

Oil Shale – Status and Prospects  
Presentation to  
Garfield County Energy Advisory Board  
October 1, 2009

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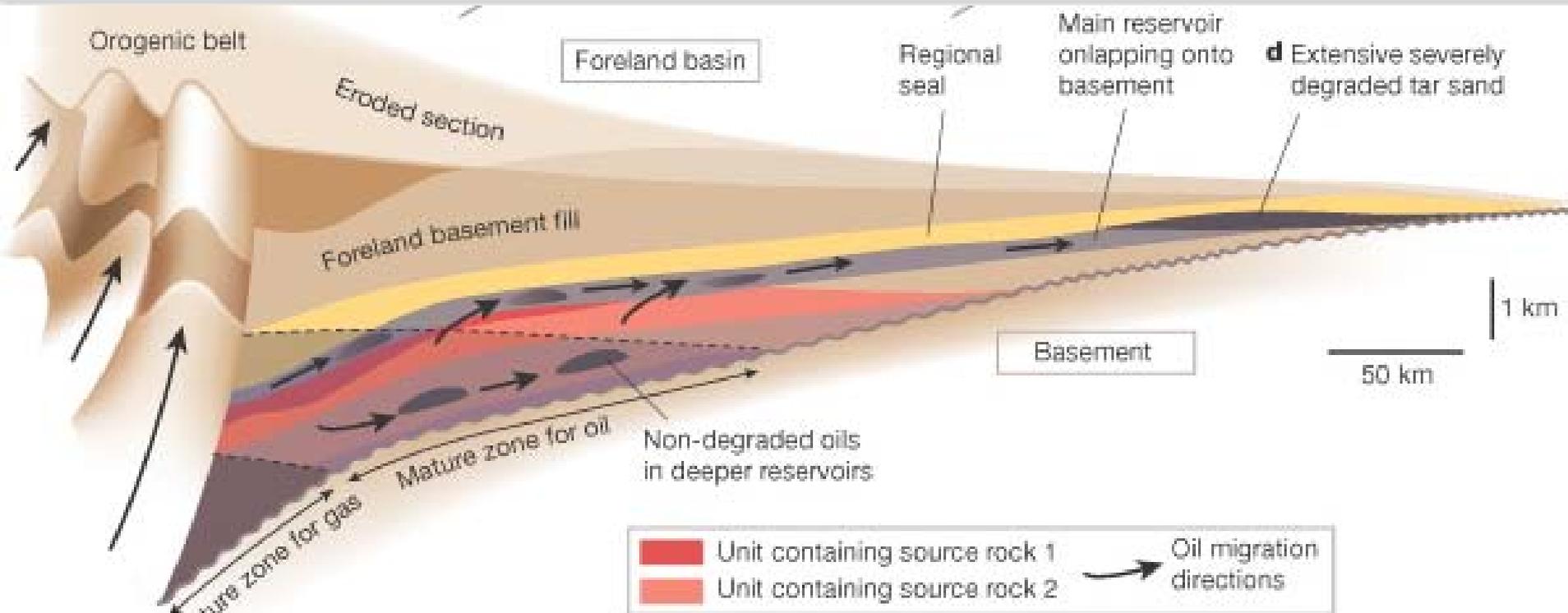


# Outline

- ▶ General concepts
- ▶ Oil shale
  - Oil shale terminology
  - Oil shale development in the U. S. now
  - Oil shale technology – a quick overview
  - Where is the oil shale in the world, and who is producing shale oil
  - Issues
- ▶ Information on COSTAR and the Oil Shale Symposium



# Oil shale & oil sand – opposite ends of the Petroleum System



- ▶ Oil shale is immature source rock, unmigrated, rich in hydrogen
- ▶ Oil sand produces heavy oil that is commonly far traveled and degraded, lower in hydrogen than normal oil

# What is oil shale?

- ▶ Organic rich sedimentary rock formed in lake or marine environments
  - Commonly carbonate rich; many not classical argillaceous mudstones
  - Kerogen-rich, primarily algal and bacterial
  - Immature precursor to oil & gas
- ▶ Produces oil upon heating



# Oil shale terminology

- ▶ The name oil shale represents a double **misnomer**, as geologists would not necessarily classify the rock as a shale, and its kerogen differs from crude oil.
  - Wikipedia, [http://en.wikipedia.org/wiki/Oil\\_shale](http://en.wikipedia.org/wiki/Oil_shale)
- ▶ The term "oil shale" is a **misnomer**. The rock is a **marlstone**, and the hydrocarbon is a waxy molecule called kerogen. Kerogen is a proto-petroleum — oil and gas are generated when kerogen is exposed to heat deep in the Earth's oven.
  - Grinning Planet, <http://www.grinningplanet.com/2005/12-13/oil-shale-article.htm>
- ▶ Hying oil shale is nothing new. As geologist Walter Youngquist once wrote, "Bankers won't invest a dime in 'organic marlstone,' the shale's proper name, but 'oil shale' is another matter."
  - Grinning Planet, <http://www.grinningplanet.com/2005/12-13/oil-shale-article.htm>

