

# Validation of an Integrated Hydrogen Energy Station

Project ID: TV-06

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This presentation contains no confidential information

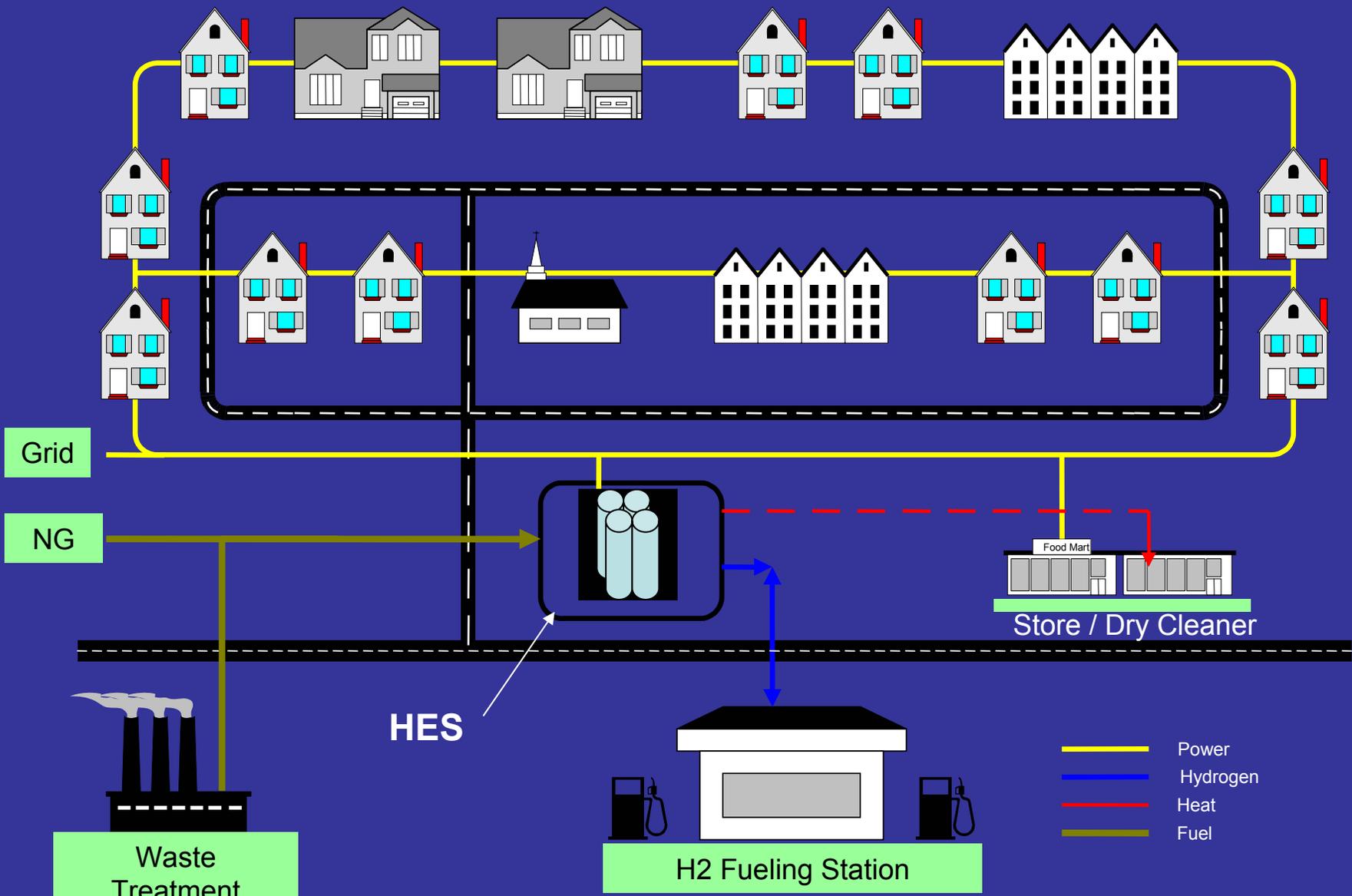


FuelCell Energy

**AIR**  
**PRODUCTS** 

The Air Products logo, consisting of the word "AIR" above "PRODUCTS" in a bold, sans-serif font, followed by a stylized logo icon of a triangle with horizontal lines.

