# EOR and IOR in Wyoming

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SPE/WGA MEETING
CASPER, WYOMING
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ENHANCED OIL RECOVERY INSTITUTE

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# Wyoming Then and Now


Salt Creek Wyoming, 1910-1930
Courtesy of: UW American Heritage Center
Wyoming Oilfield Photography
Collections:

Pinedale Anticline 2012
Courtesy of National Geographic Magazine

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# Disclaimer and Acknowledgements

All data and information contained within this presentation are from public sources. Furthermore, all analyses and interpretations have been conducted with publically available data.



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  - Steve Melzer – Melzer Consulting
  - Vandy Jones – EORI

# AGENDA

- Overview of Wyoming's Energy Industry
- Introduction to the Enhanced Oil Recovery Institute
- Most EOR production within Wyoming comes from CO2 EOR projects
- 100+ Tcf of CO2 reserves
- Characterization and development of ROZs

# Wyoming

Large Energy Producer

- Coal - #1 in U.S.
- Natural Gas - #3 in U.S.
- Oil - #8 in U.S.
- Wind
- Uranium – largest reserves in the U.S.

If Wyoming were an independent nation, it would be one of the 10 largest energy producers in the world. Wyoming's total energy production is approximately equivalent to Norway or Mexico.

**Description: Murphy No. 1 Oil Well (Dallas Dome) 1st discovery well in Wyoming**
**Photo Date: 1896**

**Courtesy of: University of Wyoming Historical Archives (Samuel H. Knight Papers)**

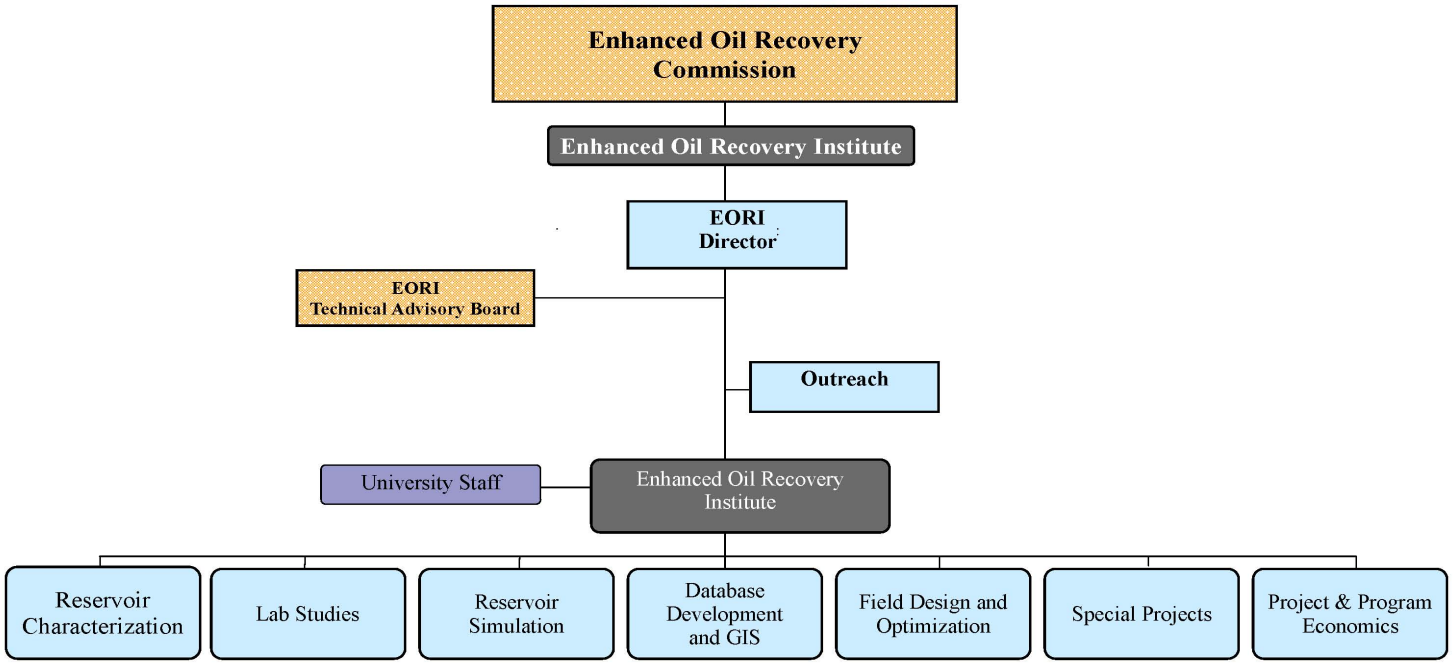
# Wyoming Oil Production

- First oil production – 1885 Dallas Dome
- Cummulative oil production = 7+ billion BO
- Half of total produced from the Bighorn Basin
- Waterflooding continuously utilized since the late 1940s. Current water cut in largest fields is 97+ percent.

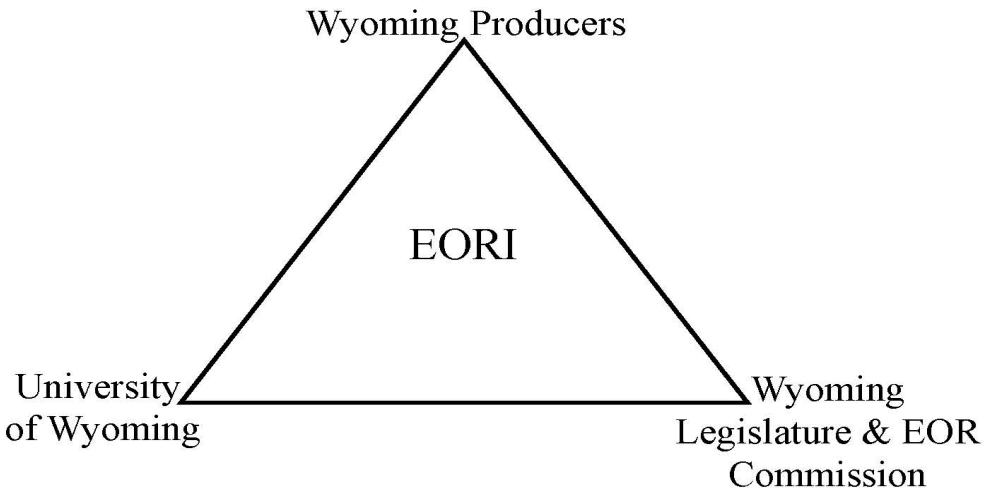
# Enhanced Oil Recovery Institute

- Created by the Wyoming legislature in 2004
- Located at the University of Wyoming
- EORI Mission
  - Conduct applied research to recovery Wyoming's stranded oil
  - Assist Wyoming operators with development of IOR and EOR projects
- 20+ full-time multi-disciplinary staff
  - 20+ university professors and graduate students
  - Consultants
  - Operators

# Organization



# Enhanced Oil Recovery Institute Triad




# Energy Innovation Center

- Laboratories for study of multiphase flow, petrophysics, improved oil recovery, enhanced oil recovery, characterization of reservoir matrix and fluids, and coal processing.
- 3D Audio/Visual Lab.
- Advanced software for reservoir modeling.
- State-of-the-art meeting rooms.