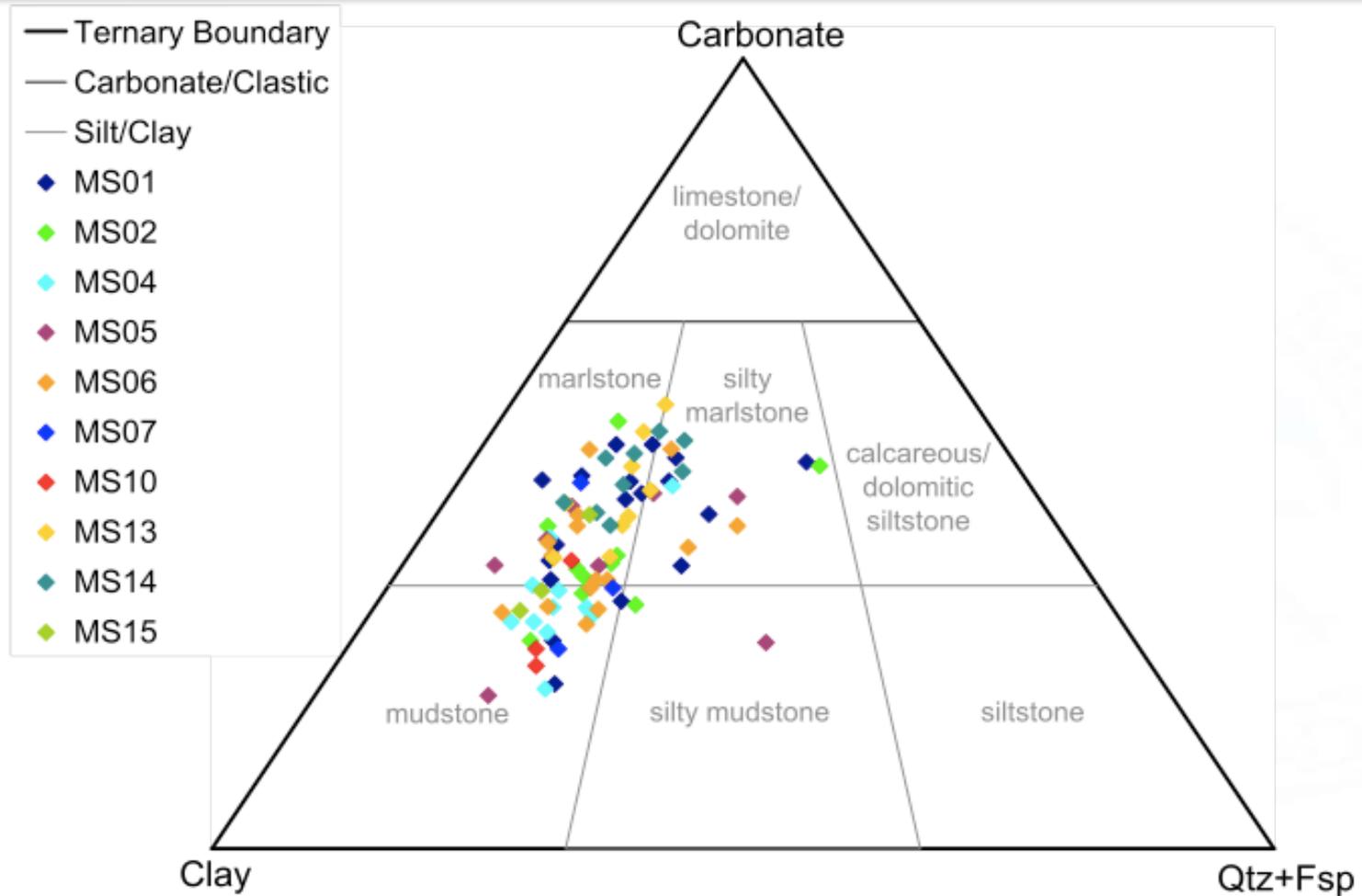


# Oil shale terminology

- ▶ ...we propose that mudstone be the generic term for all fine-grained argillaceous rocks and that shale be restricted to laminated fine-grained argillaceous rocks, following its original definition by Hooson (1747) ...although we grew up with and like shale (only one syllable is needed for pronunciation) as the general term for argillaceous rocks, here we restrict it to its original sense of a **laminated**, argillaceous rock.
  - Potter, Maynard, and Depetris, Mud and Mudstones, Springer, 2005, pp. 256-257
- ▶ Marl, n. An old term loosely applied to a variety of materials, most of which occur in loose, earthy, or friable deposits and contain a relatively high proportion of calcium carbonate or dolomite....**Certain varieties are excellent as cement materials**....As the term covers a wide range of materials and designates no particular well-defined composition, it should not be used without specific definition.
  - Glossary of Selected Geological Terms, Stokes and Varnes, 1955



# Oil shale composition



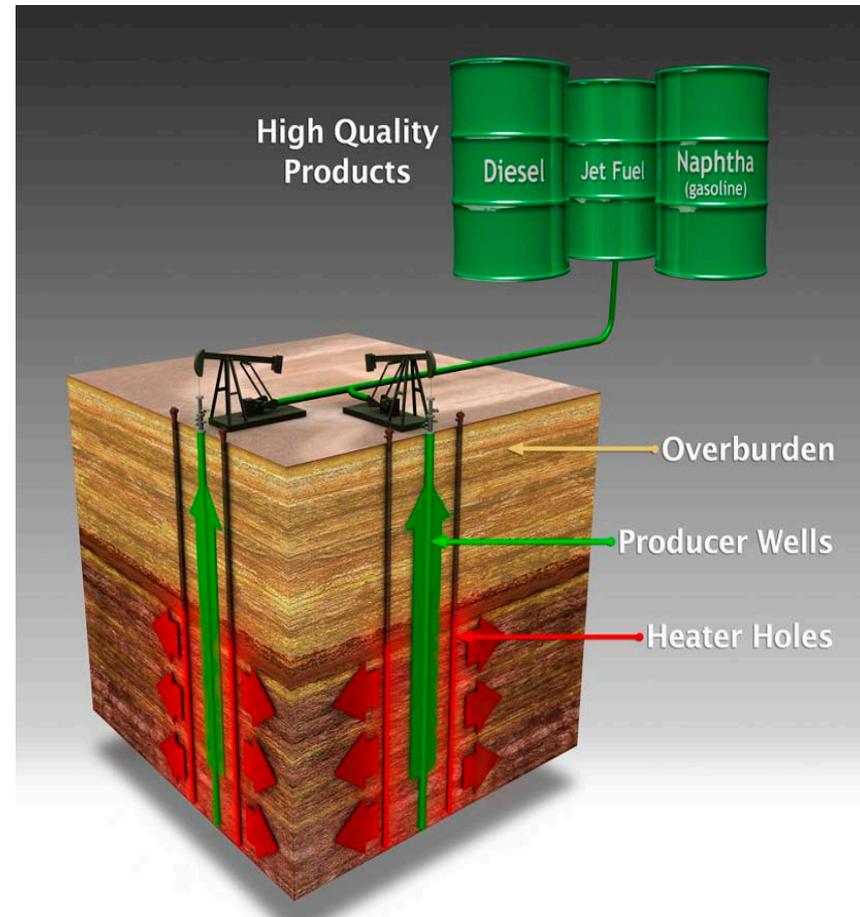
# Oil shale development in the U. S. now

