Oxygen Transport Membrane Based OxyCombustion for CO_2 Capture from Coal Power Plants

Jamie Wilson, Maxwell Christie, Nick Degenstein, Minish Shah, Juan Li (Praxair, Inc.),

V. Venkateswaran (ENrG Inc),

Eric Eddings and Joseph Adams (University of Utah)

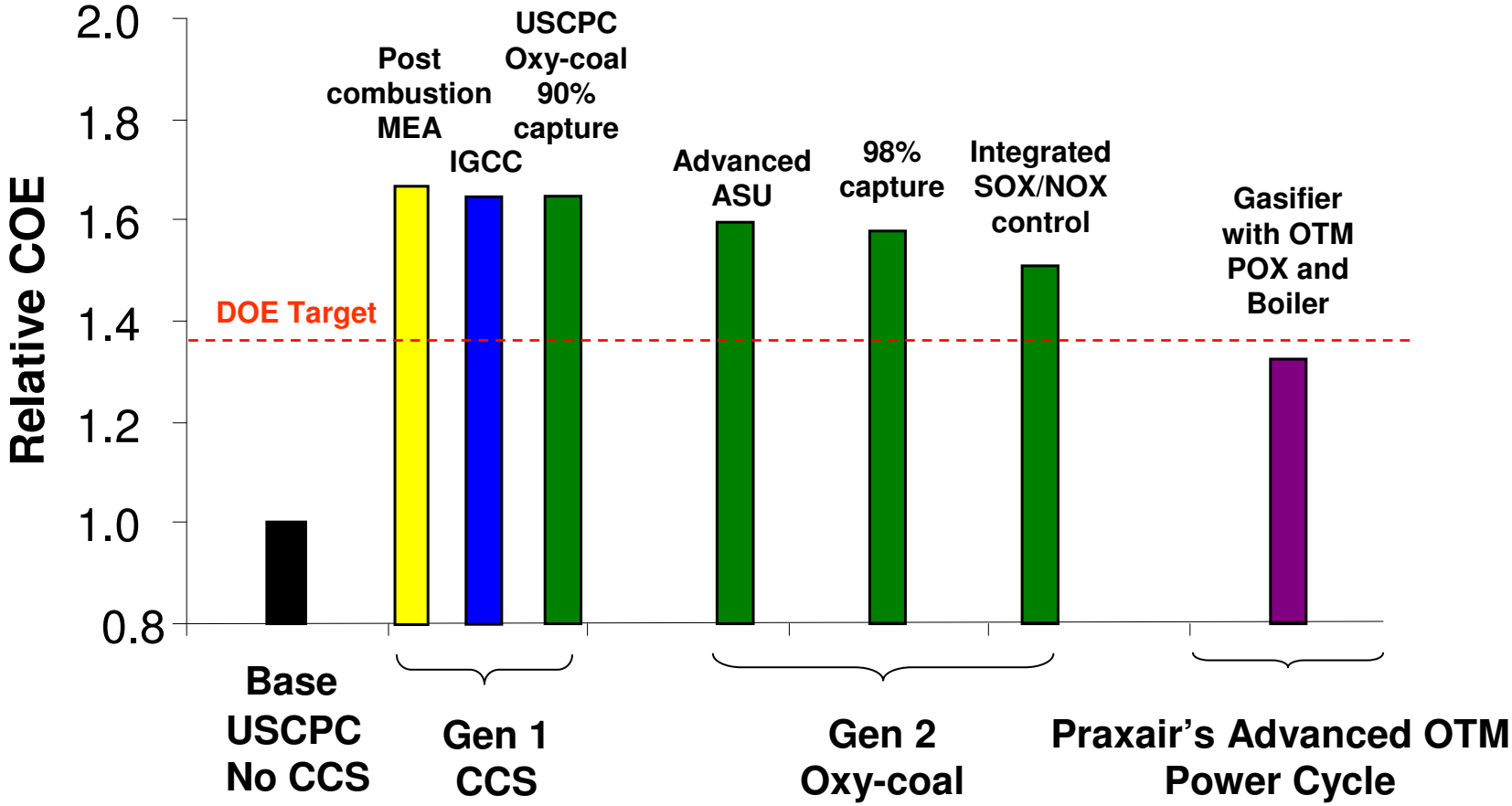
Praxair

Praxair Clean Coal Technologies	
Oxy Coal Combustion	• Oxygen Supply • CO_2 Capture • Oxy-Coal Burners • High Temperature Coatings • Tar Mitigation Solutions • Oxygen Transport Membrane (OTM)

