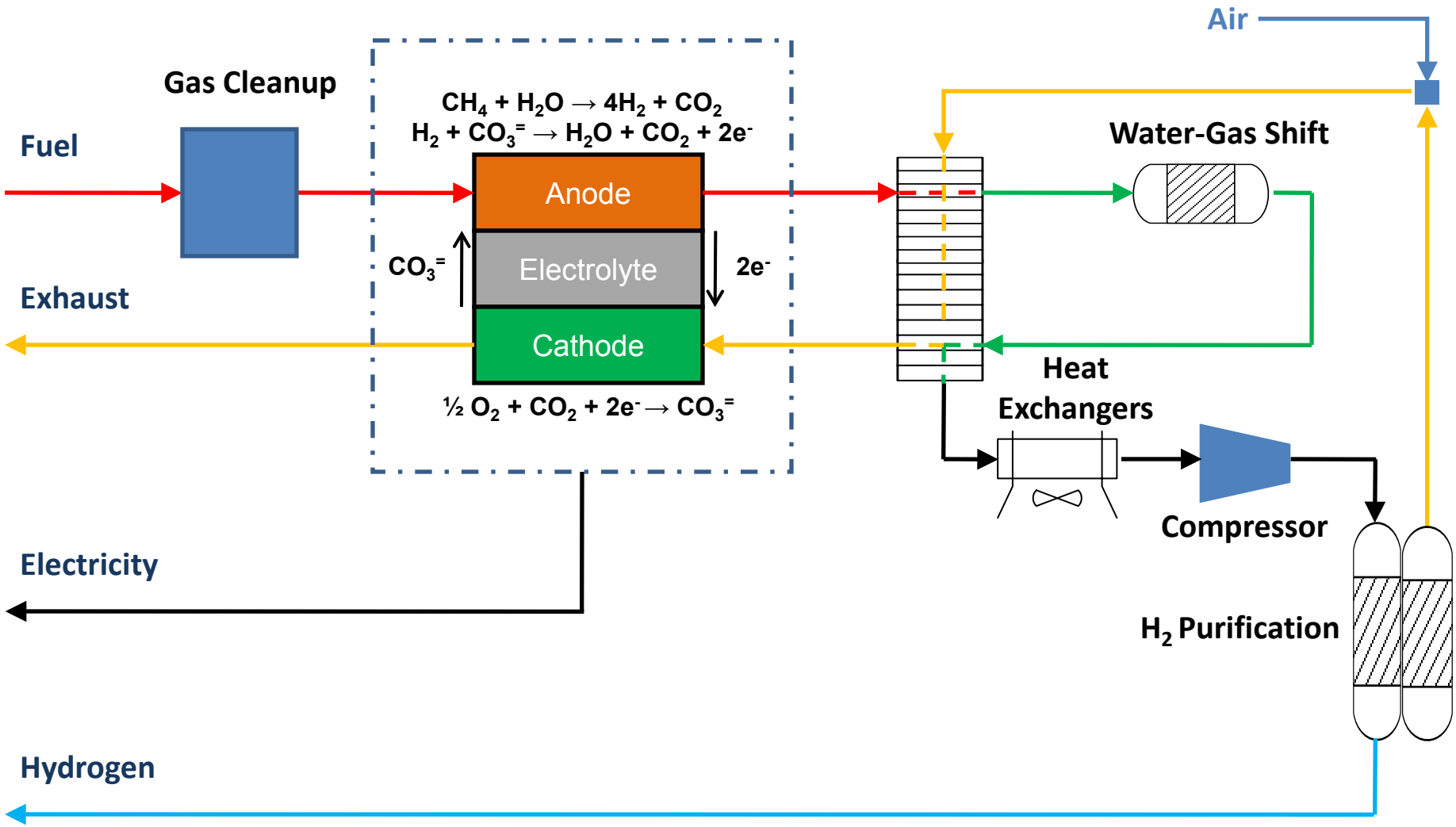
Hydrogen Product at Low Temperature and High Pressure

