


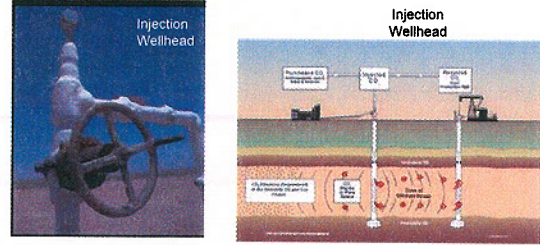

EERC
EERC Technology... Putting Research into Practice

North Dakota's Enhanced Oil Recovery Opportunity and Bakken Insights
Presentation to the North Dakota Legislative Council
Interim Energy Development and Transmission Committee
October 24, 2007

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for Research




CO₂ Enhanced Resource Recovery (CO₂ EOR and CO₂ ECBM)

CO₂ EOR – How It Works


- CO₂ dissolves in oil, lowers oil viscosity, reduces interfacial tension, and swells the oil, thereby allowing oil affixed to the rock and trapped in pore spaces to flow more freely.
- The early phase of oil production (called primary production) decreases the fluid pressures in a reservoir. CO₂ injection repressures the reservoir, thereby reestablishing a drive mechanism. CO₂ EOR can follow primary production but typically follows a water injection (waterflooding) phase
- A portion of the injected CO₂ will be produced with the oil and water, separated at the surface, and recycled to be used again in the reservoir. The recycle volumes, as a percentage of total injection volumes, will vary from 0% early in the flood to as much as 60% in a very mature flood.
- Typically 90%–100% of the purchased CO₂ volume is retained in reservoir (dead end pores and channels).



CO₂ Flooding Projects

- Are low-return/high-cashflow/long-life investments
- Require large investments up-front
- Have high operating costs
- Are technically demanding projects ("nimble")
- Not all oil reservoirs are flood candidates
- Are best placed in a portfolio with low-cost/high-return projects

*Adapted from Wilkins, M. Presentation at the 2006 EOR Carbon Management Workshop – "CO₂ EOR Issues and Economics, Is It as Profitable as We Think?"

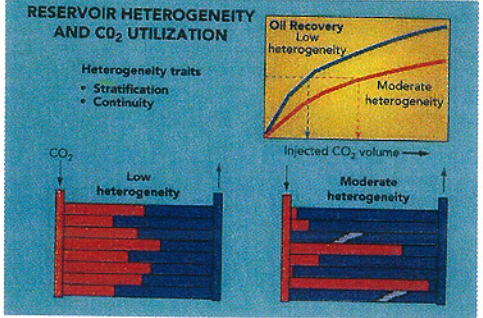


Reservoir Heterogeneity Degrades Project Efficiency*

RESERVOIR HETEROGENEITY AND CO₂ UTILIZATION

Heterogeneity traits

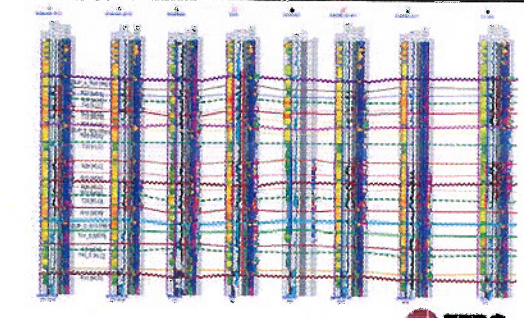

- Stratification
- Continuity



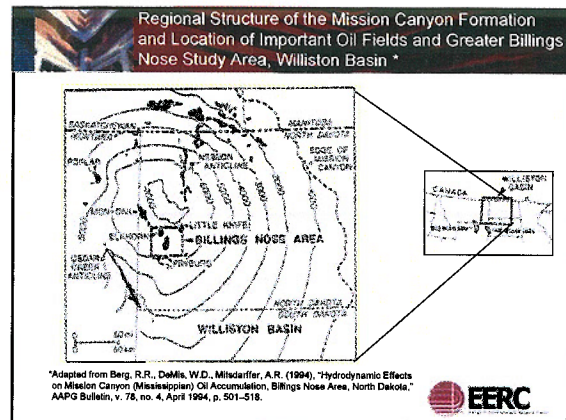
* Adapted from Bradley, T. Presentation at the Dec. 2006 EOR Carbon Management Workshop entitled "CO₂ EOR and Carbon Capture – Some Issues to Consider"

