Challenges and Opportunities for Oil Shale Development in Utah

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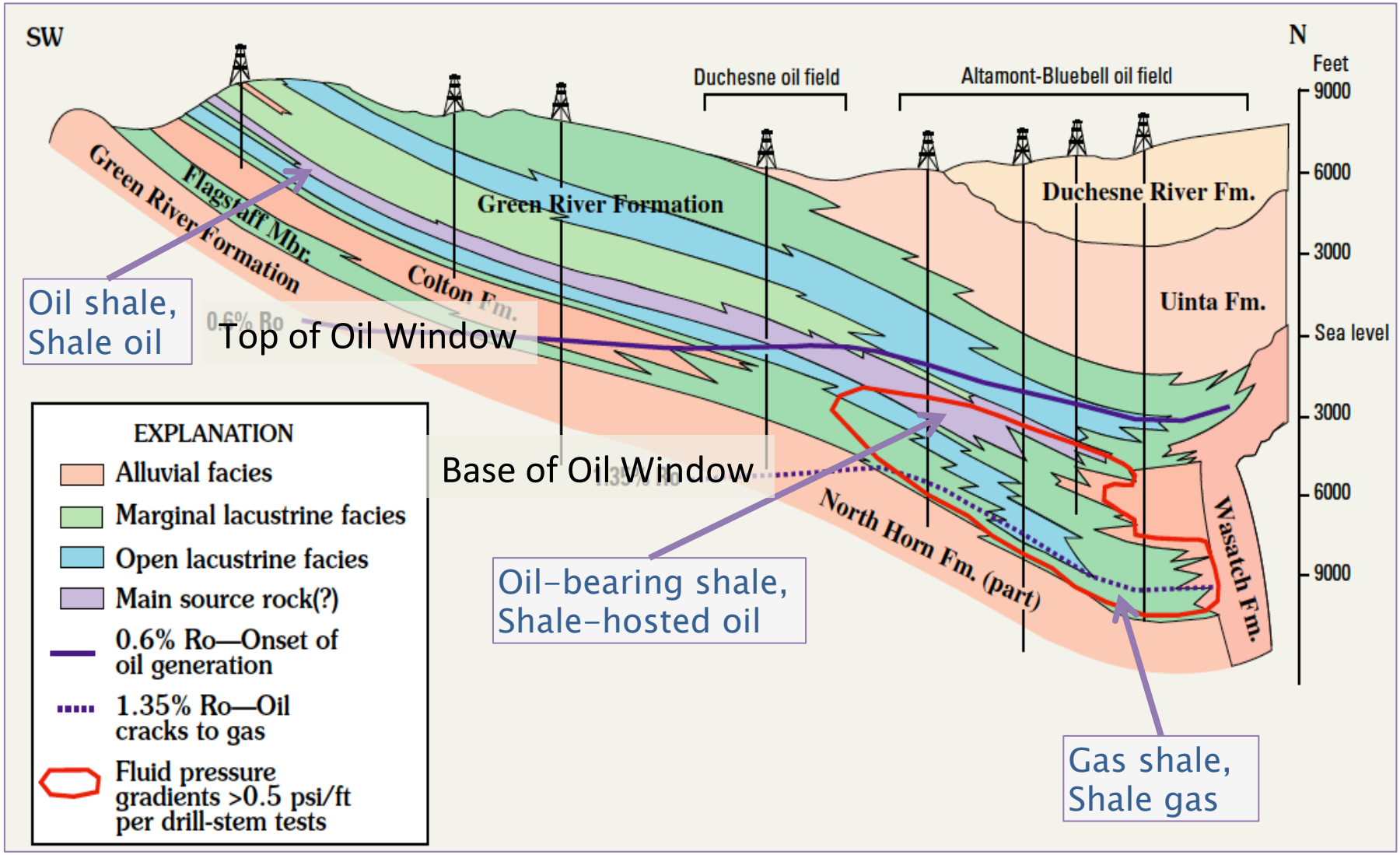
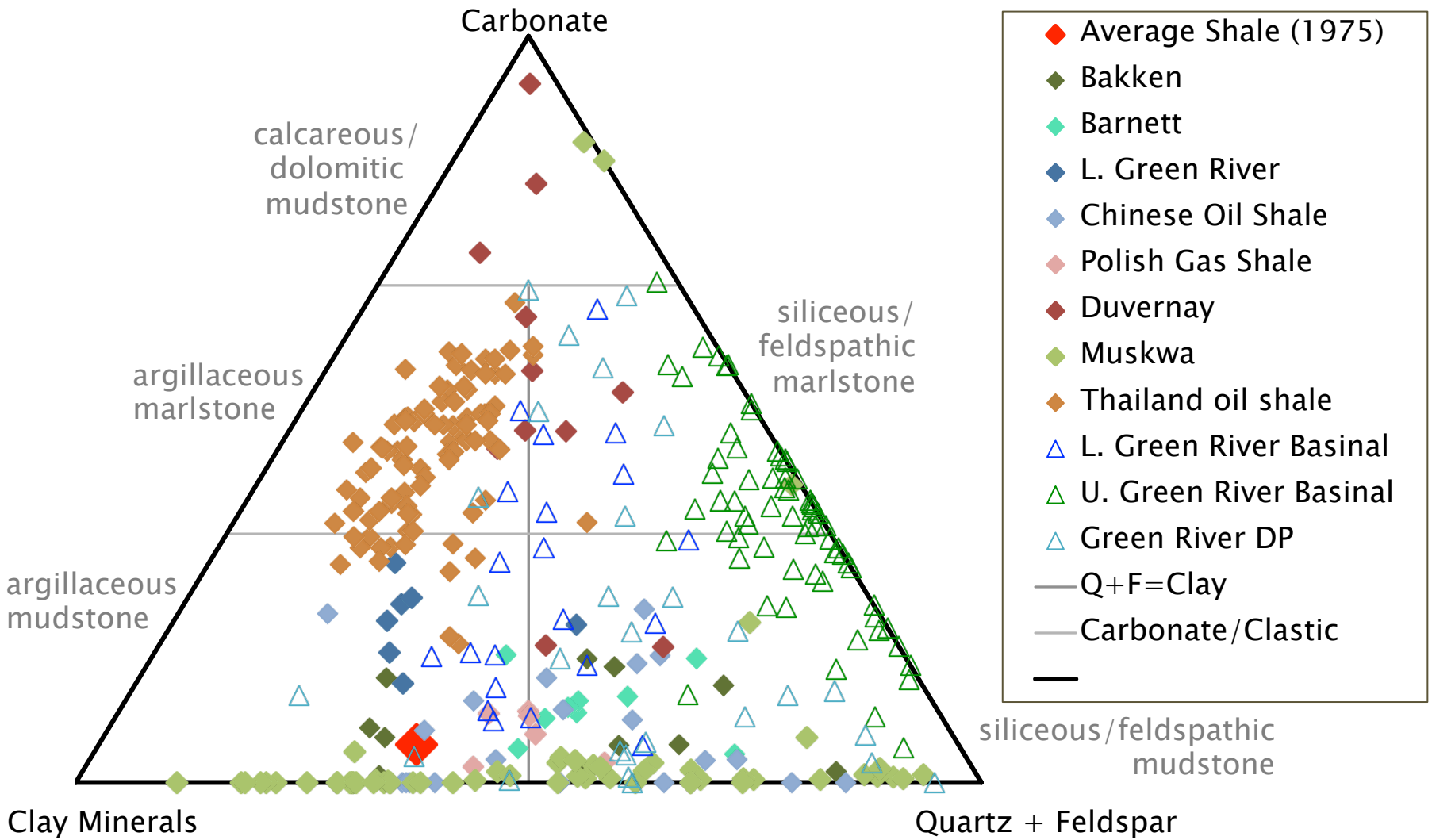
Outline

- Shale-hosted hydrocarbons
- Utah's oil shale resource in global perspective
- Critical issues for oil shale development
- Commercial oil shale technology
- Water – the current battleground
- Oil shale production and the future
- Conclusions

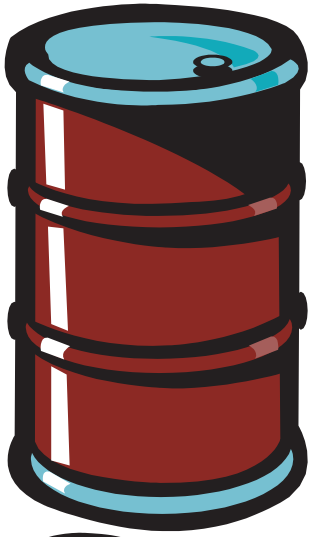
Oil Shale, Oil-Bearing Shale and Gas Shale