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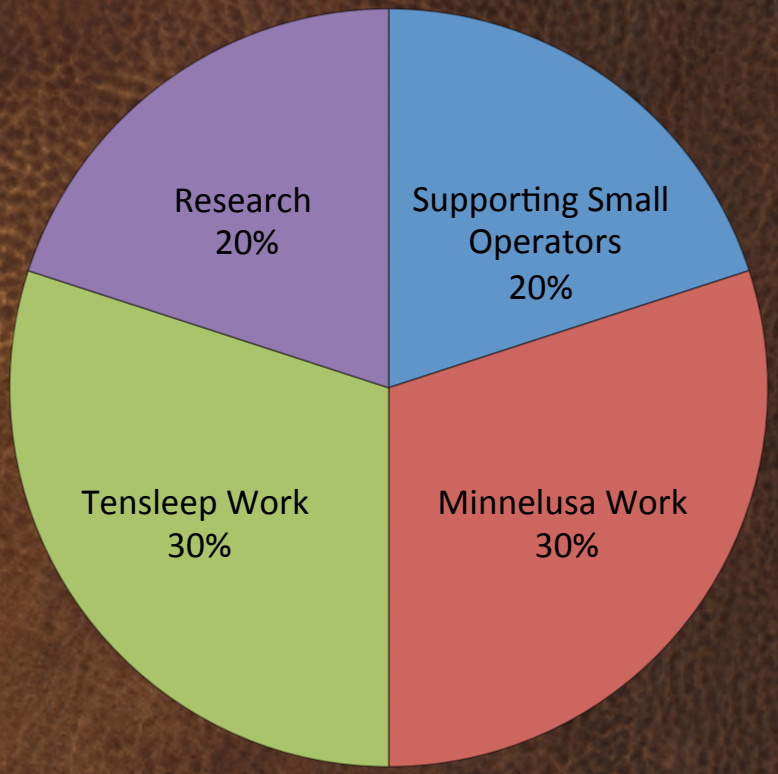
# Goal for Investment of EORI Funds




- Support Small Operators
- Minnelusa Work
- Tensleep Work
- Research

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# Current Projects

- Conformance improvement through use of gels, polymers, and foams.
- Characterization of residual oil zones (ROZs) in the Tensleep.
- Improved characterization of Wyoming reservoirs.
- Improved water flooding.
- Chemical flooding with ASP, SP, and P.
- CO2 flooding.

# Factors Influencing Current Oil Boom

- New Seismic Tools
- Horizontal Drilling and Improved Completions
- Higher Oil Prices

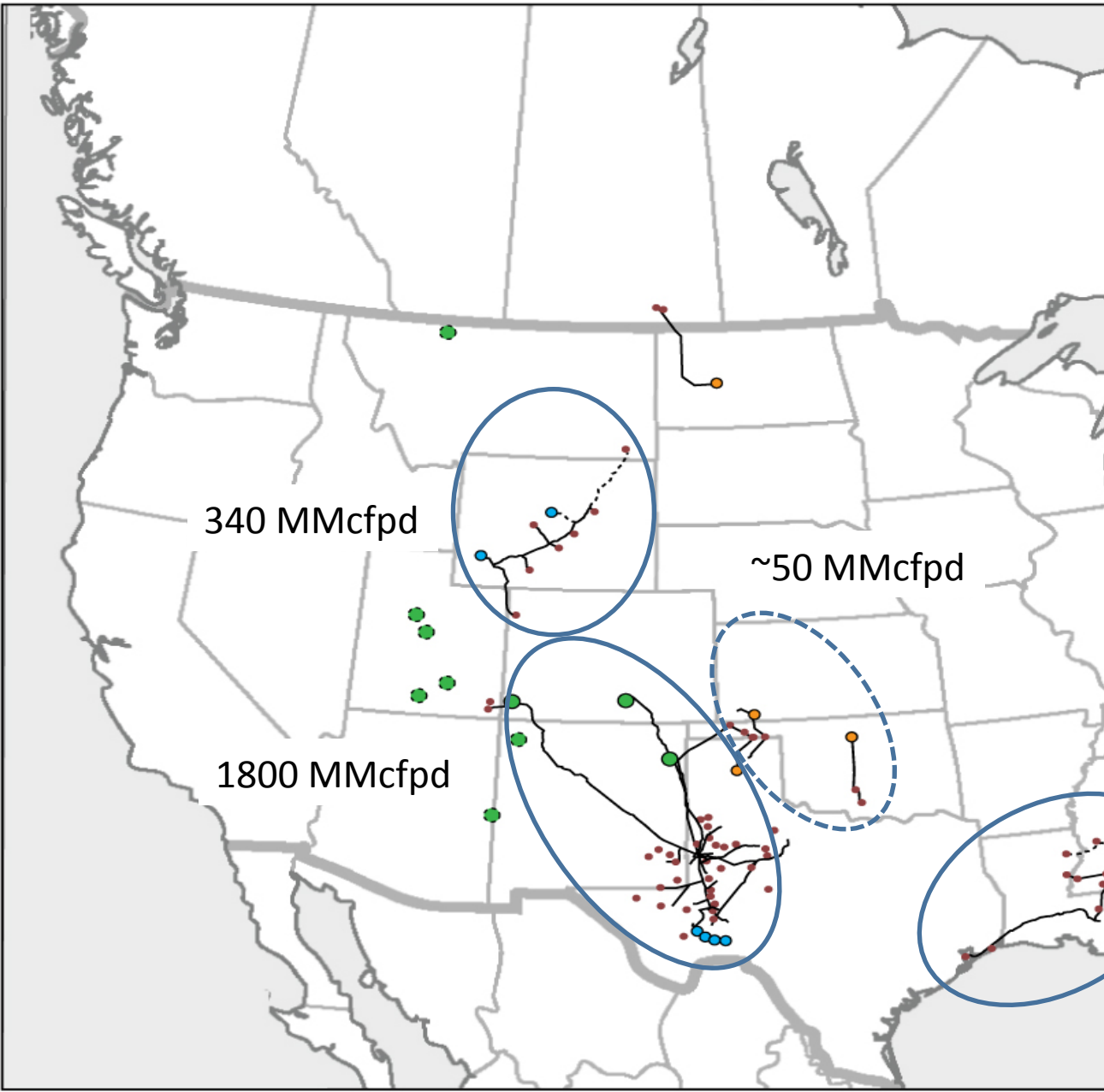
# New Technical Developments

- Characterization and Development of ROZs
- CO2 Foam
- Advanced Primary Floods – Unconventional Reservoirs
- Use of horizontal wells in mature fields

Modified from Melzer 2012, 6th Wyoming Annual CO2 Conf; DiPietro et al., 2012, Denbury Resources Investor Report 12/2011; www.zero.no.

