Validation of an Integrated Hydrogen Energy Station

Project ID: TV-06

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This presentation contains no confidential information

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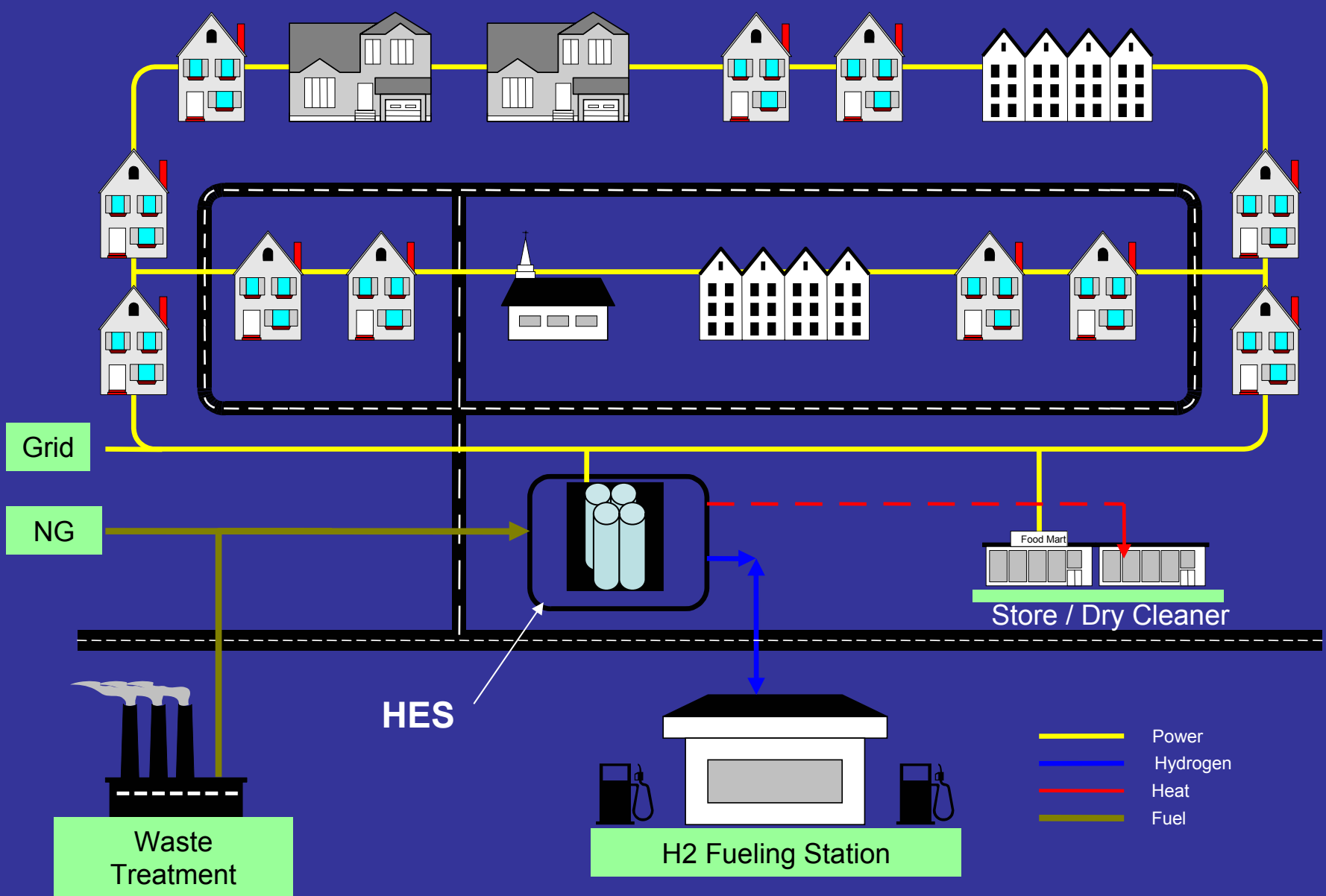
Hydrogen Energy Station Vision



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_2 Refueling Infrastructure
    - I. Hydrogen and Electricity Coproduction
- **DOE Targets**
  - **H_2 Production (Table 3.1.2 of HFCIT Program Report), Task #3.**
    - Cost of H_2:
      - $3/kg 2005
      - $1.50/kg 2010
  - **Energy Station Coproduction of H_2 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