Diversity of *Shale* Composition



Global Oil Shale Resource Estimates



1. Green River Formation
4,280,000 million barrels

2. Other United States
619,000 million barrels

11. Canada
15,241 million barrels

13. Sweden
6,114 million barrels

10. Estonia
16,286 million barrels

4. Russia
270,944 million barrels

15. Ukraine
4,193 million barrels

16. Kazakhstan
2,837 million barrels

3. China
328,000 million barrels

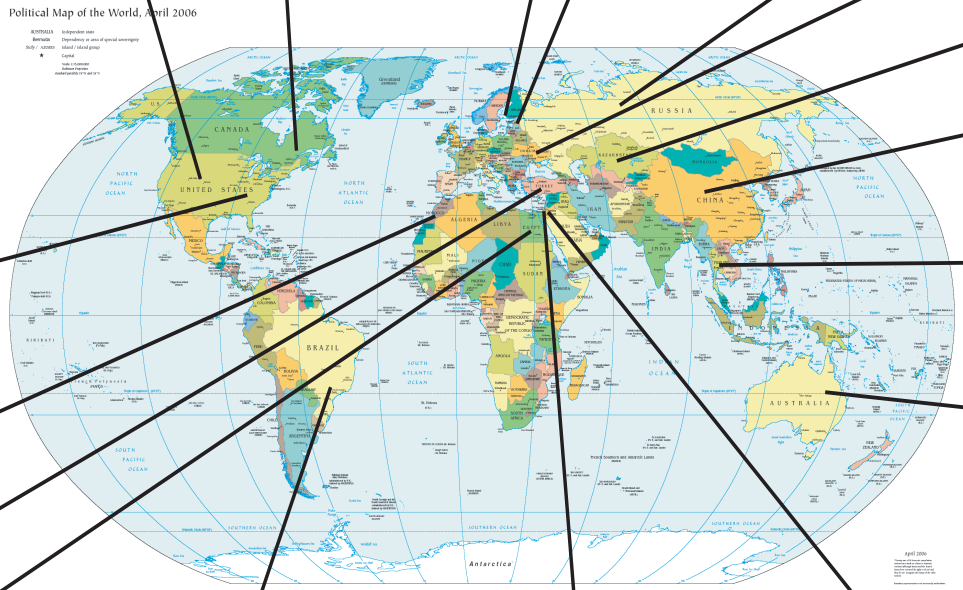
12. Thailand
6,401 million barrels

9. Australia
24,000 million barrels

8. Morocco
37,800 million barrels

17. Turkey
1,985 million barrels

14. Egypt
5,700 million barrels



7. Brazil
80,000 million barrels

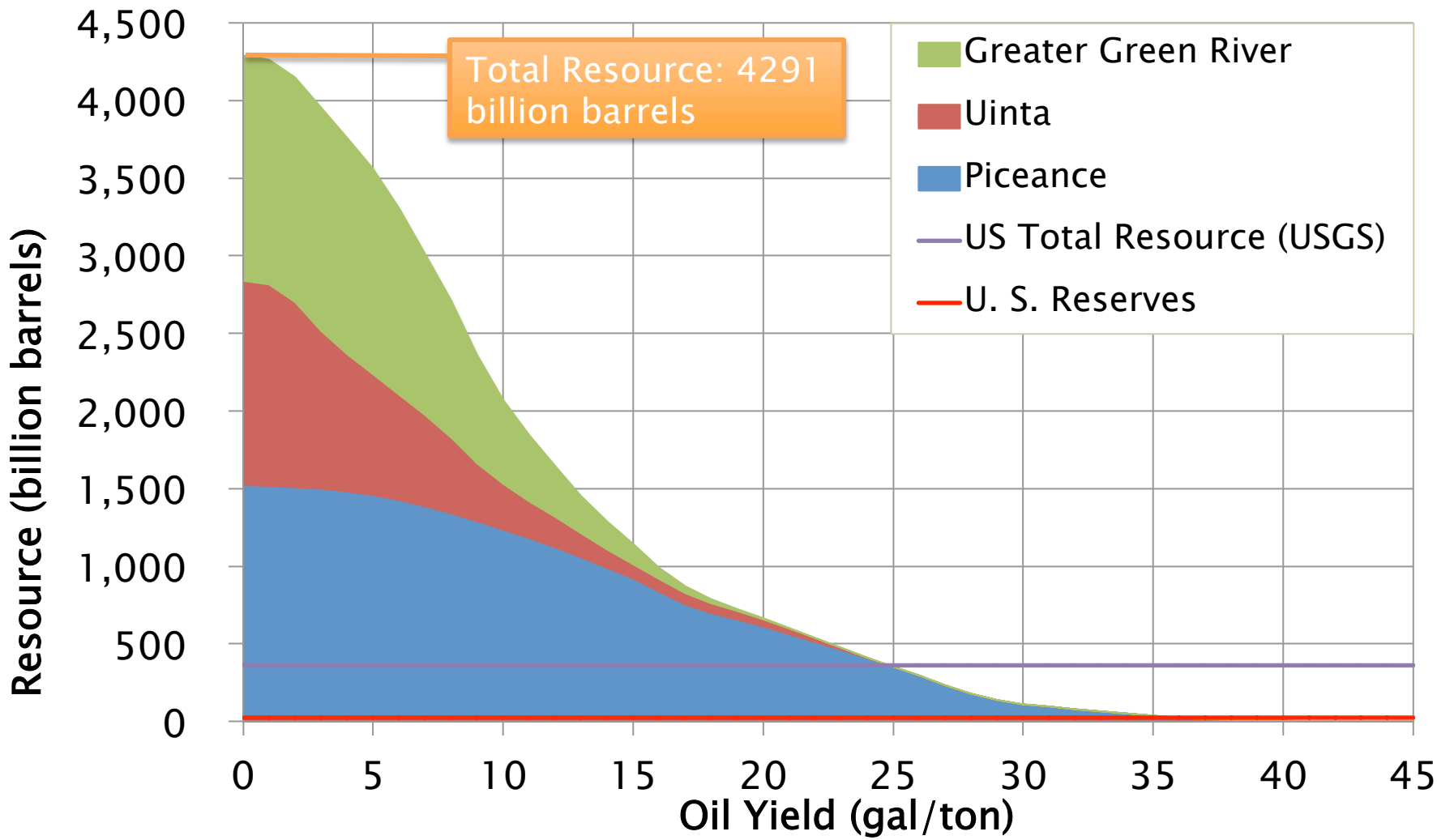
5. Israel
250,000 million barrels

6. Jordan
102,000 million barrels

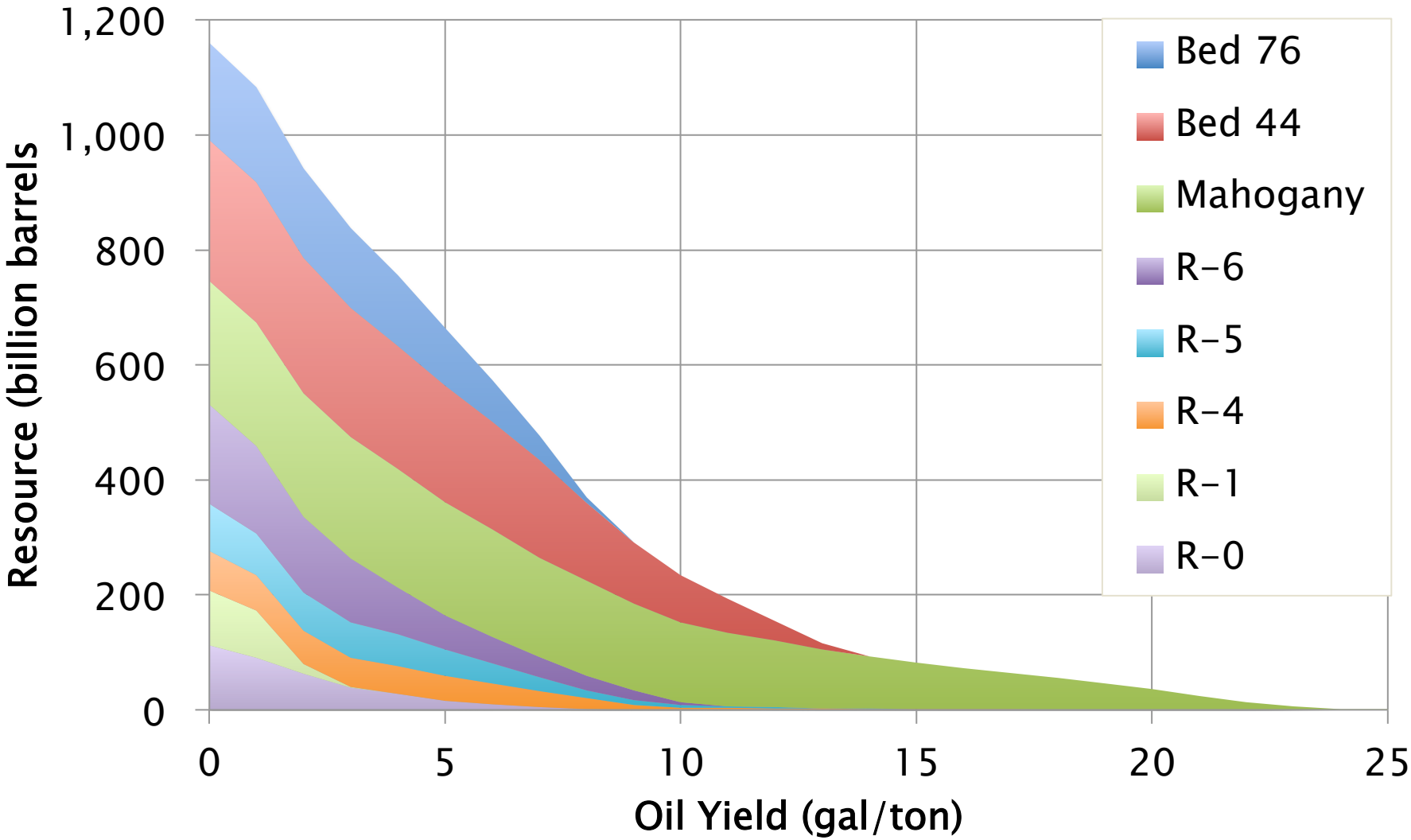
Data Source: J. R. Dyni, Geology and Resources of Some World Oil-Shale Deposits, (2006) U. S. Geological Survey Scientific Investigation Report 2005-5294, U. S. Geological Survey, Reston VA

