NETL CO_2 Capture Technology for Existing Plants

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

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Introduction

- Project Overview
- Technology Fundamentals
- Progress and Current Status
- Plans for Future Testing

Project Overview

Project Goals

- Asses feasibility of Advanced Oxy-Combustion Power Cycle that uses ceramic membranes (OTM) in place of Cryo ASU.
- Advance OTM technology to pilot demonstration phase

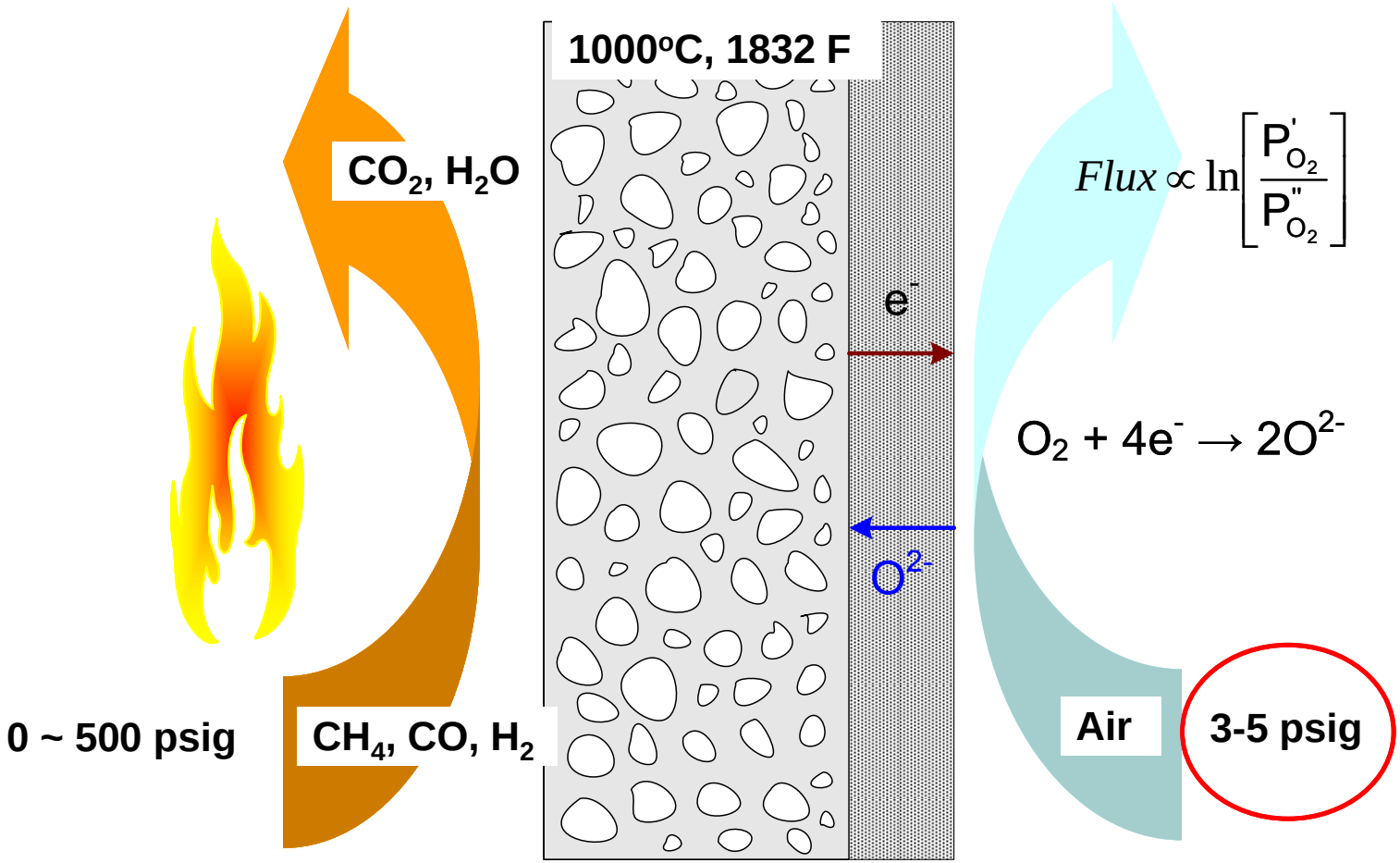
Schedule, Budget & Partners

	Phase 1											Phase 2			
	2007			2008				2009				2010			
	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
DOE (65%)	$ 3.24 M											$ 2.19 M			
Praxair (35%)	$ 2.19 M											$ 1.18 M			
NYSERDA			$ 0.25 M					$ 0.5 M							
												Total		$ 9.11 M	

