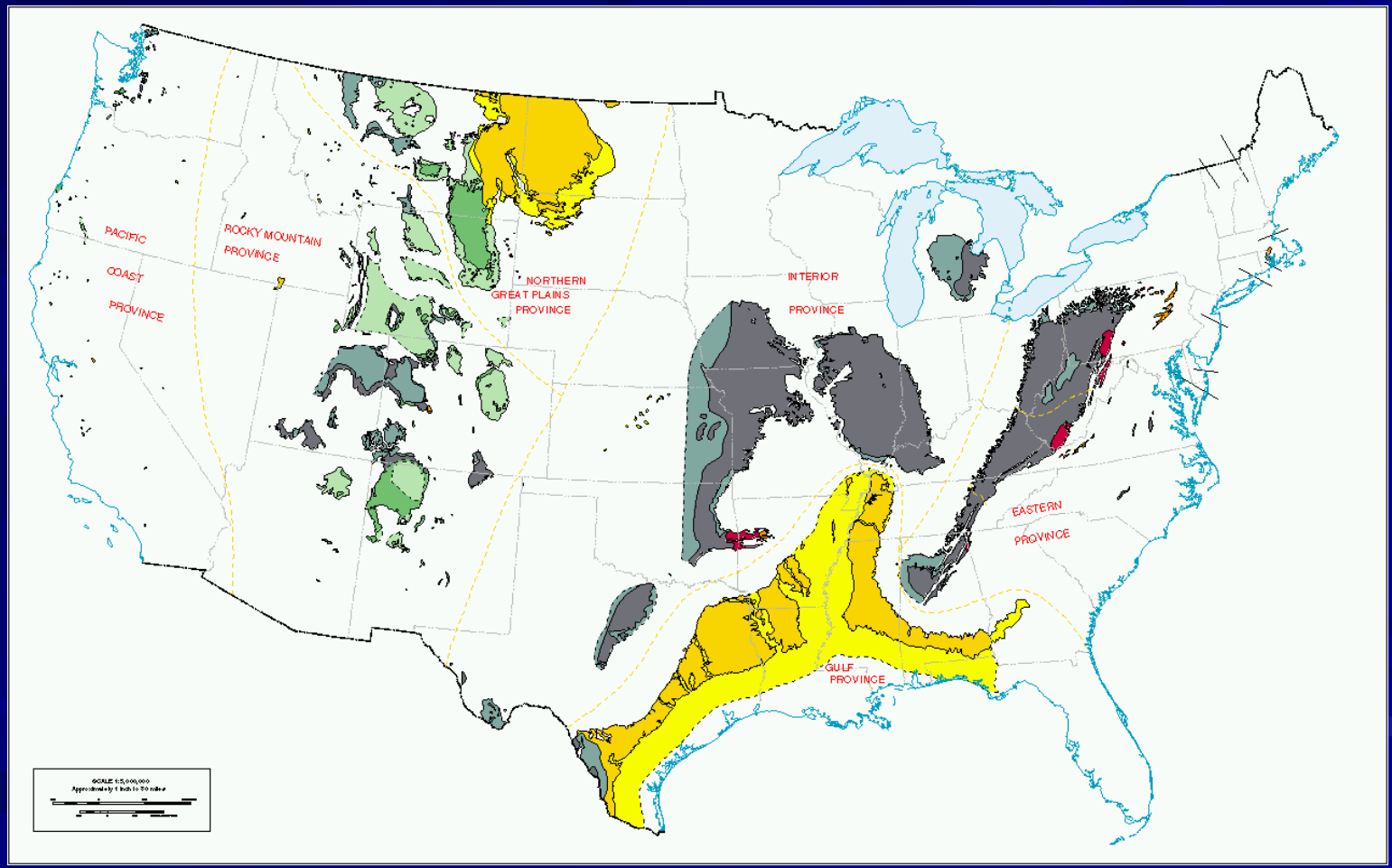
Experience with Gasification of Low Rank Coals

Workshop On Gasification Technologies
Bismarck, North Dakota
June 28, 2006

Phil Amick
Chairman
Gasification Technologies Council

U.S. Coal Resource Regions (Lower 48)



Source: Energy Information Administration

IMPACTS OF FUEL CHOICE ON GASIFICATION PLANTS

Environmental	**- Generally independent of Fuel Choice** **- Sulfur 0.5% to 8%, Sulfur Removal Technology changes but emissions can be constant** **- Slag quality maintained**
Oxygen	**- Usage increases as ash and moisture increase** **- Main Component of Auxiliary Power Consumption**
Heating Value	**- Throughput needs determine size and number of gasifiers**