Updates from 26th through 31st Oil Shale Symposia, Colorado School of Mines

Green River Formation Oil Shale Resources



Utah Oil Shale Resource



Data from U. S. Geological Survey

Critical Issues for Oil Shale Development

- Availability of land
- Availability of capital
- Reasonable regulatory framework
- Popular acceptance
- Moderate carbon footprint
- Moderate water footprint

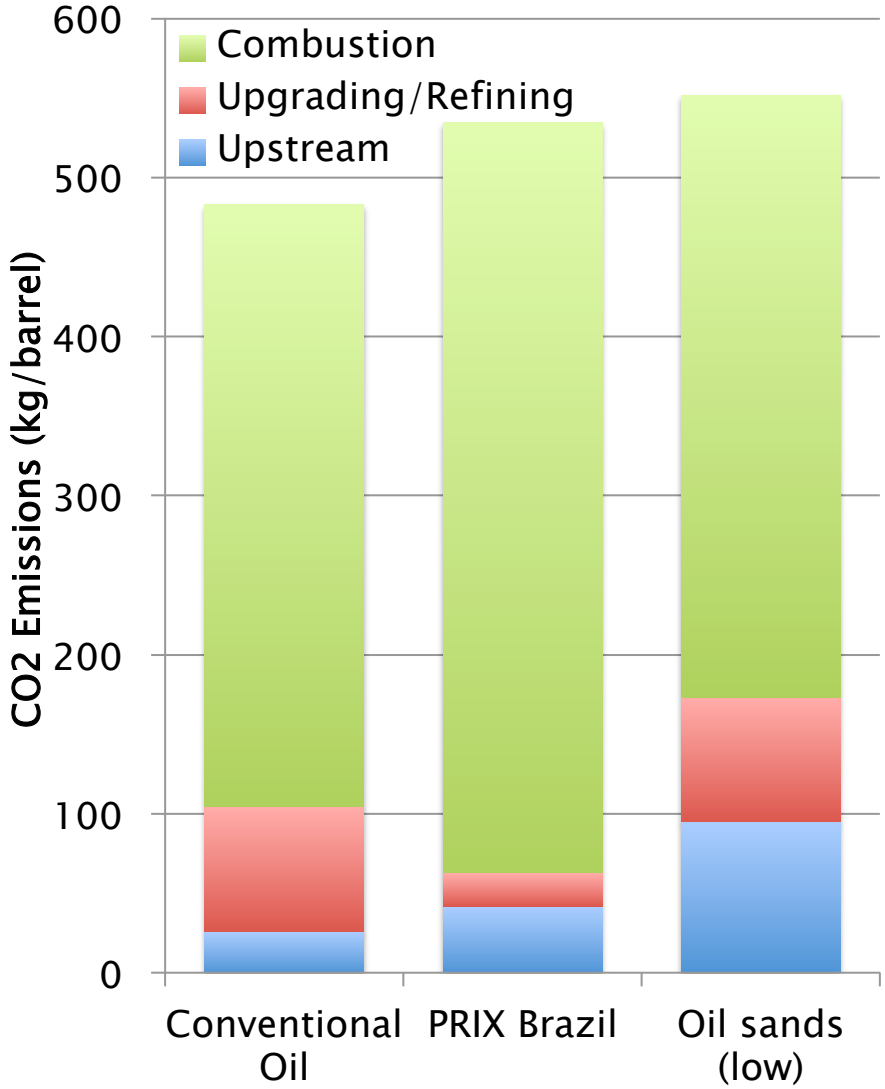
Commercial Shale Oil Technology

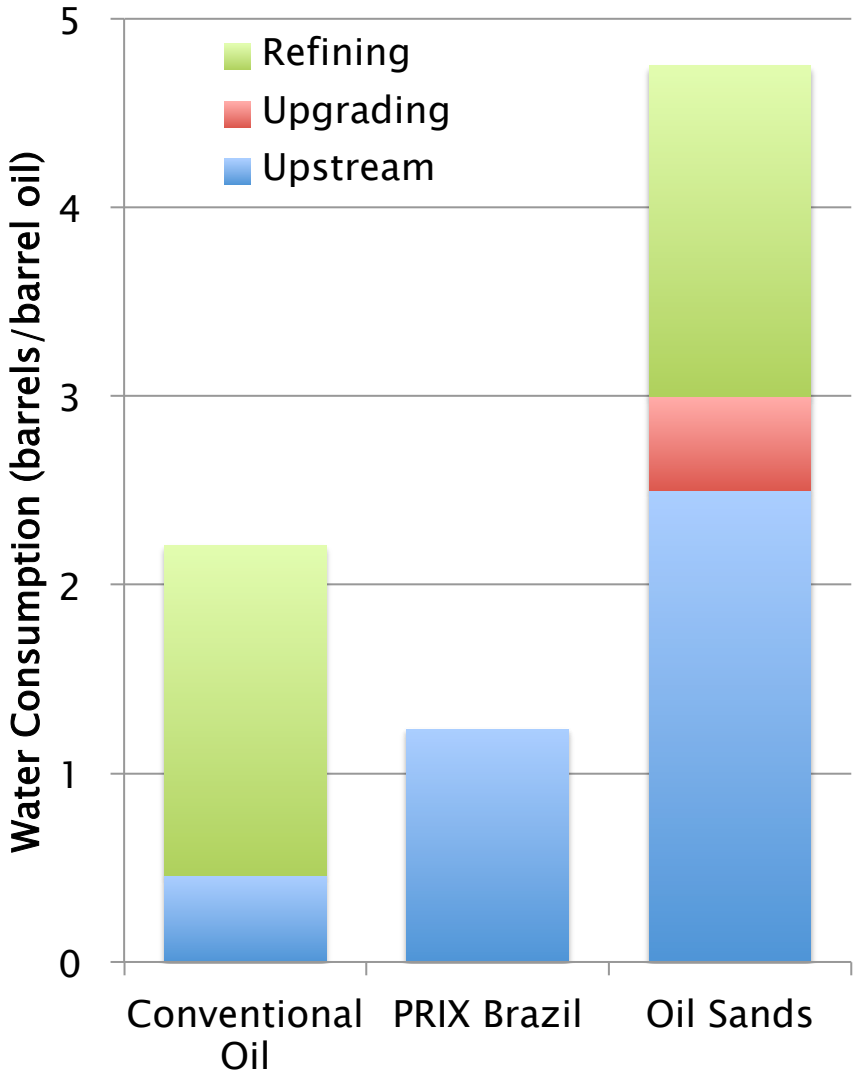
A Proven Process in Brazil

Vertical surface retorts have operated for >30 years in Brazil

1. The retort heats crushed rock to approx. 500°C
2. Organic matter in the rock called kerogen is converted to hydrocarbons
3. Remaining rock, called spent shale, is returned to the mine pit
4. Progressive surface reclamation begins
5. **Several variations globally including Paraho, PetroSIX™ and PRIX**