# Hydrogen Energy Station Vision



# Objectives

- Overall Project
  - To demonstrate the economic and technical viability of a hydrogen energy station using a high temperature fuel cell designed to produce power and hydrogen
  - Maintain safety as a top priority in the system design and operation
- Past Year
  - Completed Phase 2- System Design
  - Phase 3 Go / No-Go Decision
  - Submitted Continuation Application

# Objectives by Phase

- Phase 1A- Evaluated PEM (Completed FY03)
- Phase 1B- Evaluation of HTFC Coproduction (Completed FY04)
  - Co-production efficiencies: 55%-60% (LHV)
  - Potential to meet the DOE targets while producing power for less than 0.10 \$/kW
- ✓ • Phase 2- System Design In Progress (In Progress)
  - Select Fuel Cell Technology
  - Engineering Development
  - GO / No-GO Decision
- Phase 3: Detailed Design and Construction (FY06 – 07)
- Phase 4: Operation, Testing, Data Collection (FY07 – 08)

# Overview: Budget

- **Total Project Budget:**
  - \$1,446,877
- **Cost Sharing:**
  - DOE - \$723,438
  - APCI and Partners – balance.
- **FY2005 Total Spend**
  - \$413,866 k
- **FY2006 DOE Funding**
  - \$1,620,086 (Pending Approval)

# Overview: Technical Barriers and Targets

- **DOE Technical Barriers**
  - **Technical Validation (Section 3.5.4 of HFCIT Program Report), Task #4.**
    - B. Storage
    - C. H<sub>2</sub> Refueling Infrastructure
    - I. Hydrogen and Electricity Coproduction
- **DOE Targets**
  - **H<sub>2</sub> Production (Table 3.1.2 of HFCIT Program Report), Task #3.**
    - Cost of H<sub>2</sub>:
      - \$3/kg 2005
      - \$1.50/kg 2010
  - **Energy Station Coproduction of H<sub>2</sub> and Electricity (Table 3.1.2, Task #4)**
    - Durability > 40,000 hours
    - Electrical Efficiency > 40%

