The Potential For Secondary Recovery Projects in Wyoming

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Purpose of This Presentation

- Discuss the potential for future secondary recovery (water flooding) projects in Wyoming
  - Estimate potential reserves for new secondary oil recovery projects in Wyoming
  - Estimate the potential additional tax revenue to the state from these future secondary recovery projects
  - Estimate the impact on employment
- Open a meaningful discussion on ways to encourage the initiation of additional waterflooding and other EOR projects in the state

Agenda – Items of Discussion

- Summary of major findings from this study
- Procedure used to estimate potential reserves from new secondary recovery projects in Wyoming
- Impact of Wells in “Target Fields” on Wyoming’s production
- Discussion and conclusion

Summary of Major Findings From This Study

Summary of EORI Findings Based on Published Data

- **343 MMBO** - *minimum* potential reserves from new secondary recovery projects in Wyoming
- **277 oil fields** – the *minimum* number of oil fields that are good candidates for future secondary recovery projects
- **$2.35 billion** – the *minimum* state severance and ad valorem tax revenue from these future secondary projects
- Thousands of Wyoming jobs would be created by implementing additional secondary recovery projects

Procedure Used to Estimate Potential Reserves from New Secondary Recovery Projects in Wyoming

Procedure

- Assumption: in general, secondary recovery can produce about the same reserves from a field as that from primary production
- Determine the reserves from Wyoming oil fields that are still on primary production
  - Utilize public data from the Wyoming Oil & Gas Conservation Commission (from December 28, 2017)
  - Use current cumulative primary production numbers as a conservative estimate of ultimate recovery (EUR)
  - Screen these data utilizing published reports including those from the Wyoming Geological Association, Petroleum Association of Wyoming, Rocky Mountain Association of Geologists, IHS, and Drilling Info

Procedure

- Collect production information and comments for each field
  - Cumulative oil production by field and individual reservoir
  - QC number of active oil wells in each field
  - Estimate OOIP for each field/reservoir when possible
  - Calculate Recovery Factor (RF) values when possible
  - Determine average depth to reservoir
- Rule out those fields that will not see significant improvement from secondary recovery methods (those on natural water flood, gas wells, or with a high RF already)

Potential Candidates for Secondary Recovery

- There are 637 reservoirs spread across 495 fields that are on primary recovery; production totals **758 MMBO** based on WOGCC data
  - 38 of these reservoirs were eliminated because additional research reveals they had been waterflooded or were on natural water drive and would not benefit from induced water injection
  - 86 additional reservoirs were eliminated because their Recovery Factor (RF) is greater than 20% and may not show marked improvement from a water flood
- The remaining 513 reservoirs are spread across 397 fields, which are considered to be good candidates for secondary recovery
  - These 397 fields have produced in excess of **465 MMBO**

Most Productive Formations Within 397 Candidate Fields

Formation	Cumulative Oil
• Lance:	93,912,150
• Muddy:	92,568,825
• Frontier:	38,825,577
• Mesaverde:	35,805,258
• Phosphoria:	24,219,038
• Nugget:	24,096,992
• Turner:	18,164,674
• Dakota:	17,273,193
• Minnelusa:	15,997,989
• Cloverly:	15,736,775
• Shannon:	15,442,804
• Fort Union:	11,022,786
• *All Others:*	*62,071,213*

Lance Formation in southeast Wyoming.
Photo credit: Wyoming State Geological Survey

Productive Formations: Recovery Factors

Reservoir	RF High	RF Low	RF Average
Shannon	16.6	13.2	14.9
Muddy	15.5	0.5	7.5
Phosphoria	17.0	0.2	7.0
Turner	17.5	0.2	6.6
Frontier	12.7	0.1	3.5
Dakota	16.4	0.05	3.3
Fort Union	7.6	0.01	3.2
Nugget	1.8	1.8	1.8
Mesaverde	1.8	0.1	1.1
Lance	0.6	0.1	0.4
Minnelusa	No Data	No Data	No Data
Cloverly	No Data	No Data	No Data

Ranked by highest to lowest average recovery factor (RF); includes only those fields in which a published OOIP is available