- Phase 1
  - OTM performance improvement (flux, stability)
  - Down select process integration cycle
- Phase 2
  - Scale-up OTM size to that required for pilot testing
  - Basic engineering design and cost of pilot plant
- Partners
  - The University of Utah (solid fuel)
  - ENrG, Buffalo, NY (advanced substrate, OTM manufacturing)

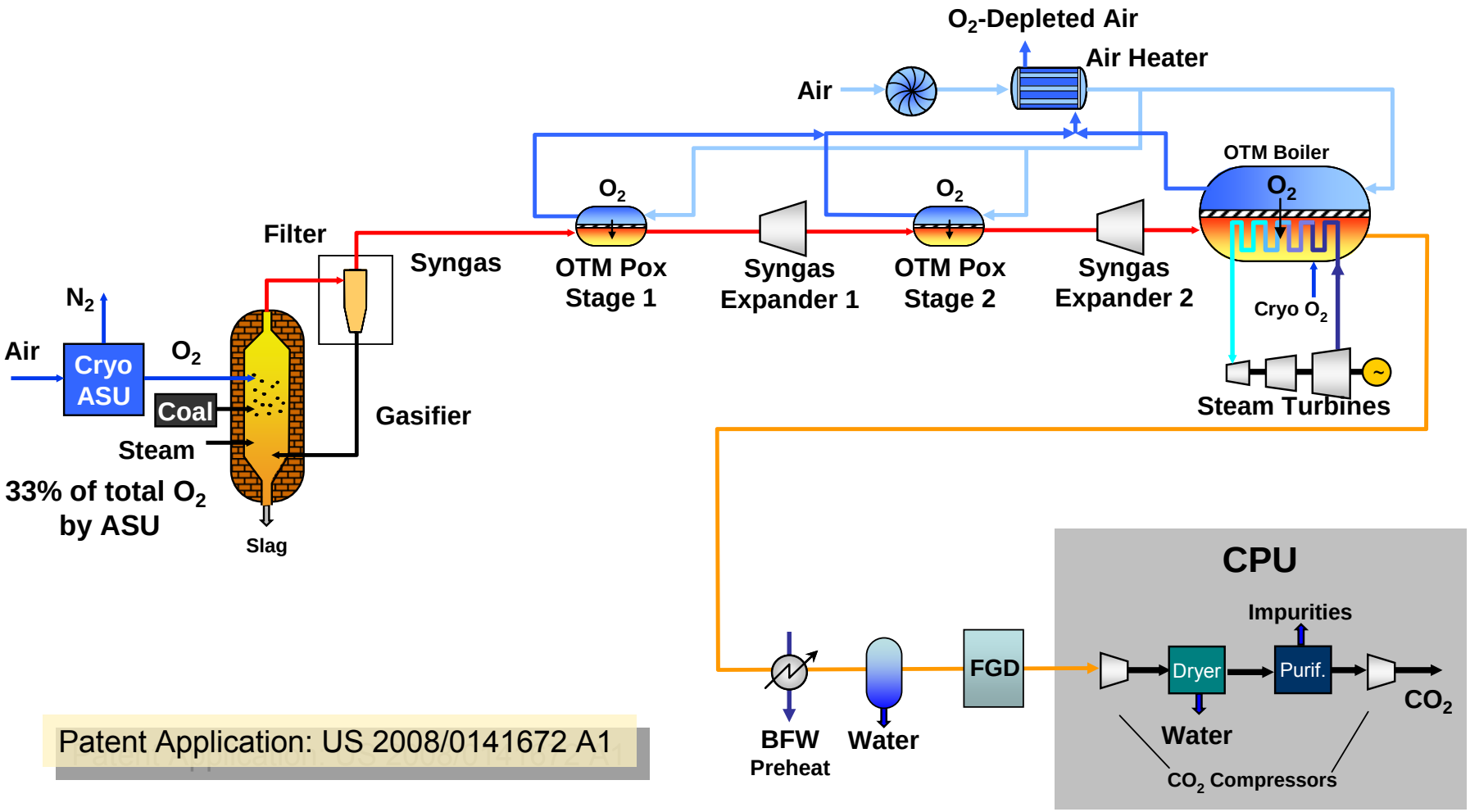
Technology Fundamentals

OTM Principle of Operation



Oxy-Combustion Without Producing Oxygen

OTM Advanced Power Cycle



Patent Application: US 2008/0141672 A1

Advantages

- Power consumption for O_2 supply reduced by >70%.
  - Step change efficiency improvement and decrease in cost of electricity for power plant with CO_2 capture.
- Conventional oxyfuel process - ŋ drops 9 to 10 % points.
  - Cost of CO_2 avoided is 25 to 30% higher than cost of capture.
- OTM-based power cycle - ŋ drops 2 to 3 % points.