Gasifying Western Coals

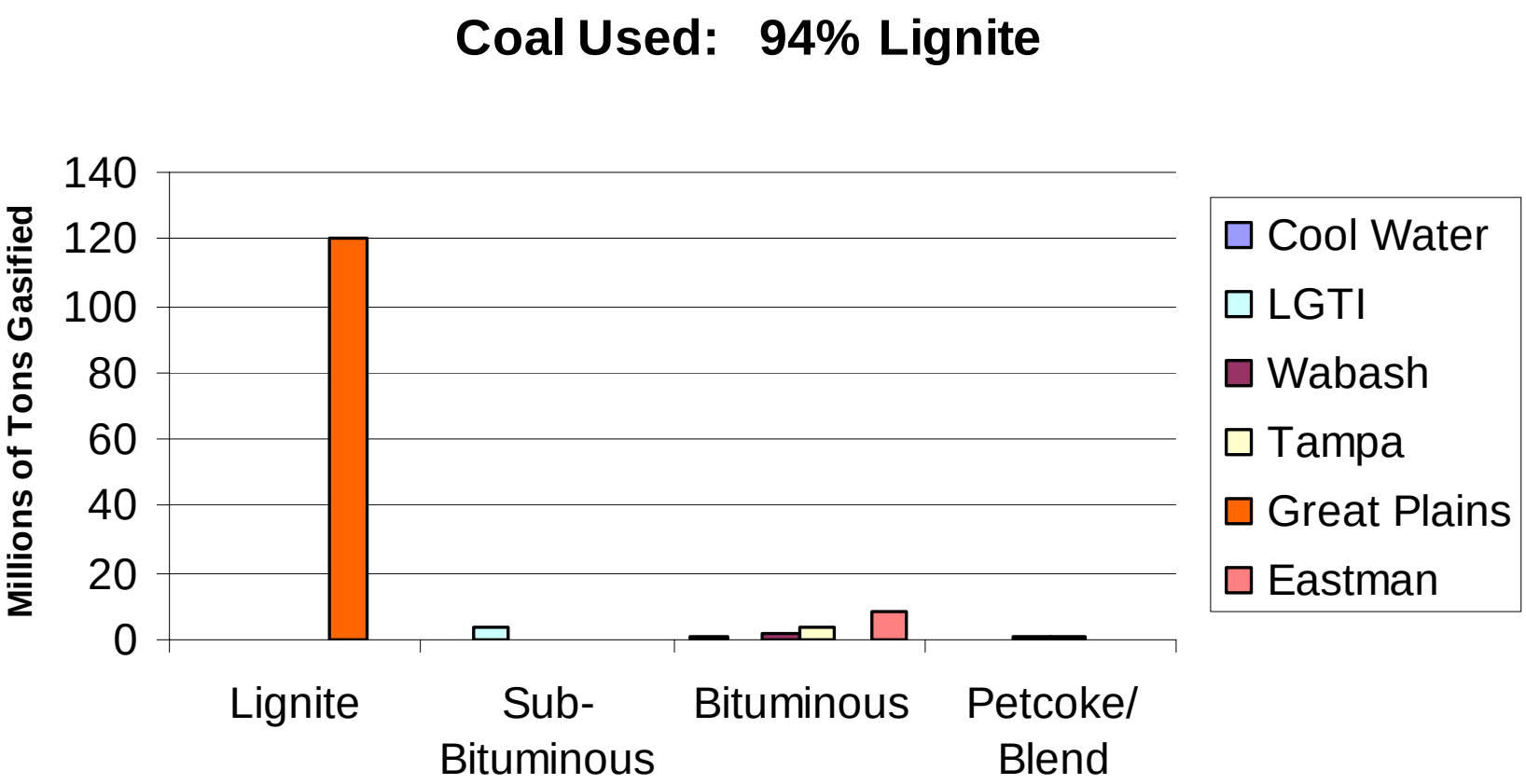
- Myths
  - Gasification doesn't wor[illegible]e
  - Technology S[illegible]
  - IG[illegible]
  - [illegible]s in the future

"Mythbusters" is a documentary show on the Discovery Channel

Gasifying Western Coals

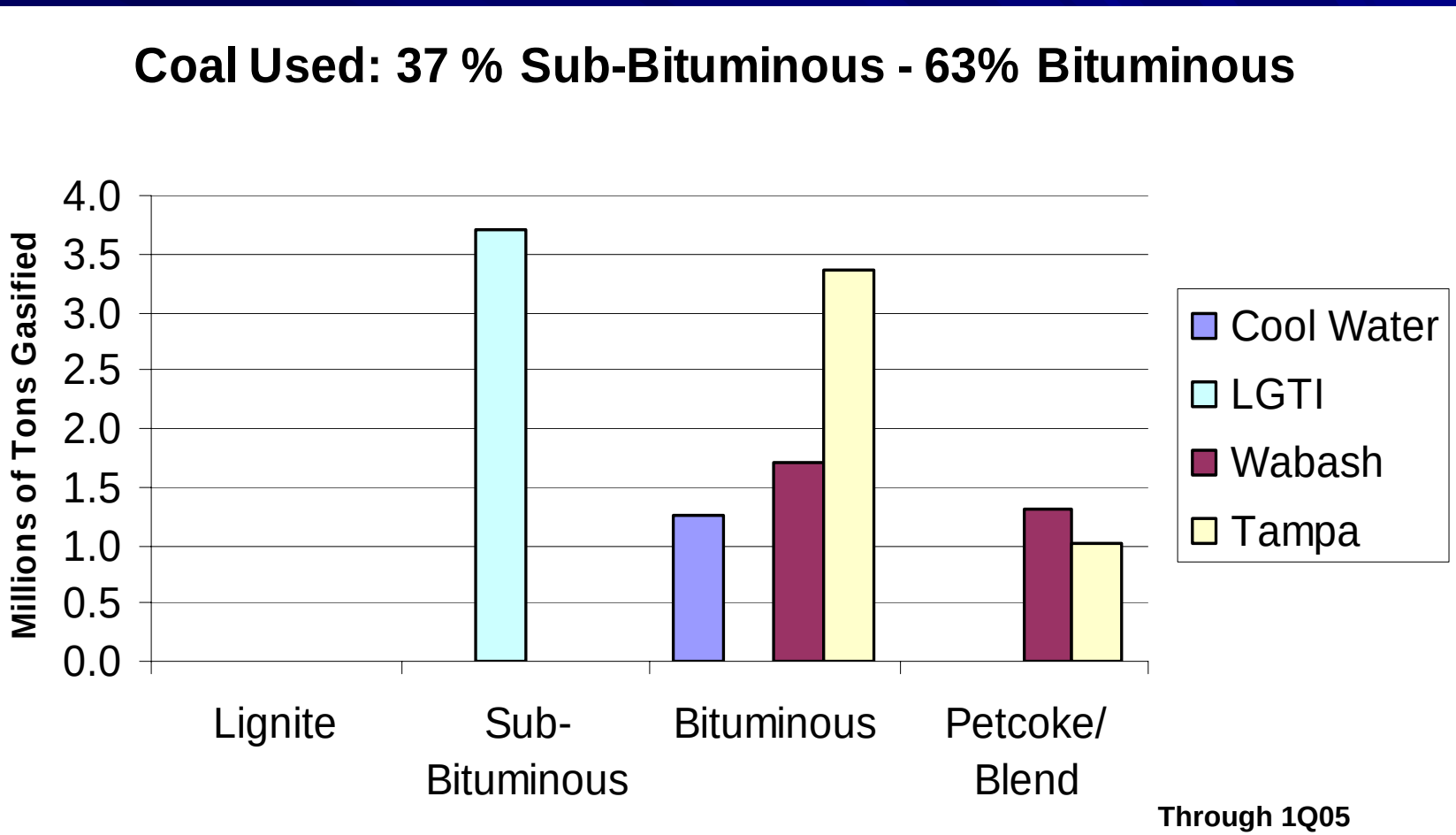
- Myths
  - Gasification doesn't work with PRB or Lignite

