Wyoming: A State Perspective

DOE-NSF Conference

Morgantown, West Virginia
June 15, 2006

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Wyoming EPSCoR

The Experimental Program to Stimulate Competitive Research

Enhancing Science and Engineering in Wyoming

Challenges Presented to EPSCoR States

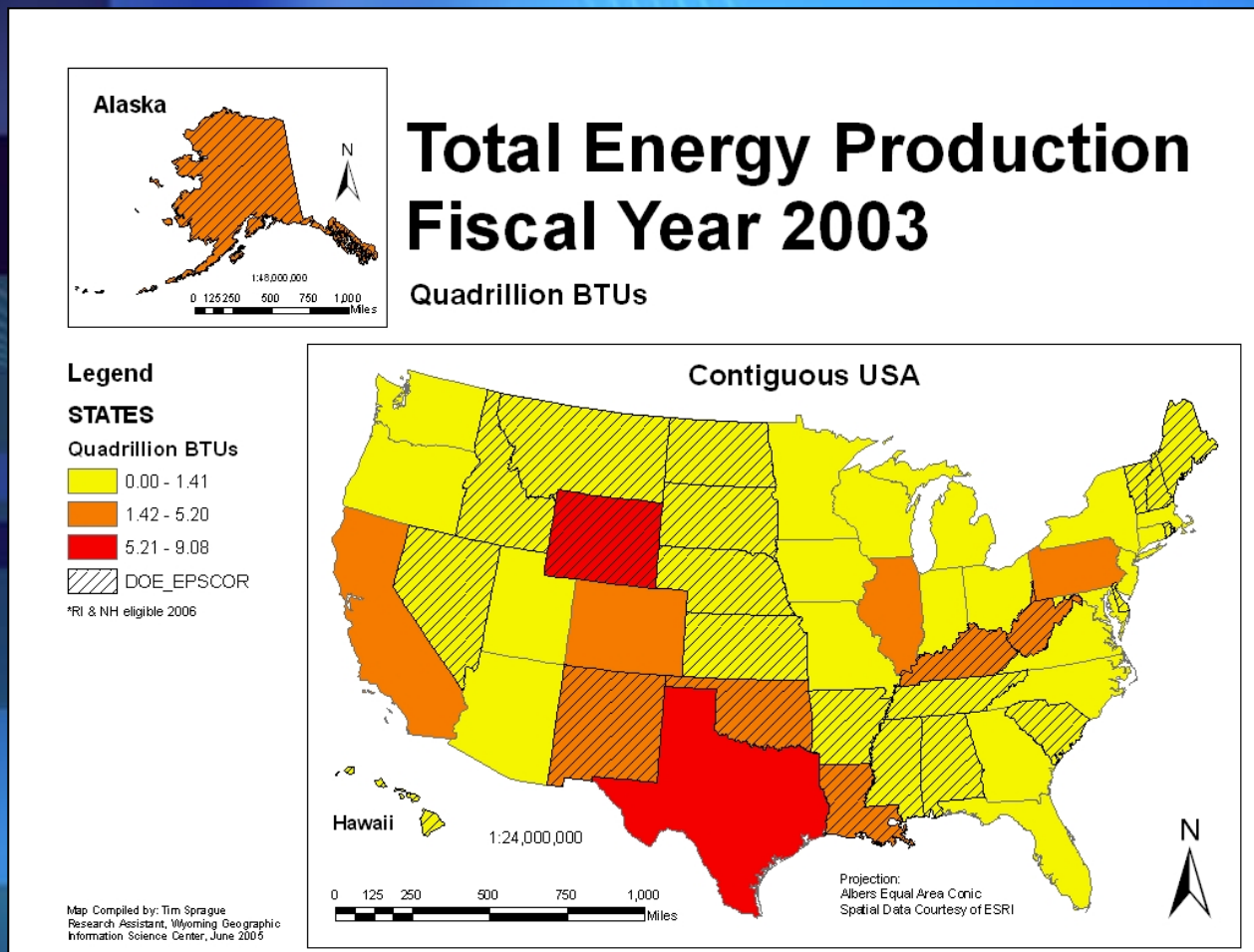
- US Department of Commerce "The Dynamics of Technology-based Economic Development"
- Examined 37 metrics related to technology businesses
- Analysis of these demonstrate that EPSCoR States have a big job here as well.