- ▶ Shell
- ▶ Chevron
- ▶ AMSO/Total
- ▶ ExxonMobil
- ▶ OSEC/Petrobras/Mitsui
- ▶ Red Leaf Resources
- ▶ Mountain West Energy

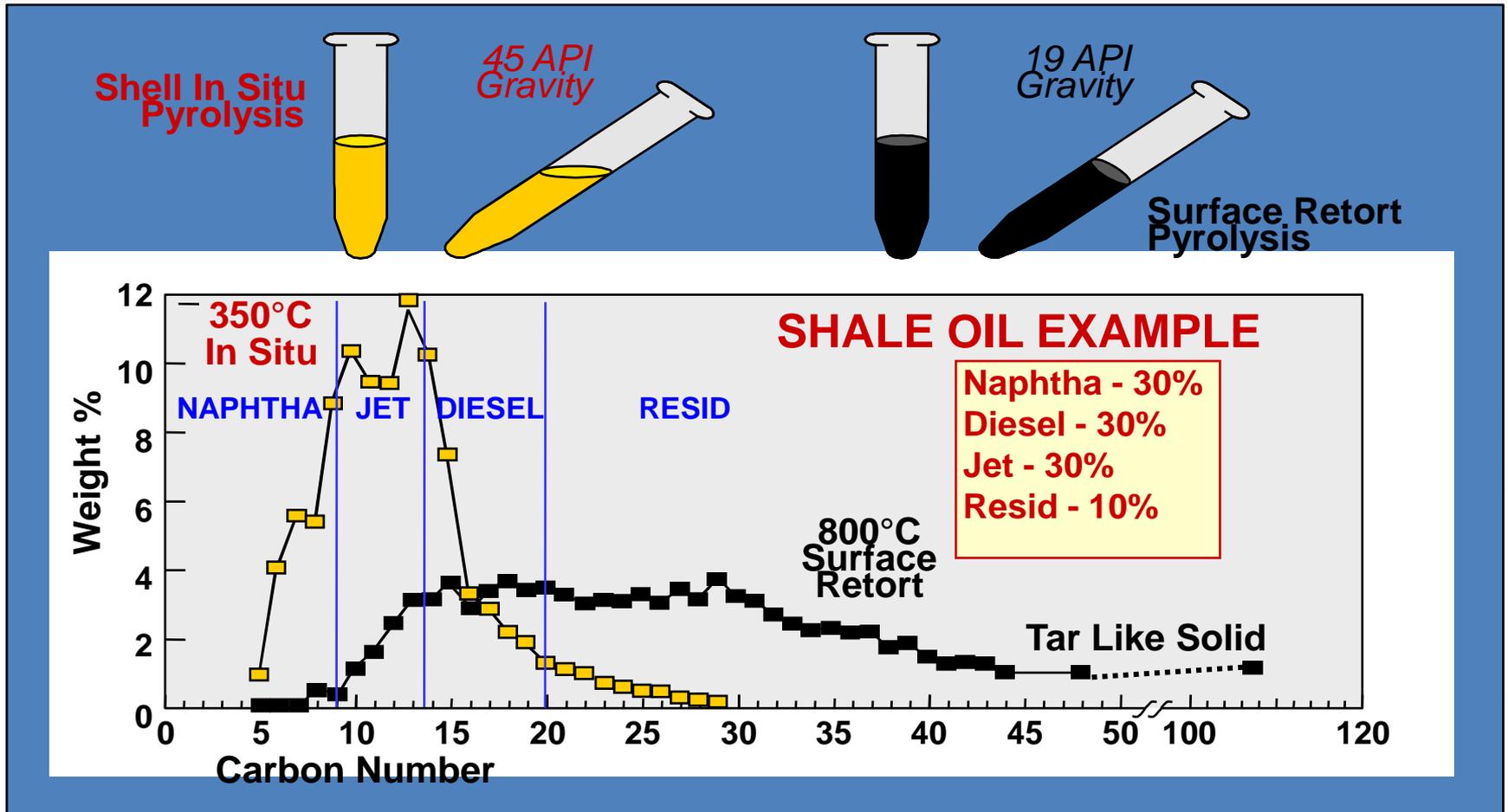


# Shell In-Situ Conversion Process (ICP)

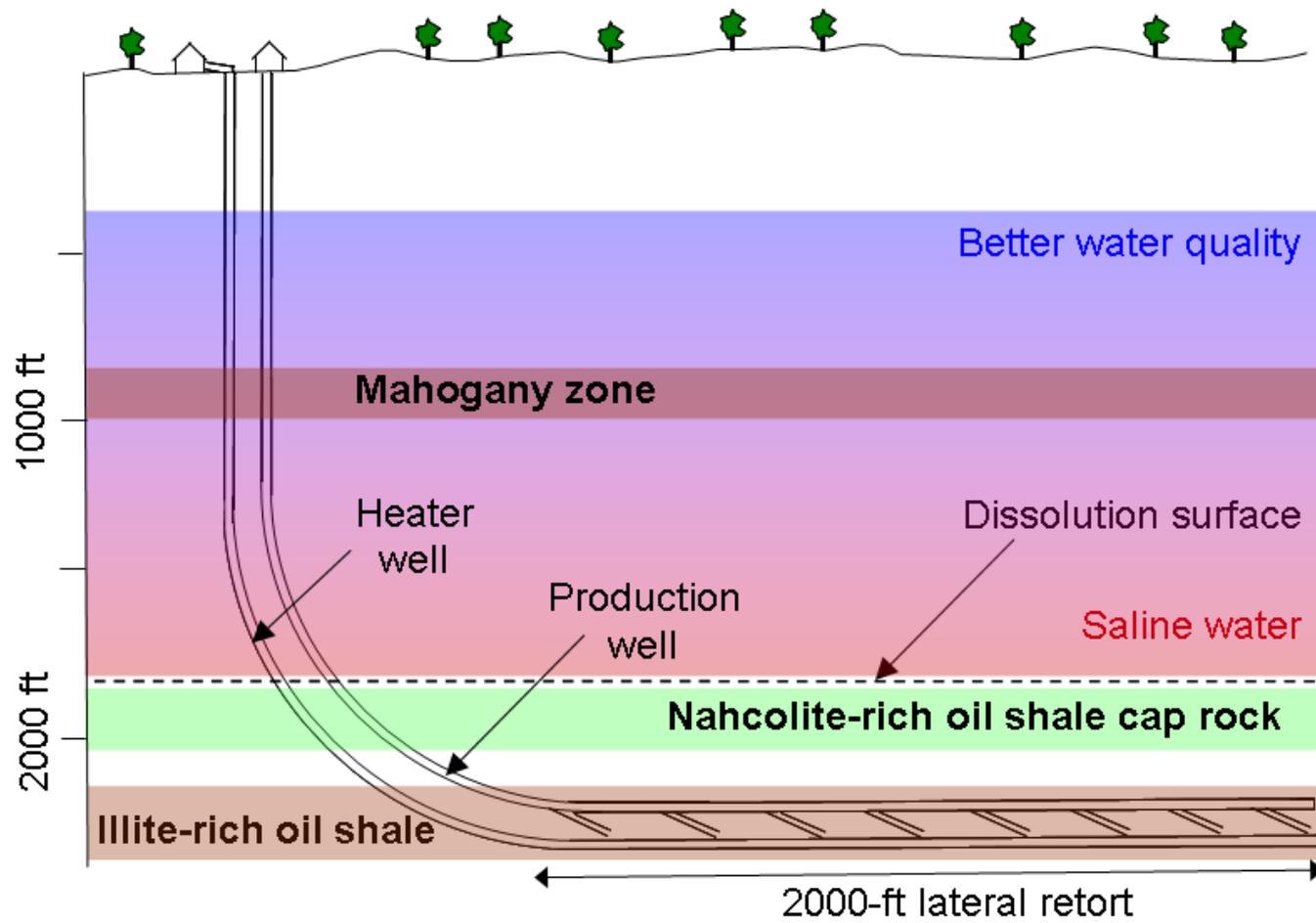
- ▶ Electric resistance heaters gradually heat shale in subsurface
- ▶ Applicable to oil shale and heavy oil/bitumen
- ▶ Accelerates natural maturation of kerogen by gradual heating in oil shale