Modern Era Coal Gasification – Power & Industrial



Source: Gasification Technology Council

U.S. Coal-to-Power Gasification



Source: Gasification Technology Council

www.gasification.org

Great Plains Synfuels Plant

Over 90% of All of the Coal Ever Gasified in the United States

- Lurgi Gasification Technology
- 54 BCF per year of Natural Gas produced
- 6 MM Tons of Lignite per Year Processed
- Commercial Operation since 1984
- Also produces fertilizer, solvents and CO2 commercially

Source: www.dakotagas.com

LGTI – Louisiana Gasification Technology, Inc

One Third of the Coal-to-Power Gasification in U.S.

- ConocoPhillips E-Gas™ Technology
- 3.7 MM Tons of PRB Coal
- 2400 tpd Sub Bituminous coal feed
- Commercial Operation 1987 – 1995
- Processed 3.7 MM tons
- Fueled (2) Siemens SGT6-3000E GTGs

Source: ConocoPhillips

Gasifying Western Coals

- Myths
  - Technology Suppliers and Developers aren't interested

Solid Fuel Gasification Experience

High Ash Coals	Lignite	Sub-Bituminous	Bituminous Illinois Basin	Bituminous Appalachian	Anthracite & Other Bitum	Petcoke
			Allied Syngas BGL			
			ConocoPhillips E-Gas			
			General Electric			
			KBR Transport			
			Sasol – Lurgi			
			Shell			
			Siemens Sustec			

Tested	
Demonstrated (500 TPD or more)	
Million Tons Operation	

www.gasification.org

Mesaba Energy Project

"Mesaba Energy Project Permitting and Environmental Information Volume", Bob Evans, Excelsior Energy and Tom Lynch, ConocoPhillips, Platts IGCC Symposium, May 10, 2006, Pittsburgh, PA

Mesaba Energy Project

Excelsior Energy is the Owner

Nominal 600 MW IGCC in Minnesota Iron Range

Fuel Flexible for Sub-Bituminous, Bituminous and Petcoke

Technology Selection May 2004

PUC Filings December 2005

Air Permit draft application filed May 2006; Final June 2006

Commercial Operation 2011

"Mesaba Energy Project Permitting and Environmental Information Volume", Bob Evans, Excelsior Energy and Tom Lynch, ConocoPhillips, Platts IGCC Symposium, May 10, 2006, Pittsburgh, PA

Orlando Gasification Project

"KBR Transport Gasifier", Peter V. Smith, KBR, Gasification Technologies conference, October 2005, San Francisco, CA

Orlando Gasification Project

Southern Company and Orlando Utilities Commission are the Owners
Nominal 330 MW IGCC in central Florida
Sub-Bituminous coal from the Powder River Basin

Commenced Design October 2005
Construction Start December 2007
Commercial Operation 2010

"KBR Transport Gasifier", Peter V. Smith, KBR, Gasification Technologies conference, October 2005, San Francisco, CA

