IMPLEMENTATION OF A GEOGRAPHICAL INFORMATION SYSTEM (GIS) FOR THE WYOMING ENHANCED OIL RECOVERY INSTITUTE (EORI)

Southwest Users Group Conference
Laramie, Wyoming
October 22, 2008

Brian Reyes, Research Geologist
Topics

- Who we are and what we do
- EOR in Wyoming
- Strategy and capabilities
- GIS for EOR
  - Data mining
  - CO$_2$ Flooding
  - Chemical Flooding
  - Low-salinity flooding
- The future for EOR and GIS

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The EORI Mandate

Recovering Wyoming *Stranded* Oil

✧ To conduct research to develop new Enhanced Oil Recovery (EOR) technologies and to promote EOR through the transfer of new and existing technologies in the state of Wyoming.

✧ To actively seek the involvement of Wyoming owners/operators, to respond to their needs, and meet their requirements through application of cutting edge science and technical know-how.

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EOR Commission

EOR Technical Advisory Board

Information Assembly and Acquisition
- Peigui Yin
  - Reservoir Characterization
- Mark Tomasso
  - Reservoir Characterization
- Carolyn Coolidge
  - Geo/Hydrology
- Shaochang Wo
  - Reservoir Simulation
- John Lorenz
  - Fracture Characterization
- Mohammed Piri
  - Reservoir Characterization
- Hertanto Adidharma
  - Reservoir Fluids
- Xina Xie
  - Pet. Engineering
- Norman Morrow
  - Chem. Engineering
- Jill Buckley
  - Chem. Engineering
- Brian Reyes
  - Geology and GIS

Technical Development
- Owen Phillips
  - Economics
- Vladimir Alvarado
  - Pet. Engineering
- Geoff Thyne
  - Carbon Sequestration/Geochemistry
- Maciej Radosz
  - Carbon Capture
- Youqing Shen
  - Carbon Capture
- Mark Leslie
  - Geochemistry
- Brian Towler
  - Reservoir Engineering

Corporate Outreach and Strategic Alliances
- Lon Whitman
  - Corporate Outreach and Strategic Alliances
- Glen Murrell
  - Marketing and Business Development
54.1 Million Barrels Of Oil produced in 2007

10-15% by EOR

10.5% by CO₂ EOR
(5.7 MMBO in 2007)
According to WSGS
~8 billion barrels of oil remain in the ground,
5-15% recoverable by EOR.

Only 5% recovery could mean $4 billion to the state of Wyoming over a period of 20 years at $70/bbl.
EORI Strategy

Information Assembly and Acquisition
- Fracture Characterization
- Reservoir Characterization
- Oil Properties
- Wettability
- Three Phase Permeability
- Rocks and Oil

Technical Development
- Carbon Capture and Storage
- Scoping Tool
- Chemical Flooding
- Water Flooding
- CO₂ Management
- Reservoir Modeling
- Screening
- Database Development
- GIS

Corporate Outreach and Strategic Alliances
- Cooperative Associations
- Contractual Projects
- Strategic Planning
- Information Transfer
  - Meetings
  - Conferences
  - Workshops
- Presentations
- Publications

Incremental Oil Production with EOR

Increased State Revenue
EORI Capabilities

✧ Technologies and analytical techniques that the EORI is working on directly, promoting or investigating in collaboration with others.

✧ Technologies
  ✧ CO₂ enhanced oil recovery
  ✧ Low-salinity water flooding EOR
  ✧ Chemical enhanced oil recovery
  ✧ Well stimulation
  ✧ Heat to power

✧ Analyses
  ✧ Screening models
  ✧ Scoping models
  ✧ Geologic models
  ✧ Reservoir characterization
  ✧ Reservoir modeling and simulation
  ✧ GIS

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EOR Challenges

- Infrastructure
  - CO$_2$ supply and transportation
    - EORI is monitoring new sources within the state.
    - Working with other state agencies (Wyoming Pipeline Authority) and mid-stream companies to overcome infrastructure issues.
- Lack of pilot data
- Production price differential (related to infrastructure)
- Data management

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Data sources

External datasets
- WY Geological Association
- WY Oil & Gas Conservation Commission
- WY Geographic Information Science Center
- WY Geographic Association
- WY Geographic Information Advisory Council
- WY State Geological Survey
- WY Pipeline Authority
- Department of Energy/National Energy Technology Lab

Internal data acquisition
- Decline curve analysis
- Lab studies

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GIS for Enhanced Oil Recovery

- Enhanced decision making.
  - Better understanding of the spatial distribution of reservoir characteristics and potentially their origin (pure research).
  - Identify spatially related entities (data mining).
- Proximity to required resources, sinks, infrastructure, utilities, etc.
- Proximity to other reservoirs with matching characteristics/potential EOR methods (sink clustering).