- ▶ High recoveries & light hydrocarbon products yielding high quality transportation fuels



# Product - better feedstock for upgrading

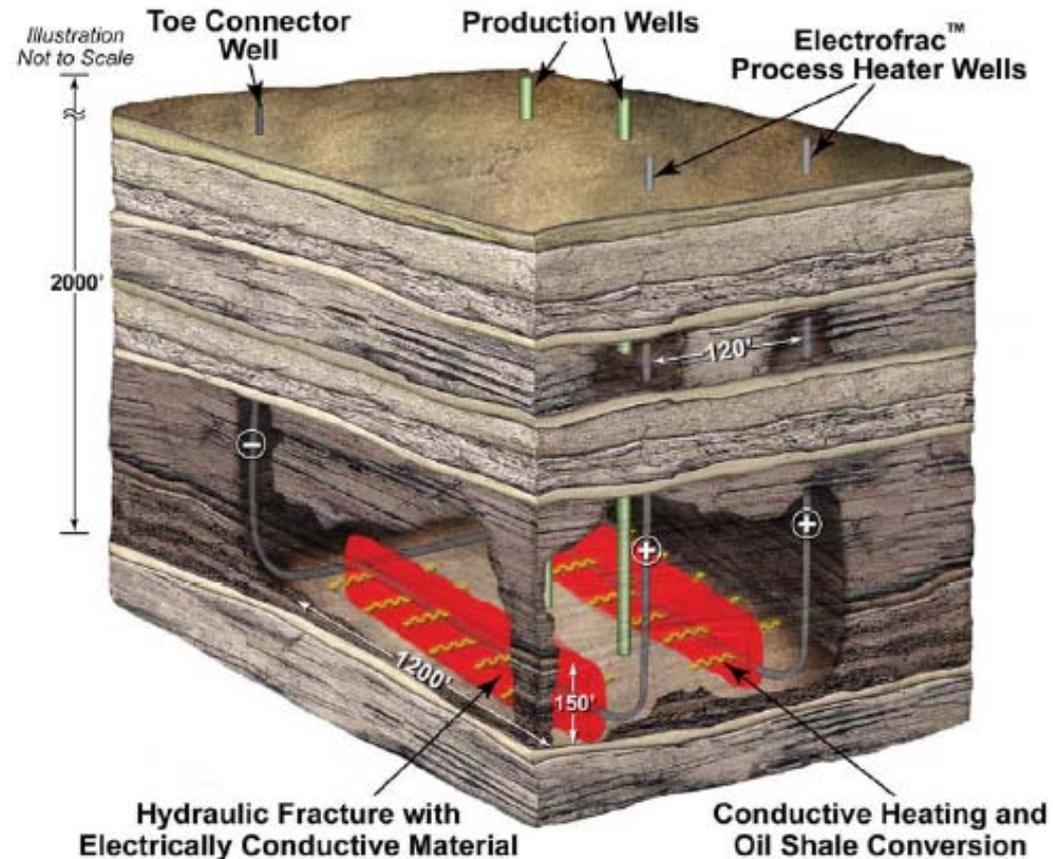


# AMSO Process



# ExxonMobil Electrofrac™ Process

- ▶ Create electrically conductive fractures (vertical or horizontal)
- ▶ Planar heat source more effective than radial conduction from wellbore
- ▶ Typical simulation
  - 150 foot fracture height
  - 5-year heating converts 325 feet of oil shale
  - 120-ft fracture spacing,
  - 74% heating efficiency



