Validation of an Integrated Hydrogen Energy Station

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Project ID
#TV006

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Overview

Timeline

- Start – 30 Sept. 2001
- End – 30 Sept. 2011
- 93% 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 FY10: $0.25 million
- Funding for FY11: $0

Partners

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

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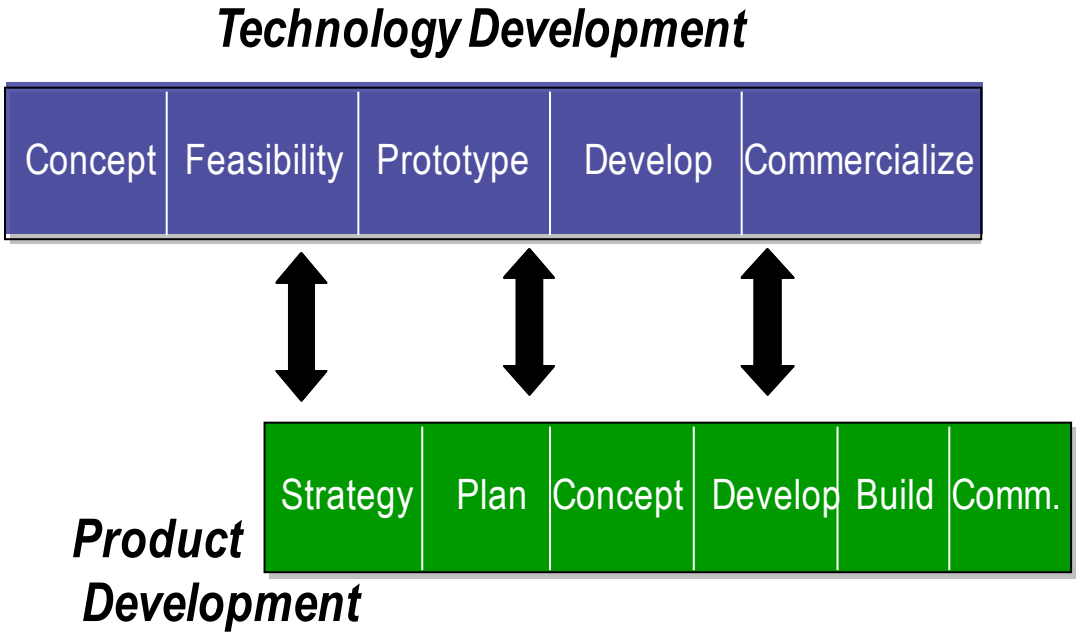
Objectives - Relevance

- **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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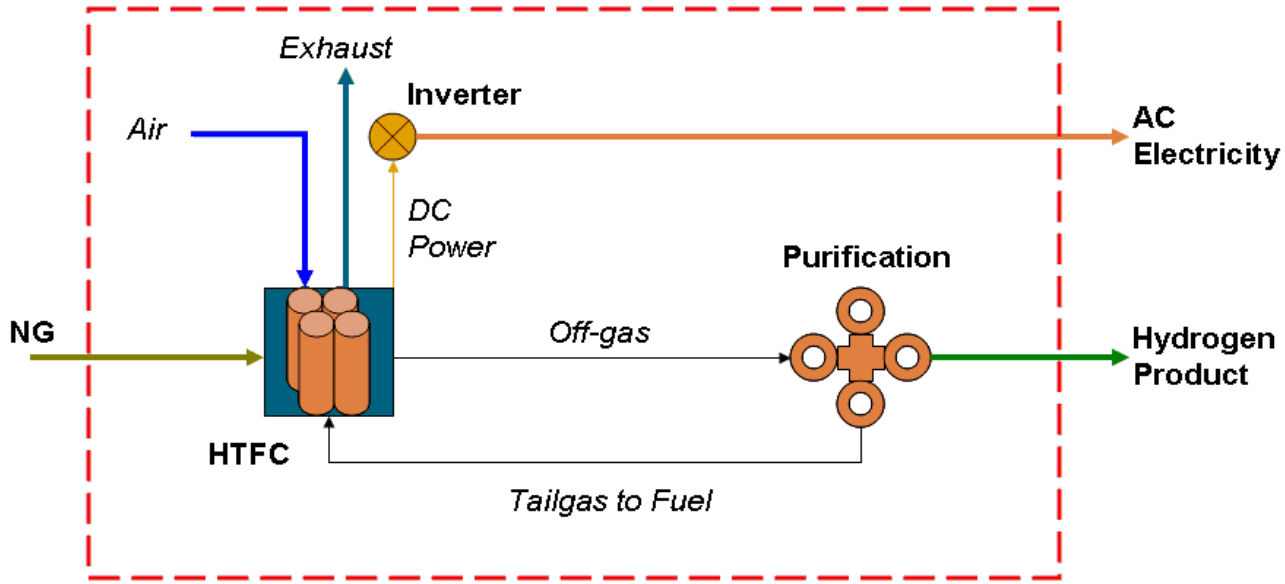
Hydrogen Energy Station Concept



