

CO₂ for EOR from Coal Gasification

Dr. Eric D. Larson
Research Engineer
Carbon Capture Group
Carbon Mitigation Initiative (CMI)
Princeton University

PetroChina-RIPED (Research Institute of Petroleum Exploration and Development) and BP seminar on “Exploration of CO₂-Contaminated Natural Gas and CO₂ Storage and Integrated Utilization of Resources”

Beijing, 24-25 April 2007

Carbon Mitigation Initiative at Princeton, 2001-2010

Carbon Capture

Carbon Storage

YEAR SEVEN: FINAL FUNDING IN HAND



“An environmental problem”

Carbon Science

Carbon Policy

\$21,150,000 funding from BP and Ford, plus new BP increment. ²

CMI Carbon Capture Group

Personnel

Williams

Socolow

Kreutz

Larson

Consonni (*Milan*)

Li (*Tsinghua*)

Post-docs

Students

Tools (plant design and simulation)

Aspen Plus

“GS” (Politecnico di Milano)

Core Research

Catalyzing early commercialization of CCS

Coal gasification systems;

Power or syngas production

Biomass gasification systems

Power or syngas production

Co-gasifying with coal

Sustainable feedstocks

DF-x collaboration (advanced capture, low-rank coals)

Polygeneration of electricity and syngas (with Tsinghua)

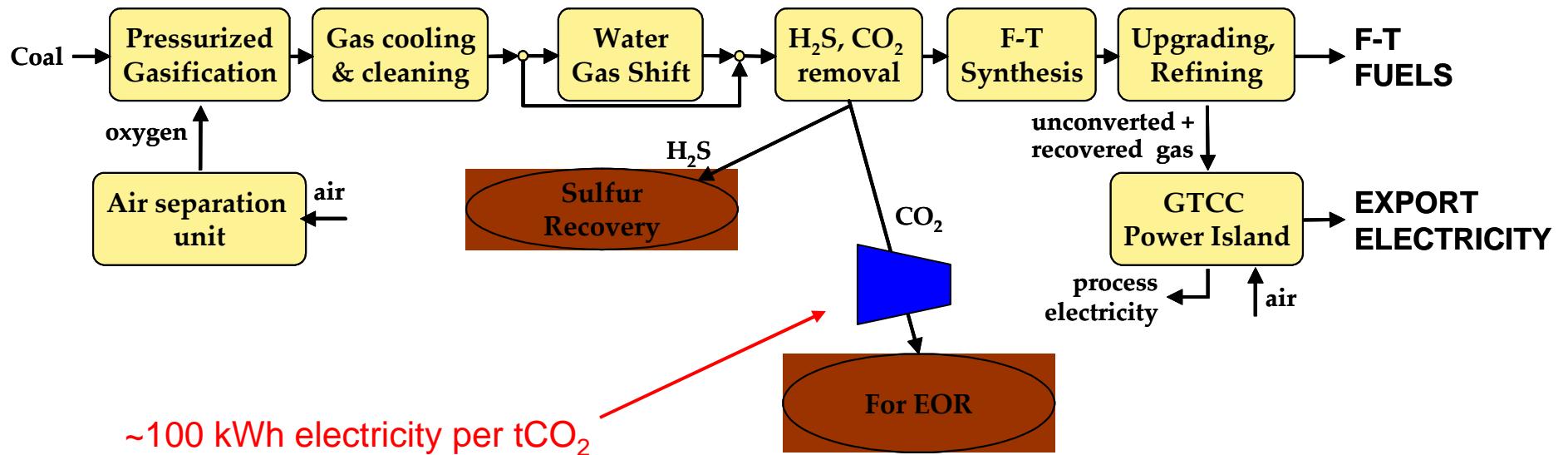
Baseload wind (with natural gas)