- Fortune 300 company with over $10 billion revenues in 2008
- One of the leading industrial gas suppliers in the world
- Largest industrial gas supplier in North and South America

www.praxair.com

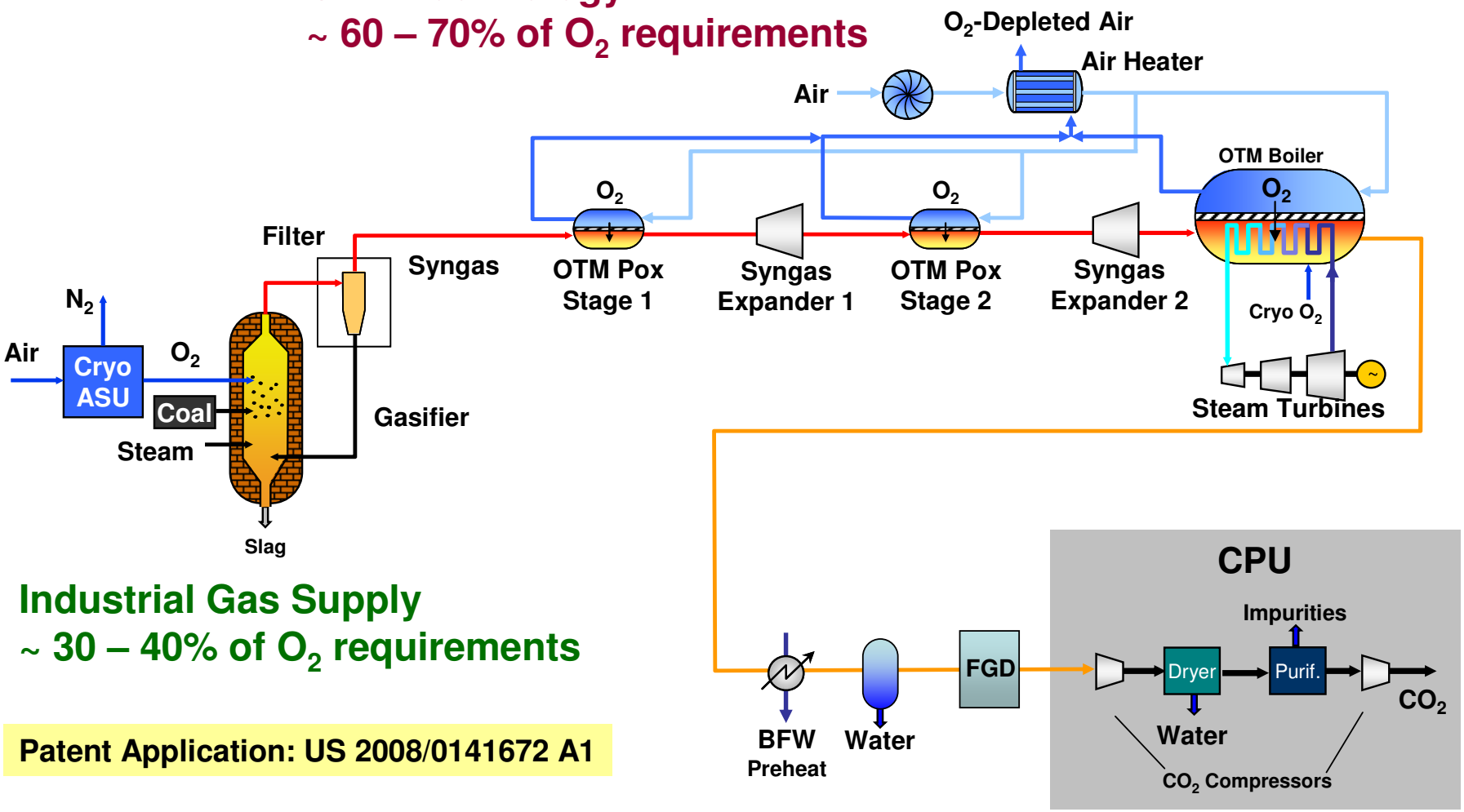
Advancing Oxyfuel Technology – Relative COE