Pacific Mountain Energy Center

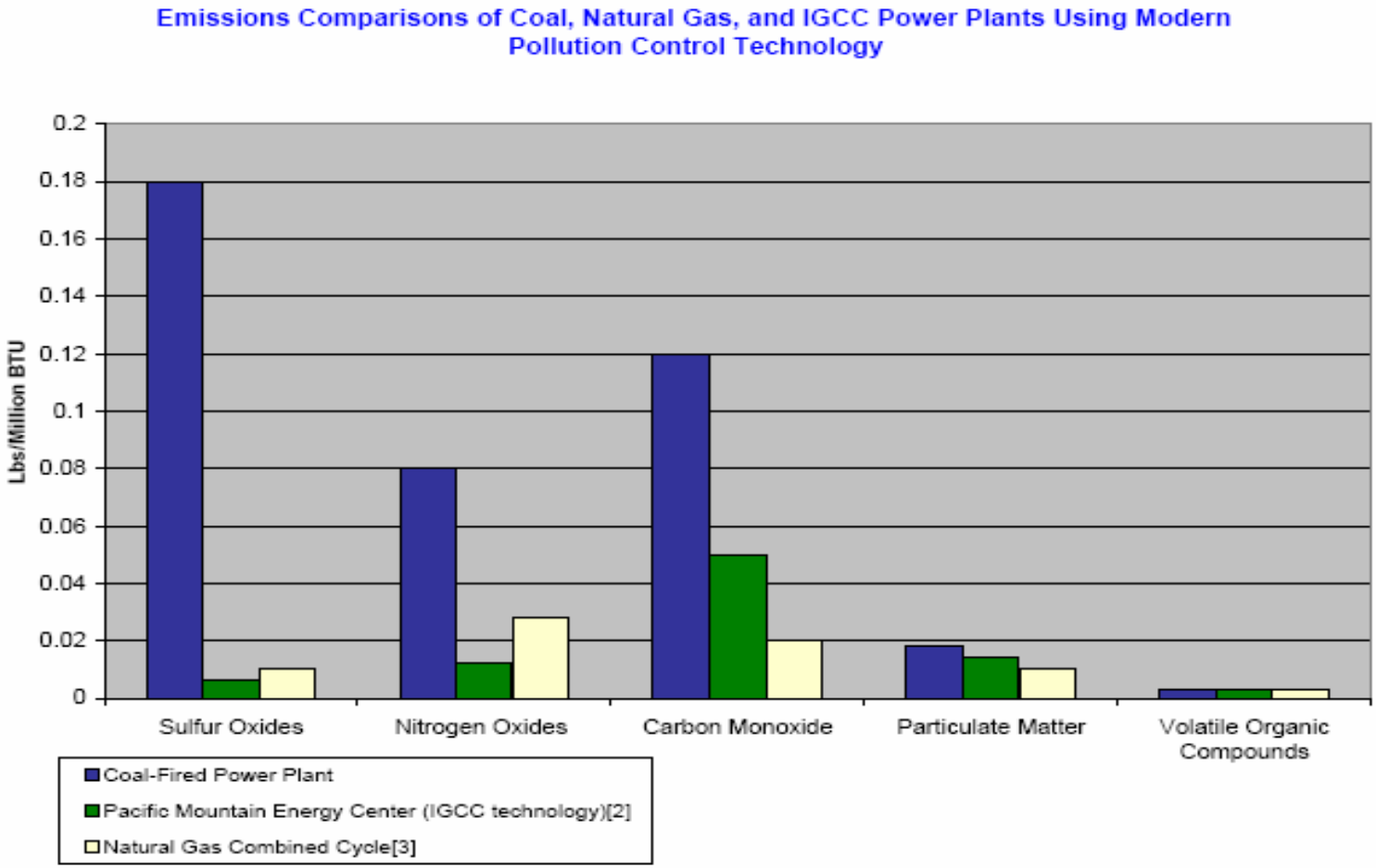
http://www.energy-northwest.com/generation/igcc/index.php

Pacific Mountain Energy Center

- Located at the Port of Kalama near Kalama, WA.
- Energy Northwest will develop, permit, construct, own, operate, and maintain the public-private development.
- Public power will purchase power from one 300 MW CT, and private companies will purchase power from the other 300 MW CT.
- Sub-bituminous coal and/or petroleum coke for feedstock
- Conceptual Engineering completed in 2005
- Qualifications RFP 2Q06
- Commercial operation in 2012

http://www.energy-northwest.com/generation/igcc/index.php

Pacific Mountain Energy Center



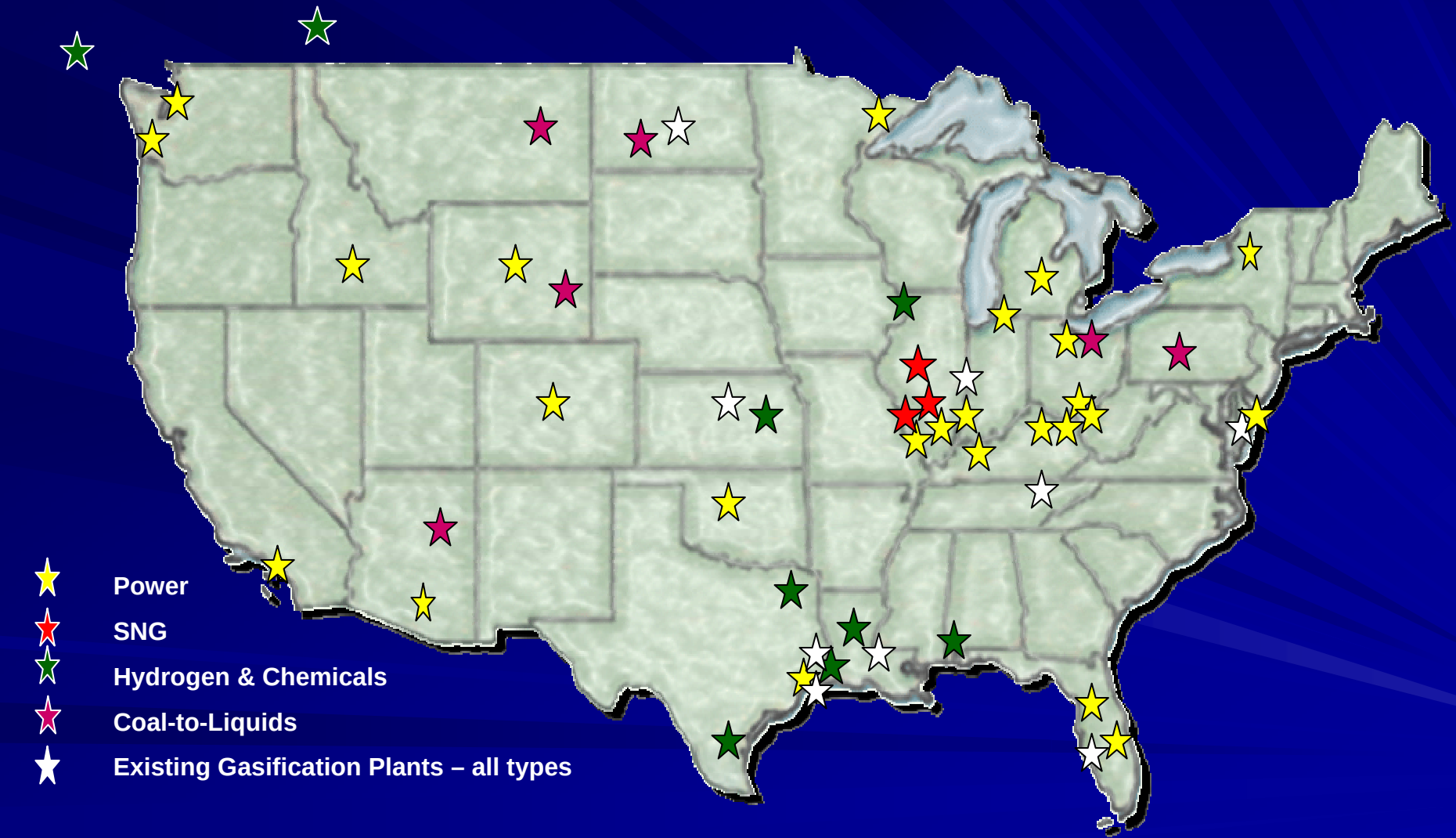
[1] Calculations based on Conoco-Phillips 2005 Preliminary Engineering Study.
[2] Calculations from 2005 Engineering Study and refer specifically to Energy Northwest's IGCC project.
[3] Numbers based on Best Available Control Technology for Natural Gas Combined Cycle power plant.