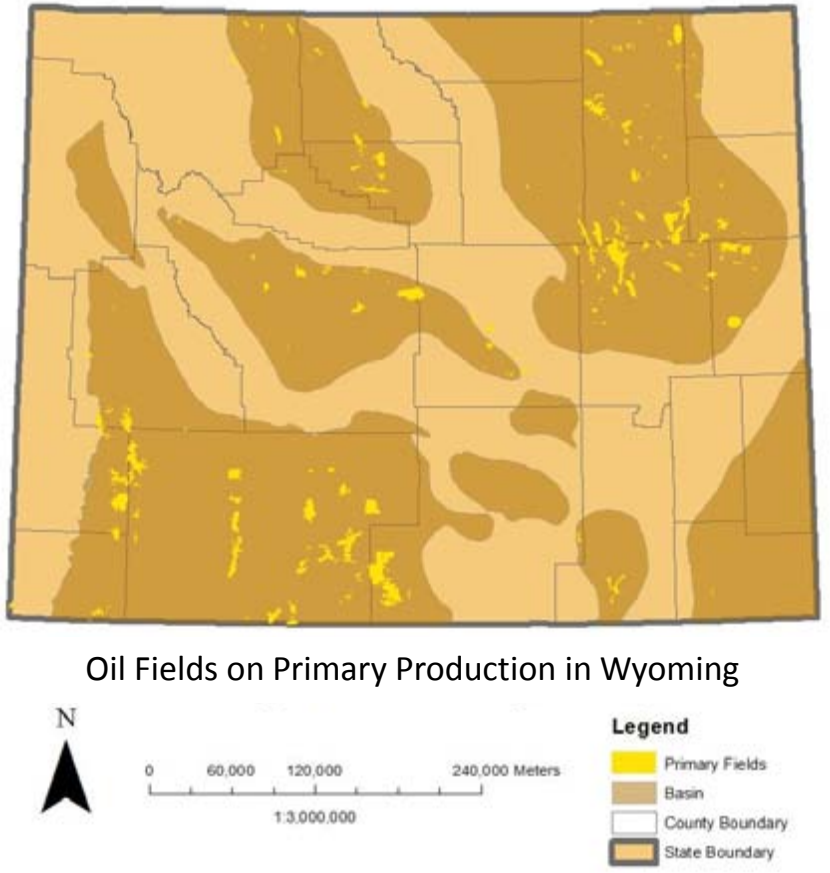
Target Fields: Selection

- To be conservative, we selected only those reservoirs that have a GOR of less than 10,000 or have produced in excess of 50,000 BO per well as those that are the most likely candidates for successful waterfloods; "Target Fields" are thereby reduced from 397 to **277**
- Total cumulative production from these 277 fields is over **343 MMBO**
- Therefore, the estimated reserves available from initiating secondary recovery in these fields is about **343 MMBO**
- Tax revenue to Wyoming from these new secondary projects would amount to over **$2.35 billion**
  - Assumes $55/BO over life of projects and 12.5% average total tax rate

This process eliminates fields such as Jonah with production of nearly 47 MMBO because the GOR is over 10,000 and the total well count results in per-well production of 21,419 BO. Many of the discounted fields are likely to contain zones that are in fact good candidates for secondary recovery.

Target Fields: Current Significance to Wyoming

- 277 target fields are producing 31,352 BOPD with an average of 5.2 BOPD per well
  - Total 2017 production ~11.4 MMBO
  - Total cumulative production 343 MMBO
- Represents about 18% of state's total production in 2017
  - Total 2017 production ~64.0 MMBO
- These fields are significant to state's oil production and will be even more so when put on secondary recovery
- ***Prematurely plugging boreholes in these fields will eliminate access to the recoverable hydrocarbon reserves still available there***



Oil Fields on Primary Production in Wyoming

Impact of Wells in Target Fields on Wyoming's Current Oil Production

Active Wells According to State Records (Dec 28, 2017)

- Total Active Wells in Wyoming: 54,158
  - Active injector, Disposal, Drilling or Drilled Permit, Dormant, Flowing, Gas Lift, Gas Storage, Monitor, Well Monitor Well (Not for Form 2 Reporting), Notice of Intent to Abandon, No Report, Producing Gas Well, Pumping Hydraulic, Plunger Lift, Producing Oil Well, Pumping Rods, Pumping Submersible, Shut-In, Suspended Operations, Well Spudded, Temporarily Abandoned
- Active wells in Target Fields: 7,226 (13.3% of total active wells)

