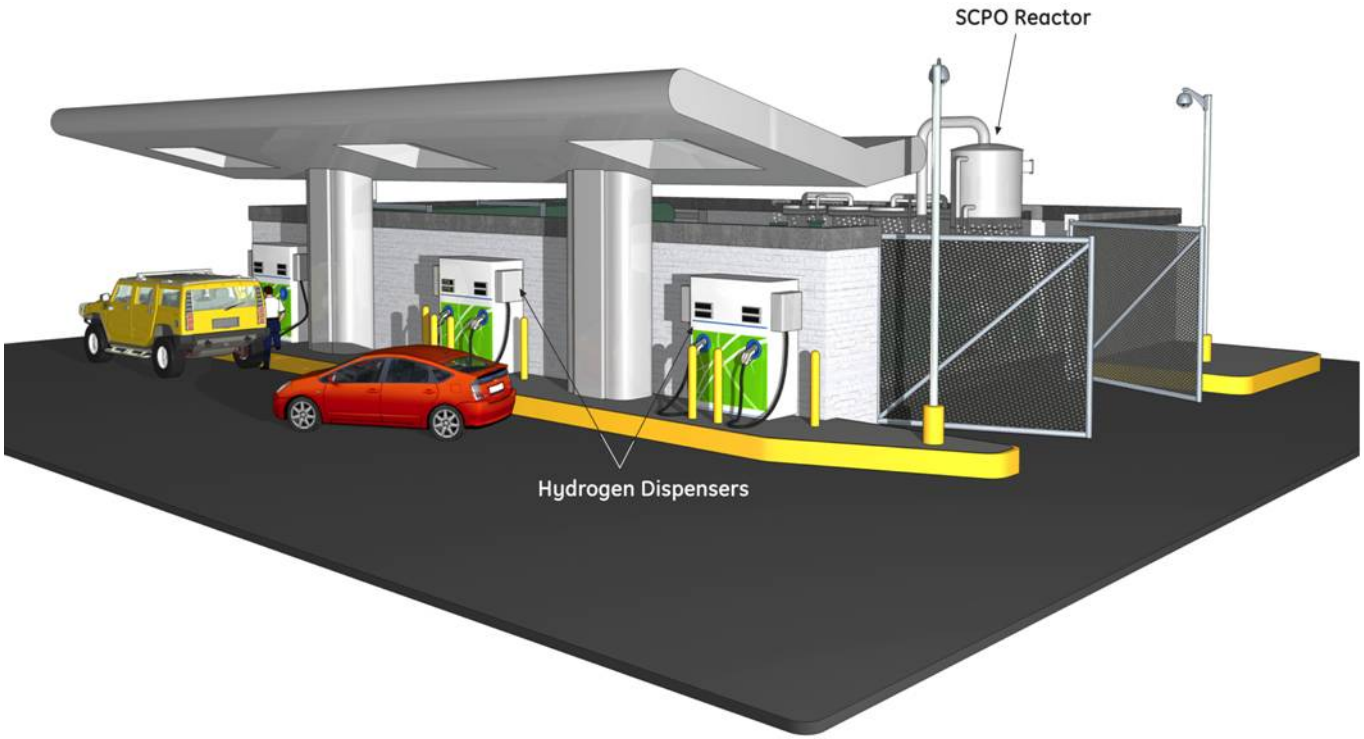
Distributed Hydrogen Fueling Station Based on GEGR SCPO Technology



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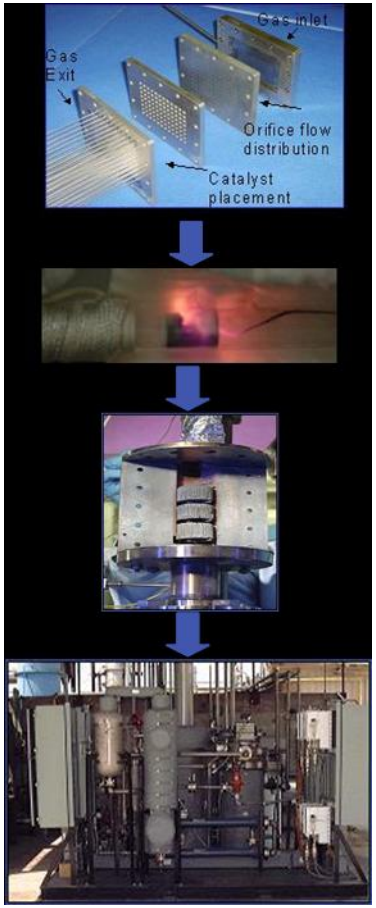
GE Global Research
DOE 11/06/2007