H₂ and DME combustion

Coal Gasification Systems for Liquid Fuels or H₂ Production → Low Cost CO₂

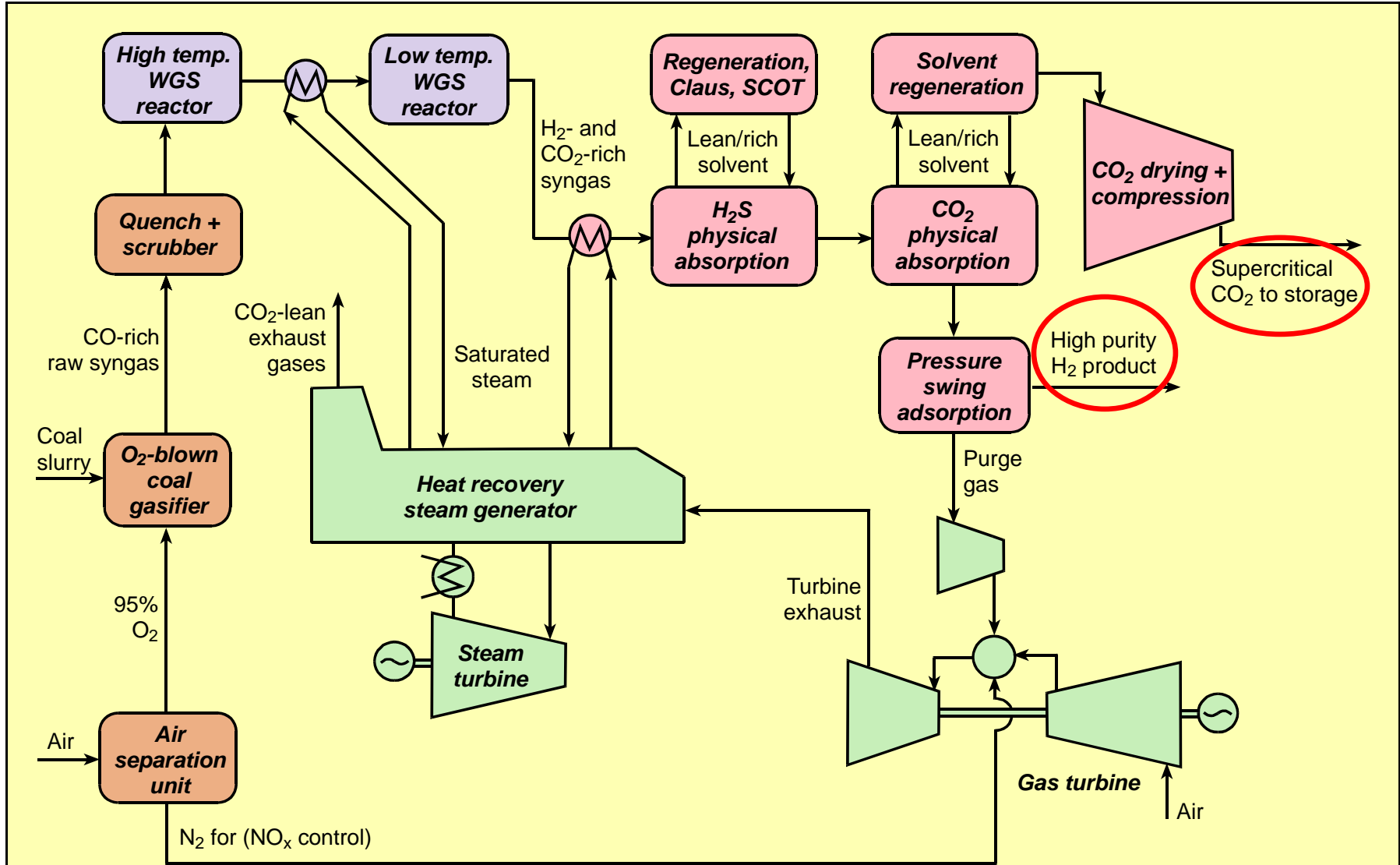
- CO₂ is natural by-product of fuels production.
- For example, SASOL Fischer-Tropsh plants in S. Africa vent ~20 million t/yr of nearly pure CO₂.
- Capturing the CO₂ at such plants for EOR use can be done with low incremental cost
 - Capture cost is essentially the cost of CO₂ drying and compression (< \$10/tCO₂).
 - CO₂ pipeline transport adds \$5-10/tCO₂ (depending on distance and flow volume).