Research Funding Not the Only Disparity

Metric	EPSCoR	Non-EPSCoR	EPSCoR Percentage
Fed R&D Obligations X 1,000	$7,093,108	$60,566,780	11.7%
SBIR Funding X1,000	$85,479	$997,259	8.6%
STTR Funding X 1,000	$5,679	$53,969	10.5%
Incubators in State	162	768	21.1%
Hi Technology Payroll X 1,000	$46,243	$470,142	9.8%
Venture Capital Invested X 1,000,000	$482	$40,234	1.2%
Mean Per Capita Income	$24,917	$28,066	89%
High School Completion	85.19	85.70	99.4%

Source: US Department of Commerce "The Dynamics of Technology-based Economic Development", April 2003, Third Edition

Energy Production by State Tells An Interesting Story



Source: 2003 State Production Figures from Energy Information Administration's Annual Report, May 2005 Monthly Report as well as other reports published by the EIA, info gathered by J. Werner, University of Wyoming, map created by Tim Sprague

What's a Quad of Energy?

- British Thermal Unit (BTU): the amount of energy required to raise the temperature of a cubic centimeter of water 1^{o} C
- 1 quad = 1×10^{15} BTU
- 1 barrel of oil contains 5.25×10^{6} BTU
- OR
  - Annual petroleum production of OK, WY and NM
  - Is one quad of energy

Export/Import of Energy by the US

2003 Imports/Exports	Quadrillion BTU
Coal	-0.49
Natural Gas	3.39
Crude Oil	21.06
Petroleum Products	2.74
Electricity	0.02
Coal Coke	0.05
TOTAL	26.77

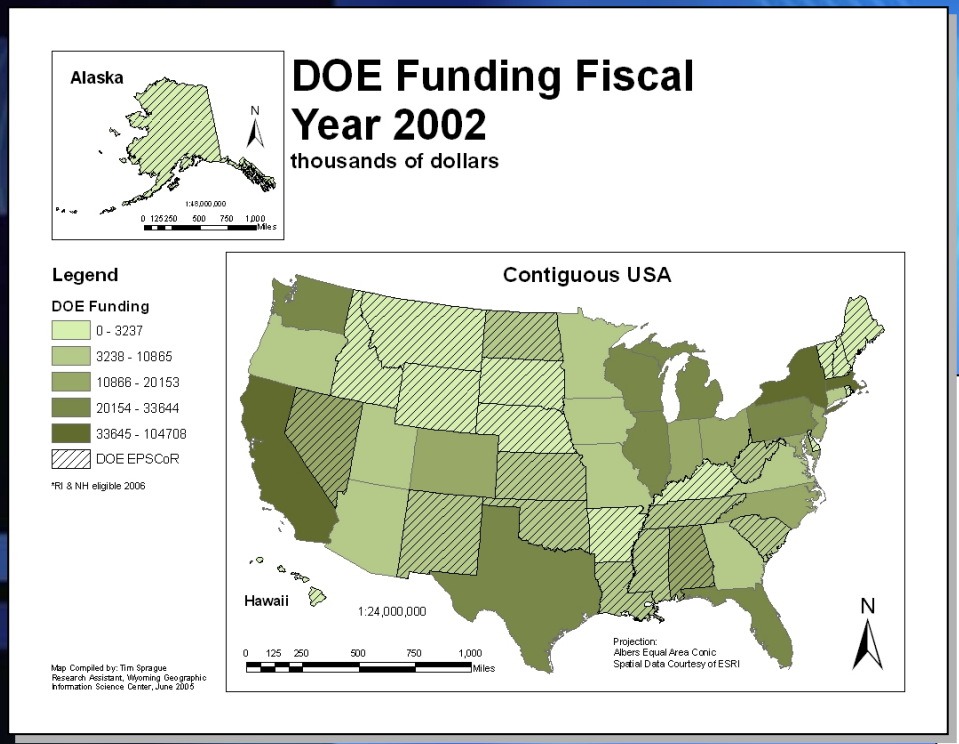
Source: 2003 State Production Figures from Energy Information Administration's Annual Report, May 2005 Monthly Report as well as other reports published by the EIA, info gathered by J. Werner, University of Wyoming