Commercial now	Demo/scale up Ready full scale in 2015	Developmental Commercialize 2015-2020	Conceptual Commercial after 2020

OTM Advanced power cycle

OTM Technology
~ 60 – 70% of O_2 requirements



Industrial Gas Supply
~ 30 – 40% of O_2 requirements

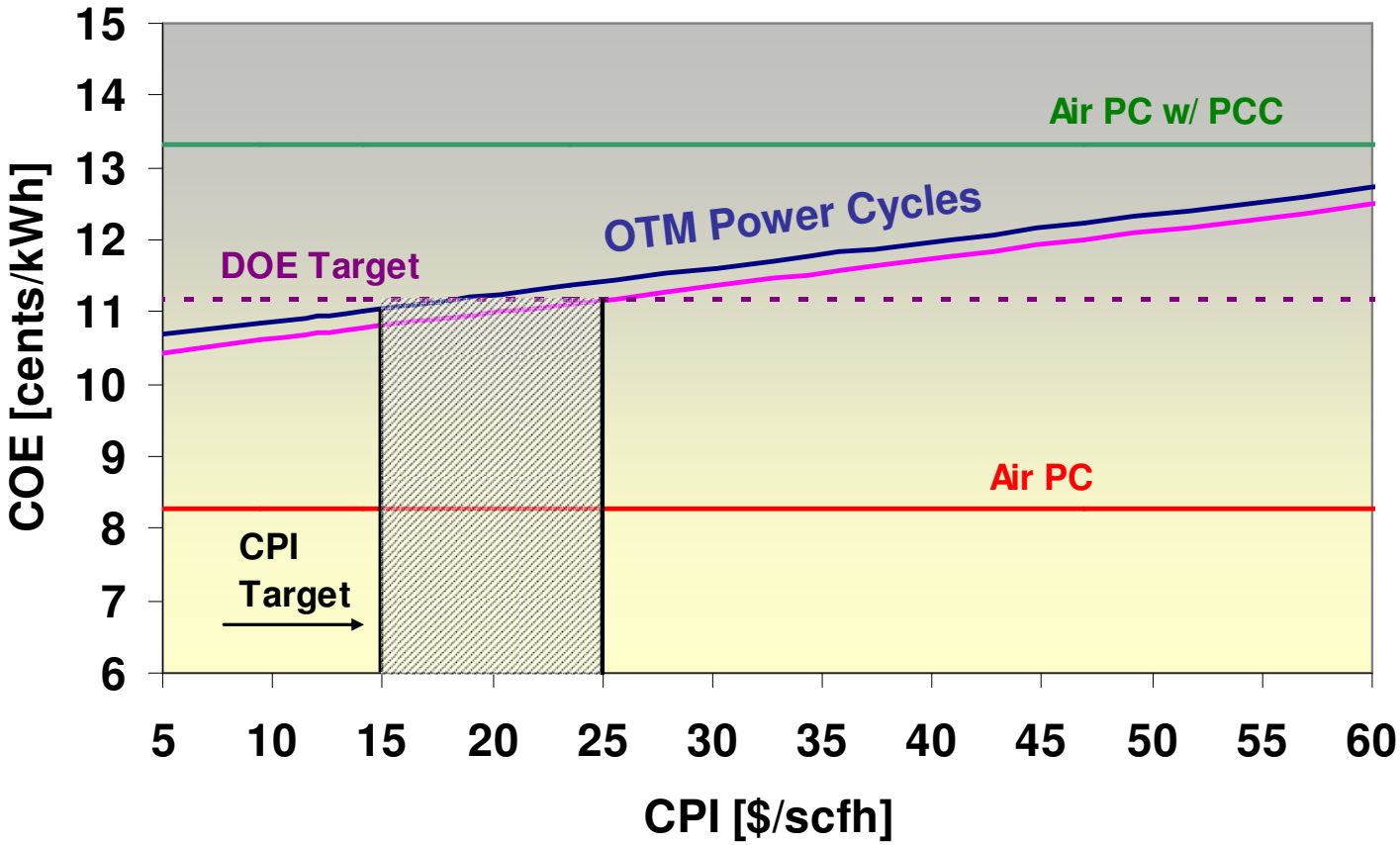
Patent Application: US 2008/0141672 A1