Fischer-Tropsch and Electricity Co-Production with CO₂ Capture



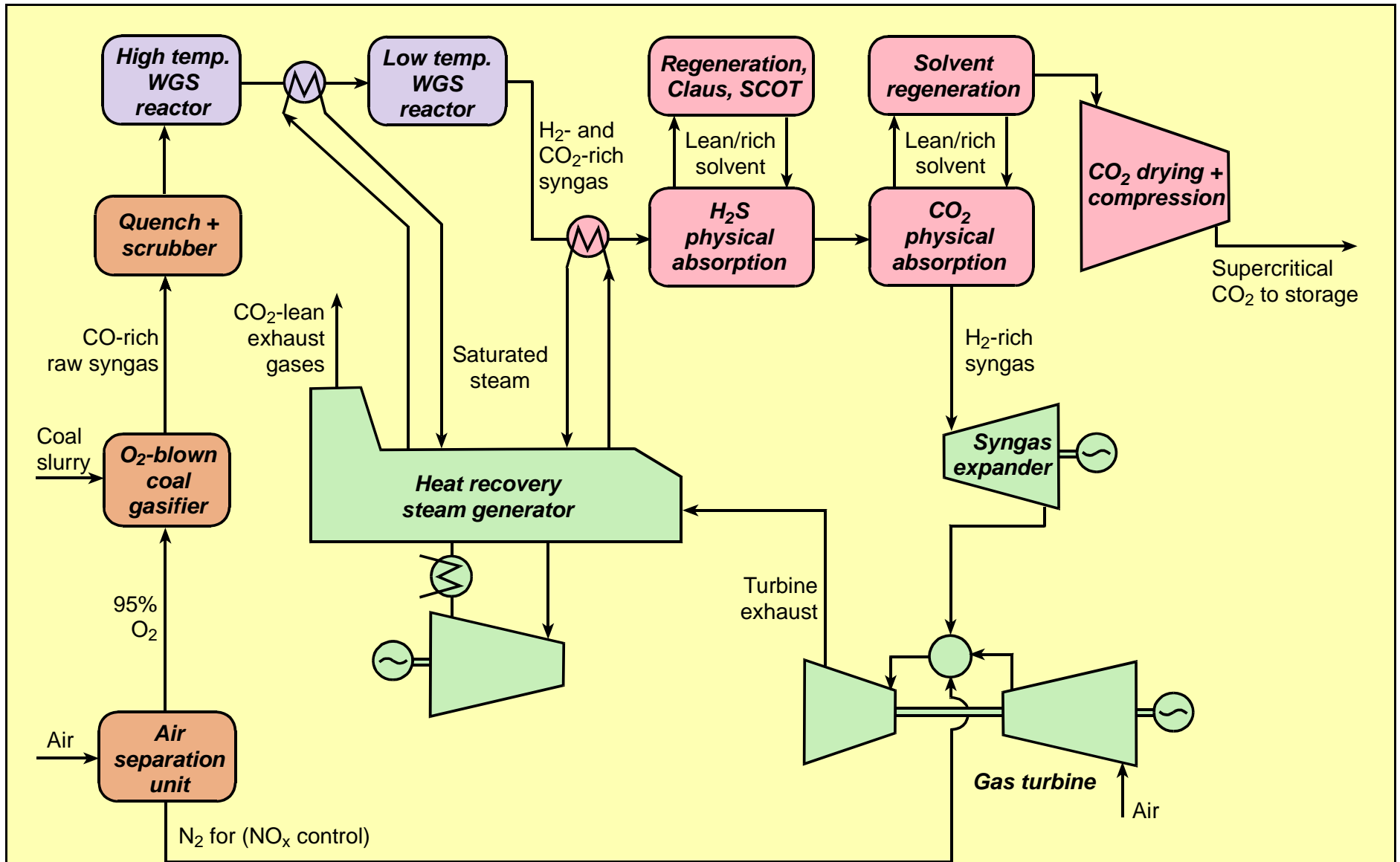
~100 kWh electricity per tCO₂
for compression to 150 bar.