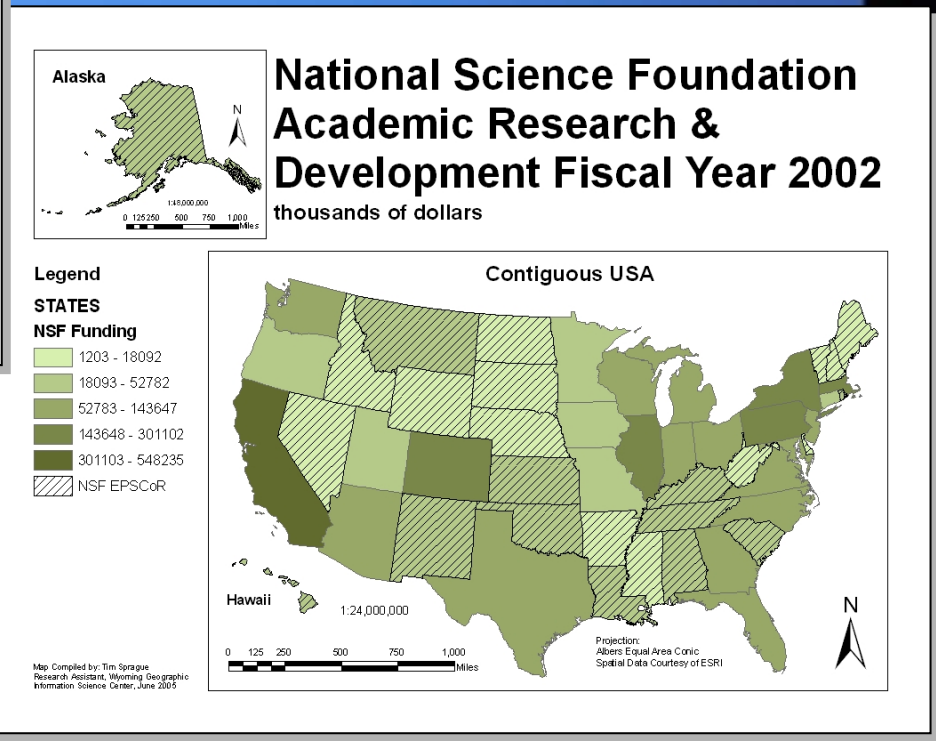
Net Energy Production by State: EPSCoR States Are Important

STATE	'03 PRODUCTION quads	'03 CONSUMPTION quads	'03 Net Production quads
Wyoming	8.46	0.4	8.06
W. Virginia	3.86	0.7	3.16
New Mexico	2.53	0.6	1.93
Alaska	2.38	0.6	1.78
Kentucky	3.06	1.9	1.16
Oklahoma	2.08	1.4	0.68
Colorado	1.87	1.2	0.67
Utah	0.96	0.7	0.26
Montana	0.84	0.6	0.24
N. Dakota	0.63	0.4	0.23
Texas	9.08	12.0	-2.92
EPSCoR States			

Source: 2003 State Production Figures from Energy Information Administration's Annual Report, May 2005 Monthly Report as well as other reports published by the EIA, info gathered by J. Werner, University of Wyoming