CO_2 Emissions and Water Consumption





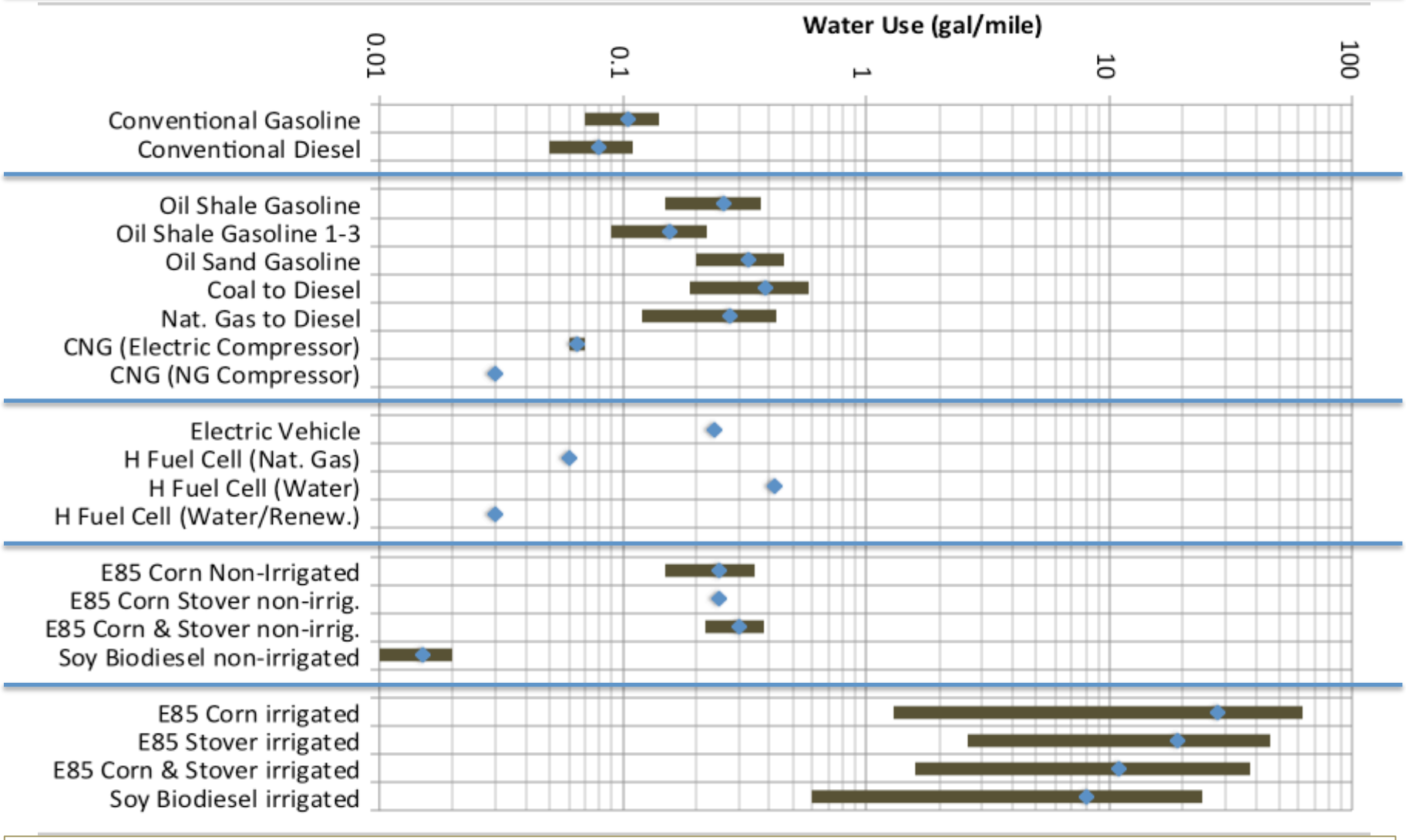
CO_2 data from Brandt; water data from Shell

Irati Oil Project in Brazil

- One billion barrels of shale oil proven up by drilling
- Expected production of 8,000 BOPD in 2016
- Will make Irati a significant independent oil producer in Brazil
- Targeted production of 25,000 BOPD by 2020

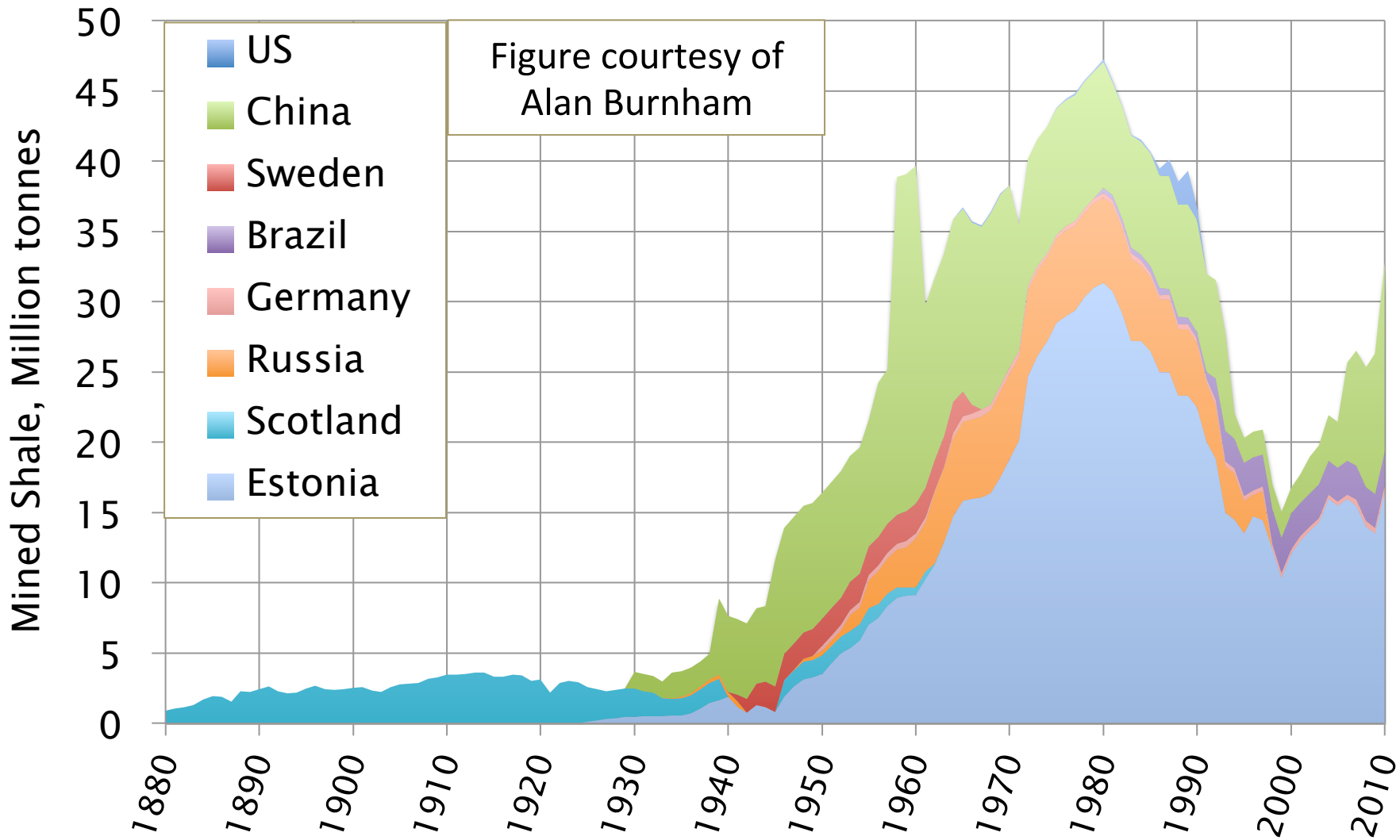
Petrobras operations near São Mateus do Sul, Paraná

