

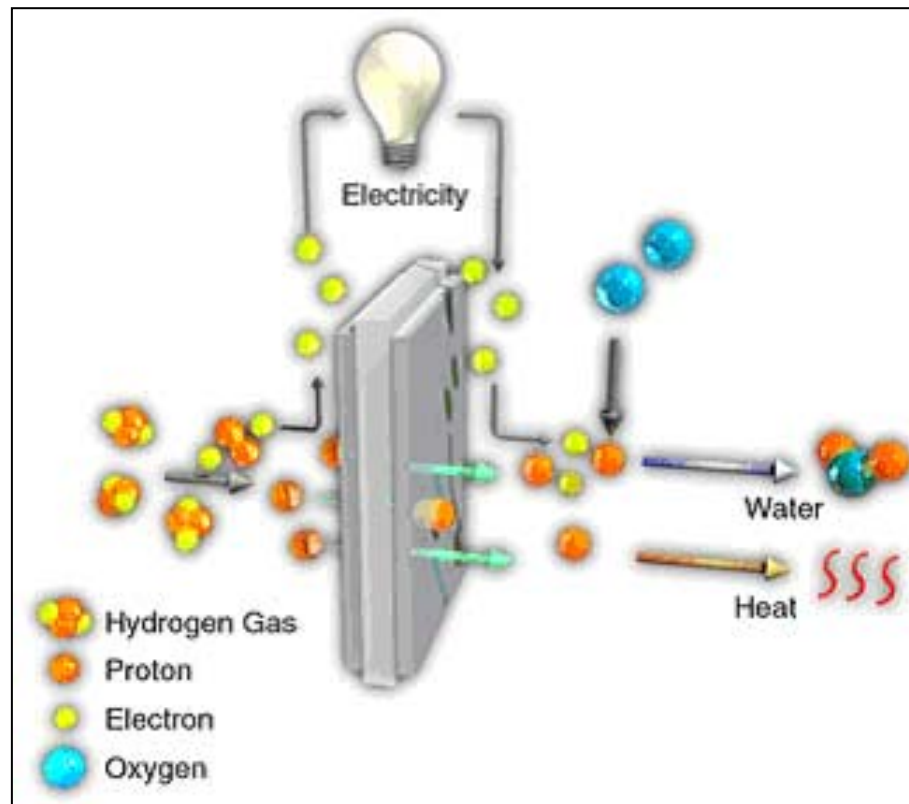
Large Scale Stationary Fuel Cell Commercialization Using Existing Hydrogen Infrastructure

Louisiana Energy Summit

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Fuel cells generate high quality, efficient, reliable, emission-free power from hydrogen



Fuel cells: Status of commercialization

Type	Status	Remark
PAFC		
AFC		
PEM / SPFC		
MCFC		
SOFC [tubular]		
SOFC [planar]	Initial prototype demonstration	Small [1 kW] systems may go fast

What is the problem with PAFC?!