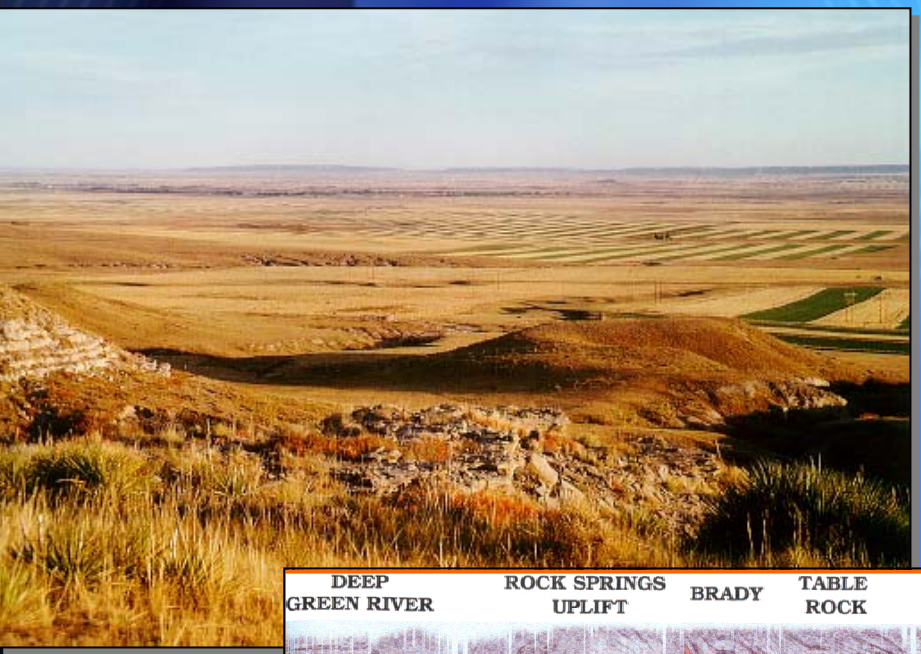
DOE & NSF Funding by State

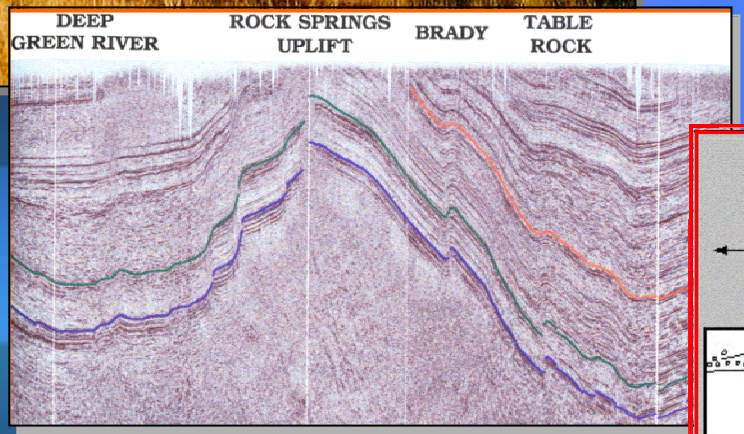




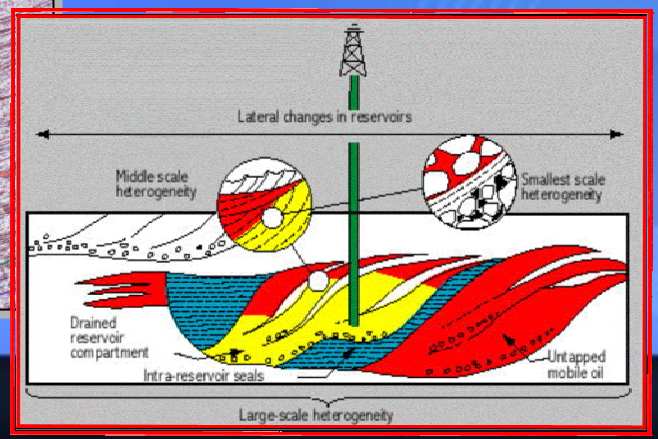
Source: http://www.nsf.gov/statistics/nsf05309/tables/b16.xls, data gathered by Aaron Laur, maps created by & Tim Sprague, UW