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

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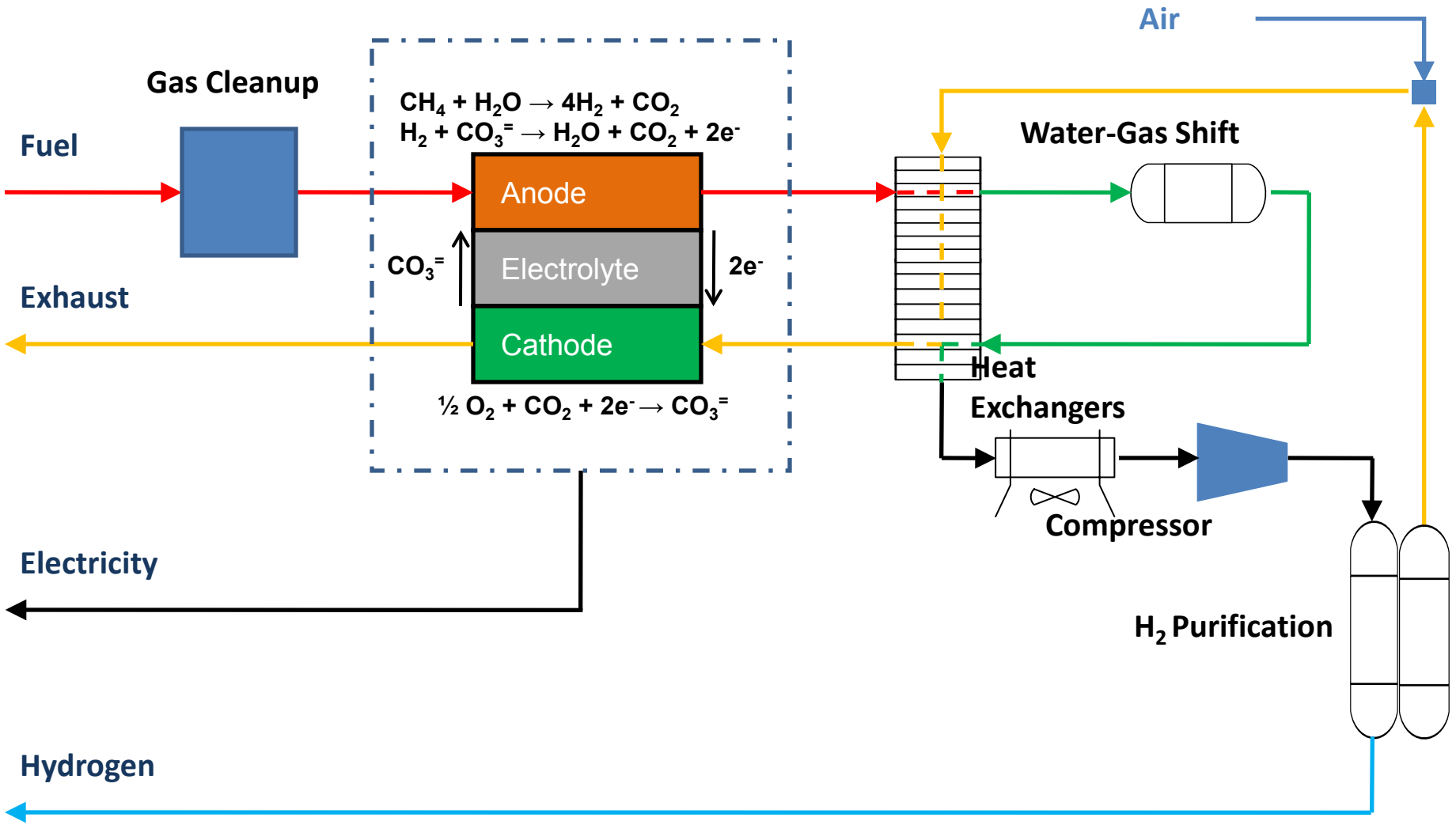
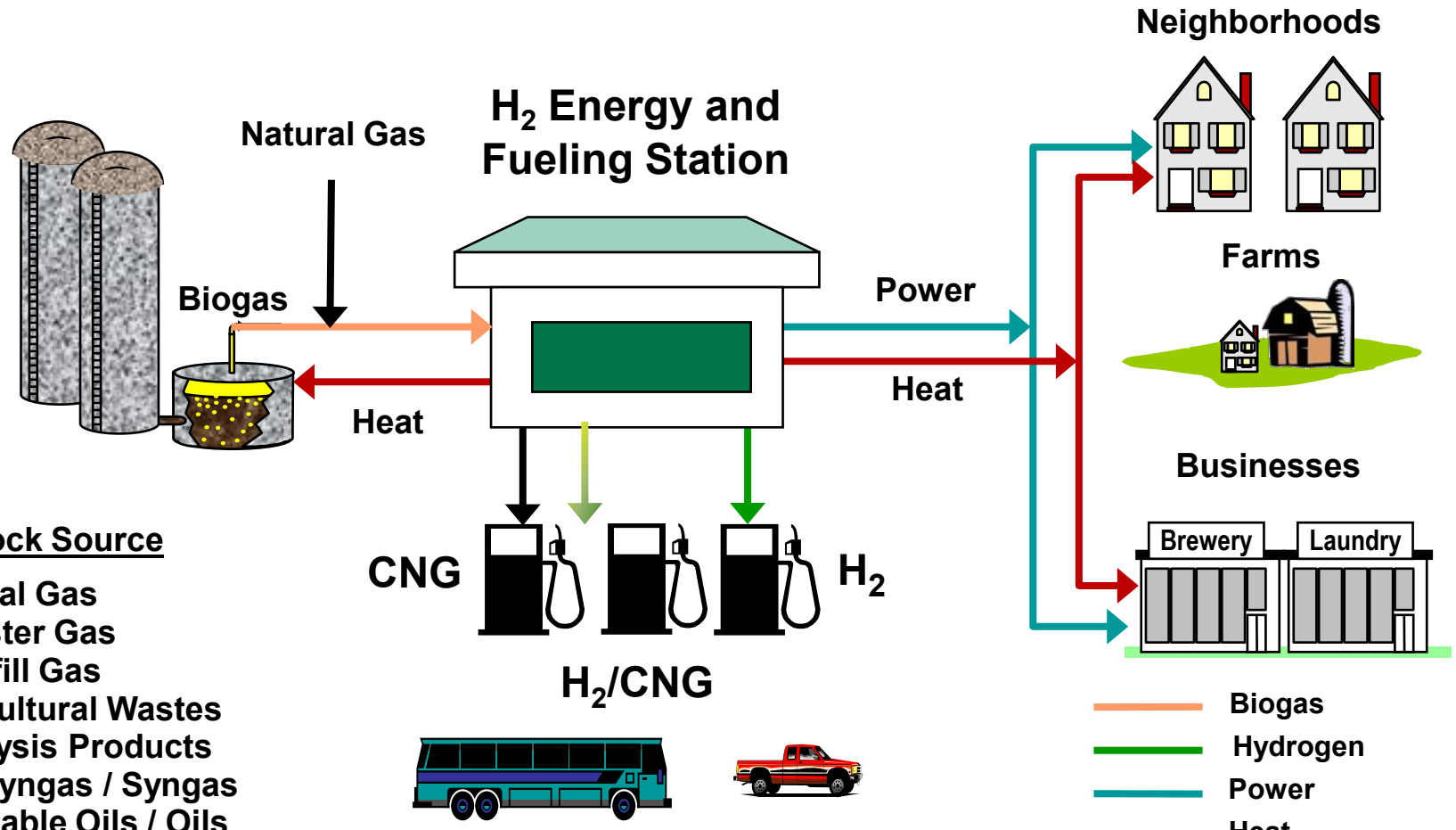
Approach