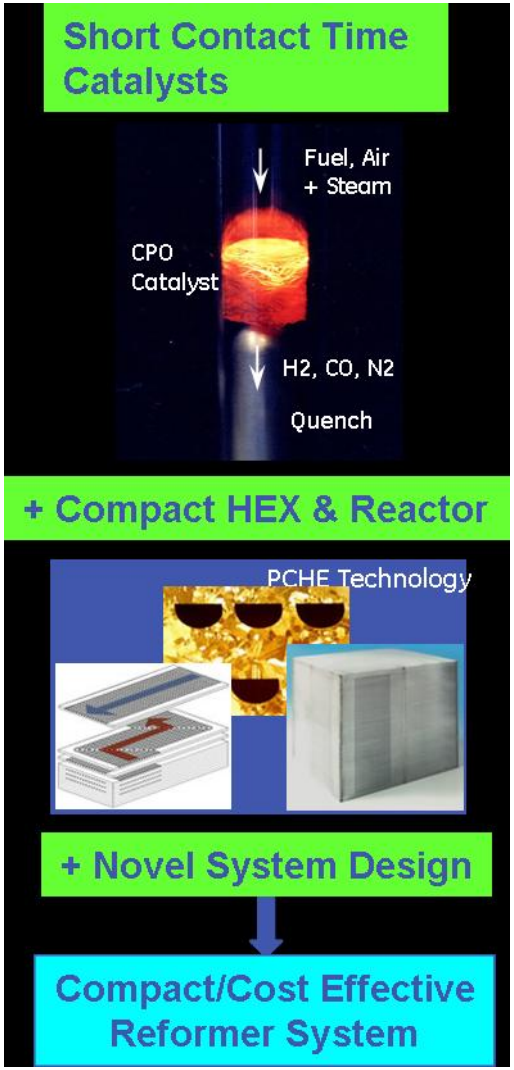
imagination at work

SCPO Reformer for Hydrogen Production

Patented Staging of CPO & SMR Catalysts



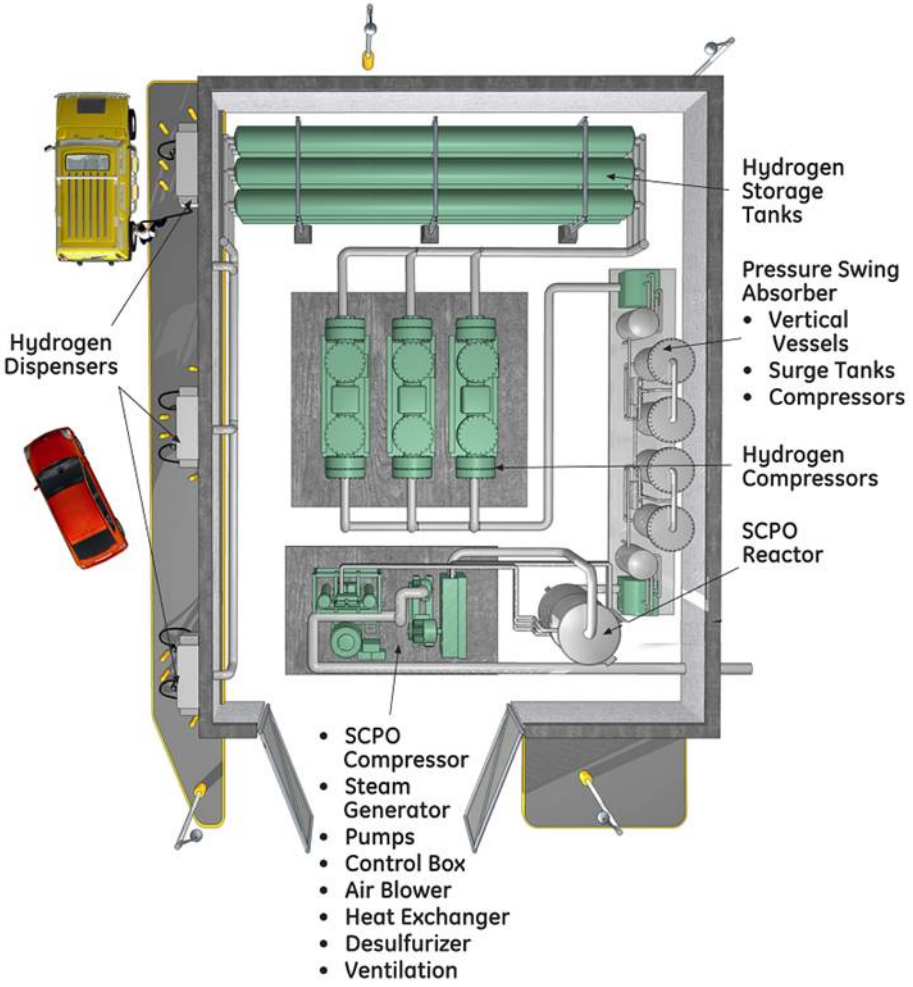
- Most cost effective hydrogen production unit
  - Compact (5 times smaller than ACR)
  - Modular design for mass production
- Ease of ownership
  - "Maintenance free" – Reformer life >10 y; Catalyst life>5 y
  - Fuel flexibility – can reform NG, ethanol & methanol…
- Environmentally sound
  - Higher efficiency
  - No emissions
- Prototype design for 60 kg H2/day. Testing in 2007.