- H_2 : 99.99%
- H_2O: Rejection and Recycle
- CO: < 0.2 ppm
- CO_2: < 2 ppm

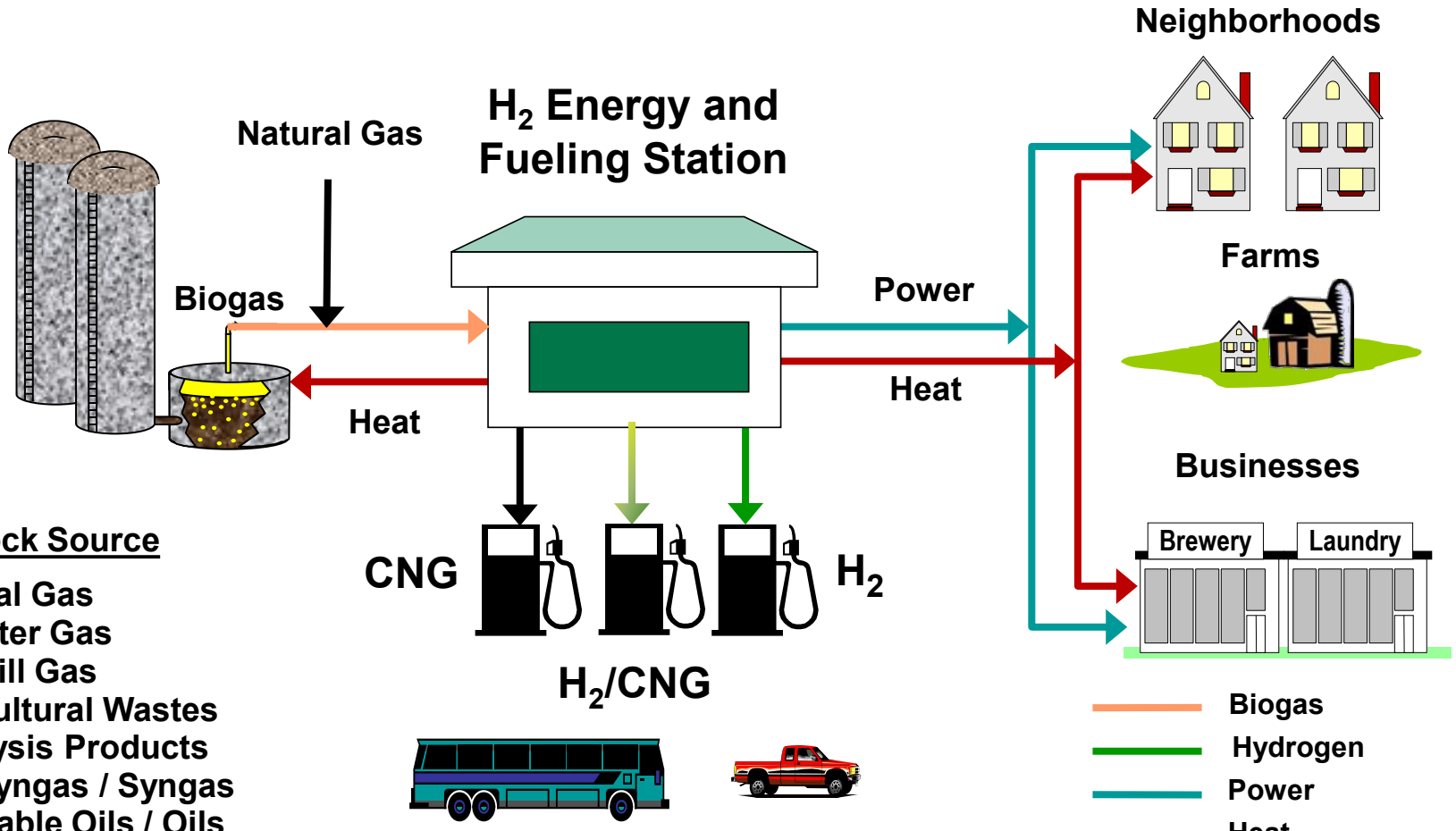
Approach

- DOE Program defined 4 phases:
  - Phase 1 – Feasibility: Evaluate PEM and HTFC
    - Completed FY04
  - Phase 2 – Preliminary System Design
    - Completed FY06
  - Phase 3 – Detailed Design and Construction
    - Design/Fabrication Completed March 2009
    - Shop Validation Test Completed March 2010
  - Phase 4 – Operation, Testing, Data Collection
    - Deployment in CA
    - Completed 31 December 2011