Murrell,2012

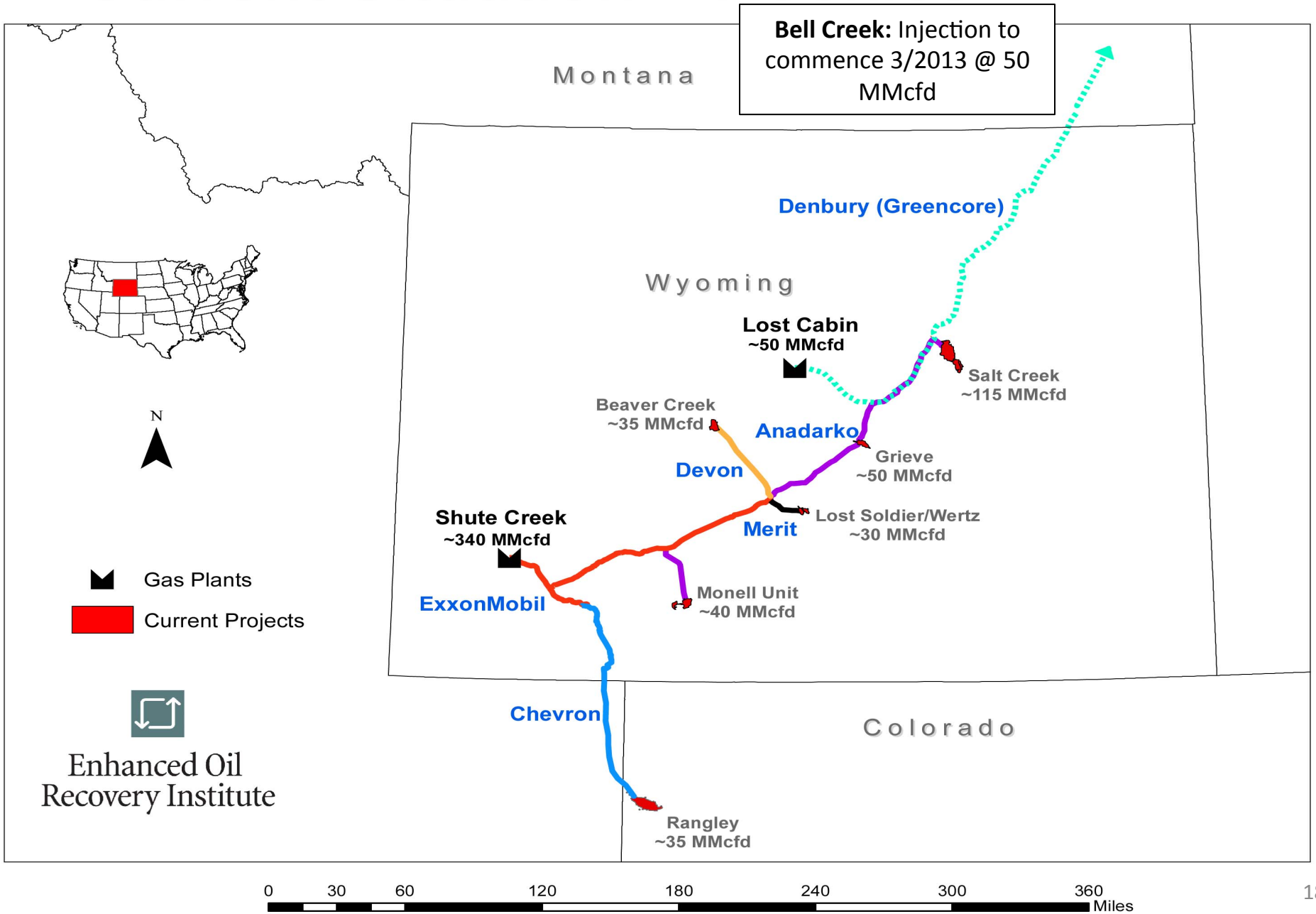
# CO2 EOR Supply in 2012




| Process | Project Name | Operator | Location | Supply Capacity (MMcfpd) |
|---|---|---|---|---|
| Natural Resources | McElmo Dome | Kinder Morgan, ExxonMobil | CO | 1,150 |
| | Jackson Dome | Denbury | MS | 930 |
| | Bravo Dome | KM, Occidental, Amerada | NM | 290 |
| | Sheep Mountain | Occidental | CO | 50 |
| | Doe Canyon Deep | Kinder Morgan | CO | 110 |
| Natural Gas Processing | LaBarge | Exxon Mobil | WY | 340 |
| | Terrell, Grey Ranch, Mitchell, and Puckett | Sandridge Energy Inc. | Terrell and Pecos Counties, TX | 75 |
| | Turtle Lake | DTE Energy | Ostego, MI | 11 |
| Conversion | Agrium, Inc. | | Borger, TX | 26 |
| | Koch Nitrogen | | Enid, Oklahoma | 35 |
| | Conestoga | | Liberal, KS | 4 |

Murrell,2012

# Current Situation – Rockies



# Shute Creek Gas Processing Plant

Description: World's Largest Carbon Capture Facility,
Shute Creek Gas Plant, Southeast Wyoming.
Date: Present

Courtesy of: http://www.trib.com and gg.uwyo.edu resp.

# CO2 Supply in Wyoming

- $CO_2$ Supply in the Rockies could increase by as much as 1 Bcfpd over next 5-10 years.
- The Madison Formation in the LaBarge Platform contain 100 TCF of CO2 reserves.
- Existing plants at Shute Creek and Lost Cabin can produce up to 390 MMcfd of CO2.
- Additional CO2 production will be developed from gas production, ex-situ coal treatment, and in situ coal gasification.

# New Technologies
# Underground Coal Gasification

Description: Underground Coal Gasification Near Hanna, WY
Date: 2012

Courtesy of: Midwest Energy News

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# Shute Creek $CO_2$ Supply Capacity vs. Average Daily Sales