  - Cost of CO_2 avoided is within 10% of cost of capture.

Challenges

- Reliability of the OTM tubes at high pressure
- Achieving membrane cost and performance targets
- Engineering design of OTM equipment
- Cost of heat recovery systems
- Risk associated with early demonstration of integration of OTM equipment in full scale coal fired power plants

Progress and Current Status

Task Structure

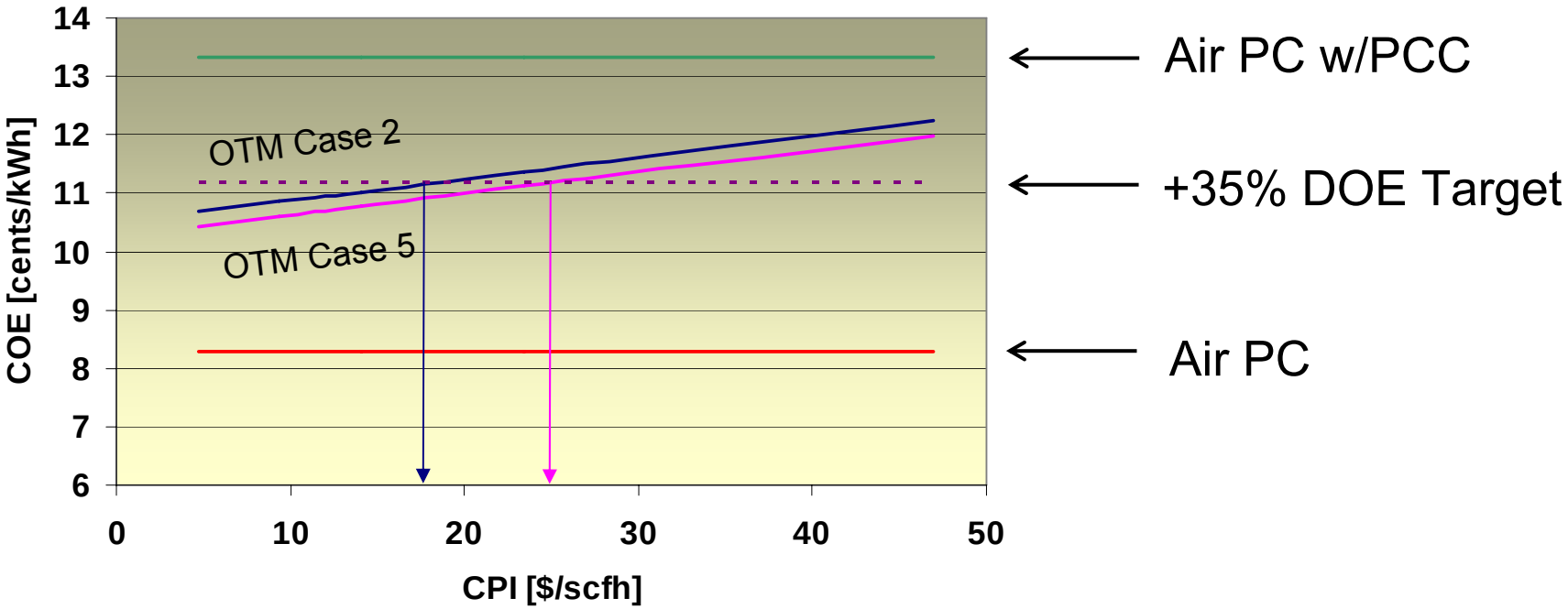
- Process and system economics
  - Process efficiency and cost estimate
  - Sensitivity to key variables.
- Membrane performance improvement
  - Materials development
  - Increase transport rates, maintain reliability
- Membrane manufacturing
  - Infrastructure for pilot phase manufacture
  - Cost estimates for HVM
- Laboratory scale testing
  - Stability and performance of membranes in realistic test conditions