Hydrogen Energy Station



Hydrogen Energy Station Vision



Feedstock Source

- Natural Gas
- Digester Gas
- Landfill Gas
- Agricultural Wastes
- Pyrolysis Products
- Bio-Syngas / Syngas
- Vegetable Oils / Oils
- Other Methane Sources

Renewable hydrogen – for onsite requirements or regional distribution

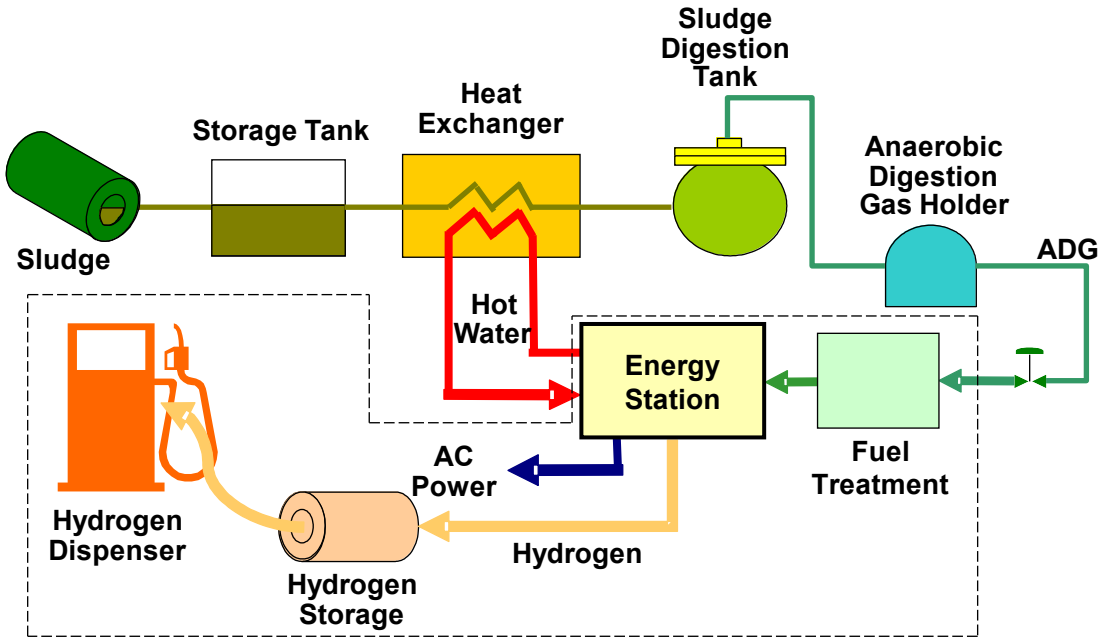
Demonstration of Hydrogen Energy Station Vision

- DOE Program – Natural Gas Feed
- Potential Host Site Identified - OCSD
  - Orange County Sanitation District, Fountain Valley, CA
  - Municipal Wastewater Treatment
  - Existing CNG Refueling Station
  - Ability to Achieve Production of both Renewable Hydrogen and Electricity

3-Year Operating Program – California Air Resources Board and South Coast Air Quality Management District

Fountain Valley Station

- 100 kg/day capacity, renewable hydrogen supply
- 350 and 700 bar fueling capability
- Host site: Orange County Sanitation District
- Anaerobic digestion of municipal wastewater



- Funding for fuel treatment and fueling station from DOE California Hydrogen Infrastructure Program with Air Products (Cooperative Agreement No. DE-FC36-05GO85026)
- Key subcontractors: FuelCell Energy, Inc. and National Fuel Cell Research Center, University of California, Irvine