# Distributed Power and Hydrogen

FuelCell Energy DFC-300



50%  
Power

15%  
Heat



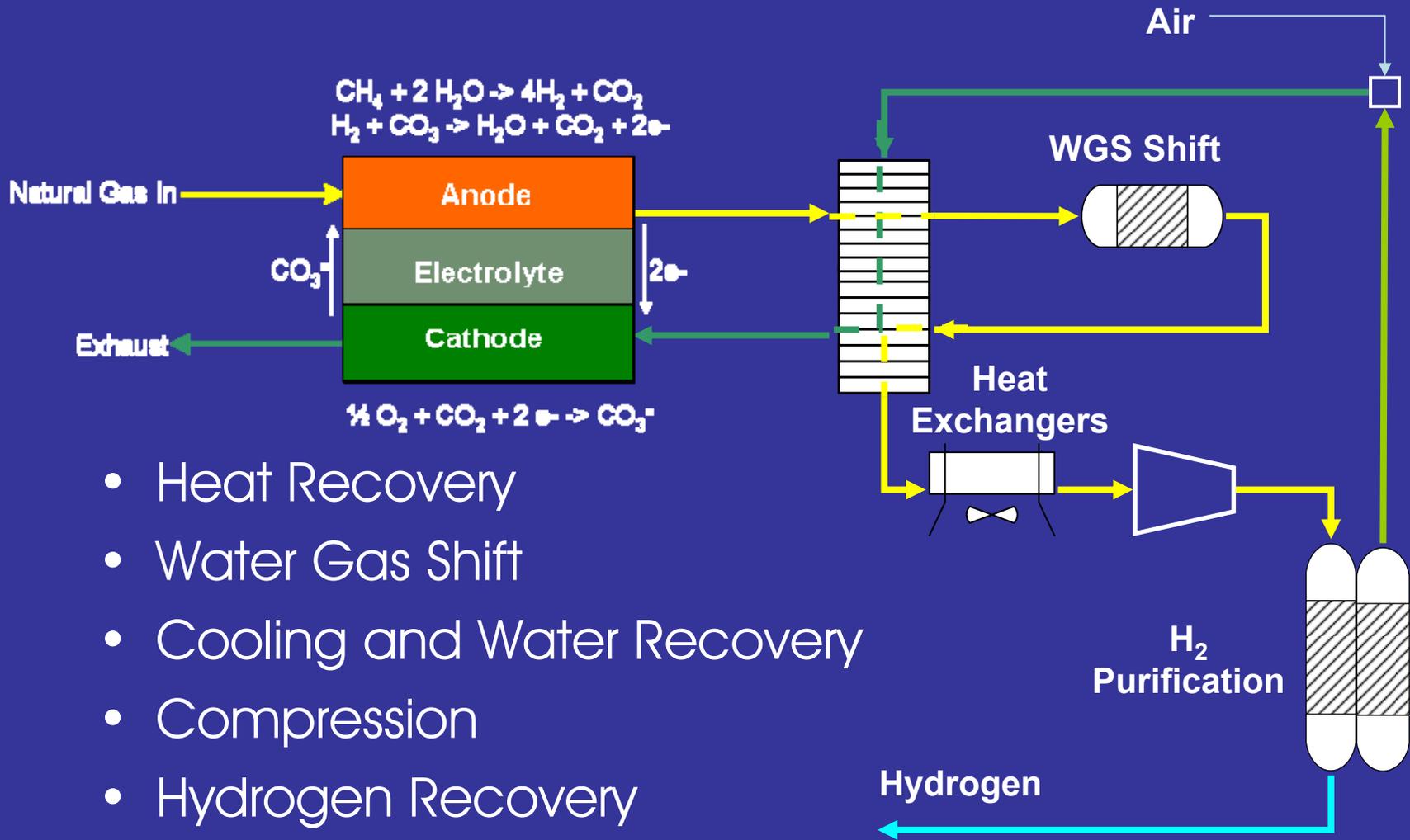
20%  
H<sub>2</sub>



# Phase 2 Plan

- **Engineering Design and Development**
  - **Detailed Engineering Development, Design, and Cost Estimate**
    - Anode Gas Handling (FCE)
    - Hydrogen Purification (APCI)
    - Integration (APCI & FCE)
  - **Economics Updated**
- **Phase 3 Go - No-Go Decision**

# Hydrogen Coproduction using MCFC



- Heat Recovery
- Water Gas Shift
- Cooling and Water Recovery
- Compression
- Hydrogen Recovery
- Tailgas Integration

# Anode Gas Handling

- Evaluated design options for processing anode exhaust
- Assessed safety and control requirements for integrating DFC power plants with APCI subsystem for H<sub>2</sub> separation
- Developed preliminary P&ID
- Sized processing equipment
- Completed cost estimates
- Developed preliminary layout
- Tested critical components

# FCE Component Testing

- Fuel Cell Operation at H<sub>2</sub> Export Design Conditions
- Electrolyte Filter
- Heat Exchanger Train
- Shift Reactor

# Purification Development Program

- Investigated over 25 different hydrogen separation and purification technologies
- Selected Pressure Swing Adsorption Process for further Development
  - Cycle Simulation Completed
  - Adsorbent Mix Selected
  - Lab Testing Completed
  - Pilot Plant Verification Completed
  - Optimized PSA system
  - Patent Applications in Progress