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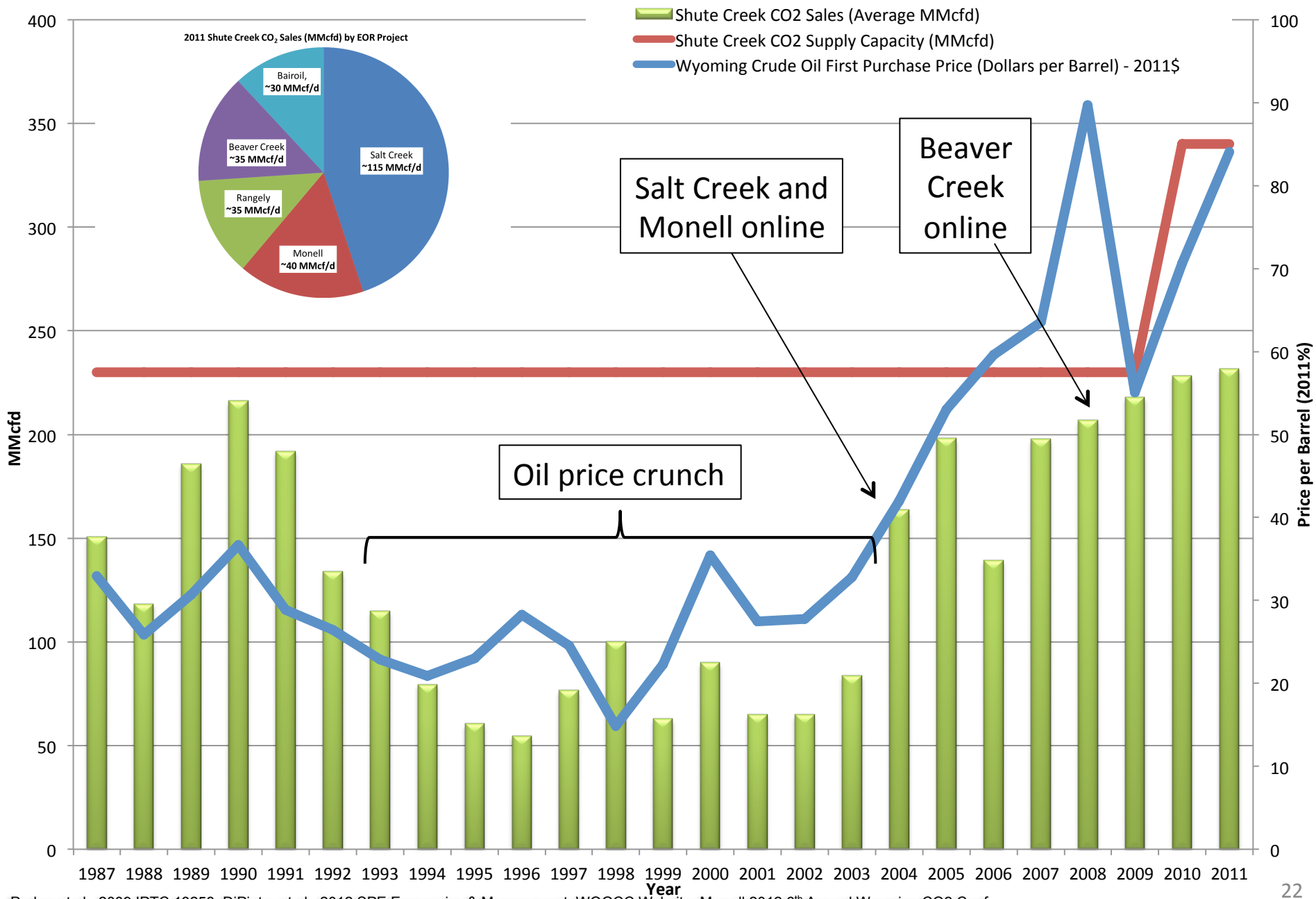
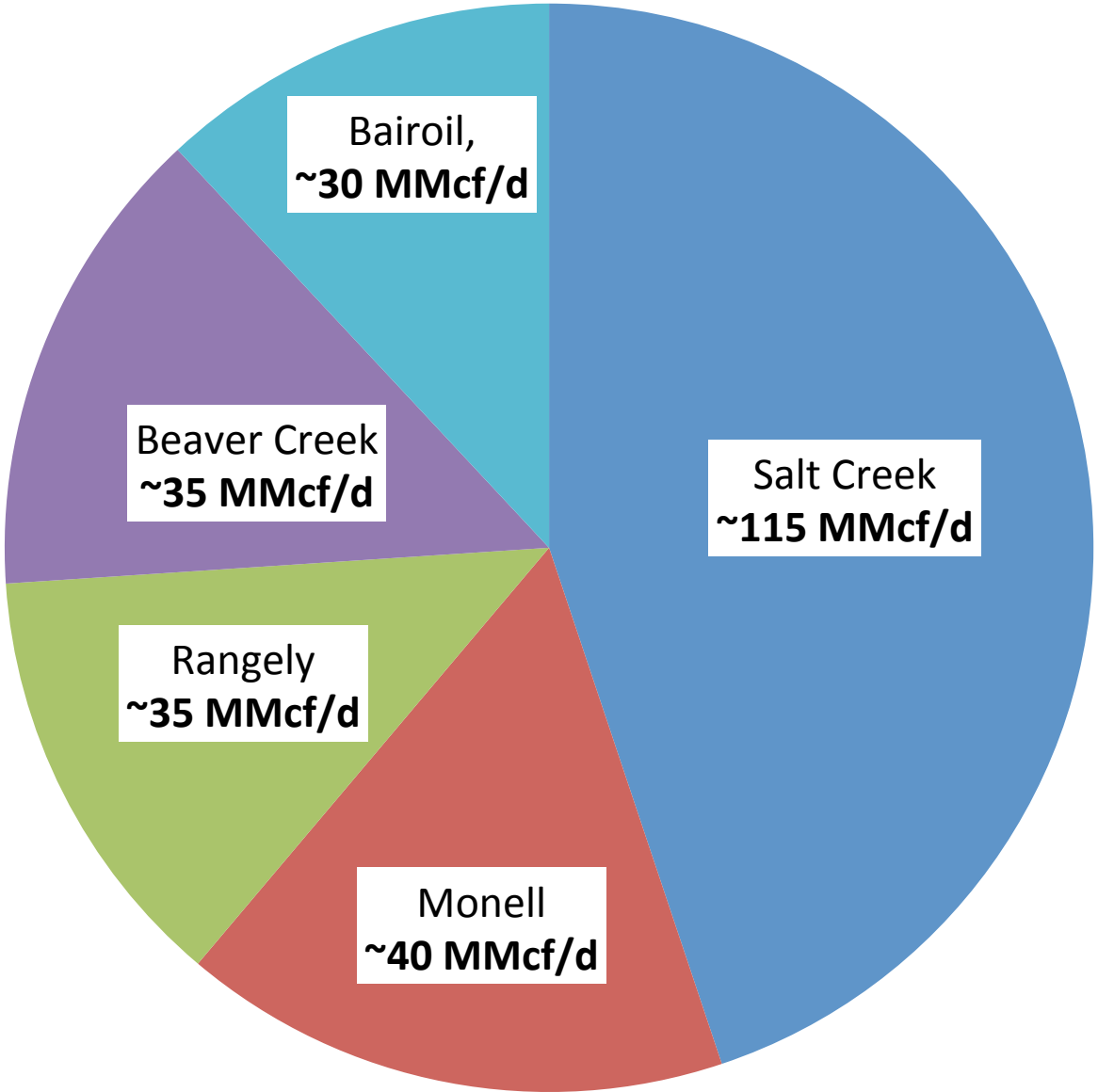



Parker et al., 2009 IPTC 13258; DiPietro et al., 2012 SPE Economics & Management; WOGCC Website; Murrell 2012 6th Annual Wyoming CO2 Conf.

# Shute Creek

Murrell,2012

**2011 Shute Creek $CO_2$ Sales (MMcf/d) by EOR Project**




Data from WOGCC website

Murrell,2012

# Wy. $CO_2$ EOR Project Summary

| Project | Field | Reservoir | Injection Start | Total $CO_2$ Purchased (MMscf) | Cum. Incr. Oil* (bbls) | RF* (% OOIP) | $UR_{NET}$* (Mscf/bbl) |
|---|---|---|---|---|---|---|---|
| **Bairoil** | Lost Soldier/ Wertz | Tensleep, Darwin/ Madison, Flathead | 1986 | 331,328,494 | 65,828,061 | ~8% | ~5 |
| **Beaver Creek** | Beaver Creek | Madison | 2009 | 38,283,234 | 2,459,387 | ~2% | ~15 |
| **Salt Creek** | Salt Creek | Wall Creek 2 | 2004 | 269,784,126 | 10,699,231 | ~1% | ~25 |
| **Monell** | Patrick Draw (Monell Unit) | Mesaverde Almond | 2004 | 65,917,029 | 7,481,084 | ~7% | ~9 |

* Incremental recovery, utilization ratio and recovery factors are highly sensitive to analytical assumptions. We have been as conservative as possible and our assumptions may not match those used internally by operators.

Murrell,2012

# Utilization Ratio*

$$URnet = CO2\ purchased / Incremental\ oil$$

- A measure of economic efficiency.
- Dependent on flood design and maturity.
  - *WAG vs GS, number of HCPVs injected*
- Compare Salt Creek with Beaver Creek
  - SC: phased, WAG, pattern flood, 1099 MMBO OOIP.
  - BC: WAG-GS hybrid, Single development phase, 109 MMBO OOIP

$$URgross = CO2\ purchased + CO2\ recyc$$

- A measure of technical efficiency.
- Dependent on flood design and sweep efficiency.

* Incremental recovery, utilization ratio and recovery factors are highly sensitive to analytical assumptions. We have been as conservative as possible and our assumptions may not match those used internally by operators.