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OIL FIELDS WHERE MINIMUM MISCIBILITY PRESSURE (MMP) IS LESS THAN FRACTURE PRESSURE
Data Mining – Chemical Flooding

MINNELUSA 2007 FIELD PRODUCTION AND API

Legend
- Counties Oil Producing Fields
- Minnelusa Field API
- Oil Production (BRLS)
  - 0 - 70,000
  - 70,001 - 140,000
  - 140,001 - 210,000
  - 210,001 - 280,000
  - 280,001 - 350,000

Cartographer: Orie Terna
Compilation: Enrhined Oil Recovery Institute
Date: August 13, 2008
Database: WYODCC, METL, WOA
Projected Coordinate System: Al Lambert Conformal Cone
Projection: Lambert Conformal Conic
Field Reservoir Combinations (FRCs)
Centroids for Fields in Wyoming

Legend
- County
- Yellowstone
- Basin
- Field
- FRC

Map showing centroids of fields in Wyoming.
Active and Developing CO₂ Floods in Wyoming

Legend
- County
- Basin
- Yellowstone
- Active CO₂ Flood
- Developing CO₂ Flood
- Shute Creek Facility
- ExxonMobil Pipeline
- Chevron Pipeline
- Anadarko Pipeline
- Devon Pipeline
- Merit Pipeline

Cartographer: Brian Reeves
Company: Energy Storage & Recovery Institute
Date: October 2008
Data Source: WGS84, NGVD29, NGS, and USGS
Projected Coordinate System: NAD Lambert Conformal Conic
Projection: Lambert Conformal Conic

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CO₂ Sources and Pipelines in Wyoming

Refined Energy Holdings is proposing a coal to fertilizer plant near American Falls, ID, that would produce ~60 MMCFD of 95% pure CO₂ in 2011-12. In 2014-16, CO₂ would increase to ~175 MMCFD.

A pipeline from American Falls to the Shell Creek area is under evaluation.

ExxonMobil is installing 23,000 hp of CO₂ compression to increase CO₂ sales capacity by ~110 MMCFD. Start-up is planned for the 2nd quarter of 2016.

GasTech, Inc. Underground Coal Gasification (UCG) project ~15 MMCFD CO₂ estimated for 2013.

ConocoPhillips is finalizing the sale of ~60 MMCFD of CO₂ from their Lost Cabin Plant.

Medicine Bow Fuel and Power is developing a coal to liquids plant near Hanna, WY which will produce ~250 MMCFD of 95-98% pure CO₂. Projected start-up is in 2013.

Legend

- County
- Basin
- Yellowstone
- Anadarko Pipeline
- CO₂ Source
- ExxonMobil Pipeline
The EORI is working together with the Wyoming Pipeline Authority to determine the optimal character, both in terms of technical and economic factors, of a CO$_2$ pipeline system for Wyoming.
TOTAL DISSOLVED SOLIDS (TDS) FOR RESERVOIRS IN WYOMING

Legend
- Counties
- Basins
- Yellowstone
- Oil Fields

Total Dissolved Solids (PPM)
- 1,018 - 50,000
- 50,001 - 100,000
- 100,001 - 150,000
- 150,001 - 200,000
- 200,001 - 220,219

Cartographer: Brian Rowen
Company: EORI
Data: 2008
Data Sources: [http://eori.uwyo.edu](http://eori.uwyo.edu)
Projected Coordinate System: NAD83 Lambert Conformal Conic
Projection: Lambert Conformal Conic
POSSIBLE CANDIDATES FOR LOW-SALINITY FLOODING, MINNELUSA FORMATION, POWDER RIVER BASIN, WY

Legend
- Counties
- Basins
- Lakes
- Stream

Total Dissolved Solids (PPM)
- 1,018 - 50,000
- 50,001 - 100,000
- TDS > 100,001

Reservoir Buffer Zone Distance (km)
- 1
- 2
- 5
- 10

Cartographer: Brian Reyes
Company: Enhanced Oil Recovery Institute
Date: October, 2008
Date Source: http://www.nrel.hoe.gov/techlab/energy/energy.html
Projected Coordinate System:
NA Lambert Conformal Conic
Projection: Lambert Conformal Conic
GIS and EOR - The Future

✧ Volumetric calculation tool
✧ EOR specific query tools
✧ Database public release
✧ Internet mapping
✧ GIS workshops/presentations

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Wyoming's Top 30 Oil Producing Fields

1978
Wyoming Oil Production (million bbls)

1987
Wyoming Oil Production (million bbls)

1990

[Map of Wyoming showing oil production regions and data bars for each year from 1978 to 2000]
1993

Wyoming Oil Production (million bbls)

- 1978
- 1979
- 1980
- 1981
- 1982
- 1983
- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007

- BIGHORN BASIN
- POWDER RIVER BASIN
- SHIRLEY BASIN
- GREAT DIVIDE BASIN
- WASHAKIE BASIN
- KINDT BASIN
- LARAMIE BASIN

Map showing Wyoming oil production by year and basin.
Thank you.

Brian Reyes, B.Sc.
Geologist

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<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2007</td>
<td>June - WY CO\textsubscript{2} Meeting</td>
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<tr>
<td></td>
<td>October – CO\textsubscript{2} EOR with Steve Melzer</td>
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<tr>
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<td>October – Chemical EOR with Gary Pope</td>
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<td></td>
<td>October – Single Well Chemical Tracer Testing with Charlie Carlisle</td>
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<td></td>
<td>November – Geologic Fractures with John Lorenz</td>
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<td>2008</td>
<td>May – WY CO\textsubscript{2} Meeting</td>
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<tr>
<td></td>
<td>September – WY EOR/IOR Meeting</td>
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<tr>
<td>2009</td>
<td>February (TBA) – Geologic Fractures</td>
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<td></td>
<td>March (TBA) – Field Evaluation for EOR Projects</td>
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<td></td>
<td>June (TBA) – WY CO\textsubscript{2} Meeting</td>
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