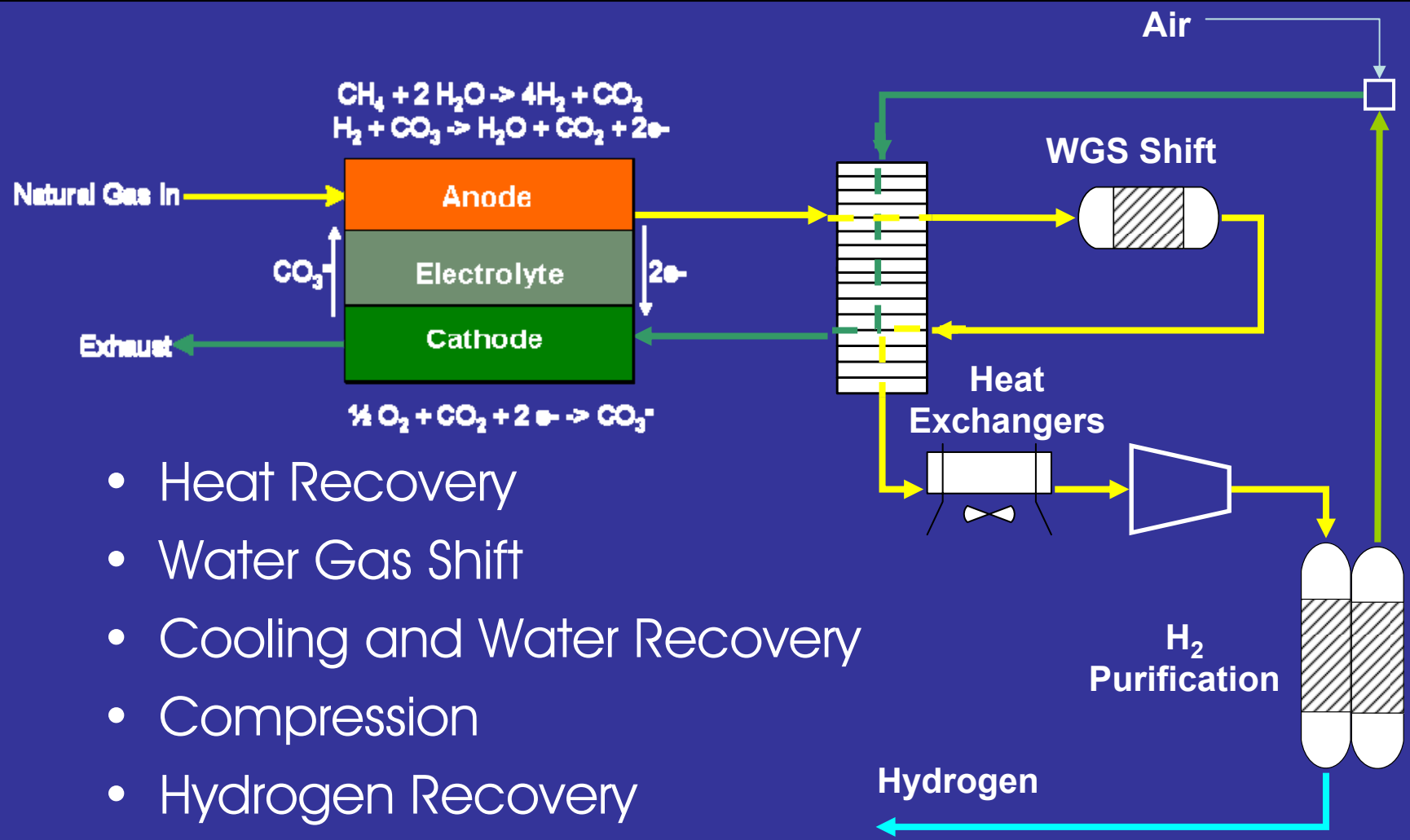
20%
H_2

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 H2 separation
- Developed preliminary P&ID
- Sized processing equipment
- Completed cost estimates
- Developed preliminary layout
- Tested critical components

FCE Component Testing

- Fuel Cell Operation at H2 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