System Definition

Distributed H2 Fueling Station

- > Plant capacity: 1500 kg/da of hydrogen produced
- > Equipment Costs
  - – SCPO Reactor (includin PSA): $1.1~$1.5MM
  - – H2 Compressor: $0.3~$0.5MM
  - – Storage: $1~$1.5MM
  - – Dispenser: $0.08MM
  - – Control + Safety: $0.02
- > Footprint:
  - – SCPO: 3.5’ Diameter; 12.5’ Height



Key Performance Metrics

Gas Hourly Space Velocity:
- SMR 30,000 GHSV
- CPO 500,000 GHSV
- WGS 20,000 GHSV

Feedstock:
- natural gas

% Feed Conversion:
- >90%

% Hydrogen Yield:
- 4.26(Nm^3/kg H2)

Production Efficiency:
- 70.3%;

Total System Efficiency:
- 66.5%

Feed and Energy

Energy input and output

- Primary Feedstock: Natural Gas
  - LHV 38,553 kJ/Nm^3
  - Usage 0.164 GJ/kg H2; 4.26Nm^3/kg H2
  - Cost ($2005) $5/MMBtu; $0.1827/$Nm^3$
- Utility: 3.48 kWhe/kg H2

Other inputs

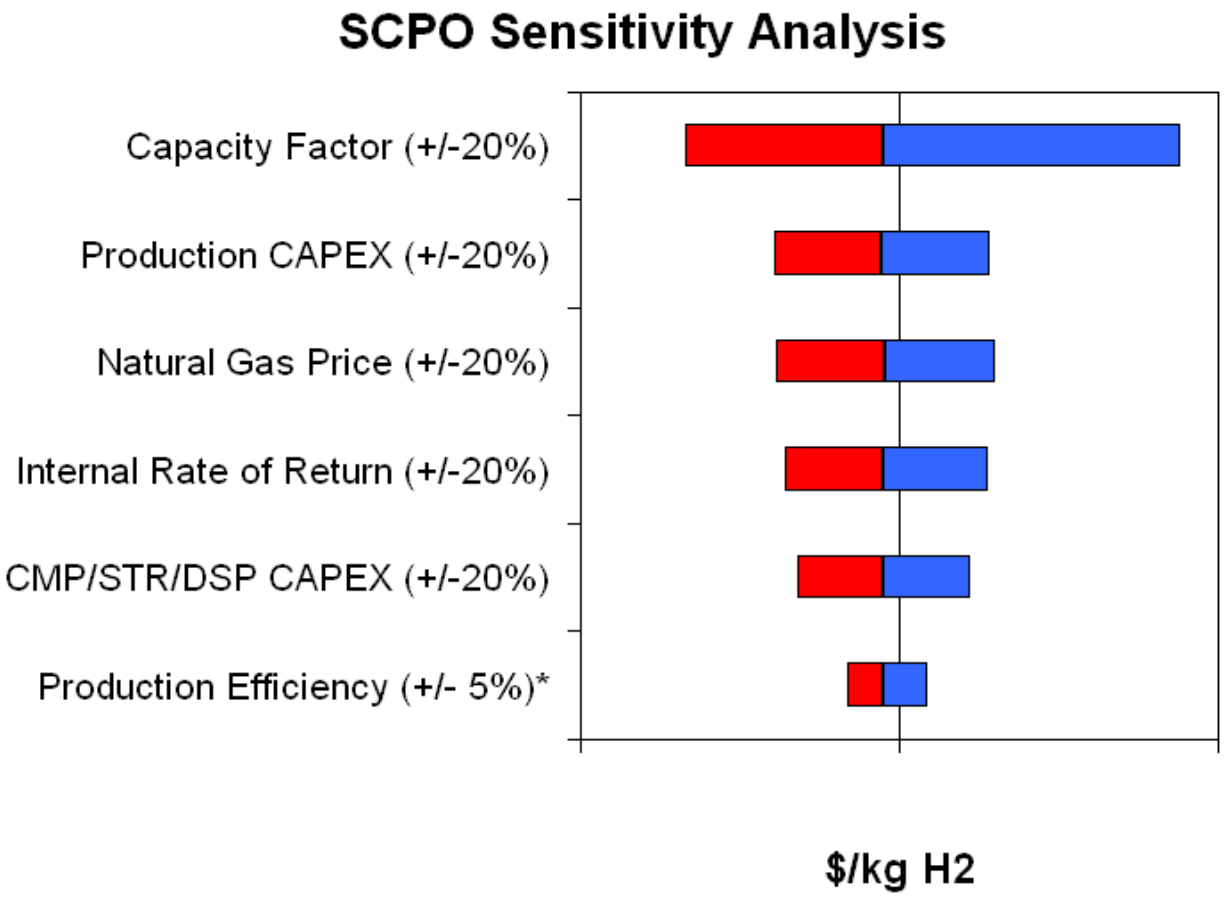
- Process water 11.3 L/kg H2

No other material input or output

Unique H2A Inputs

- Total Capital Investment: $3.3 ~ $3.5MM
- Primary feedstock: Industrial natural gas 4.26(Nm^3/kg H2) or 0.164 (GJ LHV/kg H2)
- H2 compression 150Psi to 6250 psi
  - Electricity 1.74 kWhe/kg H2
  - Compression equipment $5200/(kg/hr)
- Production energy consumption
  - Electricity 1.736 kWhe/kg H2
- Total yearly operating costs excluding energy: $0.3MM/Yr