http://www.energy-northwest.com/generation/igcc/index.php

Other Coal Projects in the West

- IGCC projects under development in Arizona and Idaho
- IGCC evaluations announced by utilities in Colorado and Texas
- CTL Project announcements in Arizona, Montana, North Dakota and Wyoming
- Four of the Twelve Proposed FutureGen Sites are in western states

Publicly Announced Gasification Project Development



www.gasification.org

Technology Suppliers

- ConocoPhillips, Shell, Allied Syngas, KBR all pursuing U.S. Low Rank Fuel Projects
- Siemens Technology announced in European Brown Coal Project
- Shell Technology announced in Australian Brown Coal Project
- GE announced Low Rank Gasification Initiative; ConocoPhillips developing advanced gasifier for lignite and PRB coals.

Gasifying Western Coals

- Myths
  - Pulverized Coal is cleaner

Coal Plant Main Stack Permit Targets

Permit Targets	IGCC Amine Based	IGCC Selexol with SCR	SCPC[1]
SO_2 Emission Rate (lb/MMBtu of coal feed)	0.03	0.01	0.16
NO_x Emission Rate (lb/MMBtu of coal feed)	0.06	0.02	0.07
Total NO_x & SO_2 TPY (based on 630MW Plant –IL6)	1,640	500	4,500

1) Wisconsin Electric Power SCPC information from April 2003 Draft Environmental Impact Statement, Elm Road Generating Station, Volume 1, Public Service Commission of Wisconsin & Department of Natural Resources, Table 7-11, p. 155 (Pittsburgh No. 8 coal)

Criteria Pollutant Comparisons

Pollutant	IGCC Bituminous	Subcritical PC Bituminous	Subcritical PC Subbituminous
NOx	0.049	0.06	0.06
SO_2	0.043	0.086	0.065
PM/PM_{10}	0.007	0.012	0.012
VOC	0.0017	0.0024	0.0027
CO	0.03	0.10	0.10

All emissions in lb/MMBtu. IGCC NOx based on 15 ppmvd/15% O2 and with no SCR. An SO2 removal of 87% reflects a very low coal sulfur content (0.22%).