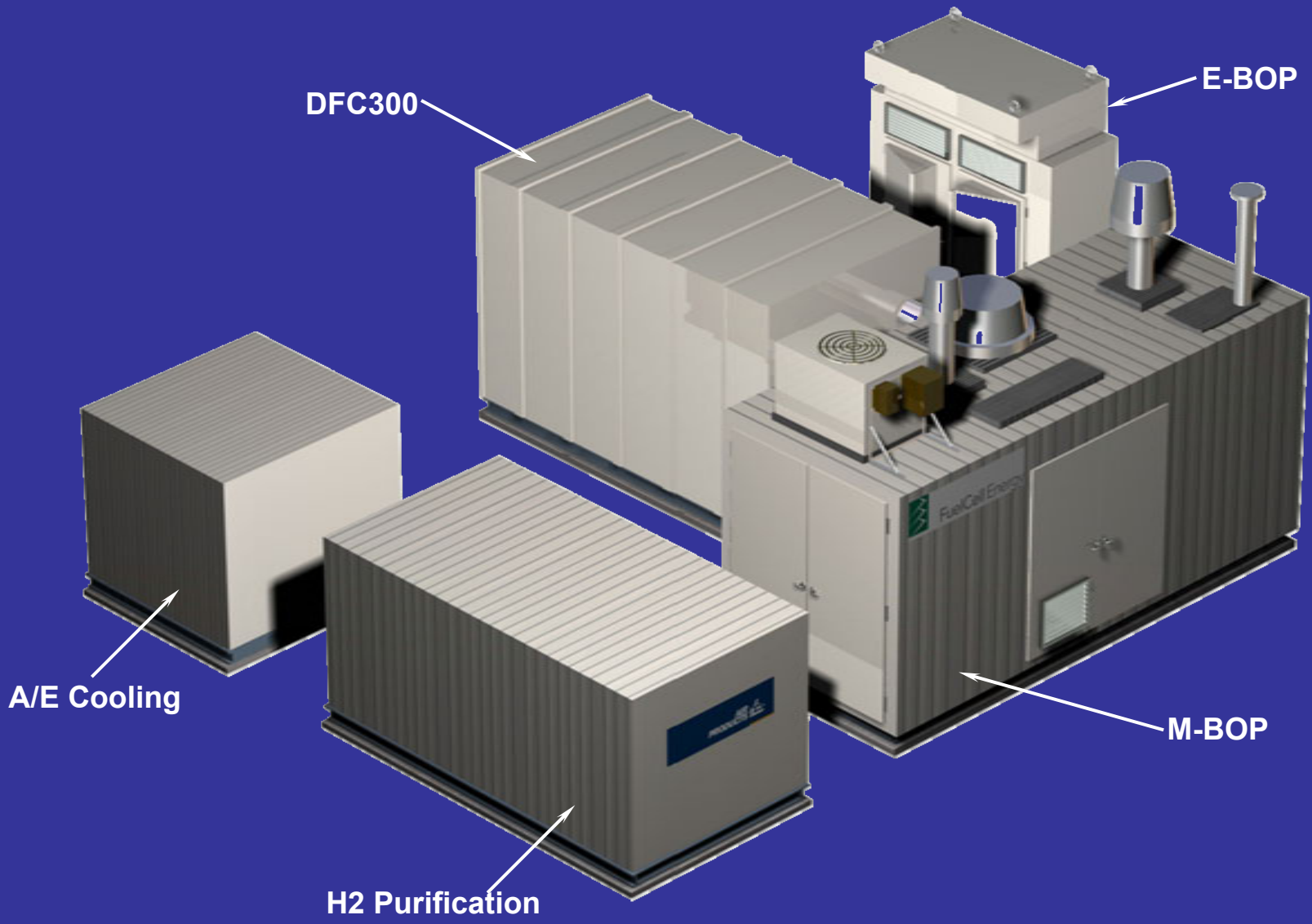
Purification System Design

- 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
Overall Efficiency (Net Power + Hydrogen Product) / (Fuel)	LHV	60%
Power Efficiency Net Power / (Total Fuel – Hydrogen Product)	LHV	49%
Hydrogen Efficiency (Hydrogen Product – Purification Power) / Hydrogen Product	LHV	68%
Hydrogen Product	Nm3/hr	~ 40
Net Power w/o & w Hydrogen	kW	~ 247 / 207
Natural Gas Flow	Nm3/hr	~ 55