www.praxair.com

OTM Power Cycle - Advantages

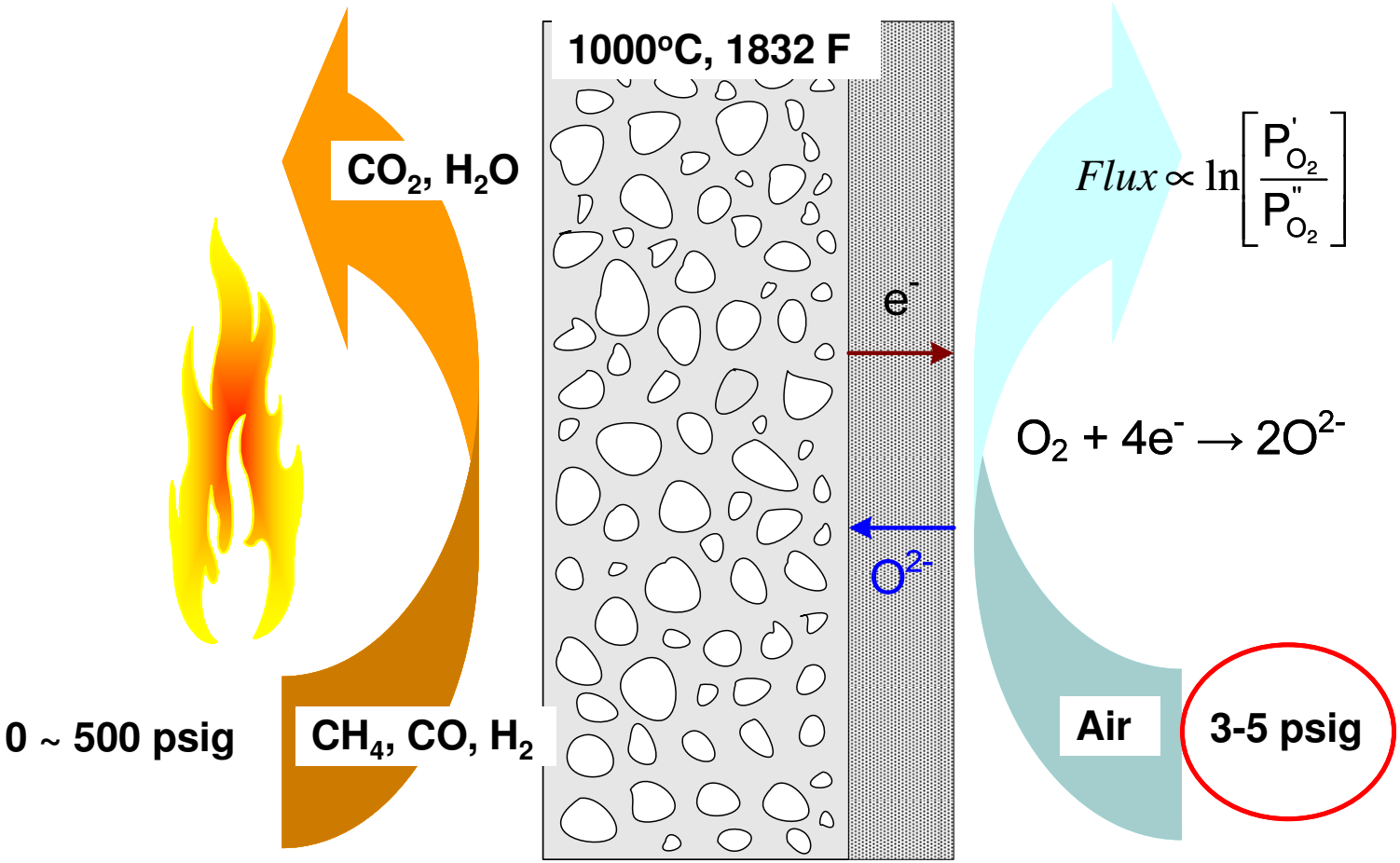
- OTM O_2 consumes ~75% less power than cryogenic ASU O_2
- Thermal energy of synthesis gas fully utilized (no quench)
- No flue gas recycle required
- High efficiency steam cycle can be used
- Latent heat recovery from flue gas