Stratigraphic Complexity

(slide courtesy of Hess Corporation)

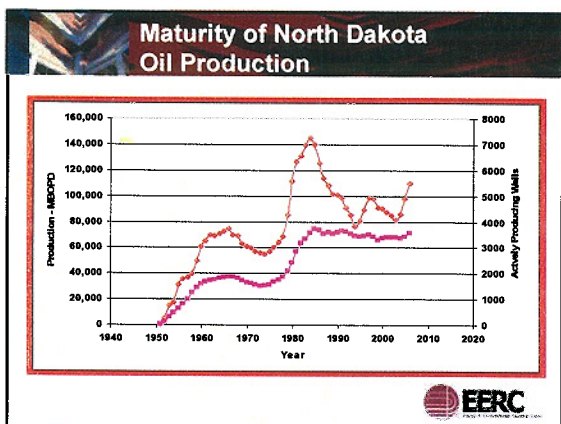
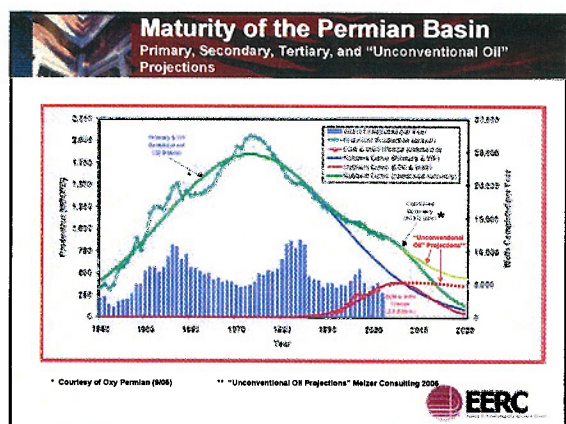



Reservoir Comparison (data courtesy of Hess Corporation)			
	North Dakota (B/DU)	Permian (SSAU)	Weyburn
OCIP (mmibbls)	280	1,000	1,400
Depth (m)	3100	1615	1450
Lamination	High	Med	Low
Min. Max. Press. (psi)	3000	1300	1740
Temperature (deg. F)	251	104	139
Ult. Rec. Factor w/ CO ₂ (%)	35-45	>63	36
Tertiary Rec. Factor (%)	5-10	~14	~10
Oil Gravity (API)	42	35	25-34
Porosity (%)	13	12	15-26
Initial Water Saturation (%)	21	16	32
Permeability (mD)	3-6	9	10-30
Well Spacing	80-160 acres	20 acres	70 acres (initial) Initial Drilled Later



The Conventional Wisdom: CO₂ EOR Opportunities Are Limited

- North Dakota's reservoirs are more compartmentalized, more heterogeneous, deeper (high T, high P), and less reserve base, leading to higher risk and cost per incremental bbl than those in Saskatchewan...
- But There Is Some Good News Too!**
- In the past, oil revenue has had to pay for everything (source, PL, field infrastructure).
- In the coming world of CCS/CO₂ EOR, capture and maybe transportation may be at least covered by others, leaving economics of the field to control new implementation of EOR projects.
- Oil prices are high.
- North Dakota reservoir modeling is under way and/or completed in several fields
- Should dramatically open up the scope of applicable reservoirs







Summary

- Hydrocarbons are a huge part of today's energy mix; pressures to wind it down are everywhere.
- But energy retooling is economically challenged.
- Part of the solution is to begin to use coal and oil with CO₂ capture and storage.
- CCS is a big portion of the answer, but CCS requires new alliances. EOR/CCS industry is just now forming to grow reservoir targets and help other industries (e.g., coal, utilities), with federal and state governments as policy partners.
- North Dakota is ideally located to lead this endeavor because of coincident coal and oil resources.