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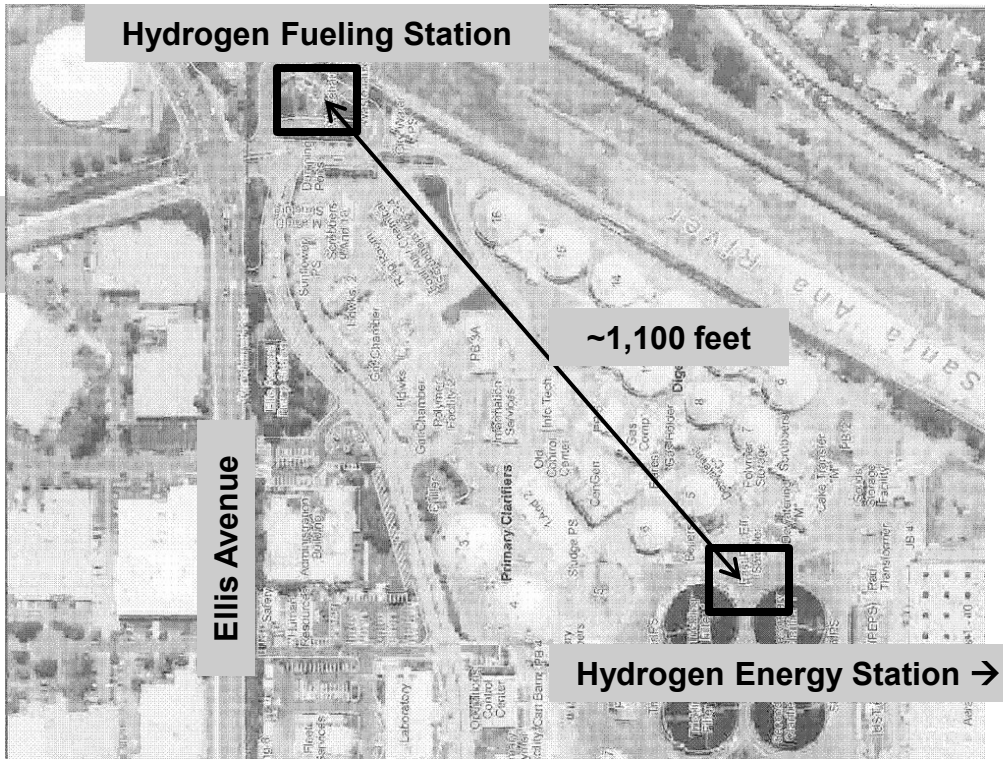
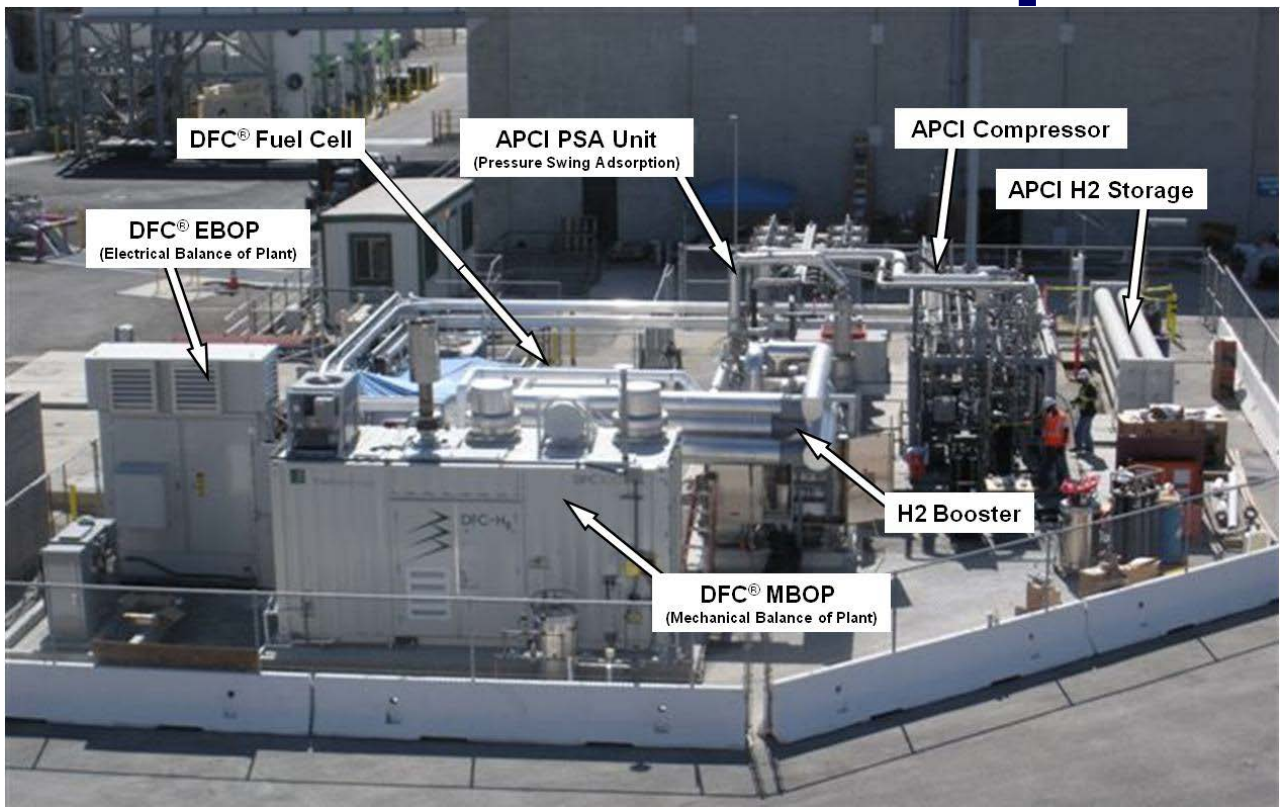
Orange County Sanitation District Site