Source: WOGCC website 12/28/2017

Most Wells In Target Fields Are Stripper Wells

- 243 of the 277 target fields (86.6%) are producing an average of less than 10 BOPD per active well (i.e. are mainly stripper wells)
  - Daily production from the 243 fields is 15,796 BO (2.3 BOPD/well)
  - Stripper wells from these "target" fields account for 9% of state's daily production
    - Total daily oil production in Wyoming is 175,525 BO (2017 statistics)
    - 15,796/175,525 = 9%
- Most of target fields contain wells that are in jeopardy of being temporarily shut-in as uneconomical or are being plugged & abandoned
  - Significant recoverable reserves commonly remain in these fields
  - Secondary production methods need to be implemented
  - Advances in technology result in new recovery strategies

Impact of The Oil Industry on Wyoming Employment

Wyoming Employment in the Oil and Gas Industry

2015 Economic report by the American Petroleum Institute employment relating to the oil and gas industry in Wyoming

- **Direct:** Jobs within the oil and gas industry
  - **30,983 jobs**
    - Drillers, Engineers, Geologists, Geophysicists, Accountants, Management, etc.
- **Indirect:** Jobs within the supply chain of the oil and gas industry
  - **8,201 jobs**
    - Pumper, cementer, acid treater, wholesale and retail jobs, welders, pipe layers, truck drivers, bulldozer operators, etc.
- **Induced:** Jobs resulting from the household spending earned from direct and indirect industry employment
  - **18,318 jobs**
    - Walmart, realtor/leasing, car salesman, hospitality, entertainment, etc.
- **Total: 57,502** jobs affected by the Oil Industry in Wyoming

Jobs Affected by the Oil and Gas Industry

Wyoming

- Each direct industry job supports an additional 0.86 jobs (down from over 1.4 jobs in 2011)
- Oil & Gas Industry supported **57,502** jobs
- Contributed **22.7%** of Wyoming GDP (2nd highest in the nation, after Oklahoma at 27.3%)

Statistics provided by 'Economic Impacts of the Natural Gas and Oil Industry on the U.S. Economy in 2015**' American Petroleum Institute

Wyoming Employment: Importance of Oil Industry

- Population of Wyoming 2016: 585,501
- Labor Force in 2016: 302,300
- 50 largest employers in the state employ 37,624 people
  - That number includes 2,080 Oil & Gas Industry-related jobs
    - Halliburton in Casper and Rock Springs account for 1,100 jobs; Sinclair Refinery 500 jobs; and Cyclone Drilling Inc. 480 jobs
- The number of direct and indirect industry-related jobs (39,184) is larger than the number of jobs provided by the top 50 employers in the state
  - Most industry-related jobs in Wyoming are with small companies
  - ***These small companies are most affected by additional regulatory costs***

**Employment data provided by CareerOneStop, www.careerinfonet.org/state [accessed Jan 8, 2018]

Discussion & Conclusion

Secondary Recovery Implementation: Benefits Wyoming

- **397 fields** are reasonably good candidates for secondary recovery and have potential secondary reserves of over **465 MMBO**
- Ruling out all fields with GOR>10,000 unless cumulative production is >50,000 BO/well leaves **277 fields** with potential secondary reserves of over **343 MMBO**
- Primary production in 2017 from the 277 “Target Fields” represents 18% of the total annual oil production in Wyoming
- If these same fields are put on secondary recovery, the impact on annual Wyoming production would be significant

Secondary Recovery Implementation: Benefits Wyoming

- New Secondary Recovery Projects: **343-465 MMBO** additional production
- State severance, ad valorem, and property tax revenue from new waterflood projects could exceed **$2.35 billion** (this value does not include any royalties on state or federal lands)
- New jobs will be created
- With application of tertiary recovery methods in these same fields, state revenue could increase by another 15-30%, or more than **$350 million**

Conclusions

- State should consider policies to incentivize development of IOR/EOR projects as part of the policy to optimize exploitation of the state's natural resources and to provide revenue to the state
- The potential for future secondary and tertiary projects needs to be seriously measured before decisions are made to force wells to be plugged and abandoned
- At risk is
  - Efficient exploitation of state's oil resources
  - Tax revenue to the state of ***at least*** $2.3 billion
  - Jobs
  - Standard of living for Wyoming residents

Thank You

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