Water Use for Alternative Fuels

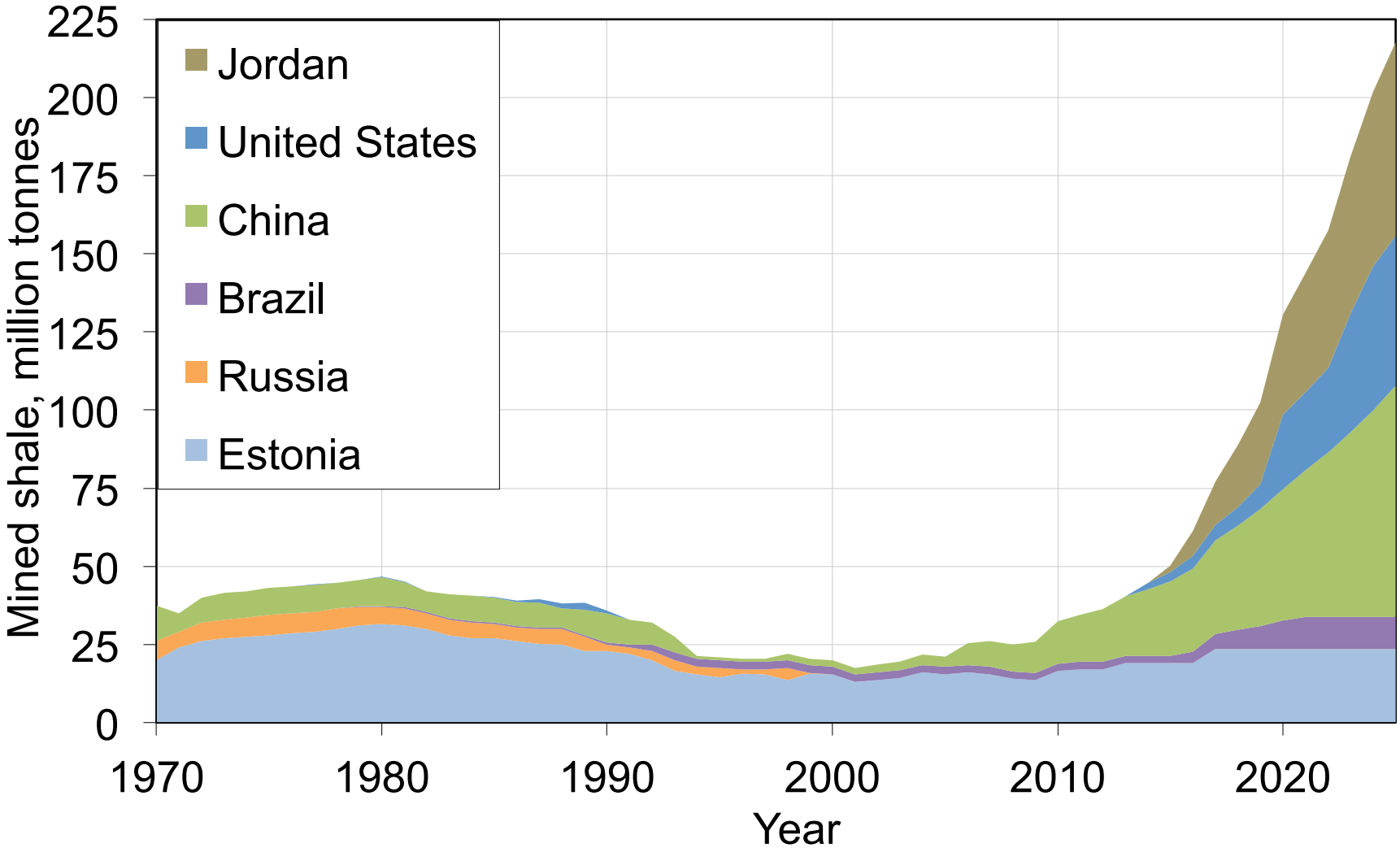


Source: King, C. W., and M. E. Webber, (2008) *Water Intensity of Transportation*, Environmental Science & Technology, vol. 42, no. 21, p. 7866-7872