- 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

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

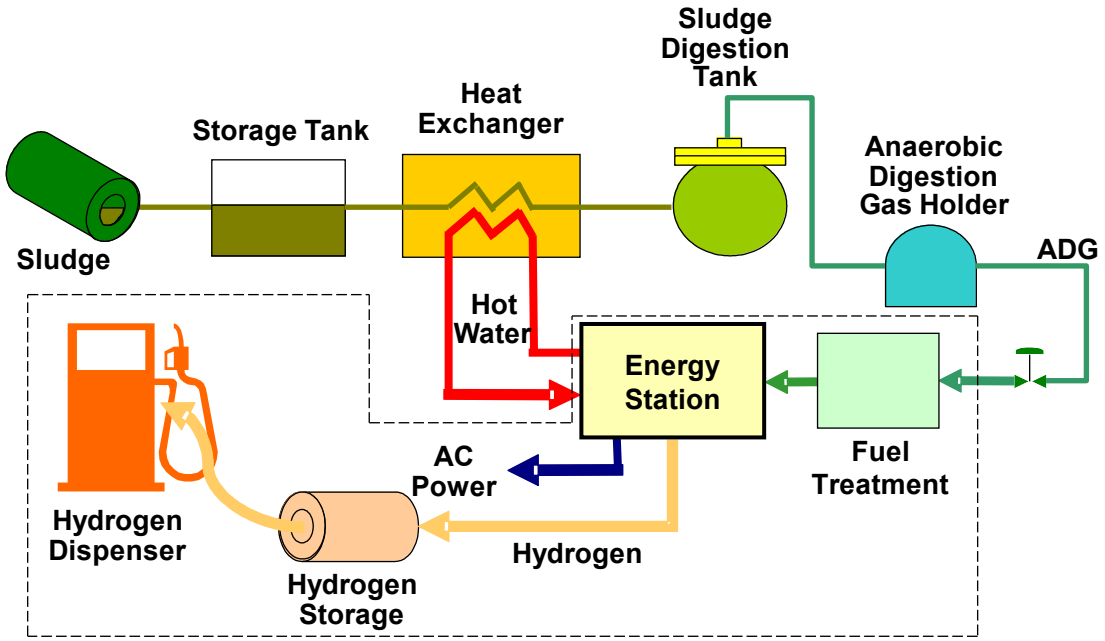
Demonstration of Hydrogen Energy Station Vision

- 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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2009-2010: Hydrogen Energy Station Shop Validation Test