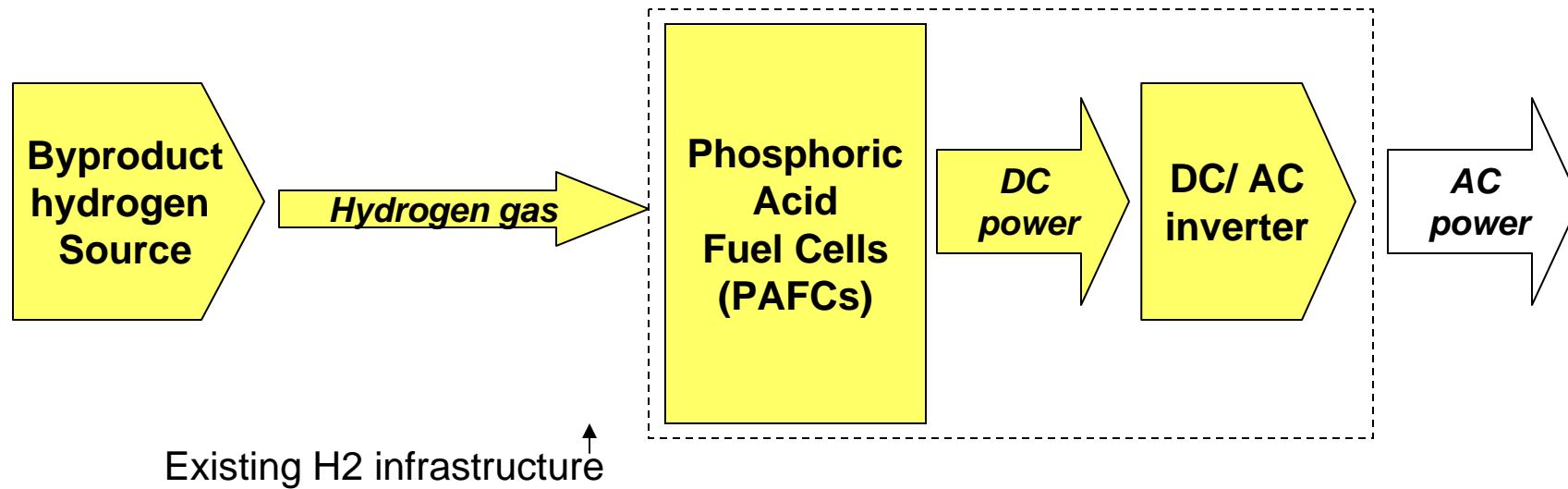
- The only fully commercial fuel cell for large stationary applications
 - Over 300 systems delivered (UTC, Fuji)
 - Excellent product has established performance, emissions benefits of fuel cells
- But they cost too much!
 - Small packaged systems (~100kW order magnitude) suffer from diseconomies of scale for the hydrogen plant
- UTC got out of the business (2000)...
- ...or so everyone thought (2004)...
- ...while Fuji has quietly been improving their technology → 75,000 hour operating life achieved
- Both UTC and Fuji are trying to engineer the capital and life cycle costs out of their system, while staying focused on commercial cogeneration markets
- **PAFC is the proven technology for stationary applications: The only challenge remaining is to get the cost down!**

Cost reduction: THE issue

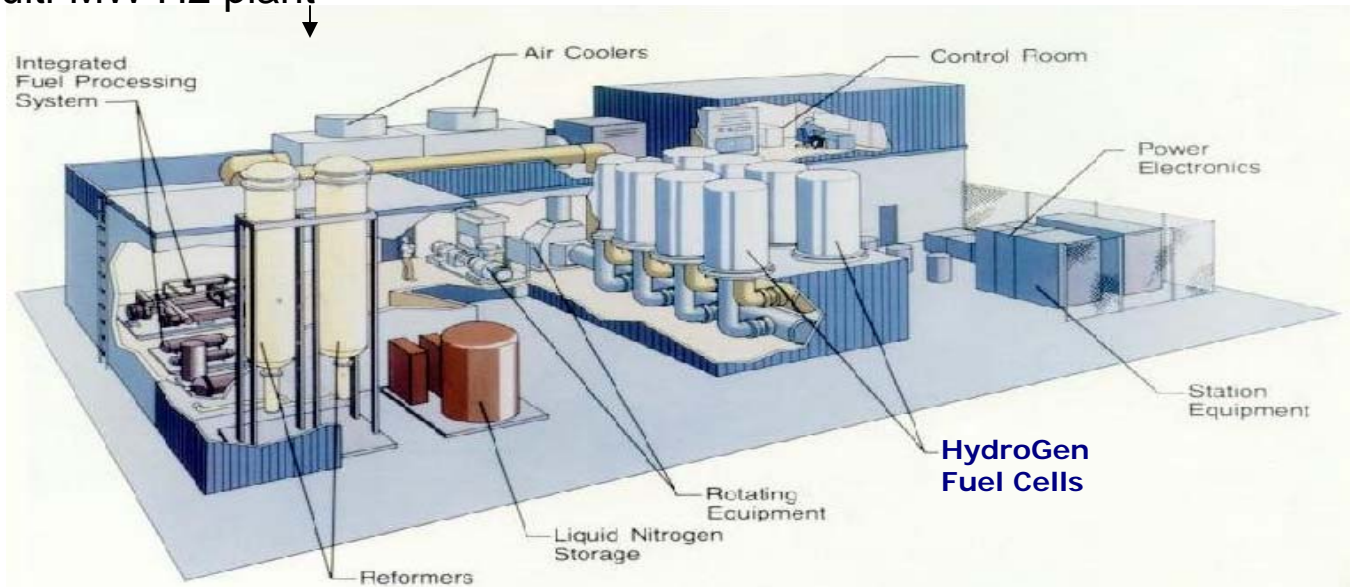
Fuel cell systems (hydrogen) have:

- **Complexity** of fuel cell technology
- **Small sized, integrated** fuel processing
- **Unbundled** fuel processing, using mature hydrogen plant technology or existing H2 infrastructure
- **Large** systems → 3-10MW

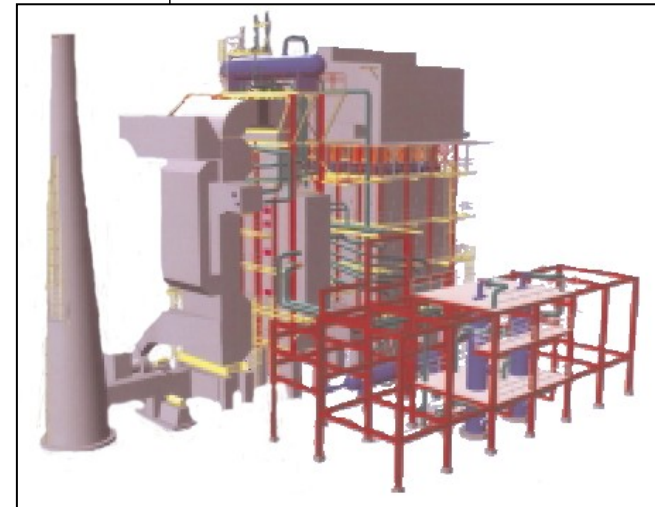
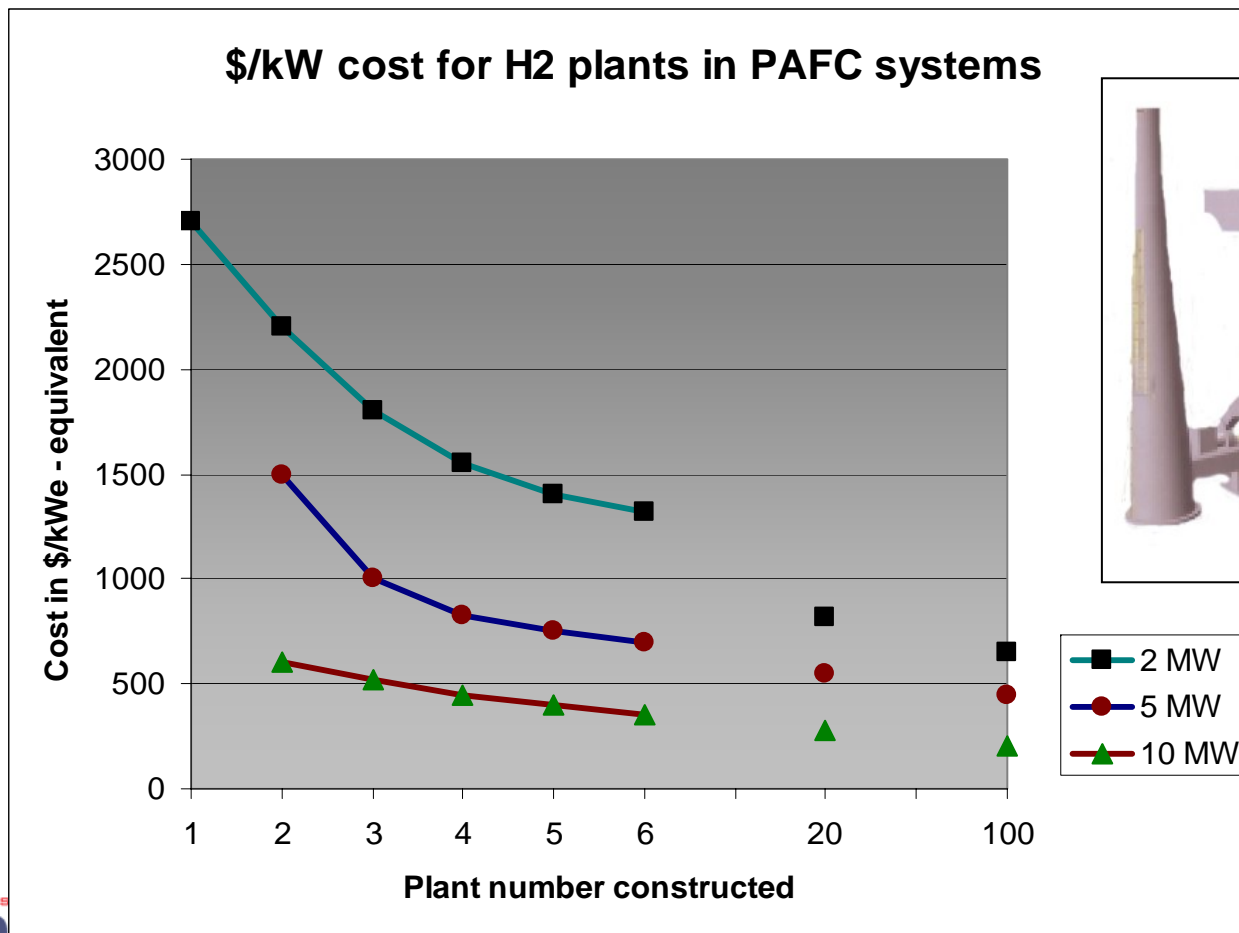
HydroGen unbundled approach