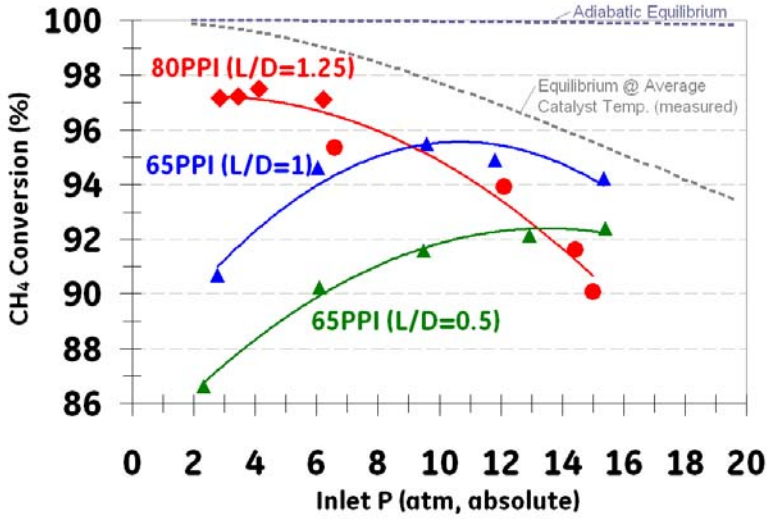
Sensitivity Analysis

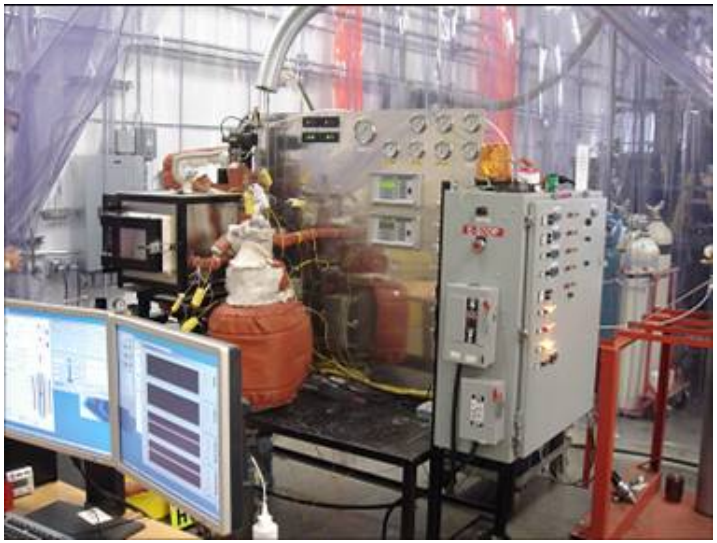


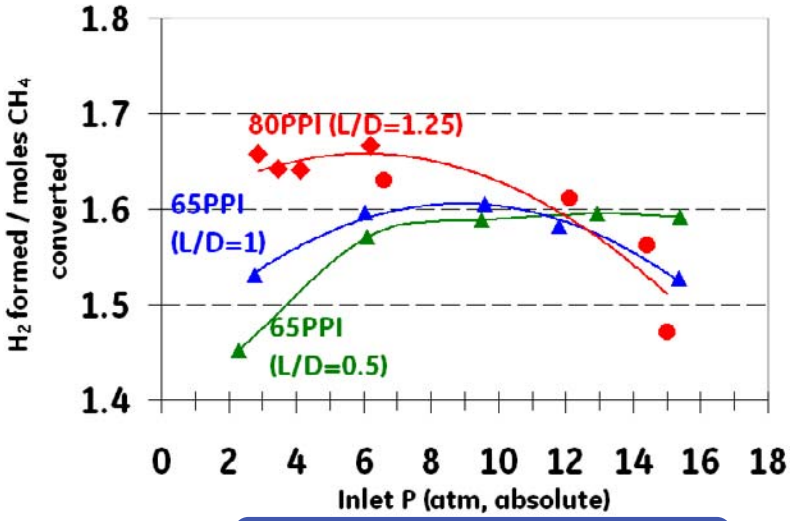
The selling price of hydrogen is driven by capacity factor, production CAPEX and natural gas price

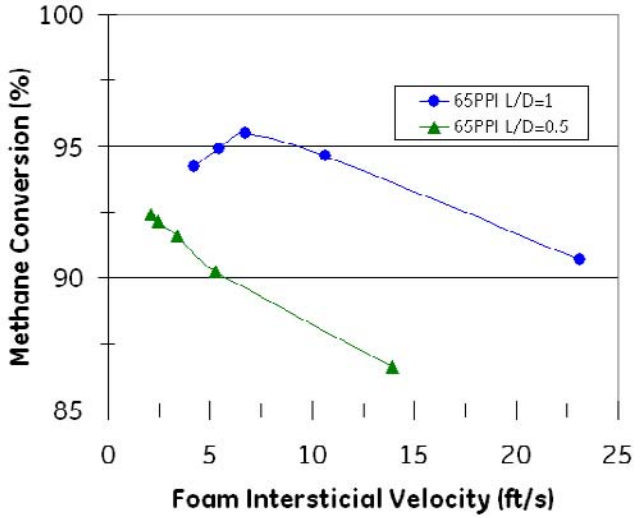
Addressing Questions & Comments from May 2007 DOE Hydrogen Program Annual Merit Review