Equipment worked well in co-production mode at FuelCell Energy's facilities

9,500 hrs operation

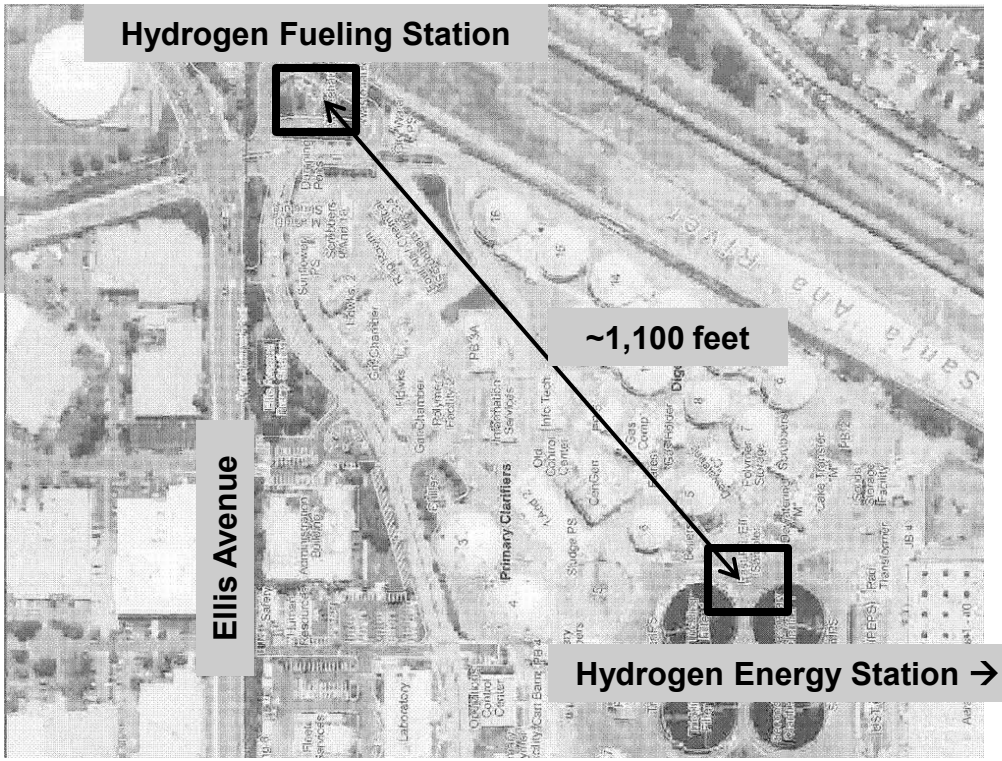
7,000 lbs H_2

Hydrogen Ready Fuel Cell Module

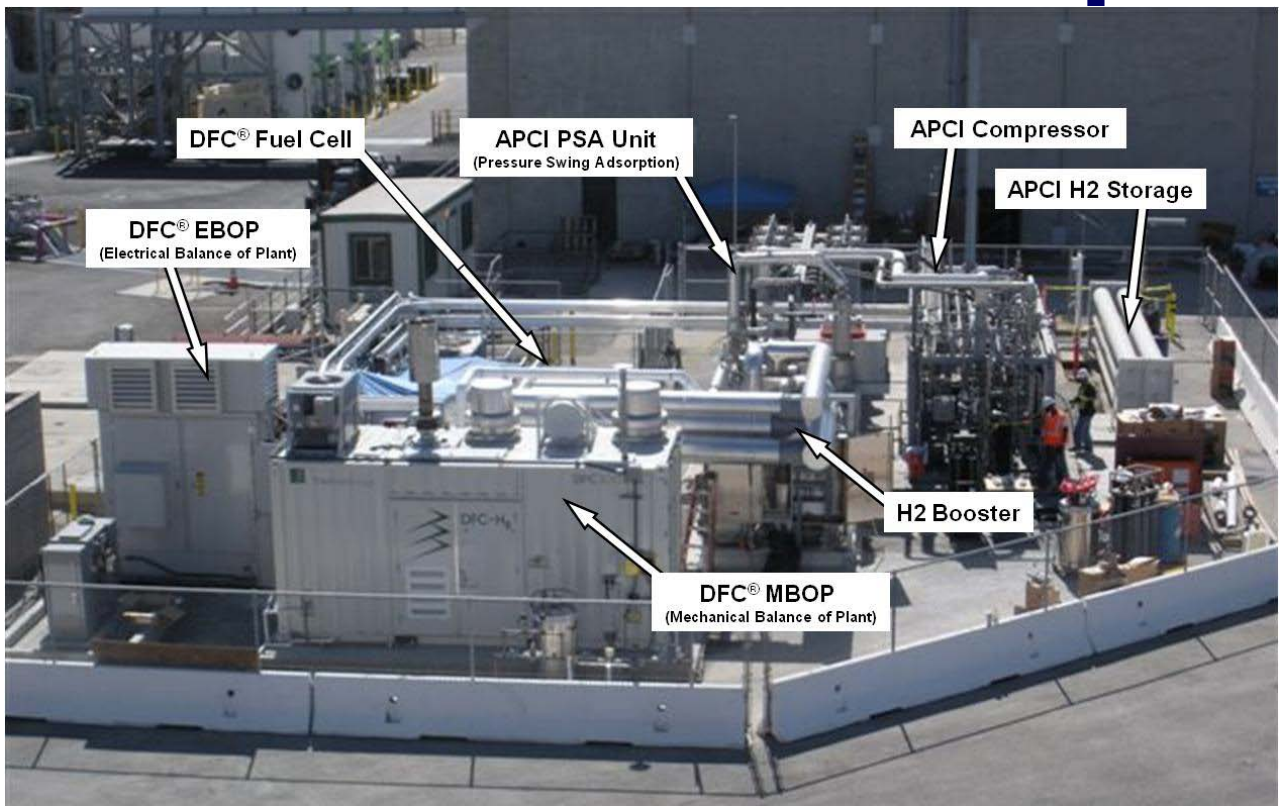
Anode Exhaust Processing and H_2 Purification System