Source: S. Khan, U.S. EPA

Water Use and Solid Waste Comparisons

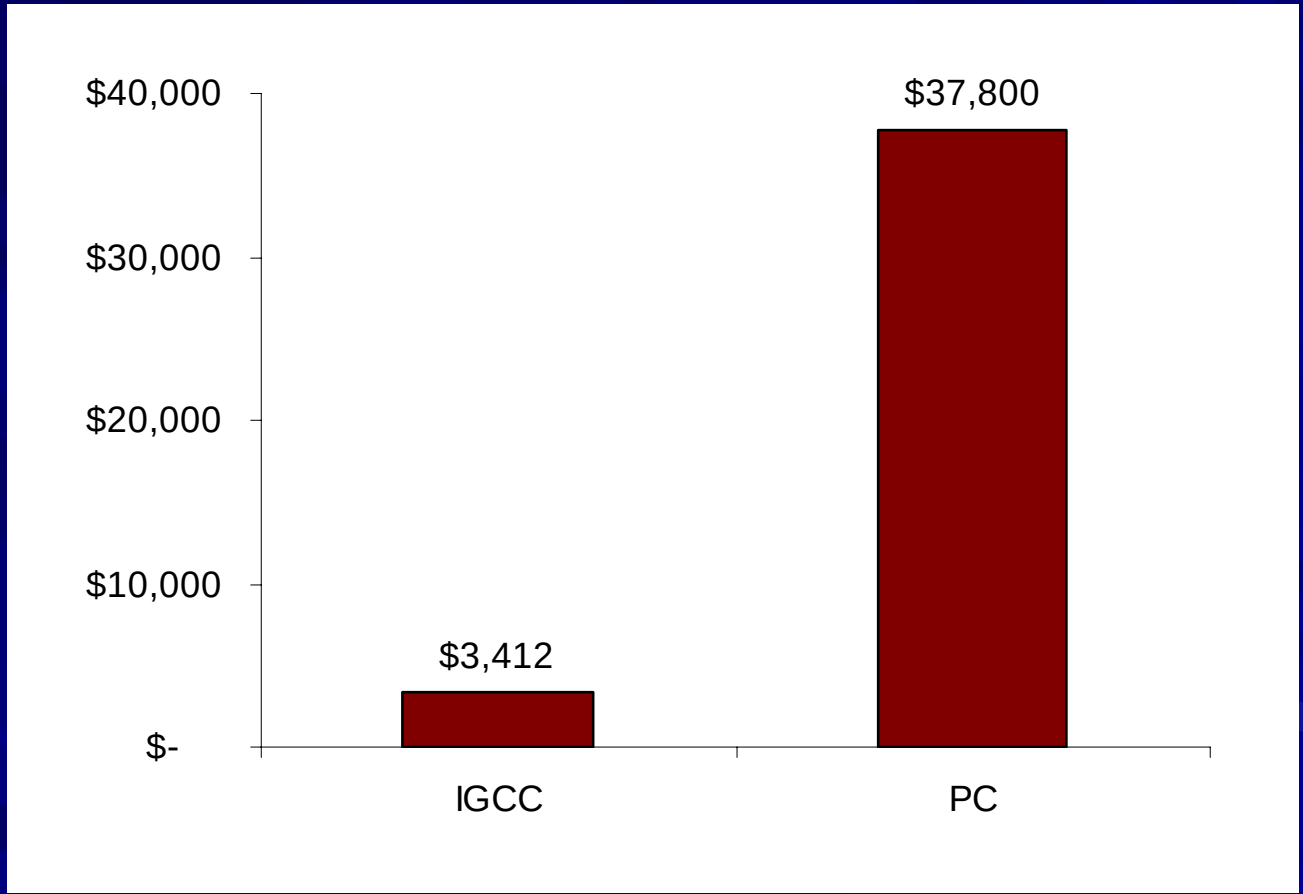
Parameter*	PC Plant	IGCC Plant	% less for IGCC
Solid waste, bituminous coal, tpd	1,090	430	60
Solid waste, subbituminous. coal, tpd	480	280	42
Solid waste, lignite, tpd	2,080	1,600	23
Plant makeup water, gpm	9,340	6,030	35
Wastewater discharge, gpm	2,910	1,960	33

Note: gasification slag included in solid waste; only recovered sulfur considered non waste.