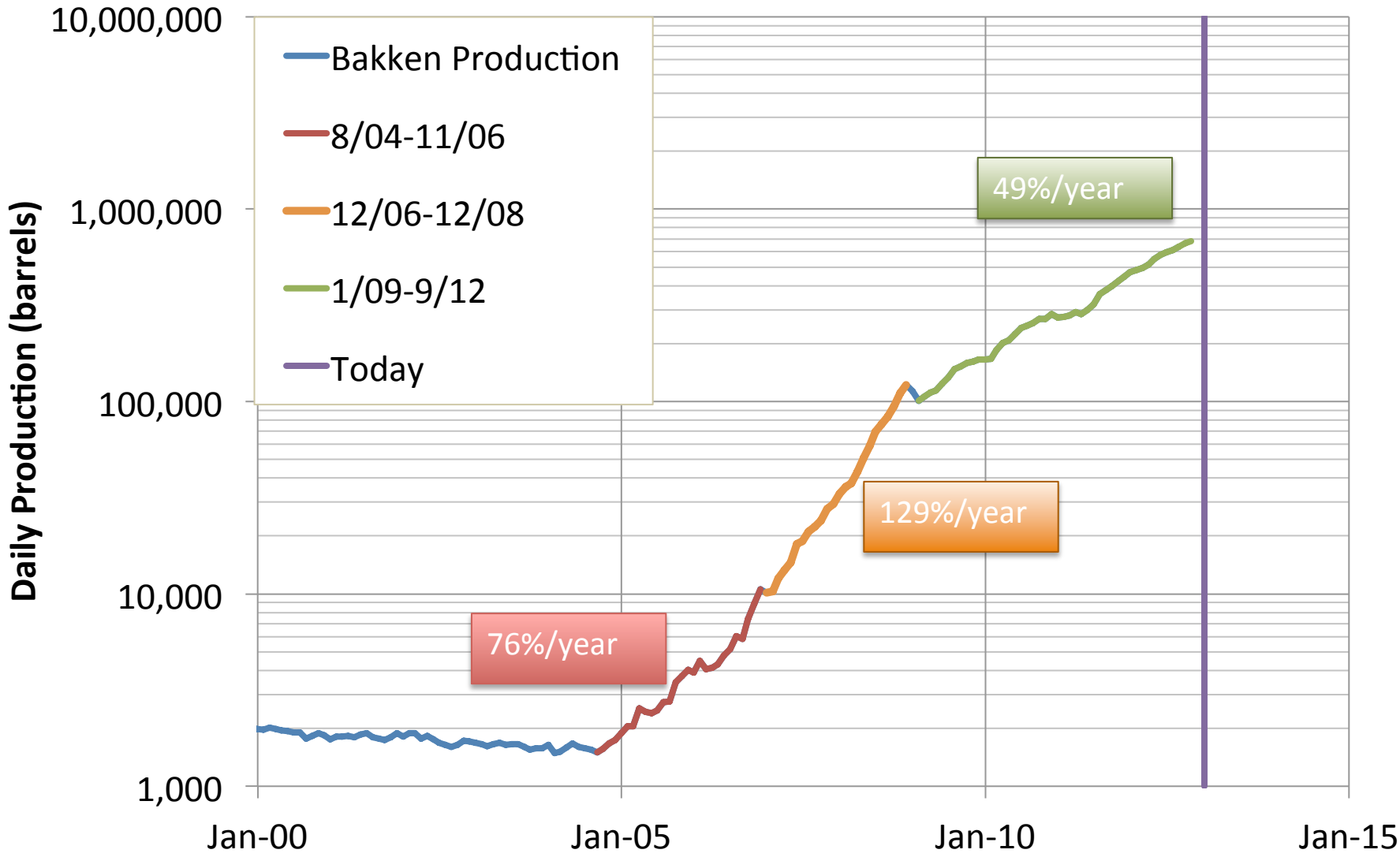
Historic Oil Shale Production



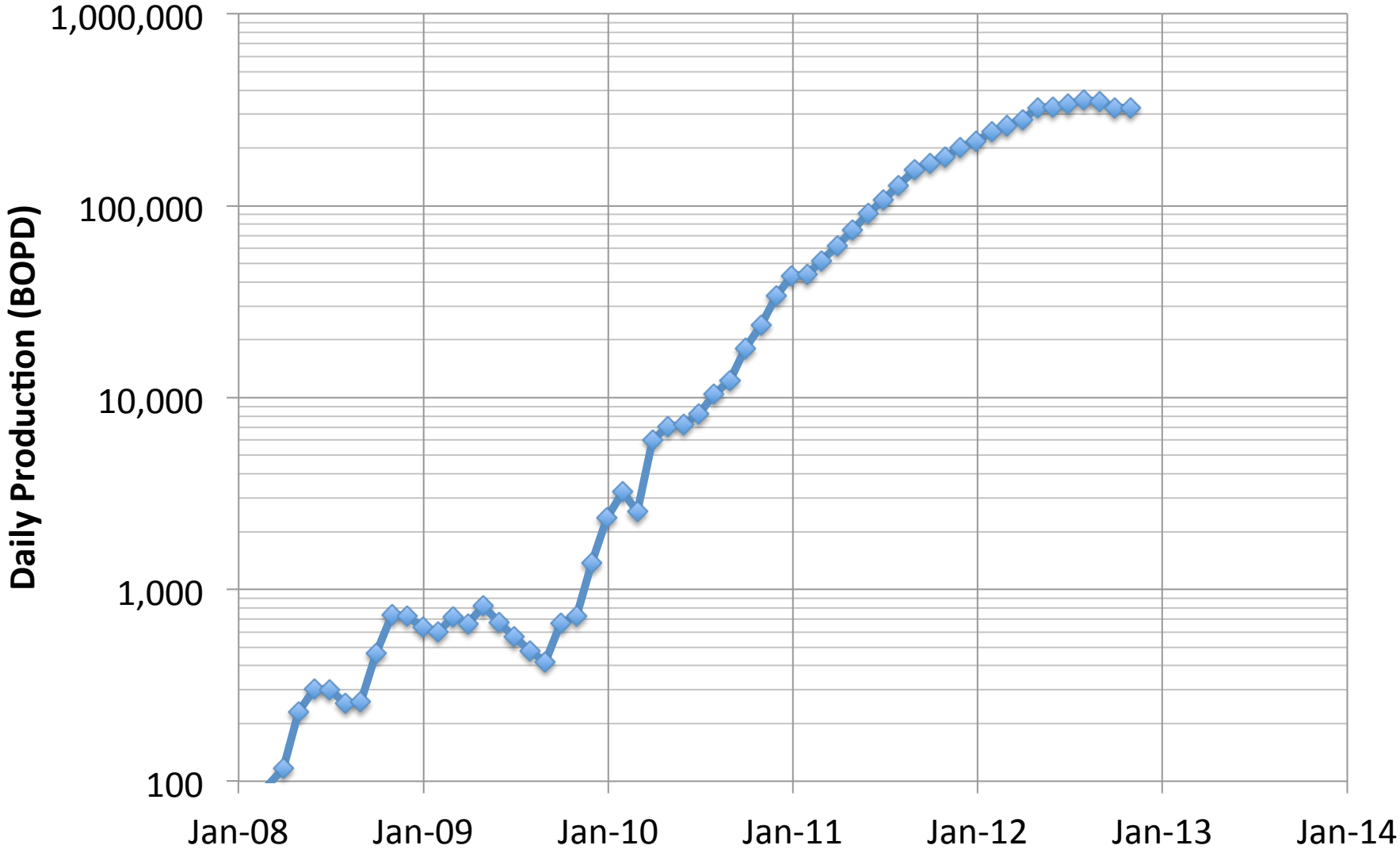
Projected Global Oil Shale Production



Bakken Production in North Dakota



Eagle Ford Production

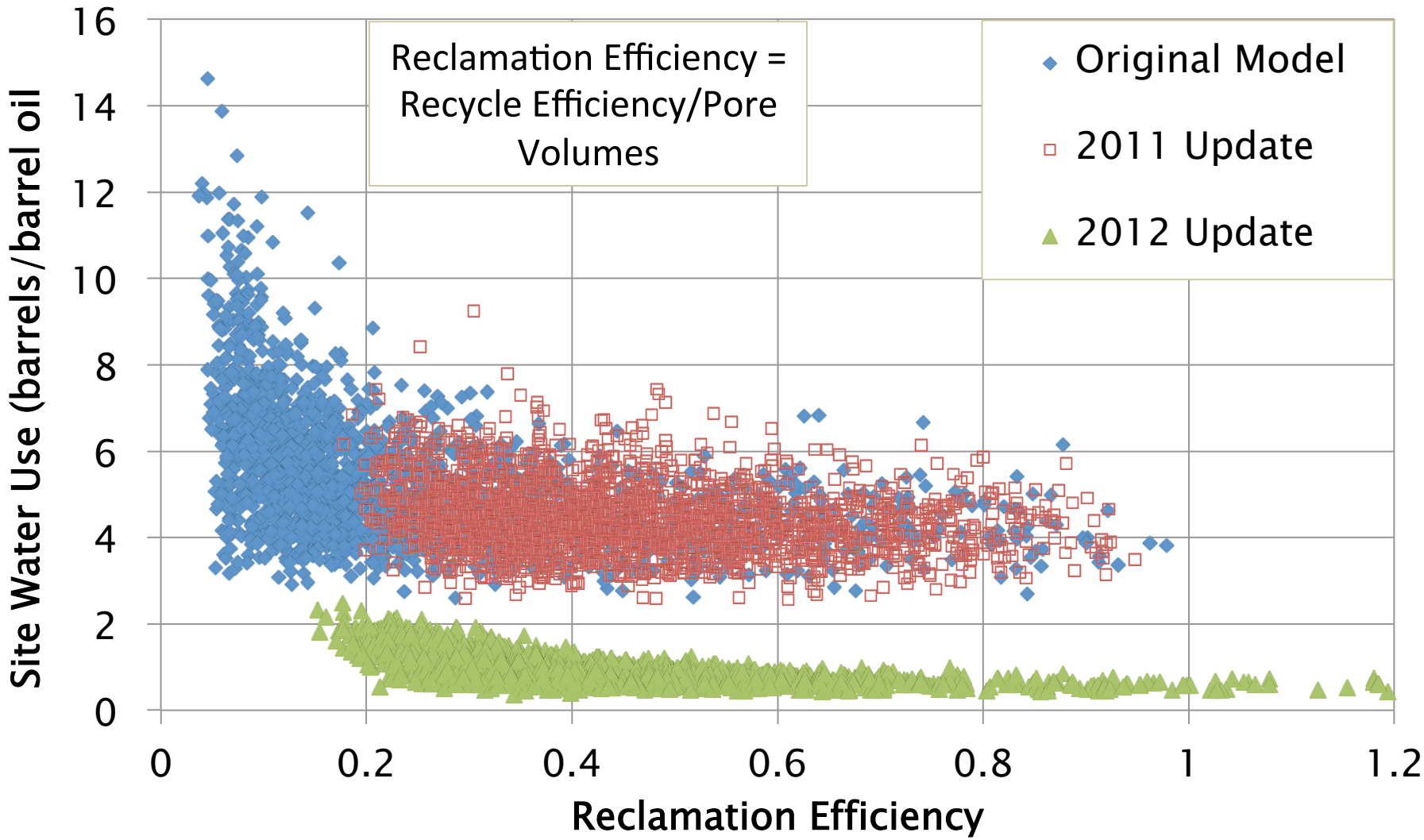


Conclusions

- Technology challenges remain significant
- Political challenges may be greater
- New players continue to appear
- "Prediction is very difficult, especially about the future."
  - Niels Bohr (1885–1962)

BACKUP SLIDES

Site Water Use vs. Reclamation Efficiency



Relative Water Usage

1-3 barrels water per barrel of oil from oil shale

Source: AMEC. *Energy Development Water Needs Assessment, Phase II Final Report.* Prepared for the Colorado River Basin Roundtable and the Yampa/White River Roundtable. January 2012.