Q&A – Latest Progress and Data









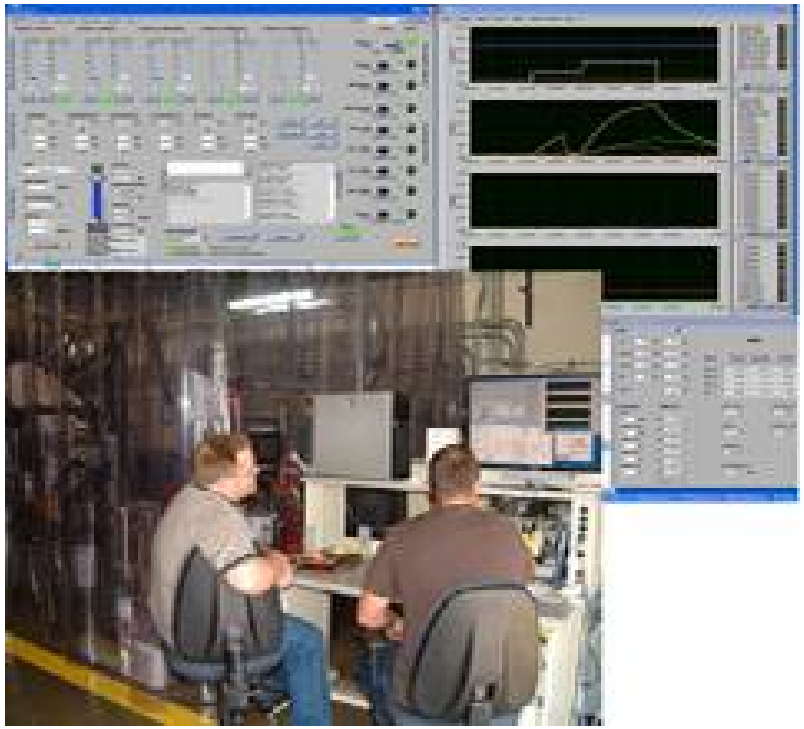
PPI and L/D are design criteria for heat and mass transfer characteristics

High Pressure Performance at GEGR, 500k GHSV, O_2/C=0.67, S/C=1

- Performance of different catalyst structures appear similar at elevated pressures

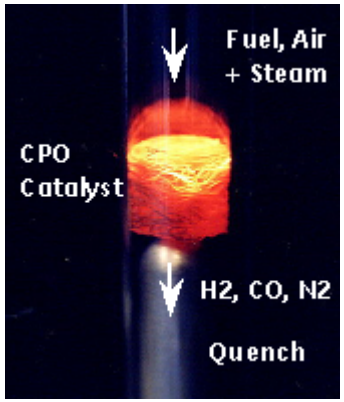
Q&A – Latest Progress and Data

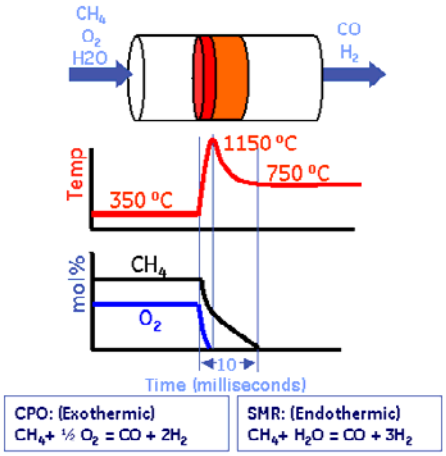
High pressure SMR and WGS being tested at 60kg/day scale



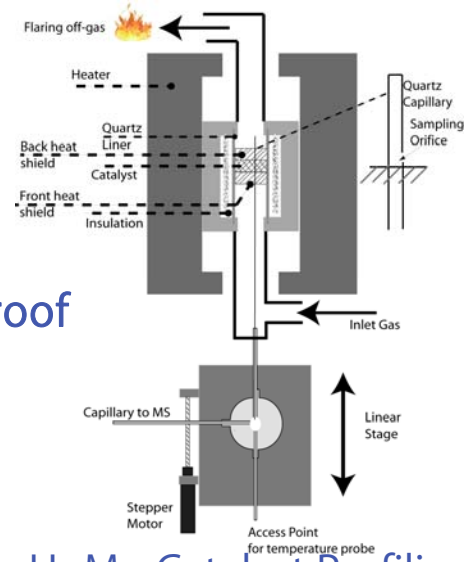
Q&A - What's New and Innovative?