# OSEC RD&D Lease - White River Mine Utah

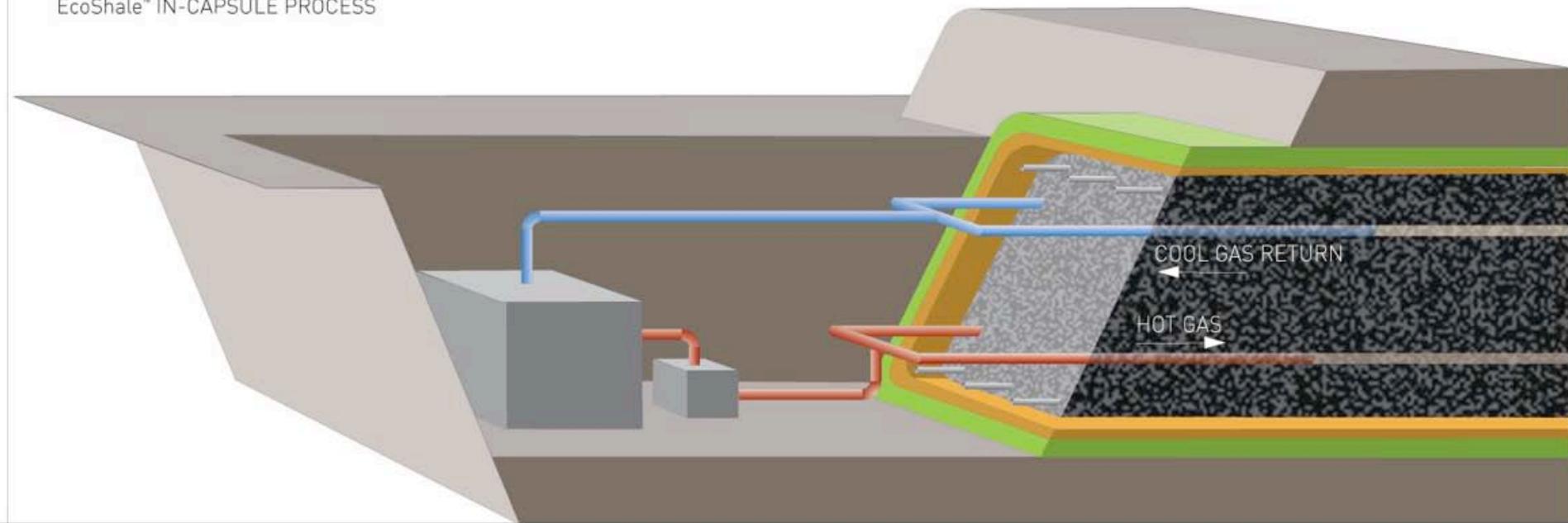
- ▶ Partnership with Petrobras and Mitsui
- ▶ Will use Petrobras Petrosix™ retort



# Red Leaf Resources Ecoshale™ Process

- ▶ Very low water use
- ▶ High Energy Return on Investment
- ▶ Pilot test completed