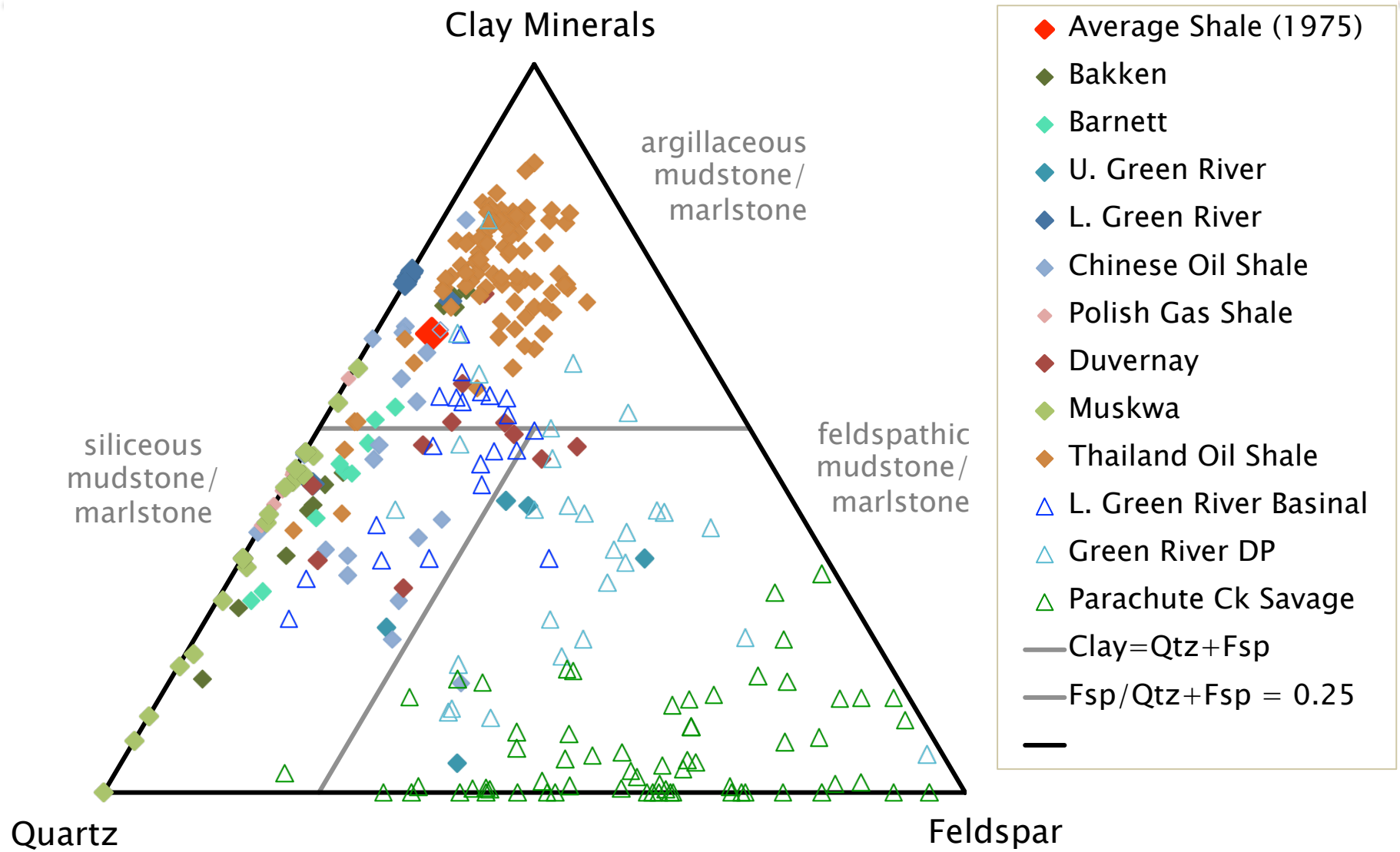
4-8 barrels water per 2-liter bottle of sweetened cola

Source: Ercin et al., (2011) Water Resources Management 25:721–741

PRIX Retort Features

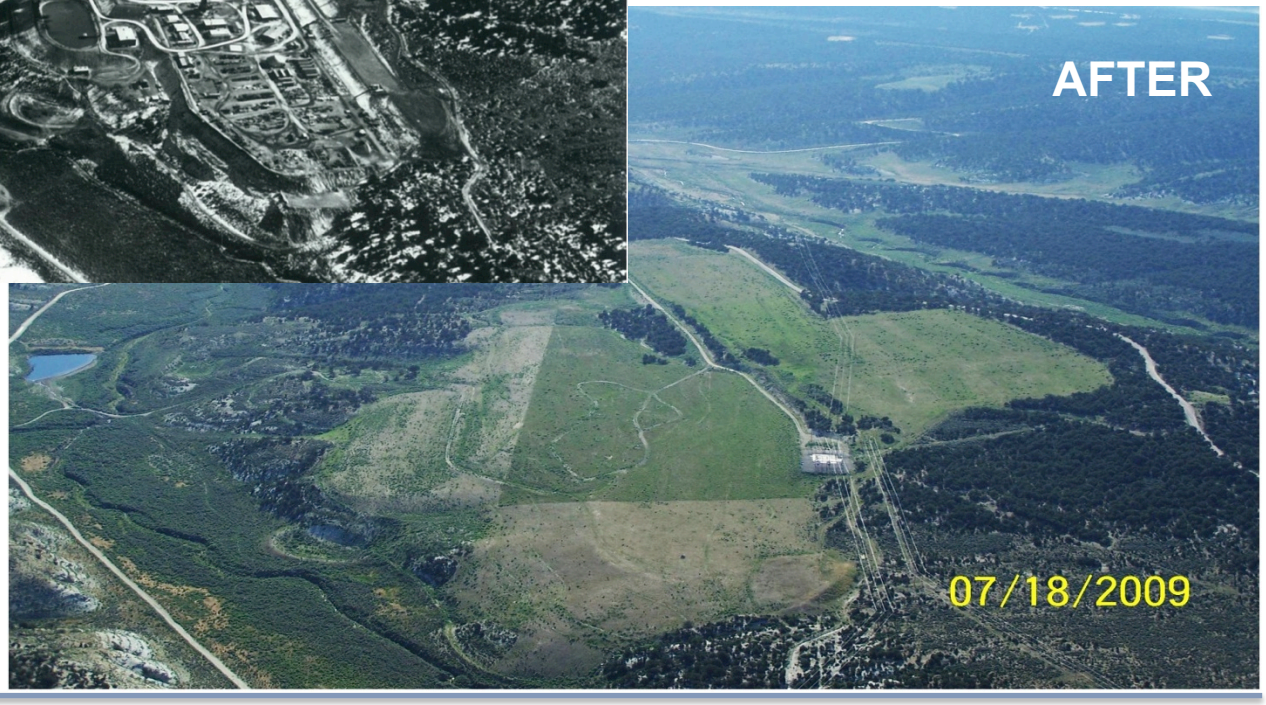
- No need for external water
- Longer residence time at pyrolysis temperature
  - Expect superior oil quality
- Lower temperature of hot recycle gas
- Energy Return on Energy Invested (ERoEI) >5
- Capacity up to 300 t/h per retort
- Oil yield >90% of Fischer Assay

Some GRF Mudstone is Unusual

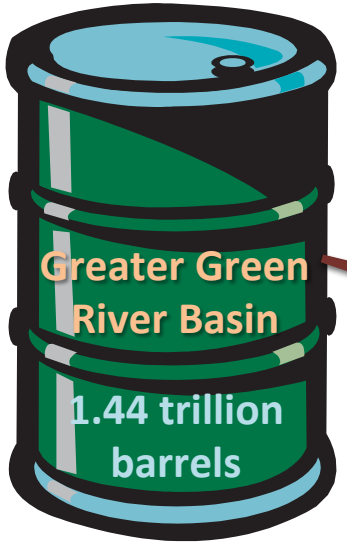


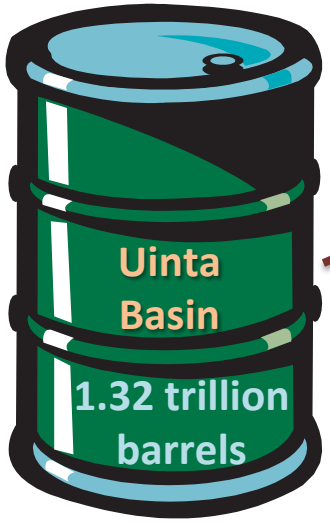
Surface reclamation was demonstrated on the prototype leases