With standard multi-MW H2 plant



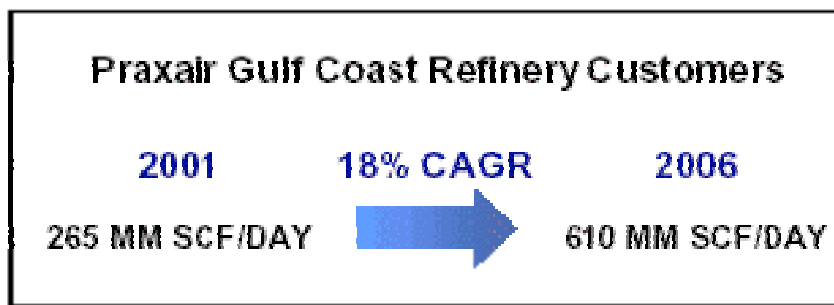
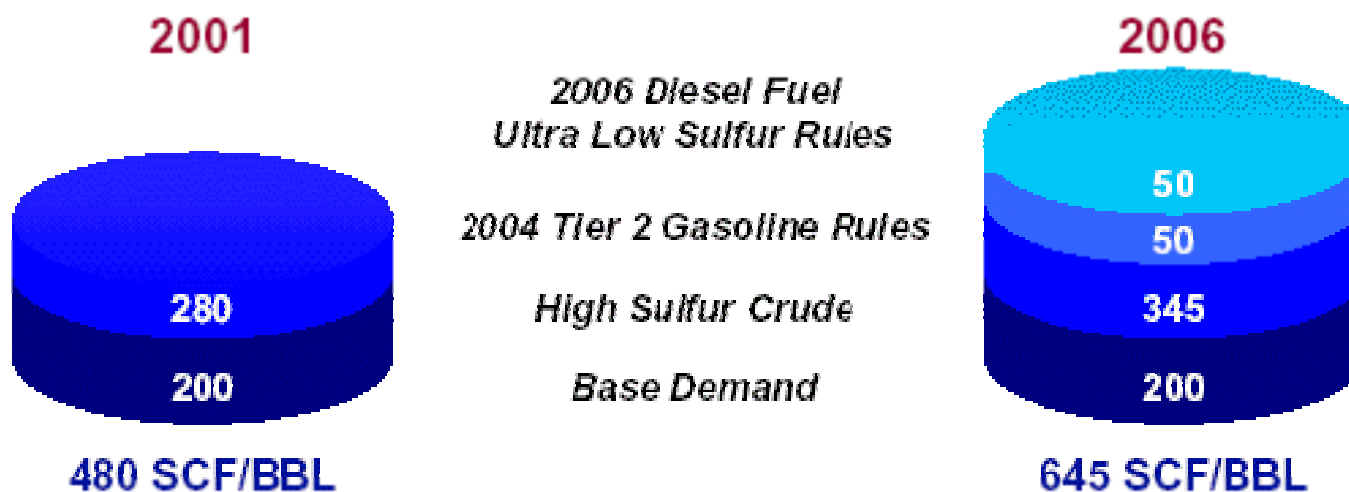
Economies of scale and serial production of standard hydrogen plant technology