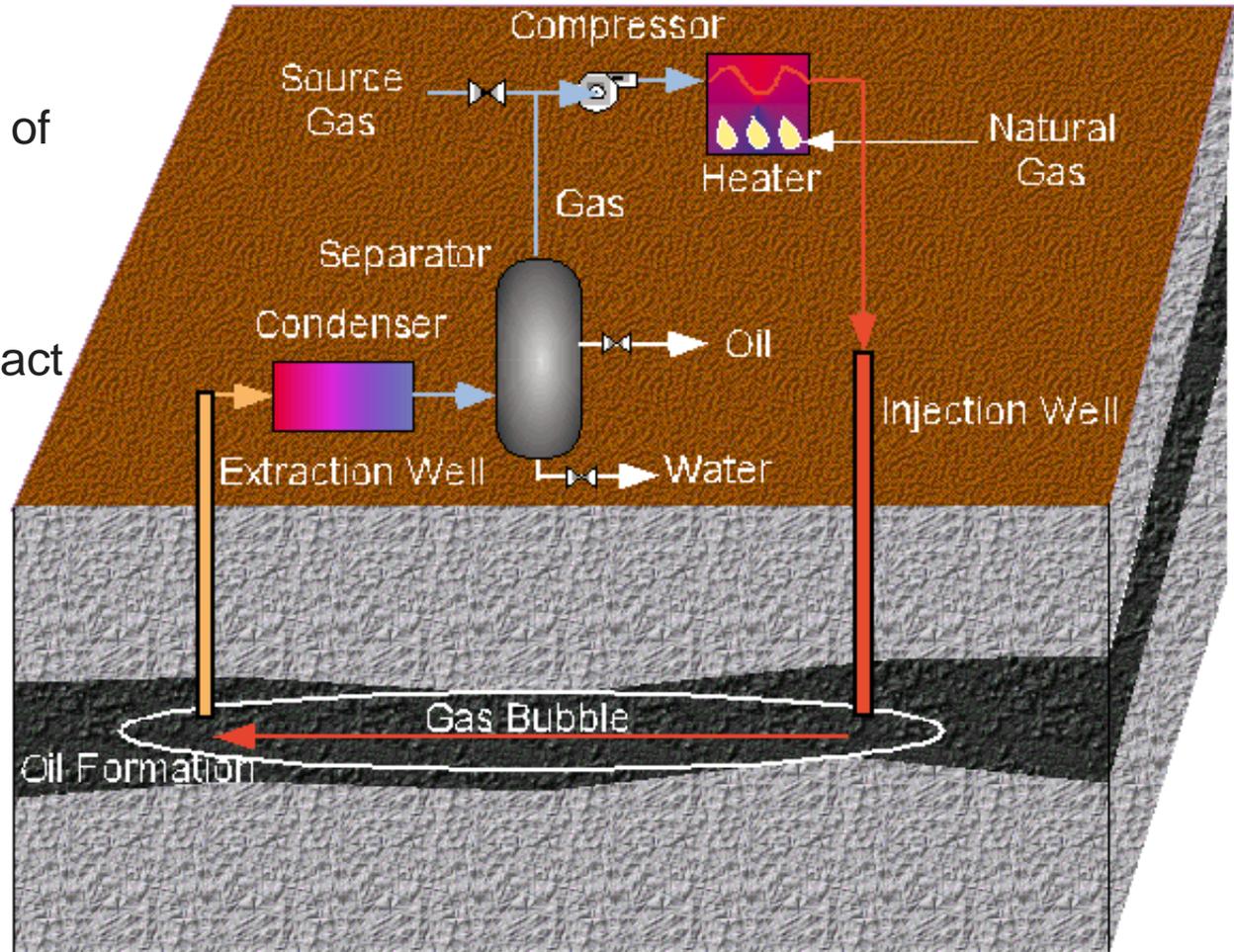
EcoShale™ IN-CAPSULE PROCESS



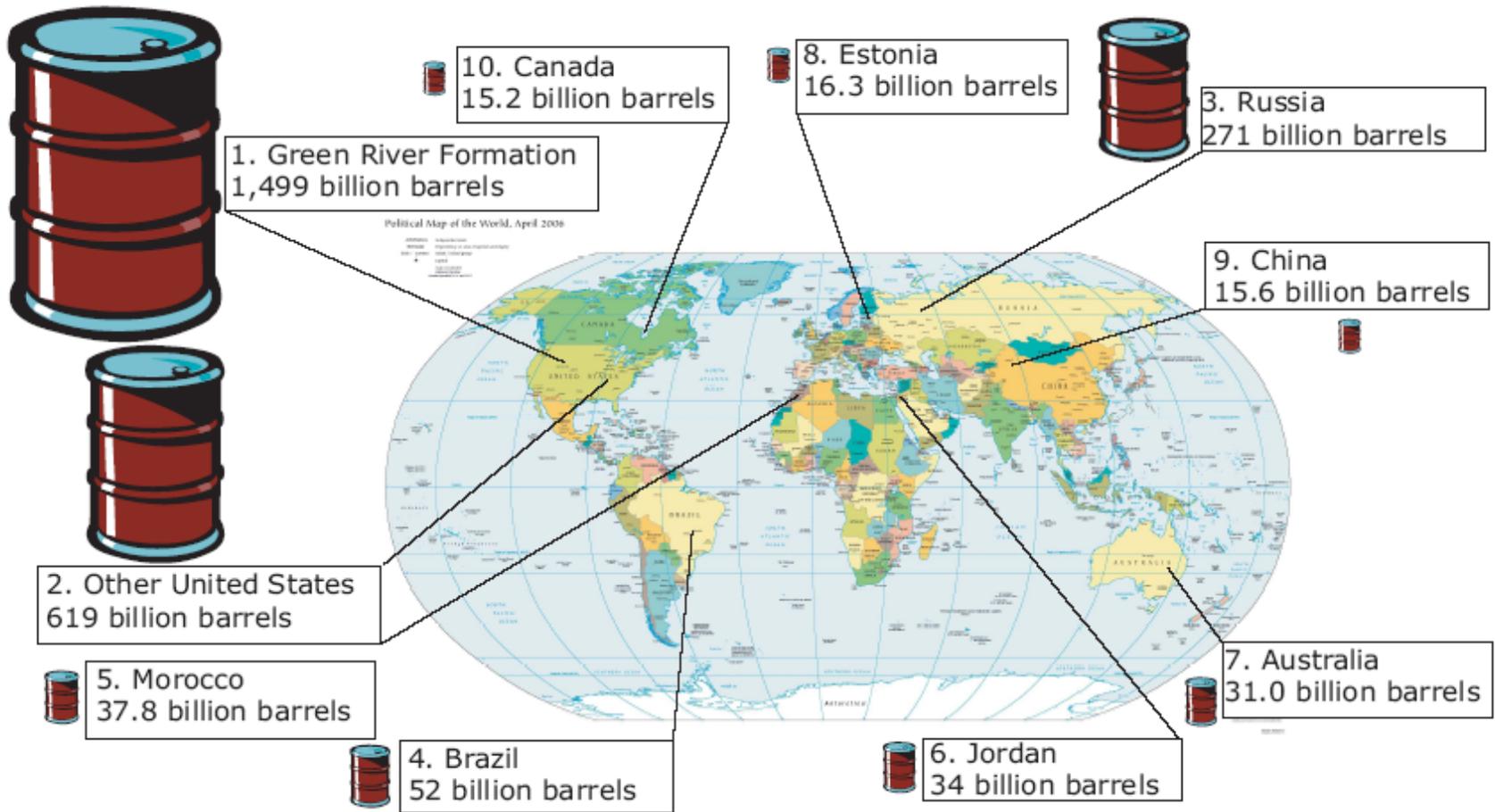
# Mountain West Energy In-situ Vapor Extraction (IVE)