Hypothesis

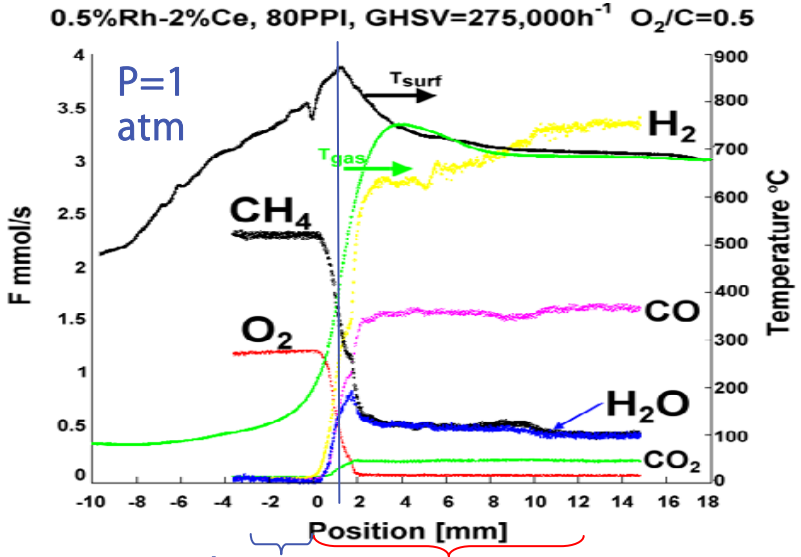




Experimental proof



UoMn Catalyst Profiling



Partial oxidation

Steam Reforming

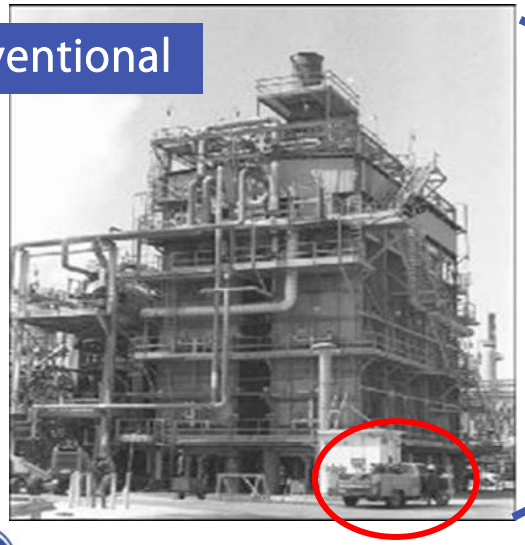
Fundamental understanding of CPO kinetics, experimental proof of hypothesis of CPO chemistr

Q&A – How's Cost Reduction Derived?

The GEGR SCPO technology uses state of the art short contact time CPO catalysts and integrates CPO, SMR and WGS all in one vessel

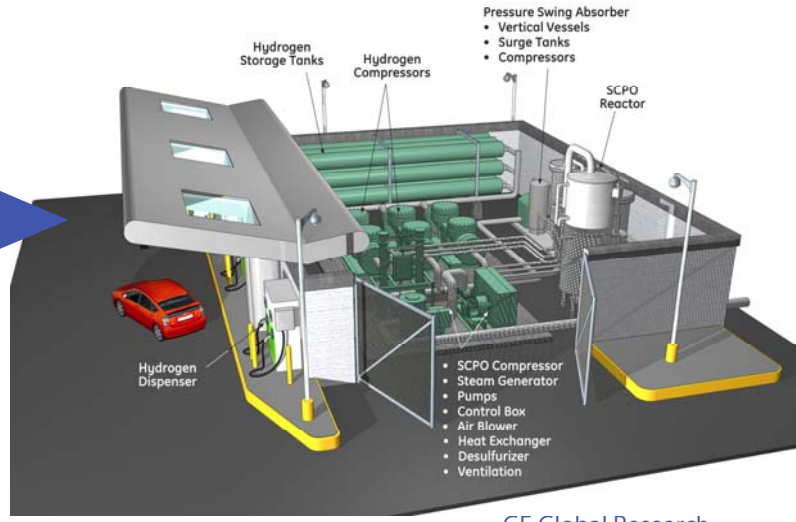
	Conventional	SCPO
Steam Methane Reforming $CH_4 + H_2O \rightarrow CO + 3H_2$ $\Delta H \cong +206$ kJ/mol	GHSV ≅ 3,000 / hr Catalyst V ≅ 30 L	GHSV ≅ 30,000 / hr Catalyst V ≅ 3 L
Catalytic Partial Oxidation $CH_4 + ½\ O_2 \rightarrow CO + 2H_2$ $\Delta H \cong -36$ kJ/mol	GHSV ≅ 10,000 / hr Catalyst V ≅ 4 L	GHSV ≅ 500,000 / hr Catalyst V ≅ 0.08 L
Water Gas Shift $CO + H_2O \rightarrow CO_2 + 2H_2$ $\Delta H \cong -41$ kJ/mol	GHSV ≅ 2,000 / hr Catalyst V ≅ 35 L	GHSV ≅ 20,000 / hr Catalyst V≅ 3.5 L

Conventional



Advanced Catalysis and integration

Shrink volume of reactor



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