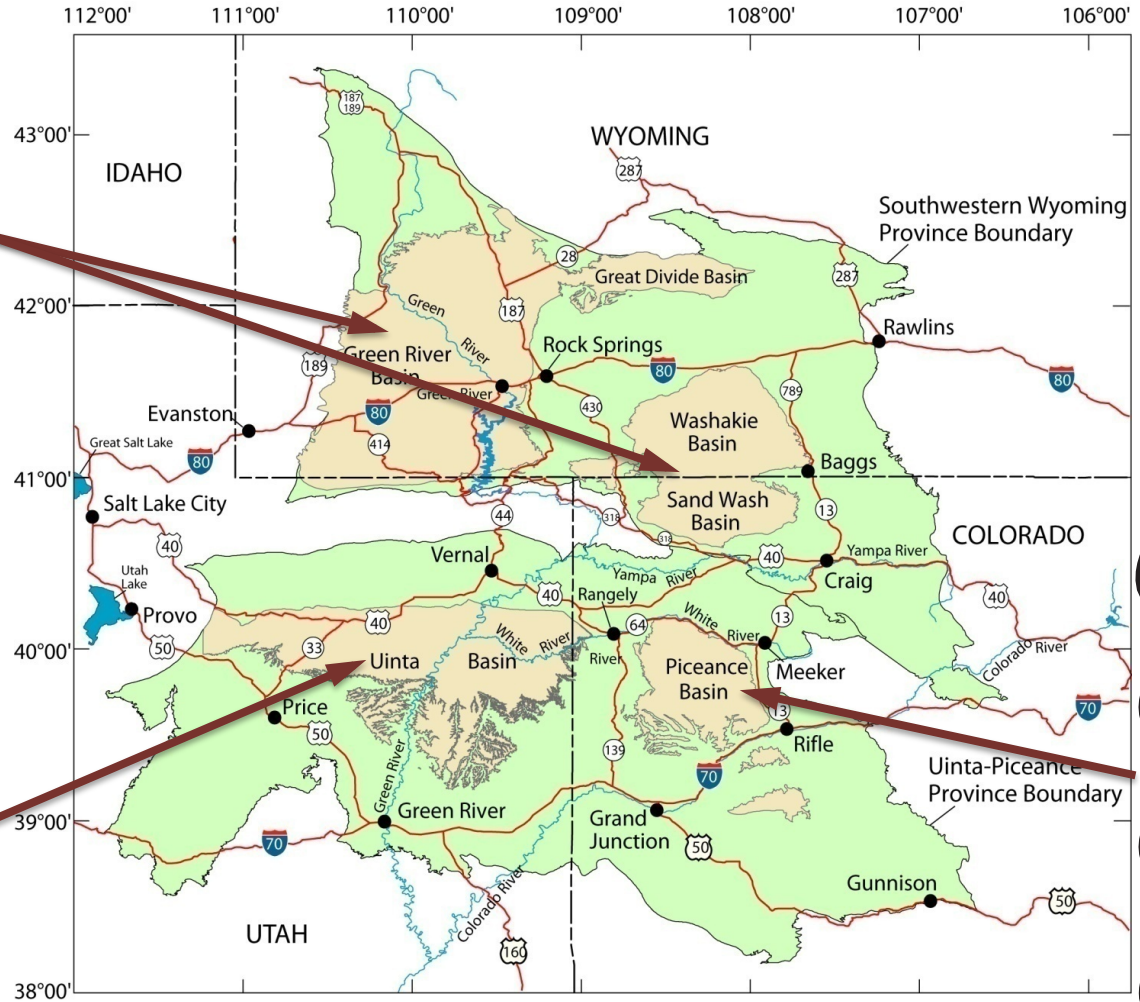
Before and after surface reclamation of Rio Blanco Corporation's Tract C-a

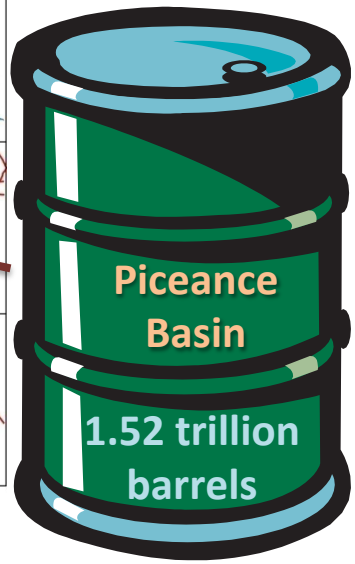


Oil Shale Resources of Green River Formation

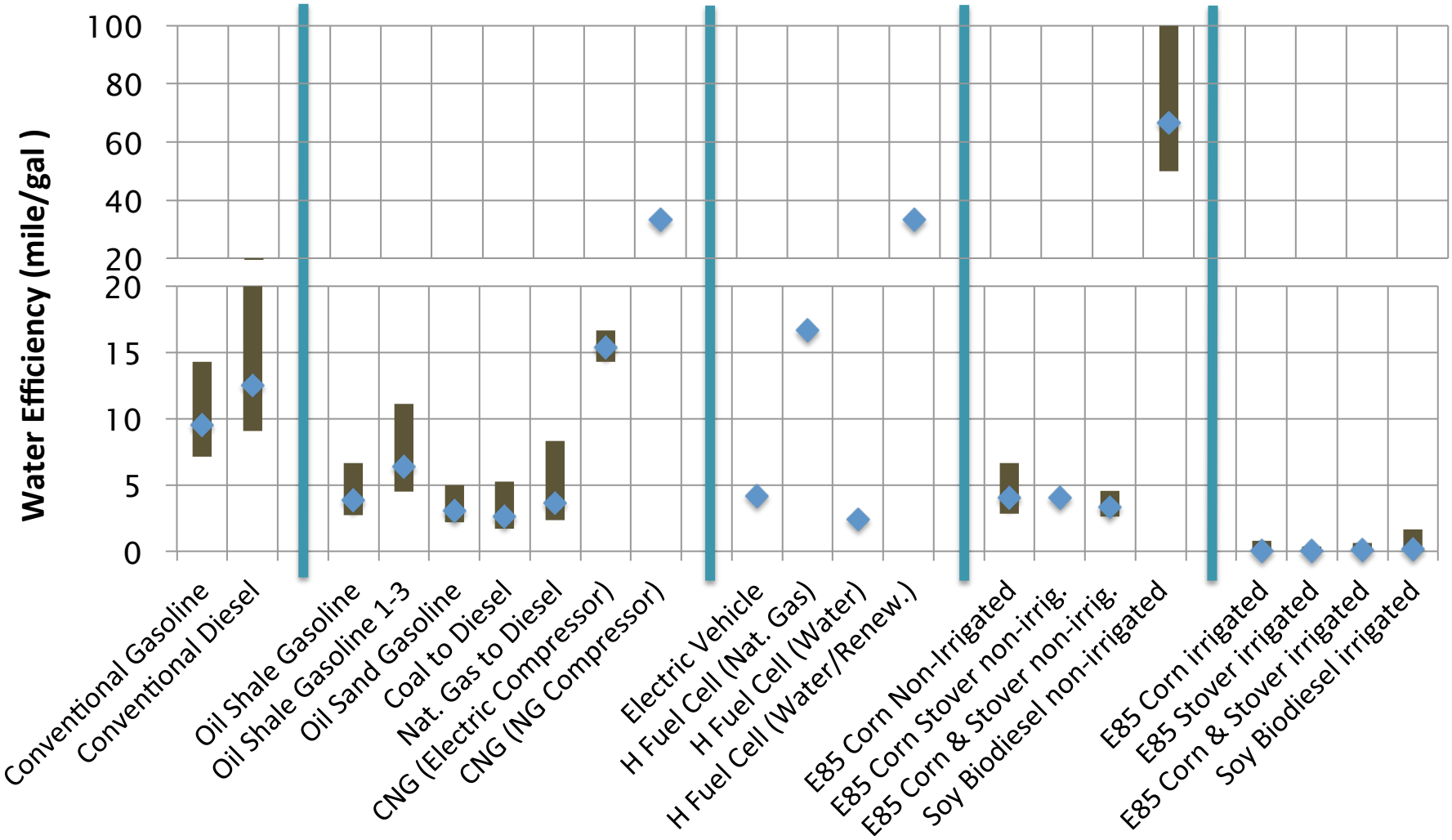








Water Efficiency of Various Fuels



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