Praxair Gulf Coast: Growing Hydrogen Use in Gasoline and Diesel Production

Hydrogen Used Per Barrel of Oil (Standard Cubic Feet)



Value proposition of the unbundled approach in multi-MW systems

- **Cost:** Economies-of-scale of mature hydrogen plant technology, and large niche applications with no fuel processing
 - Capital cost reductions
 - Fuel can be low opportunity cost in certain locations
 - Multi-MW approach also gets you on fast path to volume production of the fuel cell stacks!
- **Reliability and low technical risk:** A 10MW system has 25*400kW generators – redundancy offers system reliability even in market introduction
 - Use of standard H2 plant technology eliminates technical risk for a major component of the fuel cell power plant

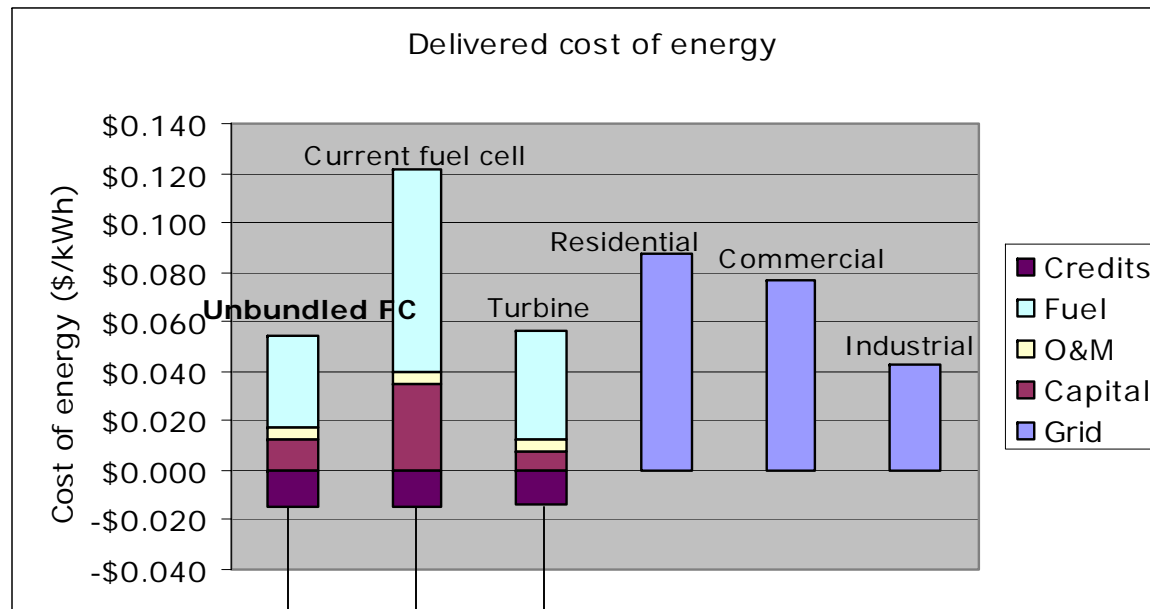
The Gulf Coast market opportunity – emissions driver

- Multiple non-attainment areas
- State Implementation Plans (SIPs) call for significant NO_x emission reductions (in HGA, approximately 70% of the projected 2007 inventory; 90+% for point sources)
- HGA SIP also calls for VOC emission reductions (approximately 25% of the projected 2007 inventory)

The Gulf Coast business case

- Available hydrogen is well over 250MW – enough to support market penetration at very high production volume (at least for fuel cells!)
- Delivered electricity costs for zero-NO_x, zero-VOC, etc. power are “very cheap”
- Very attractive generation cost for utilities and chemical companies who must reduce NO_x under the SIP

Delivered energy costs



\$0.039 **\$0.11** **\$0.042**
 Net electricity cost

Capital = \$1500/kW
Natural gas = \$4.50/MMBtu

Spreadsheet available upon request



Thank you!