Coal-H₂ Production with CO₂ Capture



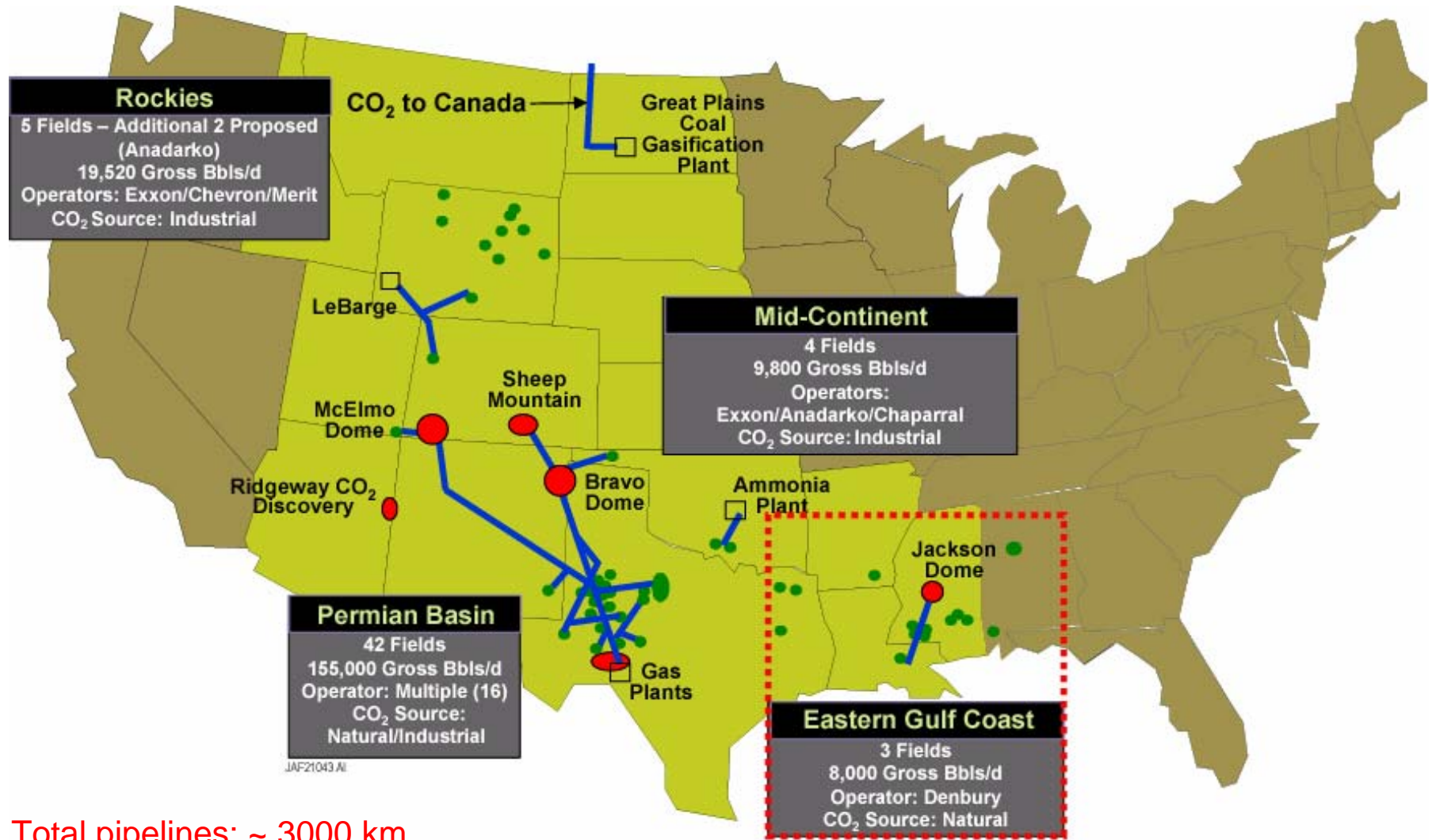
Note: China is world's largest producer of H₂ from coal today.