# Wyoming CO2 EOR

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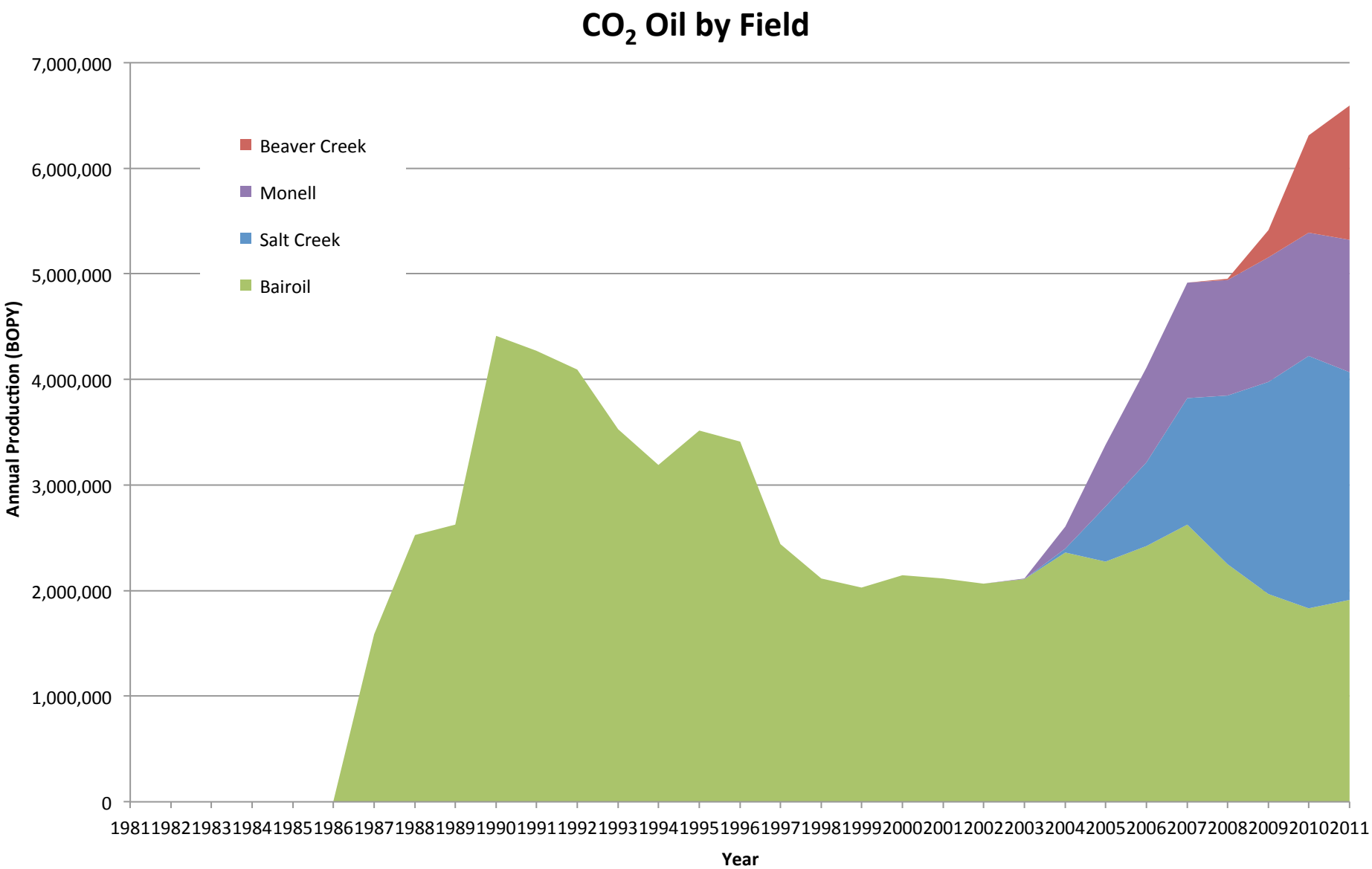
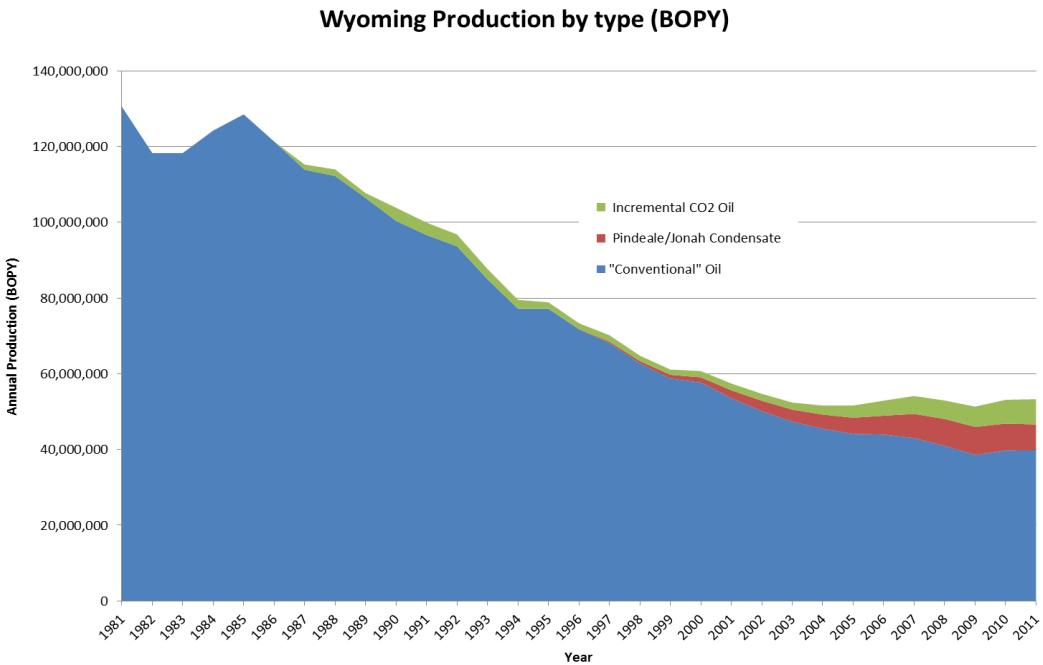
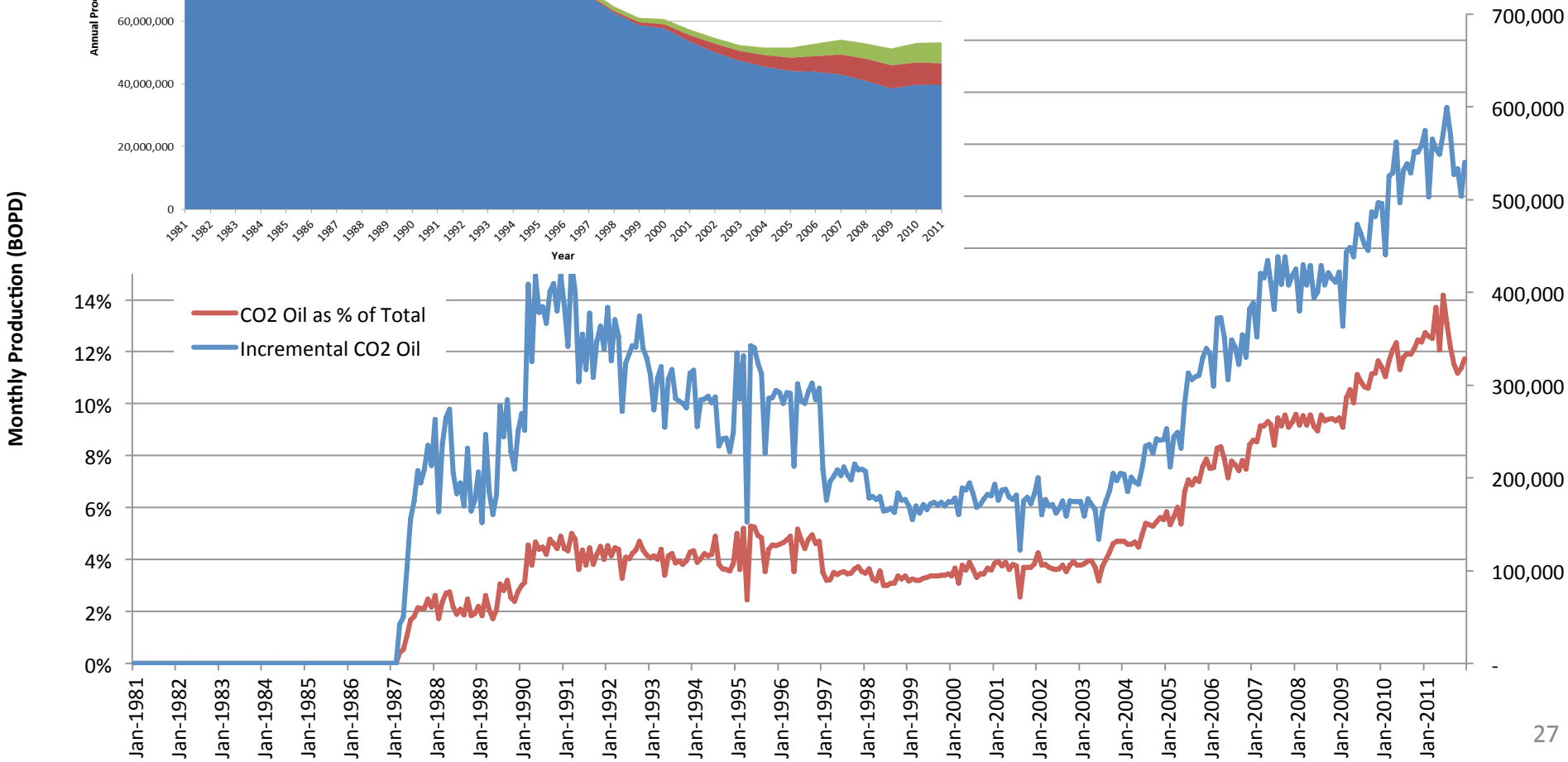