Enhanced Oil Recovery: An Example





- In many US oil fields only 15-20% of oil in place has been recovered
- Extracting another 15% requires extensive knowledge of the geology, surficial chemistry, and flow dynamics
- This is a very important problem for the nation, requiring development of new knowledge



Source: R. Steel, personal communication

Complex Mathematics Model Fluid Flow in Rock

Convection-diffusion system

$$\frac{\partial(\phi\, s_w)}{\partial t} + \nabla \cdot (\mathbf{v} f_w) = \nabla \cdot \mathbf{w}_w$$

$$\frac{\partial(\phi\, s_g)}{\partial t} + \nabla \cdot (\mathbf{v} f_g) = \nabla \cdot \mathbf{w}_g$$

$$\mathbf{w}_w = K(\mathbf{x})\lambda_w[-f_g \nabla p_{go} + (1 - f_w)\nabla p_{wo}]$$

$$\mathbf{w}_g = K(\mathbf{x})\lambda_g[-f_w \nabla p_{wo} + (1 - f_g)\nabla p_{go}]$$

Coupled to pressure-velocity system

$$\mathbf{v} = -K(\mathbf{x})\lambda(s_w, s_g)\nabla p_o + \mathbf{v}_{wo} + \mathbf{v}_{go}$$

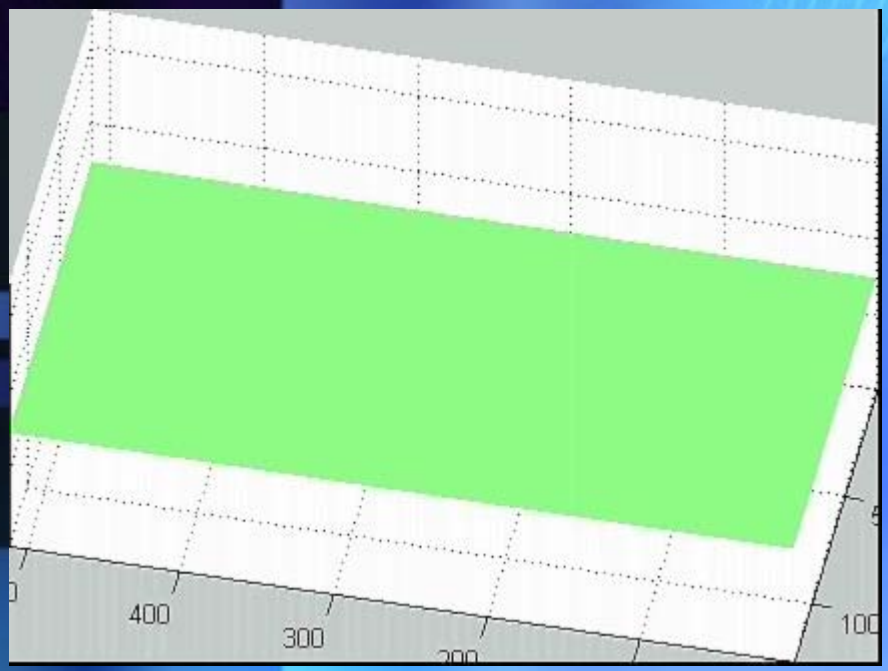
$$\nabla \cdot \mathbf{v} = 0$$

where $\mathbf{v}_{wo}$ and $\mathbf{v}_{go}$ are velocity corrections due to capillarity

- A few partial differential equations describing heterogeneous fluid flow in porous media (oil, water and gas in sandstone)
- Creating visualizations that predict flow dynamics is a very large algorithm that must computed using a supercomputer