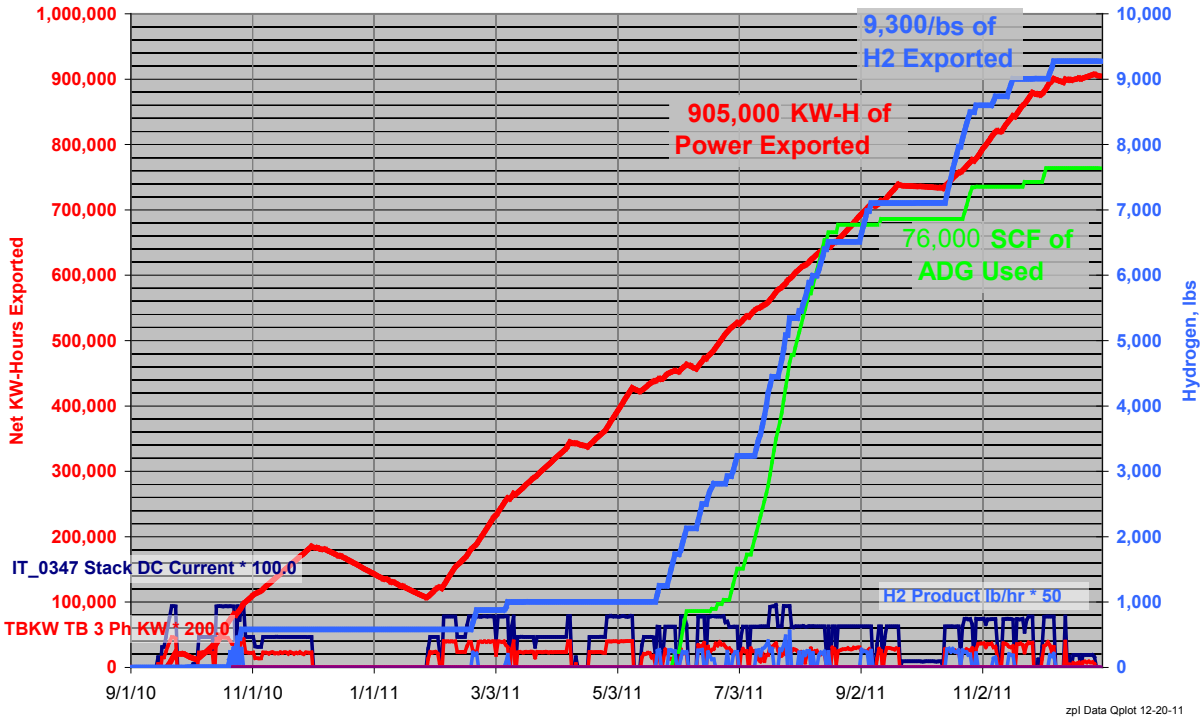


Hydrogen Energy Station Installation and Initial Operation



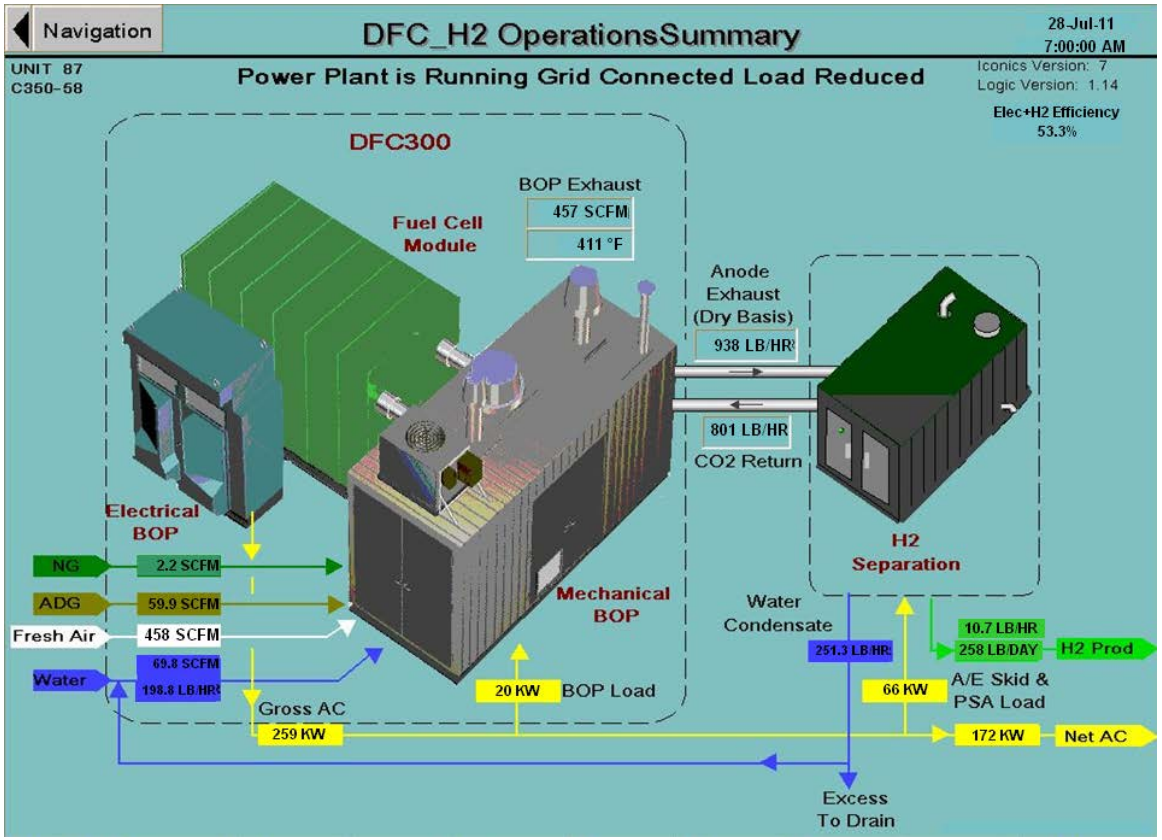
- 09 July 2010: Hydrogen Energy Station delivered to OCSD
- 20 September 2010: DFC® unit operated at full load on natural gas
- 20 October 2010: Initial coproduction of hydrogen on natural gas