Mechanical Balance of Plant (MBOP)

Orange County Sanitation District Site

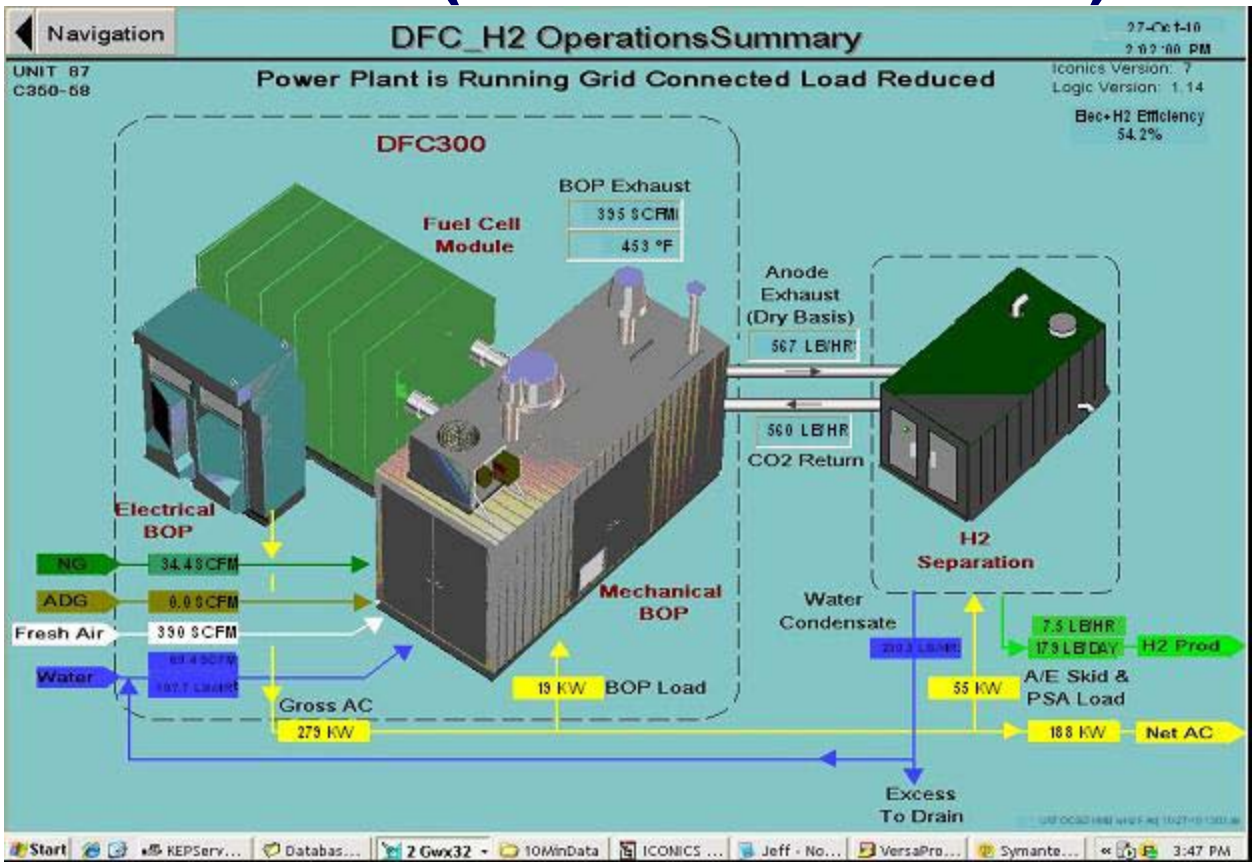


Hydrogen Energy Station Installation and Fuel Cell Operation



- 09 July 2010: Hydrogen Energy Station delivered to OCSD
- 13 September 2010: First low-load power production from DFC unit
- 20 September 2010: DFC unit operated at full load on natural gas

Initial Hydrogen Coproduction at OCSD (20th October 2010)



- Hydrogen quality met all performance specifications
- Over 1,000 hours in power and power + hydrogen modes

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Commissioning of Hydrogen Energy Station
(October 2010 – March 2011)

- October 2010: Power quality issues with local grid
- November 2010: Mechanical completion of hydrogen fueling station
- December 2010: Hydrogen Energy Station outage (power quality/inverter)
- February 2011: Power quality/inverter issues resolved

- 25 February 2011: First hydrogen from Hydrogen Energy Station to hydrogen fueling station
- 08-10 March 2011: Initial test fills of fuel cell vehicles at hydrogen fueling station