Source: S. Khan, U.S. EPA

Comparative Cost of Hg Removal

Cost per pound of mercury removed

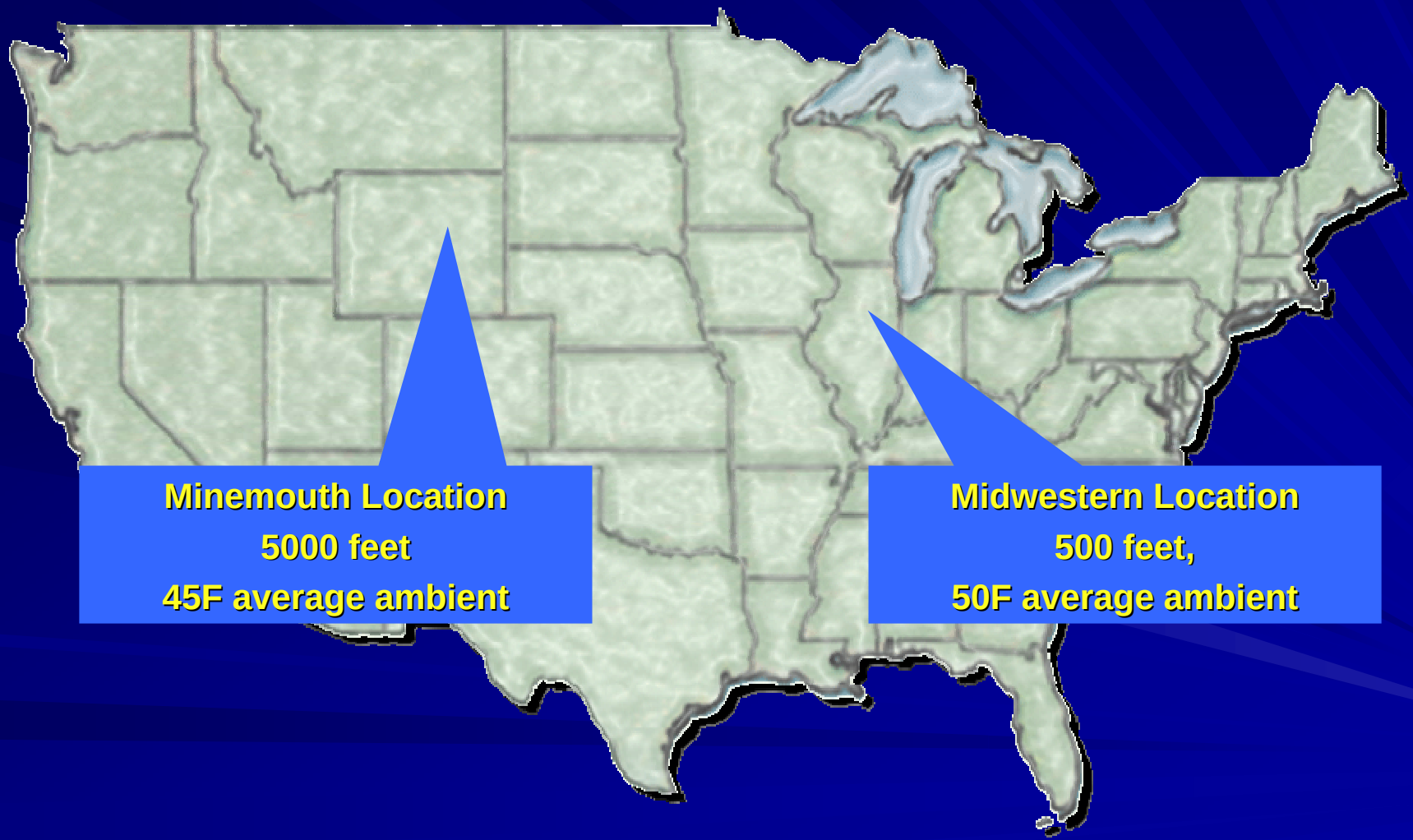


Source: U.S. DOE from industry data

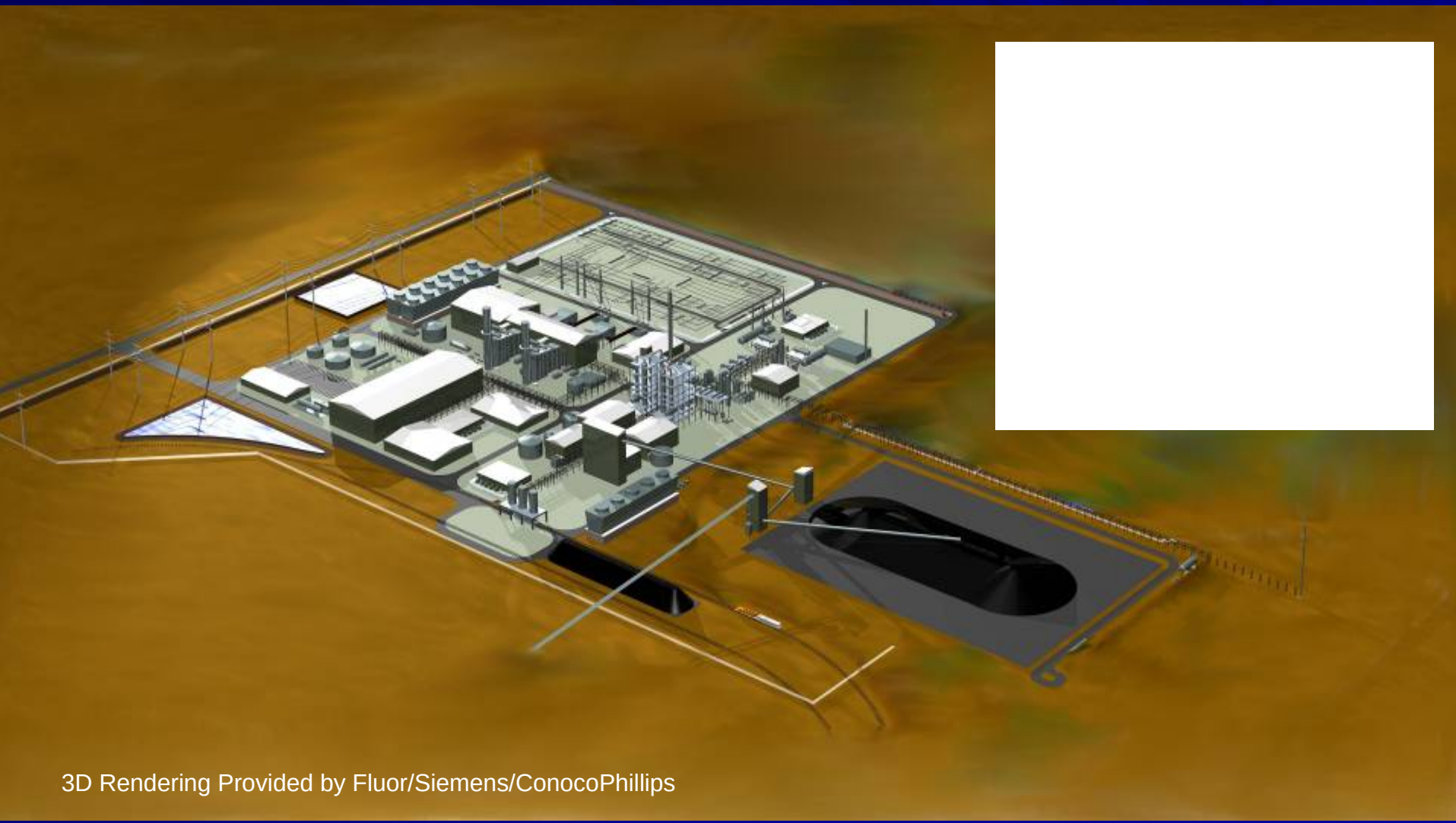
Gasifying Western Coals

- Myths
  - IGCC doesn't work at high altitude

Case Study on PRB Coal



600 MW Sub Bituminous IGCC Design Template



3D Rendering Provided by Fluor/Siemens/ConocoPhillips

600 MW Sub Bituminous IGCC Case Description

	Midwest	Mine Mouth
Site Conditions	500 ft, 50 F avg. amb.	5,000 ft, 45 F avg. amb.
Q Coal (AR, HHV), Btu/lb	8,340	
Carbon (dry basis), wt%	69	
Sulfur (dry basis), wt%	0.5	
Ash (AR), wt%	5	
Moisture (AR), wt%	30	
Acid Gas Removal	3 Col. Selexol ™	
Steam Conditions psig/F	1800/1050/1050	
Heat Rejection	Cooling Tower	Air Cooled
GTG Emissions Control	15 ppm NOx (diluent) plus SCR	
Process Wastewater	SW recycle via R.O.	SW recycle + ZLD