Source: F. Furtado and E. Felipe-Pereira, personal communication

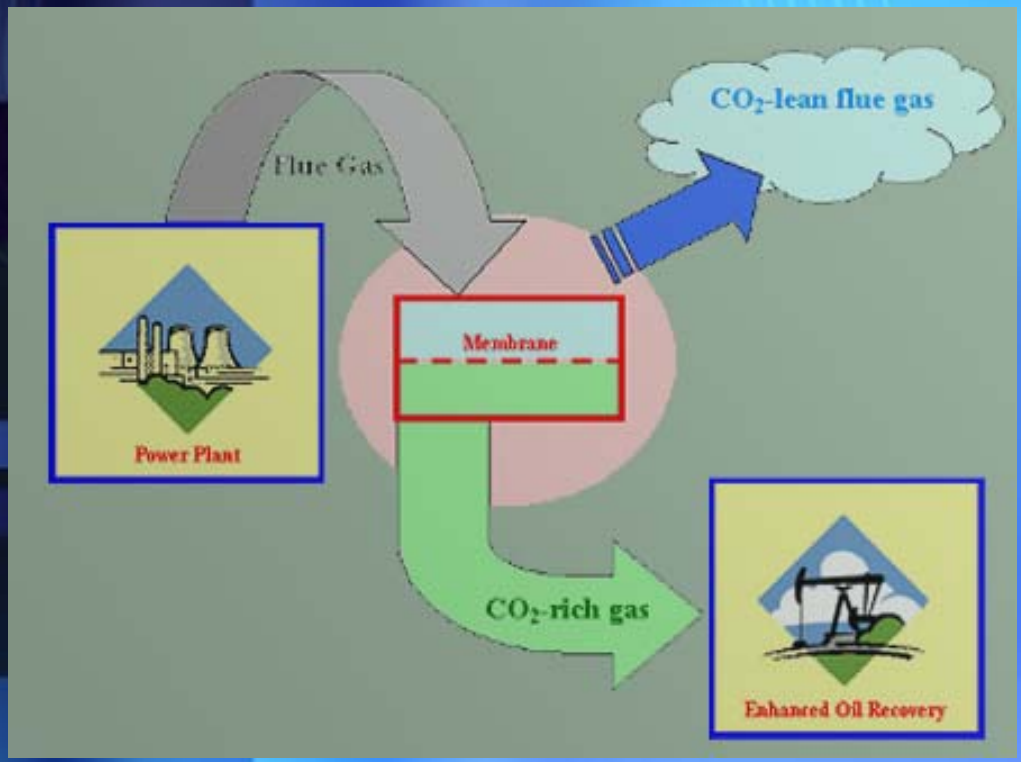
Gas Movement in Porous Rock



- This visualization demonstrates the solution of the partial differential equations that describe gas movement in porous rock

Source: F. Furtado and E. Felipe-Pereira, personal communication

CO^2 Capture



- **Holy Grail**
- Capture the flue-gas CO^2 that causes global warming, use it to squeeze more oil from the depleted reservoir, and seal the balance underground after oil stops flowing.
- Wyoming power plants put out 100 million tons of CO^2 each year
- UW is part of the Big Sky (MSU) Carbon Sequestration Partnership funded by US DOE

Summary

- State Impact
  - According to the Wyoming Geological Survey 8 billion barrels of oil remain in Wyoming fields
  - Between 5% and 15% of this could be recovered with enhanced oil recovery methods
  - Only 5% could mean 2 billion dollars for Wyoming over 20 years
- This has obvious importance to the Wyoming Legislature, and makes securing matching funding much easier
- It also represents high quality, interdisciplinary science and engineering, of obvious importance to the nation

- NSF supported our computational science initiative in Wyoming's last Implementation Award
- During proposal review excellent science should always carry the day
  - But finding the sweet spot that combines issues of importance to the state and nation also is important
  - DOE EPSCoR needs to reinforce these criteria in their proposal review, especially if they require matching funding

Thank you!