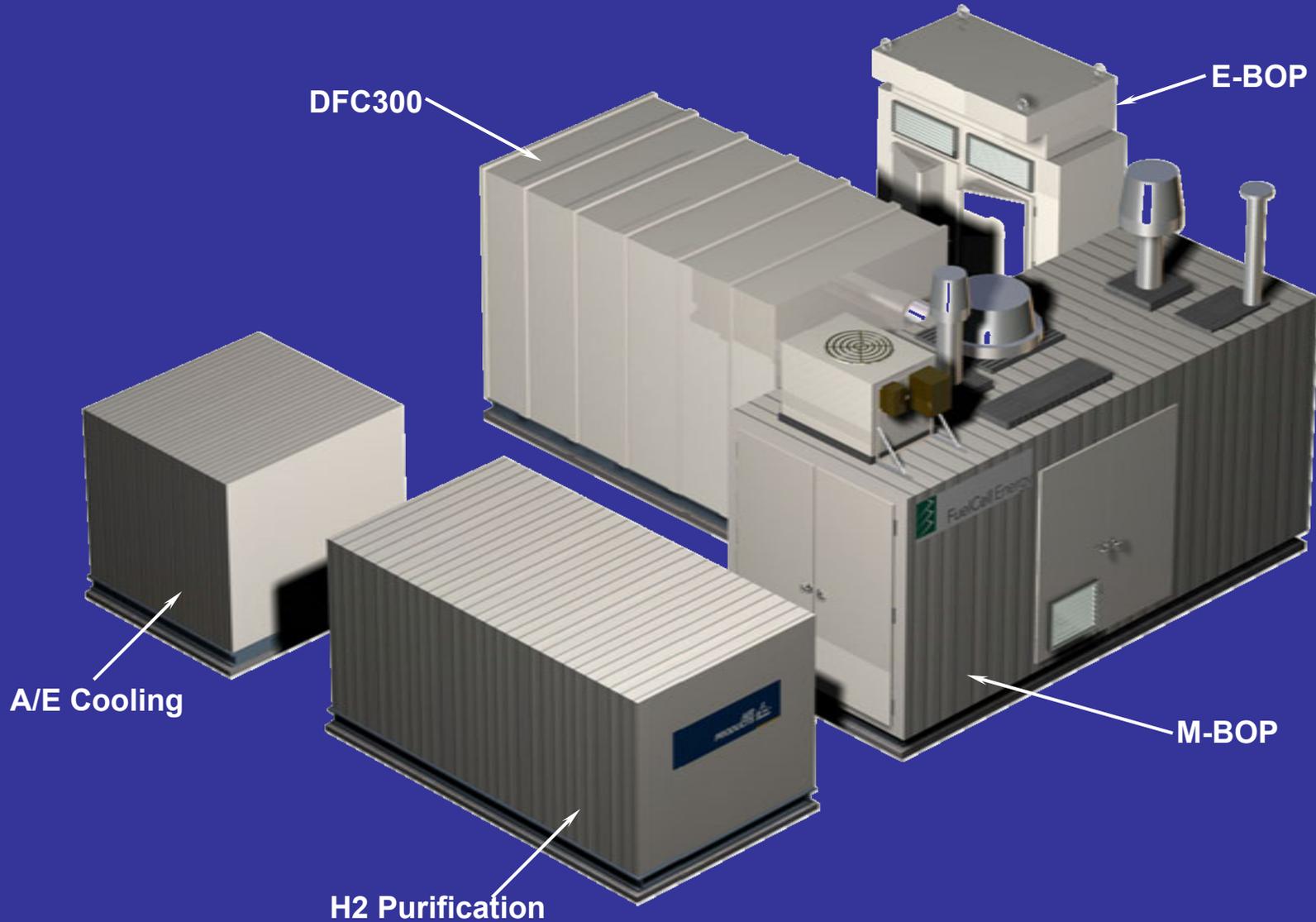
# Purification System Design

- PSA System Design Completed- PFD, P&ID, H&MB
- Compressor Specified and Selected
- Process Control Strategy Developed
- Equipment Quotes and Fabrication Estimates Completed
- Installation Costs Estimated

# Integration

- PFD
- H&MB
- Plot Plan
- Technical Risk Plan
- Preliminary Hazop
- Process Control Strategy
- Start-up / Shutdown Plan
- Installation /Construction
- Testing Strategy
- Security Review

# Hydrogen Energy Station



# Projected Performance

	Units	Phase I
<b>Overall Efficiency</b> (Net Power + Hydrogen Product) / (Fuel)	LHV	60%
<b>Power Efficiency</b> Net Power / (Total Fuel – Hydrogen Product)	LHV	49%
<b>Hydrogen Efficiency</b> (Hydrogen Product – Purification Power) / Hydrogen Product	LHV	68%
<b>Hydrogen Product</b>	Nm <sup>3</sup> /hr	~ 40
<b>Net Power w/o &amp; w Hydrogen</b>	kW	~ 247 / 207
<b>Natural Gas Flow</b>	Nm <sup>3</sup> /hr	~ 55