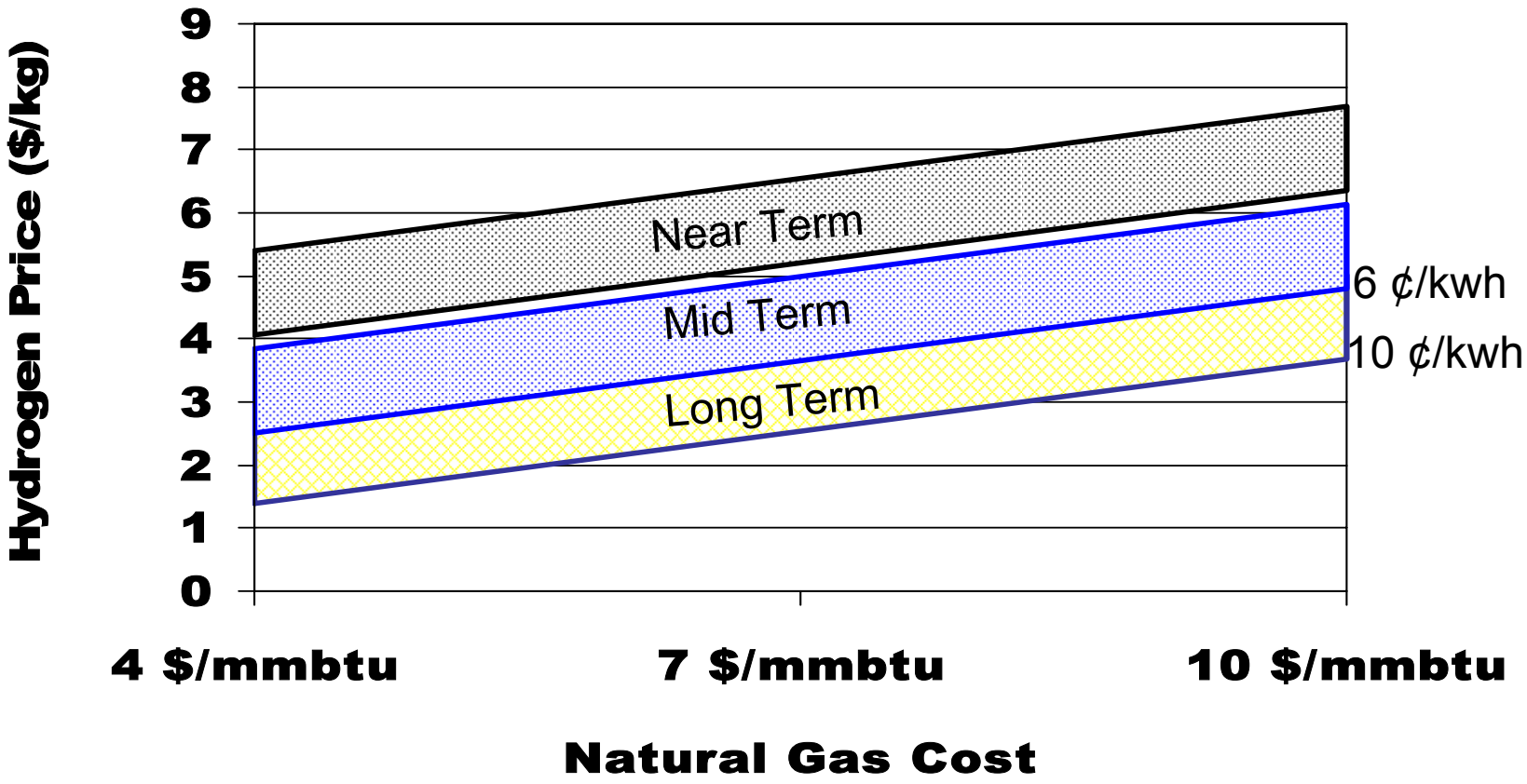
Projected Performance

	Units	Phase I	Phase II
Overall Efficiency (Net Power + Hydrogen Product) / (Fuel)	LHV	60% →	66%
Power Efficiency Net Power / (Total Fuel – Hydrogen Product)	LHV	49%	49%
Hydrogen Efficiency (Hydrogen Product – Purification Power) / Hydrogen Product	LHV	68% →	77%
Hydrogen Product	Nm3/hr	~ 40 →	~ 80
Net Power w/o & w Hydrogen	kW	~ 247 / 207	~ 300 / 243
Natural Gas Flow	Nm3/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

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