OTM Process Economics



- CPI ($/scfh) = Cost ($/sq.ft) / Performance (scfh/sq.ft)
- Assumption: Coal price $3/MMBTU

OTM Principle of Operation



Oxy-Combustion with OTM Oxygen Separation

OTM Materials

Patent Application: US 2008/0047431 Al

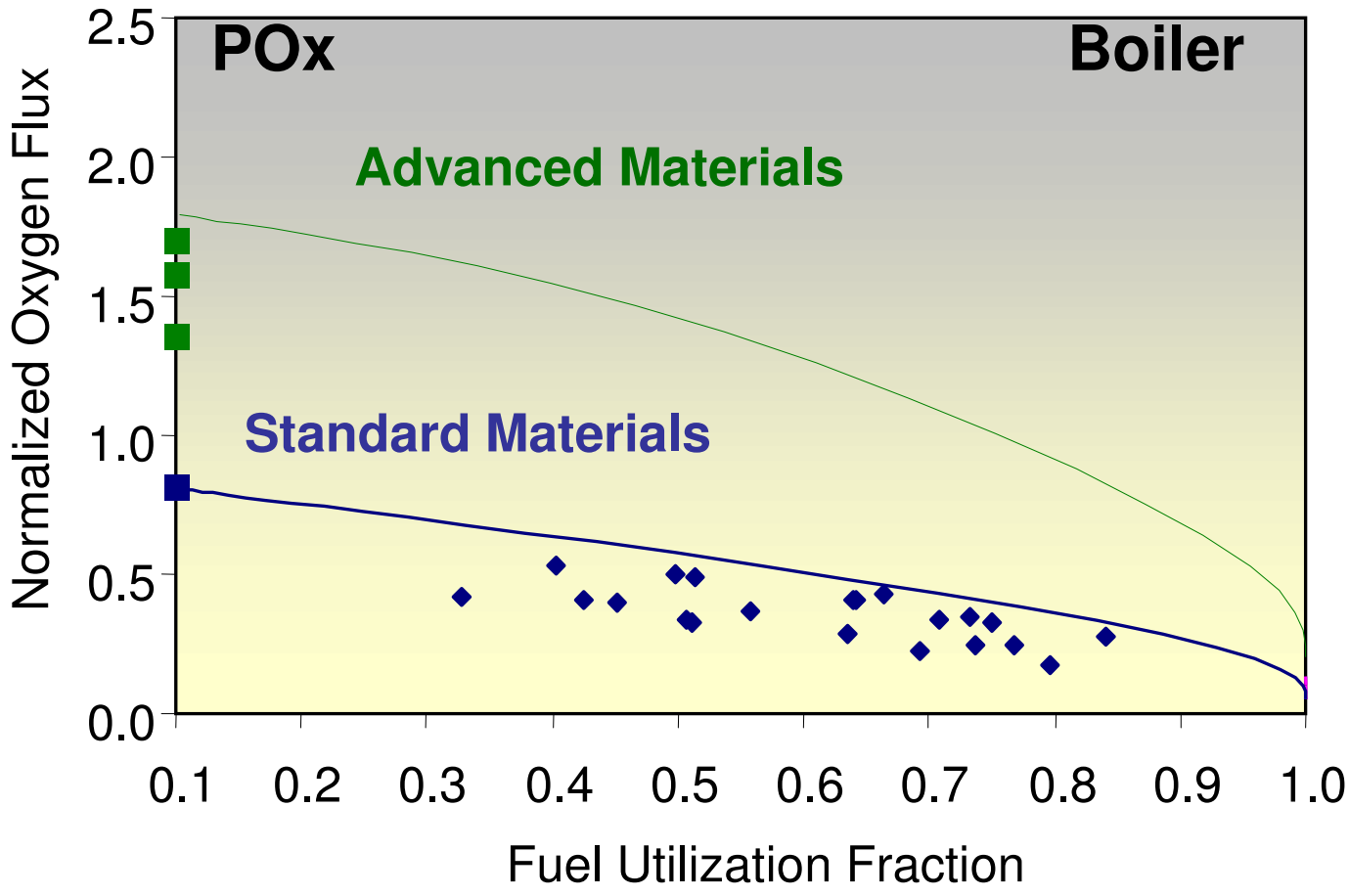
OTM Materials

- **Porous Support**
  - Doped Zirconia
- **Separation/Reaction Layer**
  - Dual phase: metallic oxide & doped Zirconia