OTM Process Economics vs Air PC

Case		DOE Base SC	DOE PCC SC	OTM Case 2	OTM Case 5
Net Efficiency (HHV)		39.7	27.2	37.15	37.4
Cost Basis (Year)		3/2008	3/2008	3/2008	3/2008
Plant Cost ($/kW)		$1,908	$3,488	$2,858	$2,834
	Coal Price ($/MMbtu)				
COE ($/MWh)	1.8	$70.5	$115.2	$97.0	$94.6
	3	$82.9	$133.2	$110.2	$107.7
	4	$93.2	$148.3	$121.3	$118.7
COE % increase over base	1.8		63.4%	37.6%	34.2%
	3		60.7%	32.9%	29.9%
	4		59.1%	30.2%	27.4%

Potential to Exceed DOE Target of < 35%

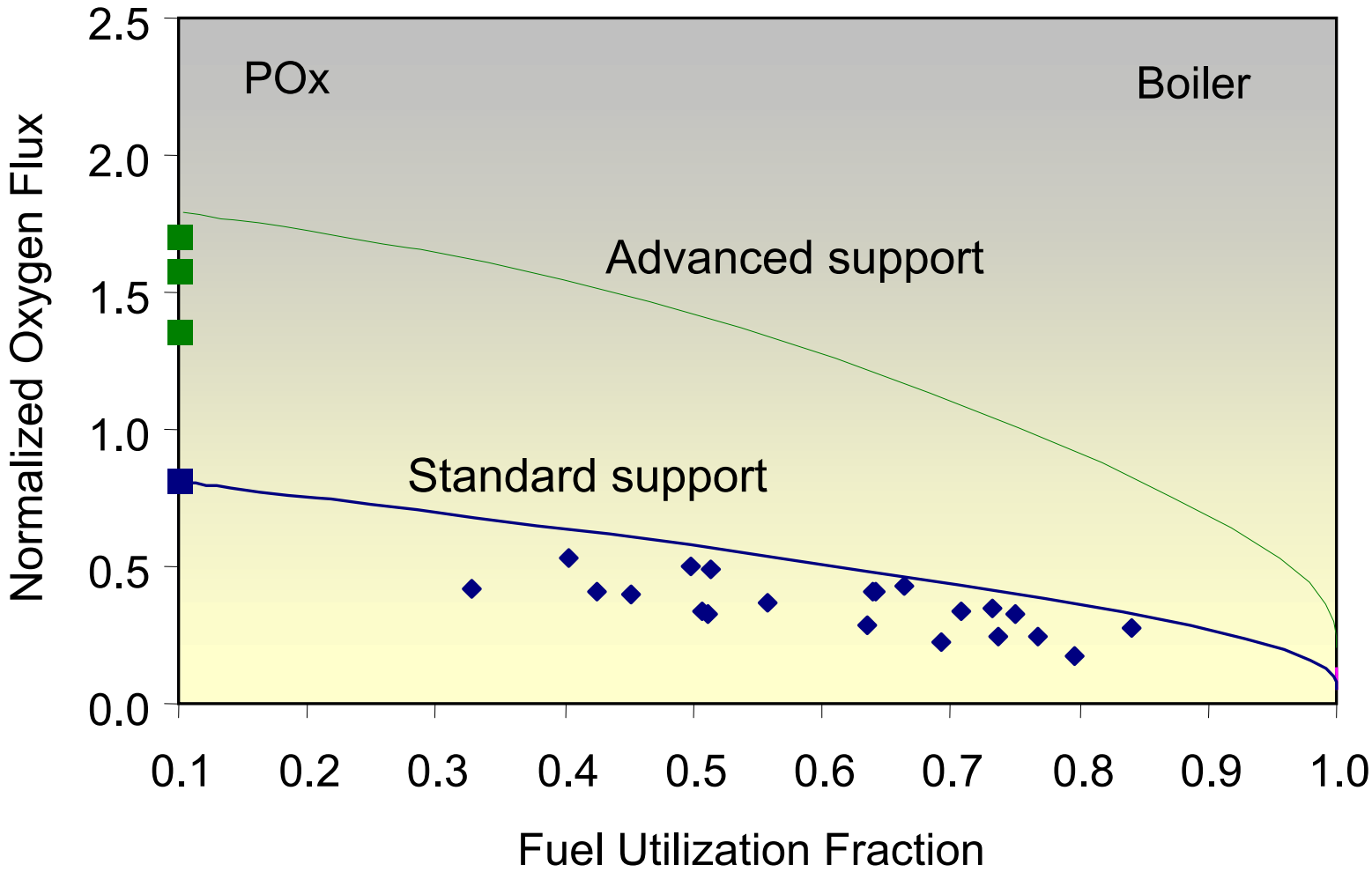
COE Sensitivity to OTM CPI



- Coal Price of $3/MM btu
- CPI* of 15 to 25 $/scfh to meet DOE targets
- OTM Module cost is < 10% of power plant capital