Murrell,2012

# Wyoming $CO_2$ EOR (@ Dec, 2011)




## CO2 Oil 1981 to present



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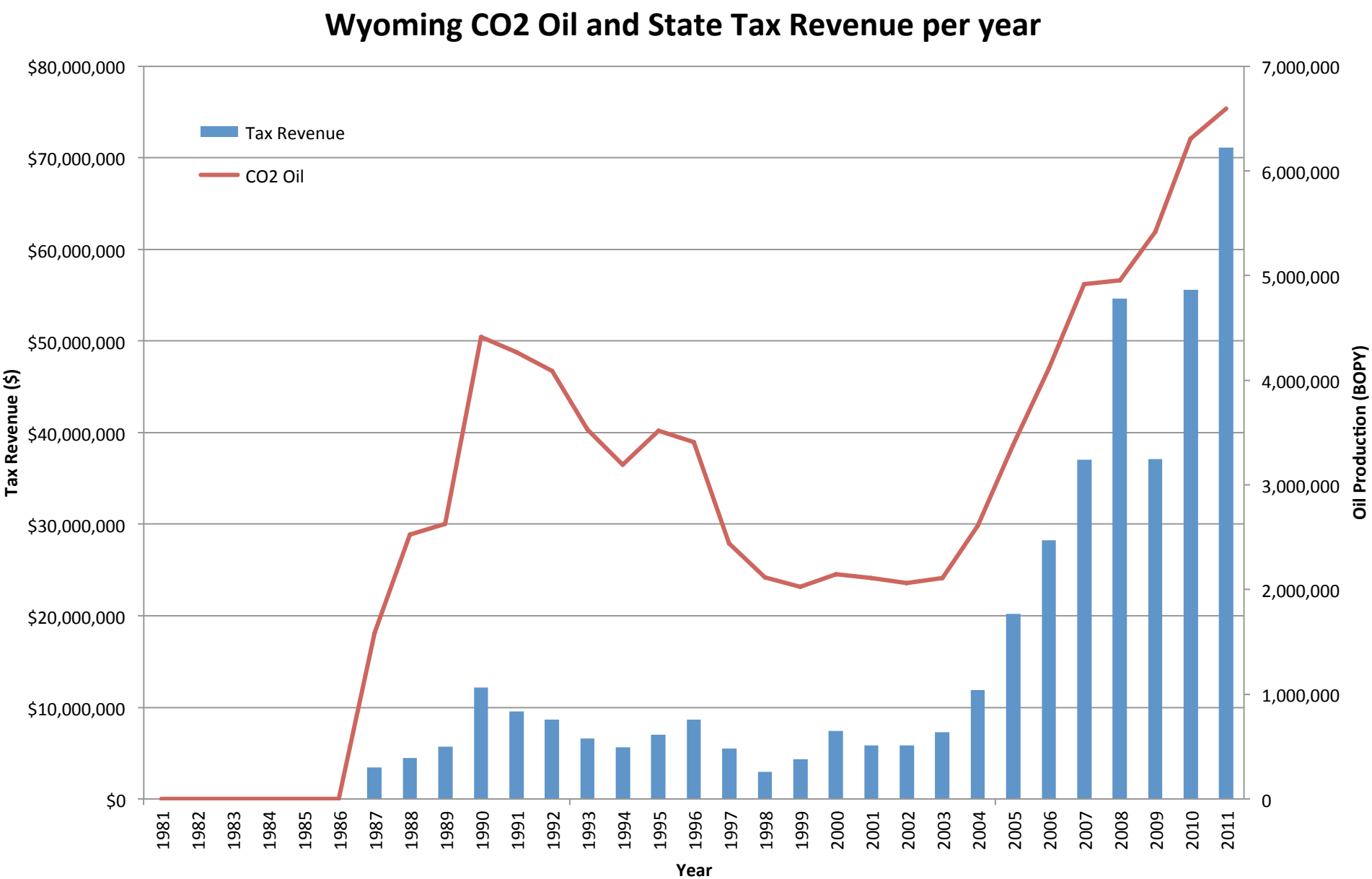
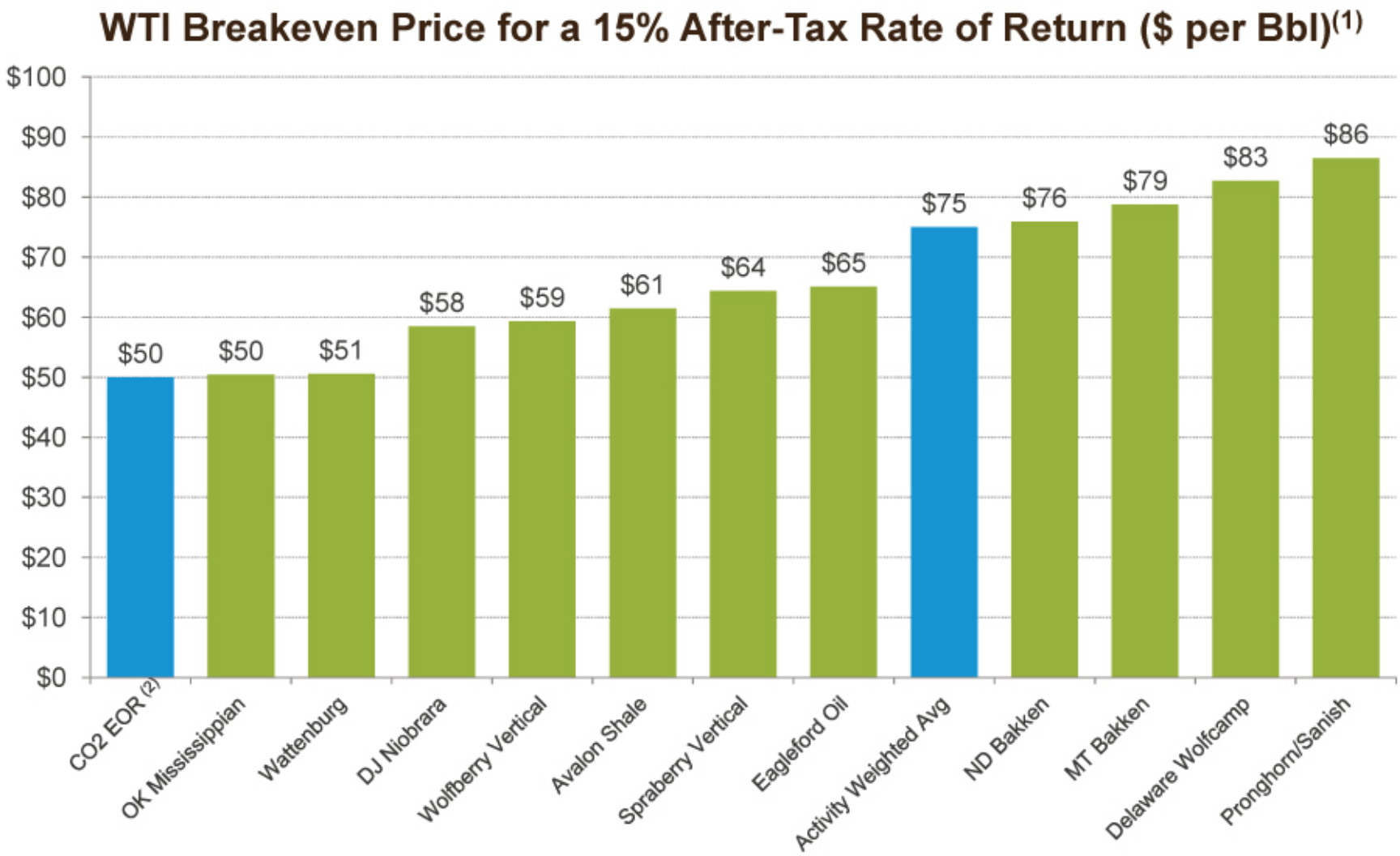
# Wyoming CO2 EOR System Analysis