Advanced OTM Materials

- **Porous Support:** Improved mass transfer characteristics
- **Separation/Reaction Layer:** Improved fuel oxidation rates

OTM Performance

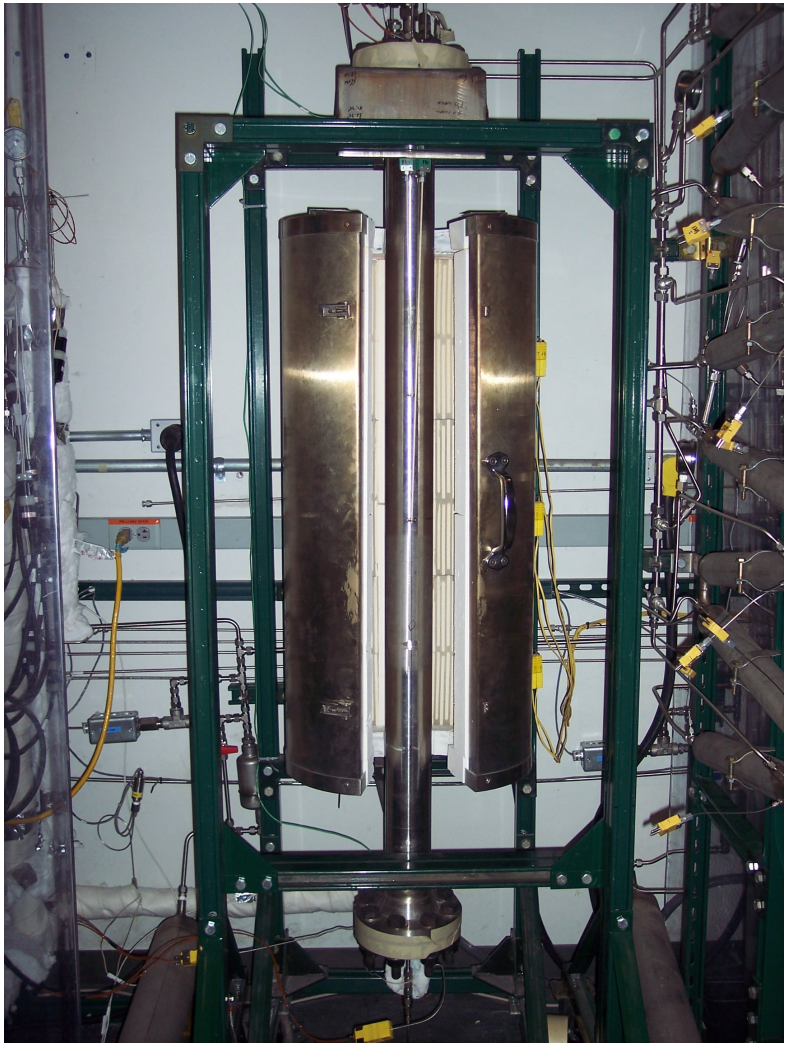


Incorporate advanced material system into full range of laboratory samples

OTM Testing Facilities

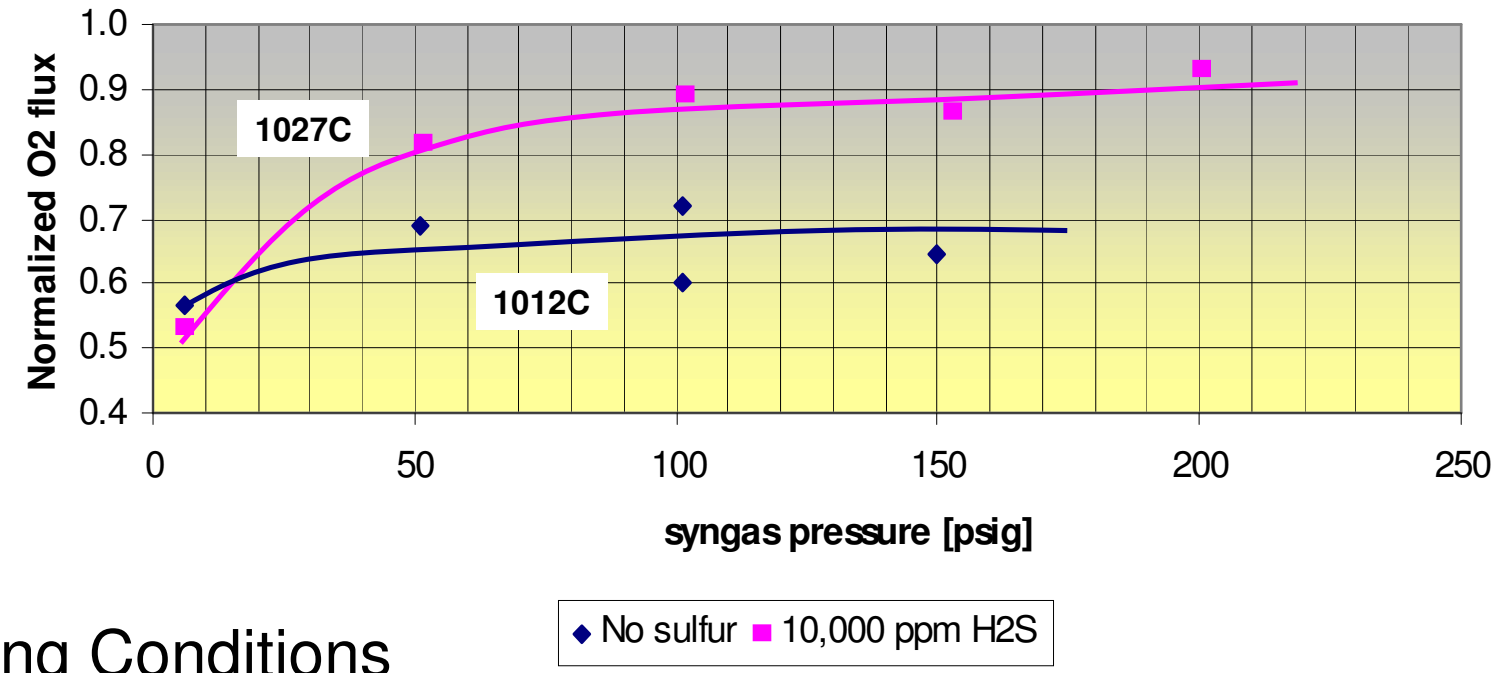
Praxair High / Low Pressure Reactors

- Single tube
- Up to 1000℃
- Up to 200 PSI outside of tube
- Stability in sulfur



OTM High Pressure Reactor
Praxair

OTM Performance



Testing Conditions

- Standard material set
- (H_2,CO,CH_4,CO_2,H_2O) w/ 1%H_2S, 560 ppm COS,
- 200 psi fuel, atmospheric air

Key Milestone: Stable Performance with H_2S and COS

OTM Testing Facilities

Utah OTM coal reactor

- Configuration
  - Multiple OTM tubes
  - Solid fuel
  - Performance/stability
- Status
  - Construction complete
  - Undergoing preliminary tests - gaseous fuels
  - Preparing for solid fuel tests

OTM Coal Reactor
University of Utah

Summary

- **Step-change technology**
  - Reduced O_2 power cost (~75%)
  - Reliability at pressure & with gaseous fuel impurities
- **Significant challenges / Next Steps**
  - Oxygen flux improvement while retaining robust tubes
  - Understanding OTM Manufacturing costs ($/sq. ft) (Phase II) & meeting manufacturing cost targets
  - Design/engineering of a large scale OTM boiler (Phase II)

Thank you.

This presentation was written with support of the U.S. Department of Energy under Contract No. DE-FC26-07NT43088. The Government reserves for itself and others acting on its behalf a royalty-free, nonexclusive, irrevocable, worldwide license for Governmental purposes to publish, distribute, translate, duplicate, exhibit and perform this copyrighted presentation.

Disclaimer

- This material is based upon work supported by the Department of Energy under Award Number DE-FE26-07NT43088. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and options of authors expressed herein do not necessarily state or reflect those of the United States government or any Agency thereof.

- The material is also based upon work supported by NYSERDA under agreement number 10080 and 10080-1. NYSERDA has not reviewed the information contained herein, and the opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York.