## ▶ Advantages

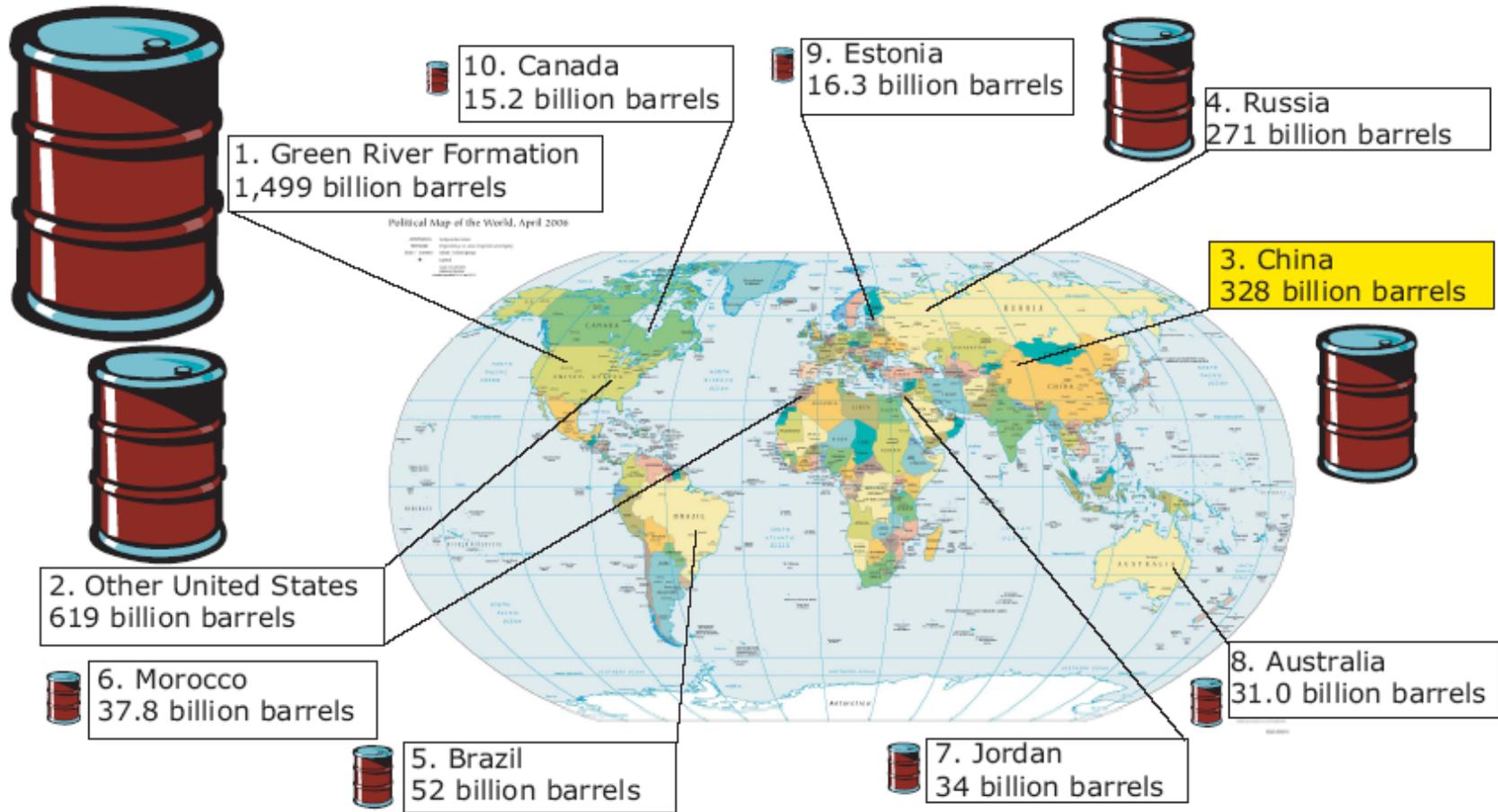
- Innovative combination of existing technology
- Scalable
- Low environmental impact
- Rapid deployment