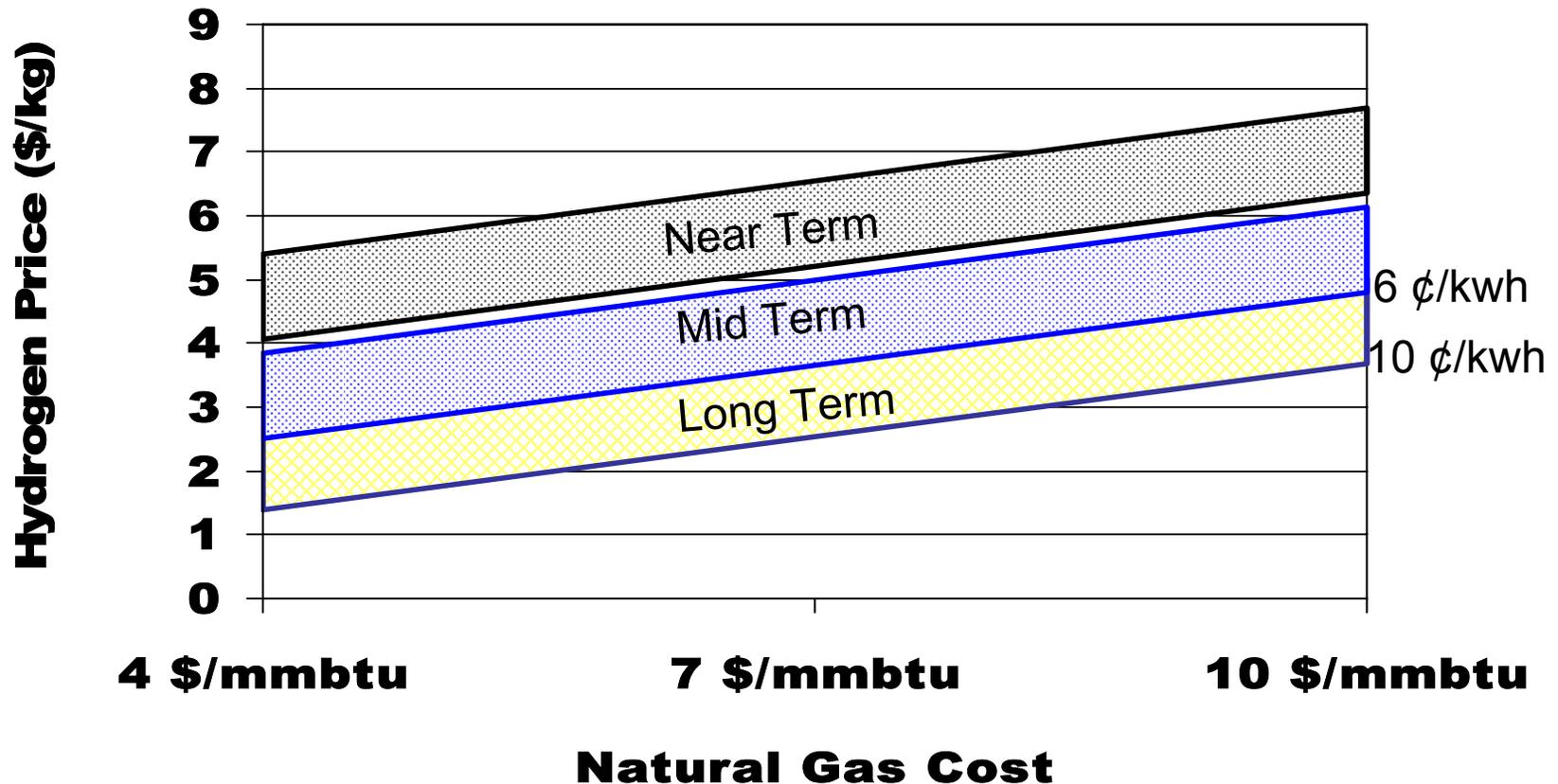
# Projected Performance

	Units	Phase I	Phase II
<b>Overall Efficiency</b> <small>(Net Power + Hydrogen Product) / (Fuel)</small>	LHV	60% →	66%
<b>Power Efficiency</b> <small>Net Power / (Total Fuel – Hydrogen Product)</small>	LHV	49%	49%
<b>Hydrogen Efficiency</b> <small>(Hydrogen Product – Purification Power) / Hydrogen Product</small>	LHV	68% →	77%
<b>Hydrogen Product</b>	Nm <sup>3</sup> /hr	~ 40 →	~ 80
<b>Net Power w/o &amp; w Hydrogen</b>	kW	~ 247 / 207	~ 300 / 243
<b>Natural Gas Flow</b>	Nm <sup>3</sup> /hr	~ 55	~ 74

# Economics: Assumptions

- Project Life: 15 Years
- Depreciation: 15 Years
- Inflation: 1.9%
- Tax Depreciation: 5 Year MACRS
- DCF Return: 10%
- Overheads: 20%
- Taxes: 37.8%
- Maintenance: Bottom Up Estimation

# Hydrogen Energy Station Economics



Product Profile: 1200 kW Power / 700 kg/day hydrogen

# Future Work

- Execute Phase III
  - Order Equipment
  - Fabricate Skids
  - Assemble and Test Complete System at FCE
  - Go-No Go for Phase 4 (18 months)
- Phase IV (FY 2008)
  - Install at Selected Site
  - 12 Month Demonstration

# Response to Reviewers Questions

- “Baloney! The numbers presented were theoretical and not bottoms up analytical...”
- “The Results need to indicate whether this is an economically-viable approach to H2 Production in the long term”
- “Public condemnation as waste and abuse of DOE funds. This is a blatant attempt to use gov’t money for incremental product/system improvements to the sole benefit of APCI and FCE.”

**Thank you**