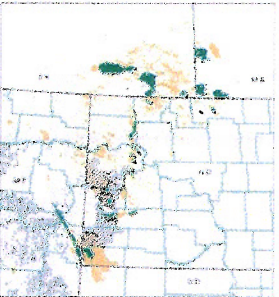


Tertiary EOR Background

- Roughly 17 mcf per ton of CO₂
- Assumed 8 mcf (net) of CO₂ needed for every barrel of incremental oil (13 mcf/bbl initial purchase) for PCOR Partnership projections. What will Weyburn tell us?
- PCOR Partnership initially used Nelms and Burke (2004) screening criteria to select North Dakota fields for detailed evaluation.
 - Subsequent collaboration with producers
 - Subsequent collaboration with ND DMR OGD
 - Waterflood performance
 - OOIP updates
 - Unitization activity

Williston Basin CO₂ EOR Opportunities



Incremental Oil Potential





Williston Basin

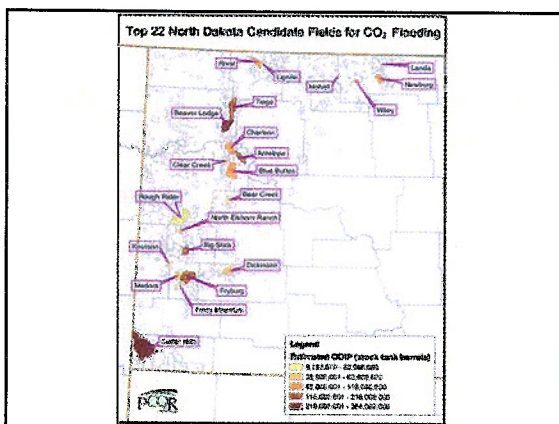
- 1.02 billion stb
- Today's value = \$60.7 billion

North Dakota

- 262 million stb
- Today's value = \$15.6 billion

At \$59.50/stb, quoted by Plains Marketing, L.P., August 8, 2006



Bakken Integrated Solutions Program

- Minimum of six members (one letter of intent)
- GIS data management :
 - Geology
 - Depositional facies
 - Rock properties
 - Geophysics
 - Tiltmeters
 - 3-D/4-D seismic
 - Completion technology
 - Fluids and proppants
 - Multistage completions
- Pool financial resources from:
 - Federal sources (RPSEA?)
 - O&G producers
 - Service companies
 - ND OGRC Funds



Bakken Forum

- EERC and Research Partnership to Secure Energy for America (RPSEA) are hosting a Bakken Forum on November 6, 2007, to:
 - Define R&D priorities.
 - Outline collaborative opportunities.



The Bakken Shale Forum

Tuesday, November 6, 2007
Grand Forks, North Dakota



Save the Date!

Tuesday, November 6, 2007

The Energy & Environmental Research Center (EERC), in conjunction with the Research Partnership to Secure Energy for America (RPSEA), is pleased to announce a forum regarding the Williston Basin's Bakken Formation.

The Bakken Shale Forum will be held at the EERC in Grand Forks, North Dakota, on Tuesday, November 6, 2007.

You are invited to attend and participate in the forum designed to facilitate a dialogue on regional Bakken shale issues and pressing challenges in the industry, as well as to create an environment for participants to network with others in the oil and gas industry. Throughout the day, input from all attendees will be encouraged to identify technical needs and research topics that will benefit Bakken shale producers. A tour of the EERC will be available to forum participants following the meeting.

More information will be available soon, so watch the RPSEA Web site at www.rpsea.org for details on the agenda and how to register.

Carned Inne Hotel Package

As a Bakken Shale Forum participant, you are eligible for a special room rate of \$84 for single/double occupancy at Grand Forks' newest hotel attraction, the Carned Inne. A block of rooms has been reserved for the nights of November 5 and 6, 2007. To take advantage of the discounted rate, book your room by October 22, 2007.

Book your room now! Call (701) 772-8404 or 1-888-33CANAD (2-3823) and ask for the EERC room block.

For more information, contact:

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