Coal-IGCC with CO₂ Capture



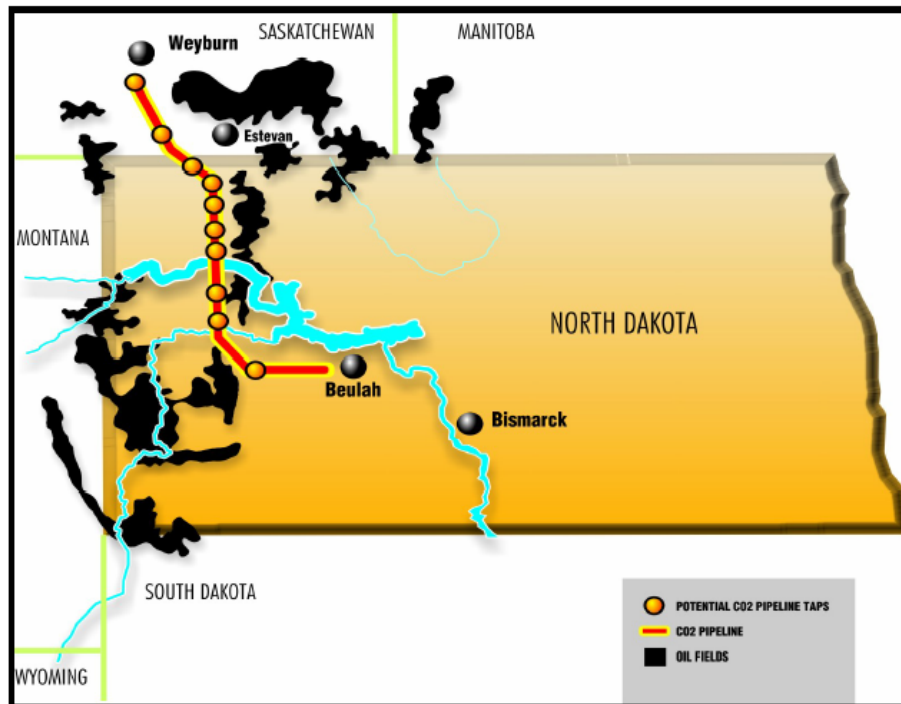
CO₂ capture less costly for IGCC than for pulverized coal steam-electric plants.

Extensive Experience in USA with CO₂ Transport For EOR



Total pipelines: ~ 3000 km

One EOR Project Uses CO₂ By-Product of Coal Gasification for Synthetic Natural Gas Production



- Great Plains Synfuels plant (Beulah, North Dakota) capacity of 170 million cubic feet/day methane from 18,500 tons of lignite → 200 million ft³/day of nearly pure CO₂.
- Operating since 1984.
- 95 million ft³/day CO₂ being sold (since 2000) to Encana Corporation for CO₂-EOR at the Weyburn oil field in Saskatchewan, Canada.
- CO₂ is transported 205 miles to the CO₂-EOR site via pipeline.

Cost Of CO₂ Capture in Generating Electricity -- Existing Technology (\$ per tonne of CO₂)

Technology	Representative Value	Range
New natural gas combined cycle plant	44	33 - 57
New pulverized coal plant	29	23 - 35
New coal IGCC plant	20	11 – 32
Existing pulverized coal plant	None indicated	31 - 56

Source: *IPCC Special Report on Carbon Dioxide Capture and Storage*, 2005

IGCC CO₂ costs likely to fall faster with experience than cost of CO₂ from pulverized coal plants..

See: E.S. Rubin (*Department of Engineering and Public Policy, Carnegie Mellon University*), M. Antes, S. Yeh, and M. Berkenpas, *Estimating the Future Trends in the Cost of CO₂ Capture Technologies*, Report Number: 2006/6, Greenhouse Gase R&D Programme of the International Energy Agency, February 2006.

Assessment of USA CO₂-EOR Potential (done by ARI, 2005)

Basin/Area	30-yr levelized economic CO ₂ -EOR potential (10 ⁶ barrels/day)	Princeton estimates for capacity of coal gasification systems that could provide the CO ₂	
		IGCC (GW _e)	Fischer-Tropsch (10 ⁶ bpd oil eq.)
Alaska	0.70	7.8	0.31
California	0.30	4.4	0.18
Gulf Coast	0.21	3.3	0.13
Mid-Continent	0.57	5.9	0.24
North Central	0.058	0.7	0.028
Permian	0.99	14.9	0.60
Rockies	0.22	3.1	0.12
Texas, East/Central	0.79	9.4	0.38
Williston	0.046	0.6	0.024
Lousiana offshore	.40	7.2	0.29
Total	4.28	57.3	2.29

- Estimates are for “state-of-the-art” CO₂ EOR [~0.2 tCO₂ (fresh) per EOR barrel].
- Each GW of coal-IGCC electricity capacity supports ~13x10⁶ bpd EOR production.
- Each barrel of FT liquid production supports ~2 bbls EOR production.