Source: ConocoPhillips

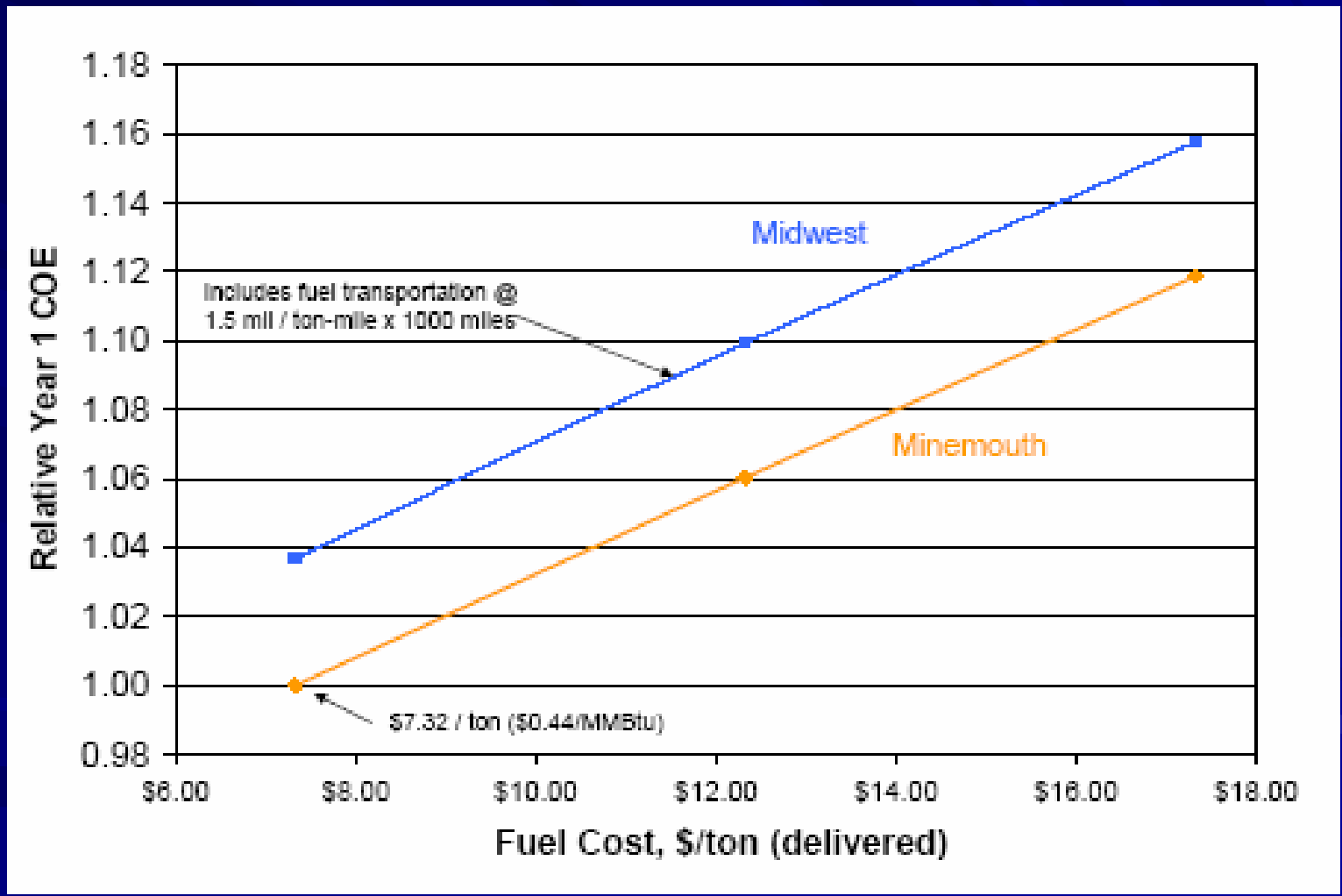
600 MW Sub Bituminous IGCC Estimated Plant Performance

	Midwest	Mine Mouth
Feed Rate, tpd (AR)	8,300	7,300
Oxygen, tpd (95% vol)	4,700	4,100
Gross Power, MW	780	670
Aux. Power, MW	130	120
Net Power, MW	640	560
Net H.R., Btu/kWh (HHV)	9000	9,100
Emissions [1]:		
NO_x, lb/MMBtu	0.02	
SO_2, lb/MMBtu	0.01	

Notes:
[1] Target permit levels

Source: ConocoPhillips

COE vs. Fuel Cost ($2010)



Source: ConocoPhillips

Gasifying Western Coals

- Myths
  - Carbon capture is in the future

Projects Implementing Carbon Capture

- Great Plains Synfuels is providing CO2 to the Weyburn oilfield
- Pernis Refinery gasification facility supplies CO2 to greenhouses in the Netherlands
- At least 2 of the expected EPACT tax credit applicants are planning carbon capture for enhanced oil recovery

Comparative Cost Impact of CO_2 Capture and Sequestration

Parameter	IGCC Plant	PC Plant
CO_2 capture, %	91	90
Unit output derating, %	14	29
Heat rate increase, %	16.5	40
Capital cost increase, %	47	73
COE increase, %	38	66

Source: S. Khan, U.S. EPA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