Ongoing Activities at OCSD

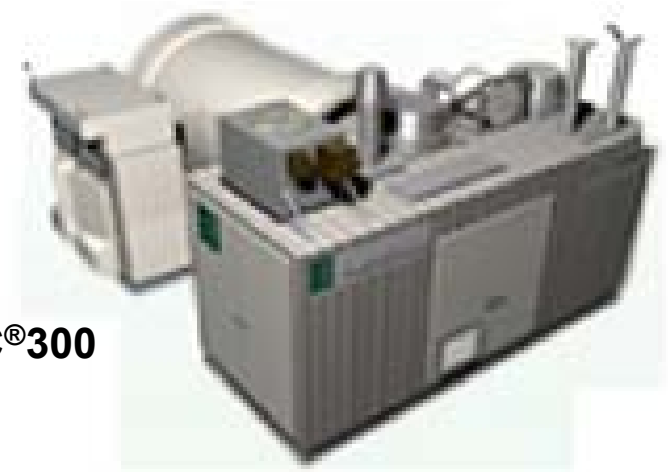
- March 2011: Obtain occupancy permit for hydrogen fueling station
- April 2011: Delivery and installation of clean-up system for anaerobic digester gas
- September 2011: Complete 6 months of data reporting under DOE Cooperative Agreement
- Operation to continue for a total of 3 years under CARB/SCAQMD sponsorship

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

- Installation at Orange County Sanitation District – Lessons learned from shop test, field trial
- Validation of process economics (awaiting completion of OCSD startup)
- Following DOE Program:
  - Product development activities for second generation system
  - Scale-up based on existing fuel cell products –
    - DFC®1500 – 400 to 500 kg/day H_2 plus 1.0 to 1.2 MW and 2 MMBTU/hr heat
    - DFC®3000 – 800 to 1,000 kg/day H_2 plus 2.0 to 2.4 MW and 4 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**
  - **Validate process economics based on system performance**

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