Hydrogen Energy Station Overall System Performance



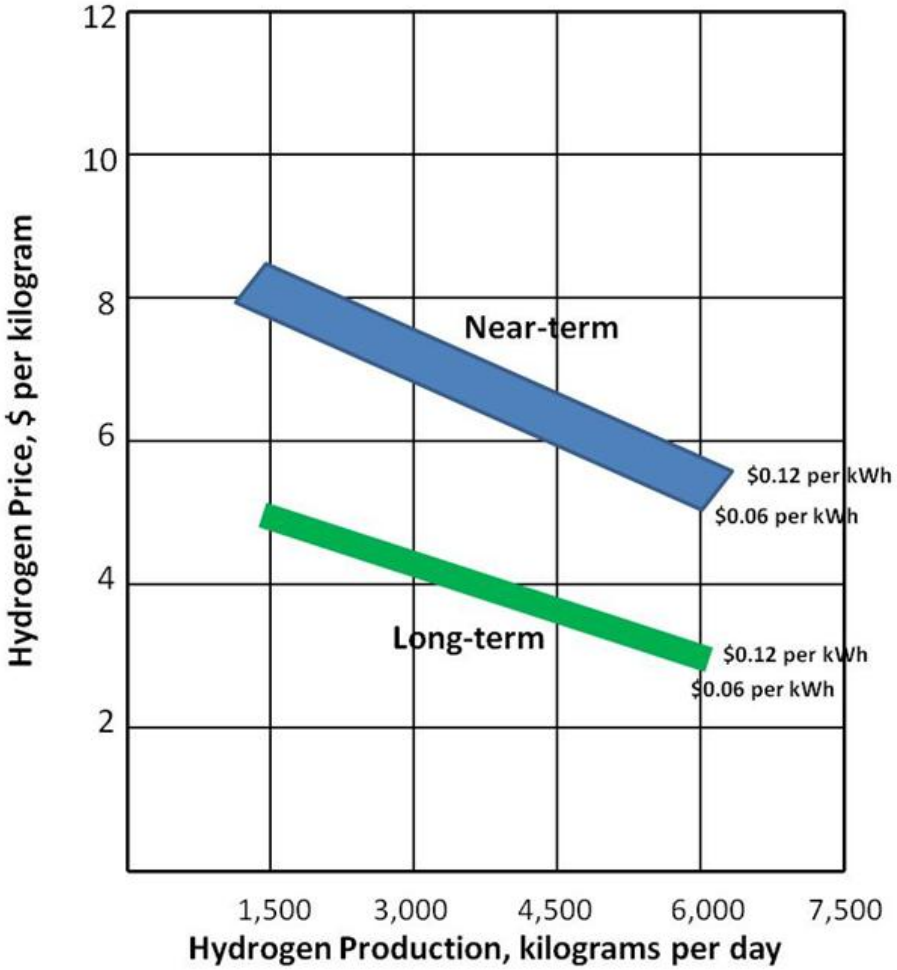
- Almost 1 MM kWh of power produced
- Ongoing power quality issues limiting coproduction rates and digester gas usage

Hydrogen Energy Station Overall Coproduction Efficiency



- Efficiency meets expected performance
- Testing performed with both natural gas and digester gas feeds

Hydrogen Energy Station Economics (updated 2011)



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Opening Ceremony for Hydrogen Energy Station (16 August 2011)

- Speakers from:
  - Orange County Sanitation District
  - Air Products
  - FuelCell Energy
  - University of California, Irvine
  - South Coast Air Quality Management District
  - California Air Resources Board
  - U.S. Department of Energy

http://abclocal.go.com/kabc/video?id=8310318&syndicate=syndicate&section

Collaboration

- **Industry**
  - **FuelCell Energy, Inc. – Subcontractor, Fuel Cell Supplier**
  - **Southern California Gas Co. – Funding to FuelCell Energy**
- **Government/Municipal Entities**
  - **U.S. Department of Energy**
  - **California Air Resources Board**
  - **South Coast Air Quality Management District**
  - **Orange County Sanitation District – Host Site, Site Improvements**
- **University**
  - **University of California, Irvine – Data Analysis, Education/Outreach Activities within CARB Program**

Future Work

- Complete 3-year operating program (31 May 2014) at Orange County Sanitation District (CARB/South Coast AQMD)
- Develop follow-on project opportunities
  - Proposal submitted for scale-up to second generation system
    - Based on DFC®1500 platform – 400 to 500 kg/day H_2 plus 1.0 to 1.2 MW and 2 MMBTU/hr heat

DFC®300

DFC®1500

Summary

- **Determine the economic and technical viability of a hydrogen energy station designed to co-produce power and hydrogen**
  - **Concept defined – FuelCell Energy's molten carbonate fuel cell plus Air Products' hydrogen purification system**
  - **Design and fabrication of demonstration unit completed**
  - **Shop test successfully completed at FuelCell Energy's facilities**
  - **Demonstration operation on renewable feedstock at Orange Co. Sanitation District**
    - **Hydrogen refueling station under DOE's California Hydrogen Infrastructure Project**
    - **Other funding: California Air Resources Board, South Coast Air Quality Management District, SoCal Gas**
  - **Updated process economics based on system performance**

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Thank you

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Acknowledgement & Disclaimers

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