# Employment

| Type of Impact | Beaver Creek Madison | Patrick Draw Monell Unit | Salt Creek Wall Creek 2 | Lost Soldier & Wertz | Totals |
|---|---|---|---|---|---|
| **Total Contribution** | | | | | |
| Employment | 386.7 | 306.1 | 592.1 | 431.3 | **1716.2** |
| Labor Income | $20.92 M | $17.1 M | $33.47 M | $23.81 M | **$95.29 M** |
| Income per Job | $54,097 | $55,859 | $56,524 | $55,206 | **$55,527** |
| Value Added | $118.65 M | $115.19 M | $226.34 M | $155.8 M | **$615.99 M** |
| **Multipliers** | | | | | |
| Employment | 10.89 | 8.47 | 8.31 | 8.90 | **8.97** |
| Labor Income | 5.06 | 4.06 | 4.03 | 4.22 | **4.28** |
| Income per Job | 0.46 | 0.48 | 0.49 | 0.47 | **0.48** |
| Value Added | 1.31 | 1.25 | 1.24 | 1.26 | **1.26** |

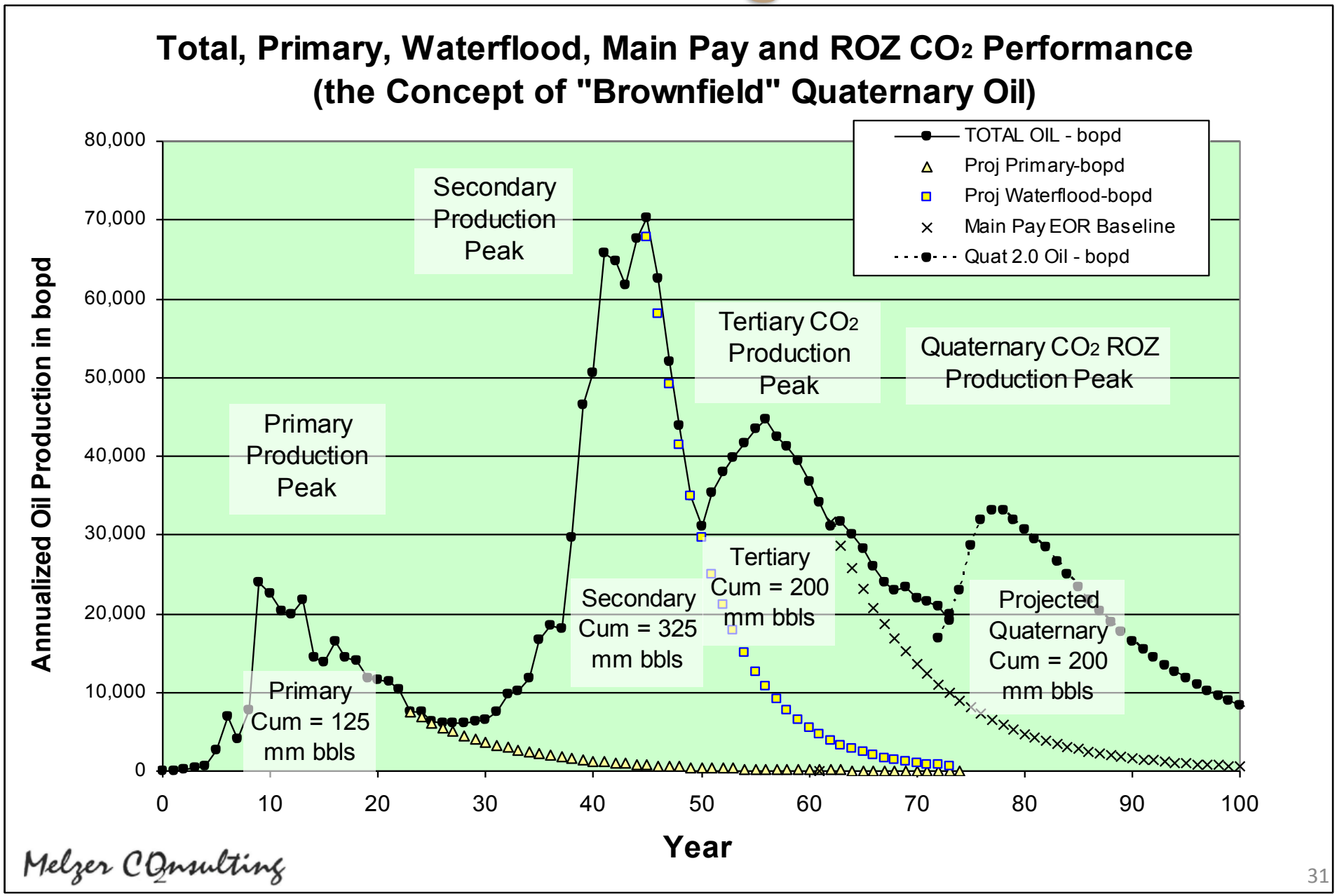
# Market Drivers – Oil Price




(1) Source: ISI Group report dated June 15, 2012. Defined as the threshold WTI oil price necessary to generate a 15% after-tax rate of return. Excludes acreage costs.
(2) Internal estimate for indicative large $CO_2$ EOR development project in the Gulf Coast Region.