*CPI ($/scfh) = Cost ($/sq.ft) / Performance (scfh/sq.ft)

OTM Performance Map



Step Change in Performance through Advanced Support

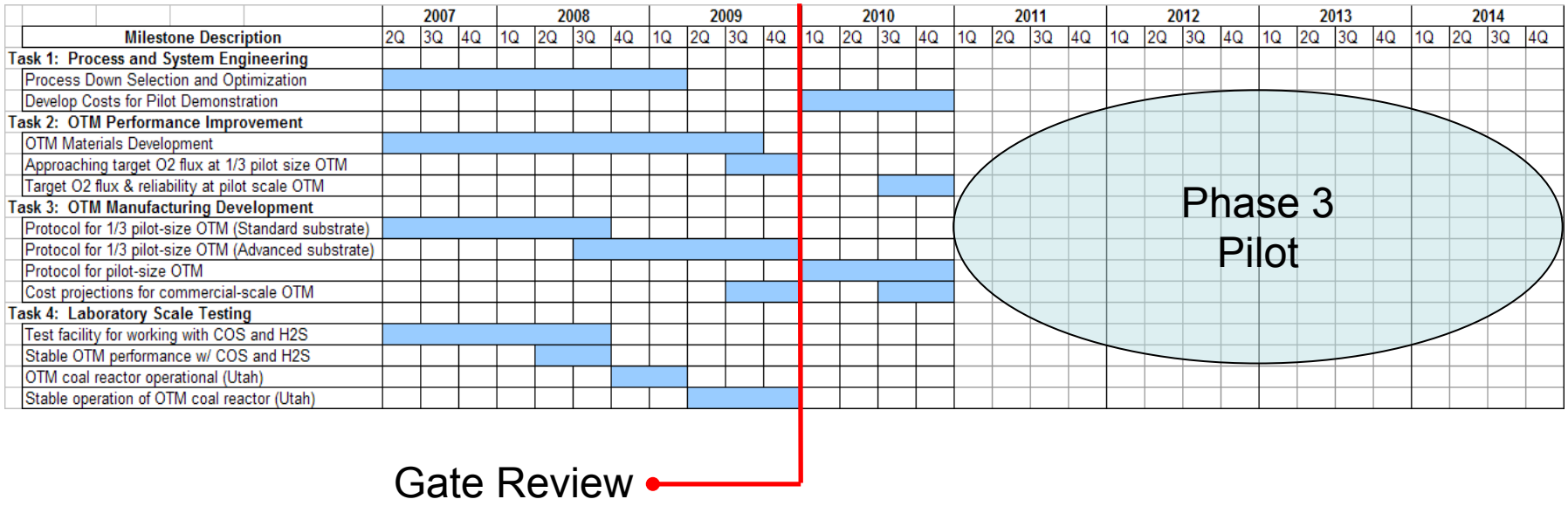
Laboratory Scale Testing

- Praxair OTM gas reactors
  - Stable performance
  - 1%H_2S, 560 ppm COS
  - (H_2,CO,CH_4) (CO_2,H_2O)
  - 800 to 1100^oC
  - 200 psi fuel
- Utah OTM coal reactor
  - Multiple OTM tubes
  - Solid fuel

Stable OTM Performance - 1%H2S, 560 ppm COS, 200 psi

Plans For Future Testing

Schedule



Phase 1	Phase 2	Phase 3
– Performance – Reliability – Economics	– Concept Design – Cost for Pilot – Partners for Pilot	– Stability in POx – Heat transfer in boiler

Summary

- Step Change Oxy-Combustion Technology
- Significant Challenges
- Advanced Substrate for High Separation Rates
- Gate Review in 4Q 2009
- Design and Cost of Pilot in 2010
- Execution of Pilot to Commence 2011

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