Blincow, 2012 6th Annual Wyoming CO2 Conference

# Market Drivers – Target Growth

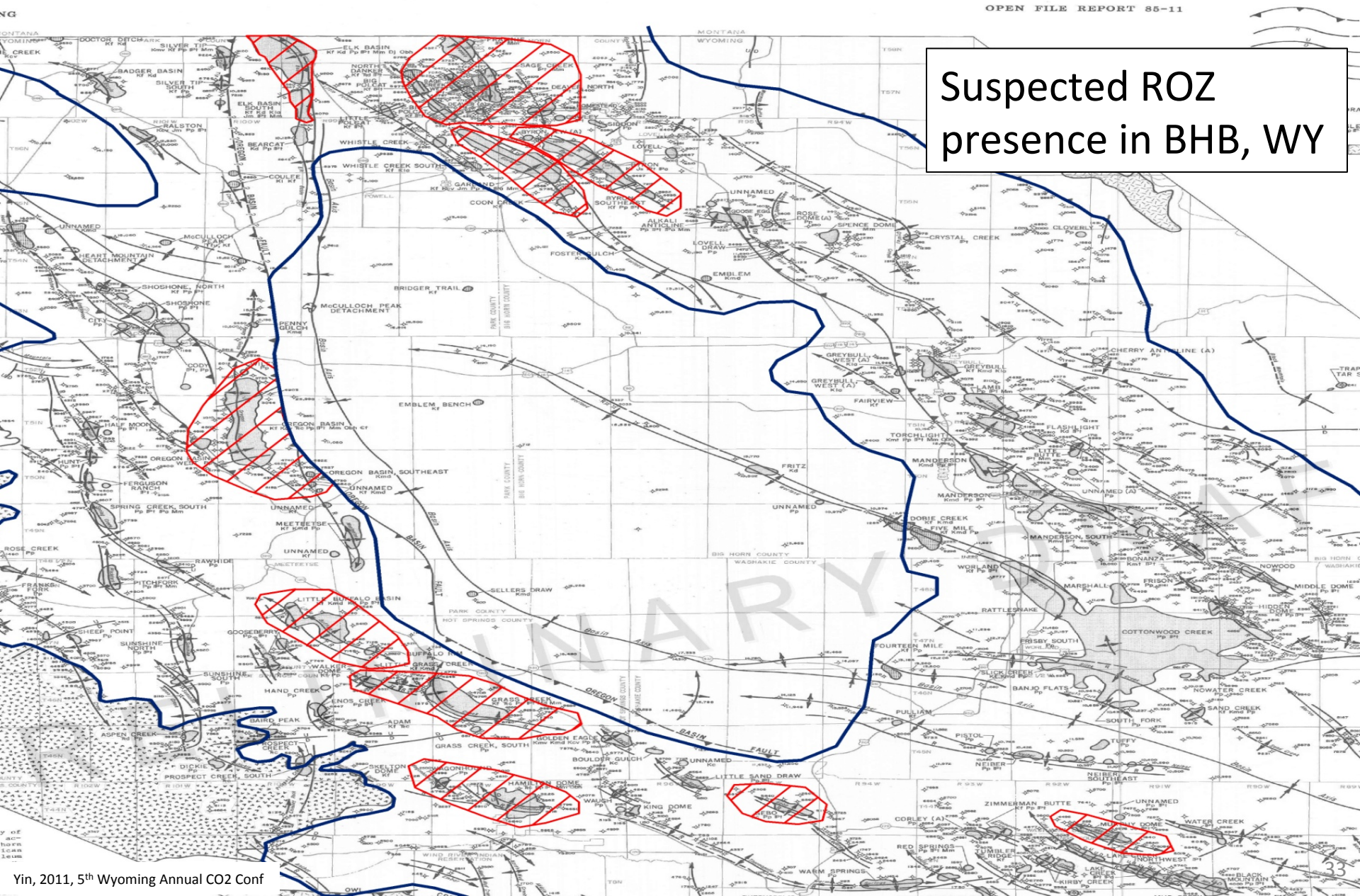


# Estimated Reserves
# Tensleep ROZs in Bighorn Basin

- 1 to 2 billion barrels of additional oil in high probability areas (in and around existing large reservoirs).
- High probability areas comprise approximately 300,000 acres of land space.
- Areas suspected of containing ROZs that have not been commercially developed comprise approximately 3 million acres of land space.

# Market Drivers – Target Growth

Yin, 2011



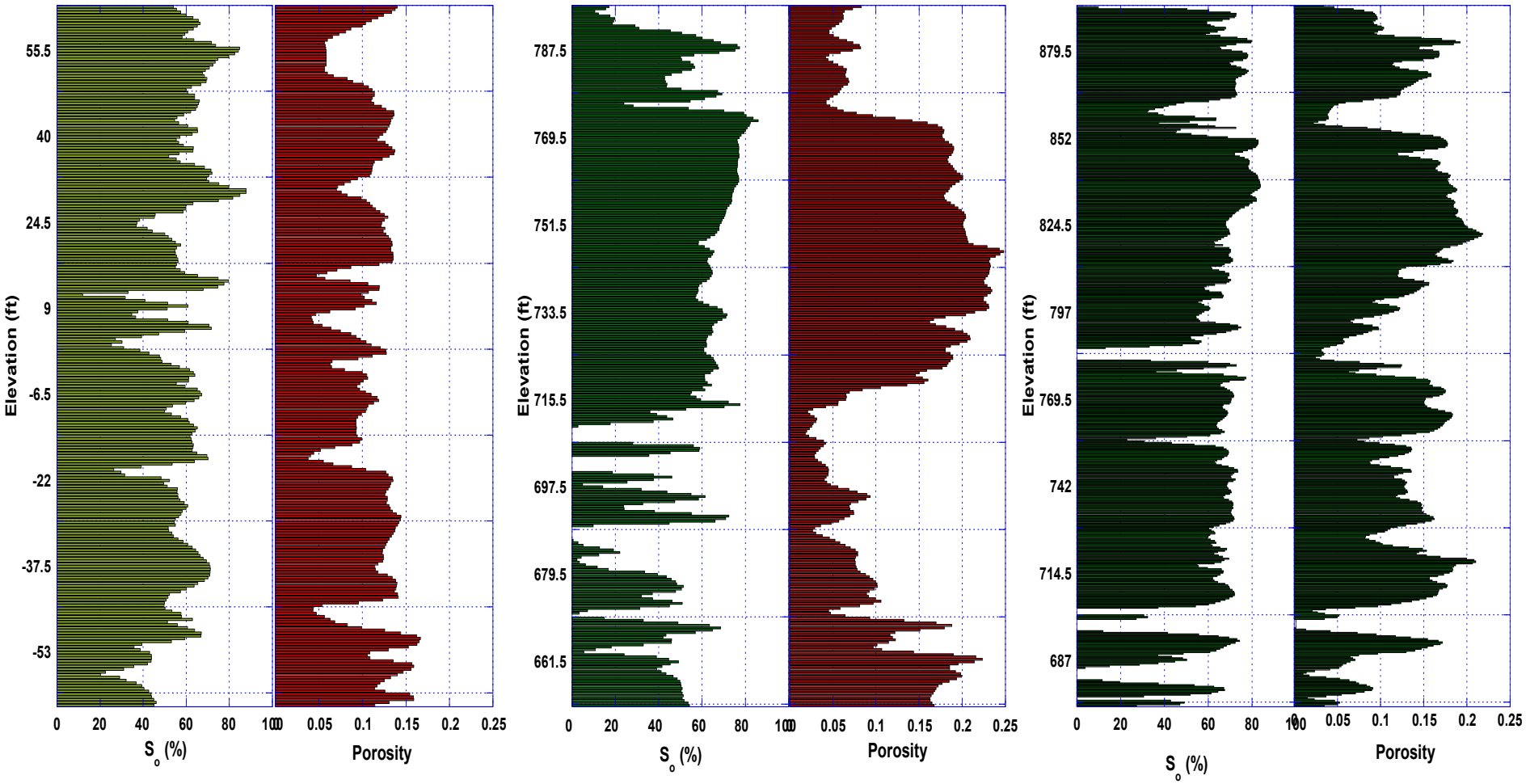

Yin, 2011, 5th Wyoming Annual CO2 Conf

# Market Drivers – Target Growth

Yin, 2011

Bighorn Basin Tensleep Profiles

**Non-commercial wells around existing reservoirs.**






Yin, 2011, 5th Wyoming Annual CO2 Conf

# Questions?

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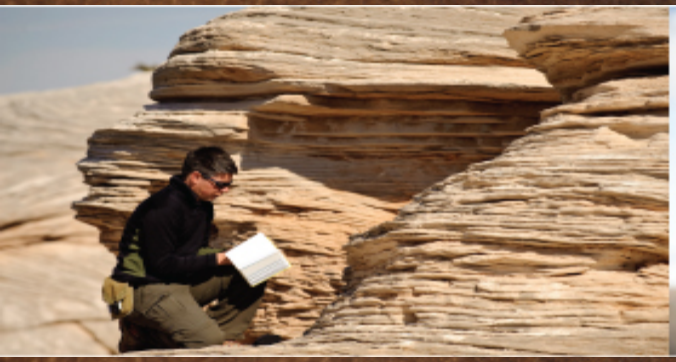

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