# Where is the oil shale in the world?



# Changing resource estimates



# Who is producing shale oil from oil shale?



▶ Brazil ~4,000 barrels per day



▶ China ~8,000 barrels per day

▶ Estonia ~8,000 barrels per day

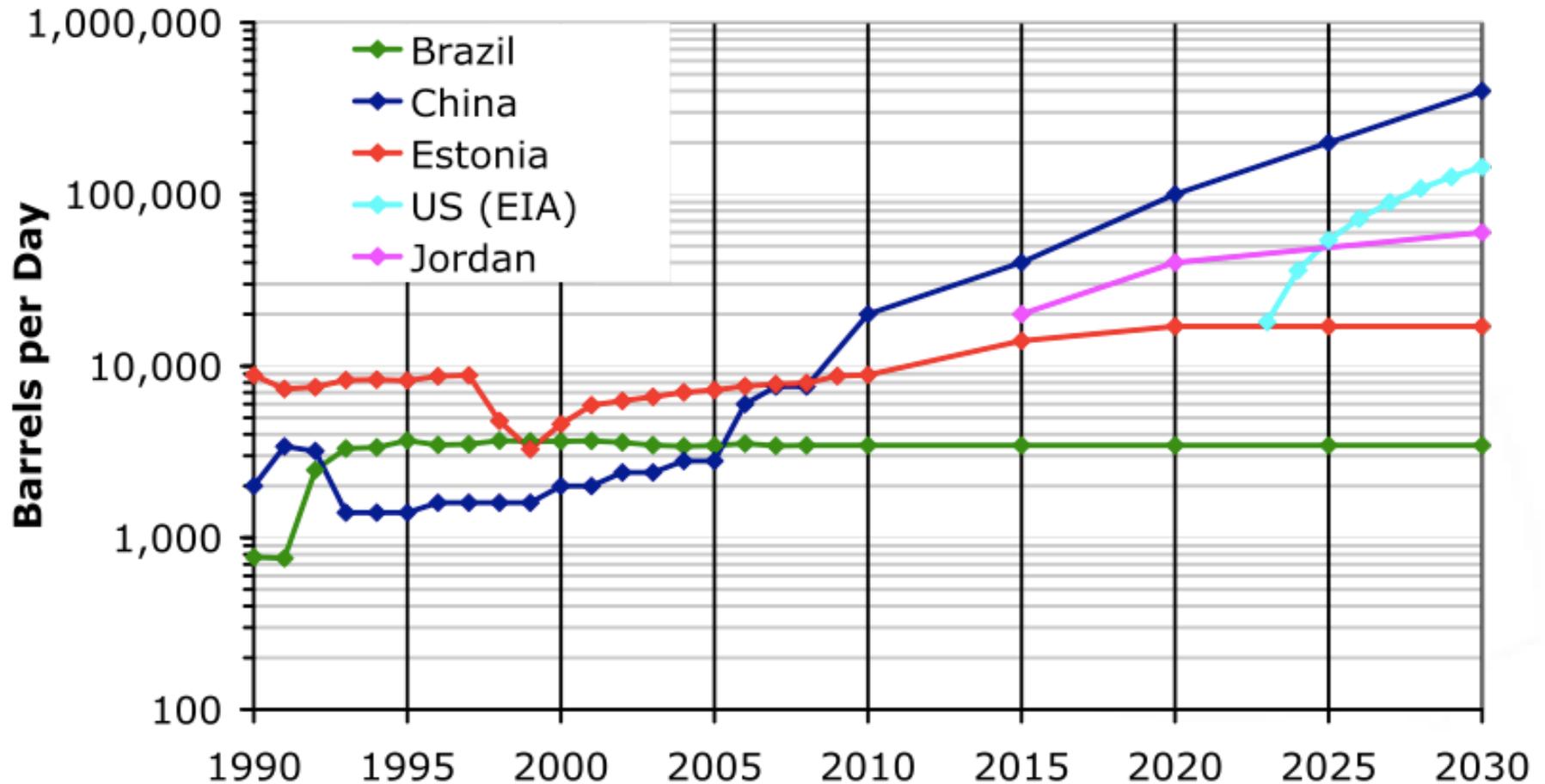


# Countries important to oil shale development

- ▶ Current leaders have likely roles in making shale oil significant in global energy mix
- ▶ Current producers
  - Estonia
  - China
  - Brazil
- ▶ Large undeveloped resources
  - United States
  - Morocco
  - Jordan
  - Australia
  - Russia
- ▶ Many others have potential to contribute to technology development & deployment



# Historic & projected production



# Four issues for progress

- ▶ Four main issues condition future progress of shale oil production:
  - Access to the resource
  - Technology development
  - Environmental impact
  - Economic viability
- ▶ Importance of each different in every country where development is under way or being considered
- ▶ Issues not necessarily independent of one another
- ▶ Interplay of natural influences (richness, depth, composition) with human influences (innovation, economics, security, cultural values) affect how companies and countries progress



# Environmental Issues for Oil Shale Development

## ▶ Issues

- Water quantity and quality
- Air quality
- Surface and ecosystem impact
- Social and economic impacts

## ▶ Data needs

- Definition process
- Baseline collection
- Management
- Dissemination

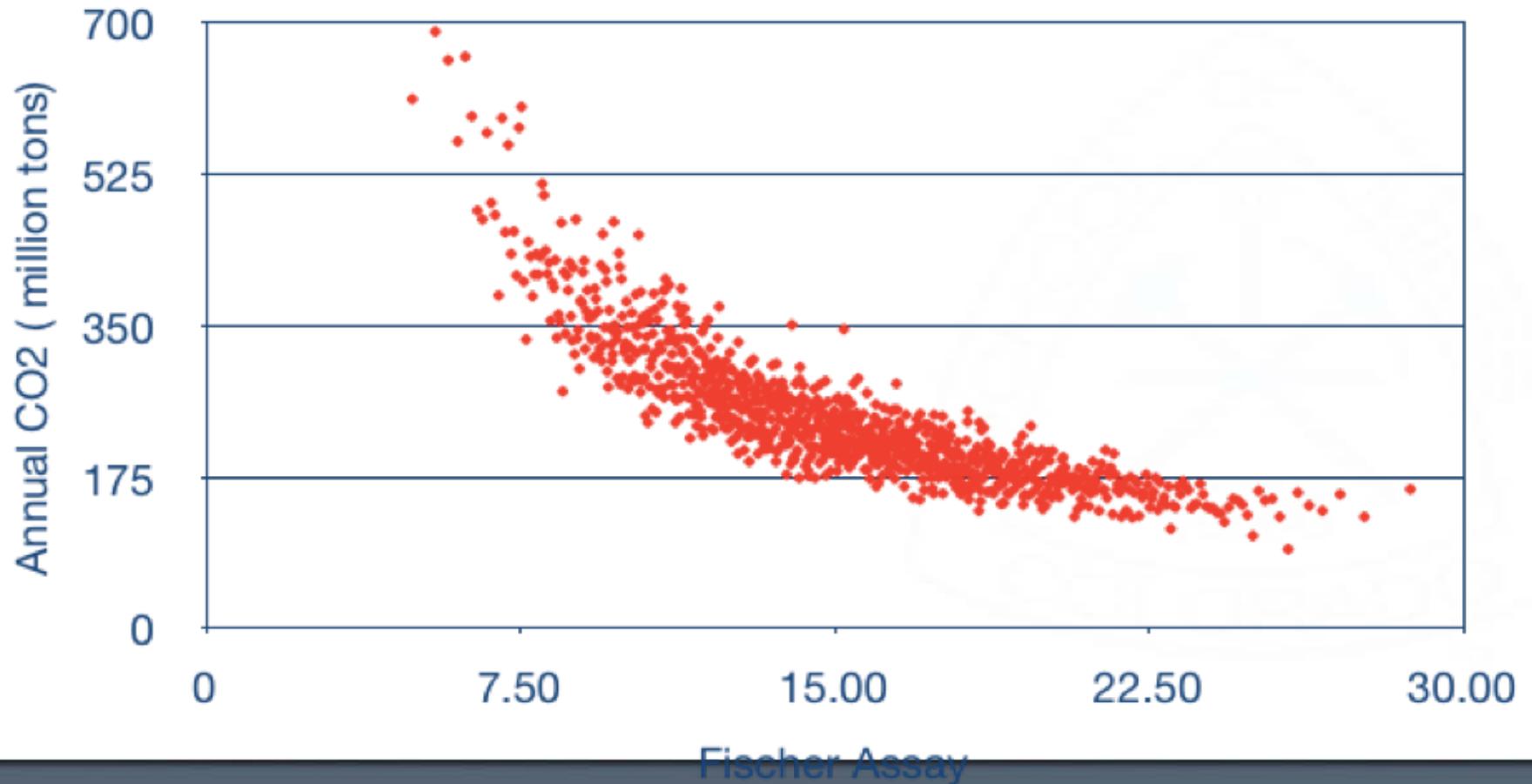
## ▶ Model development

## ▶ Impact assessment & policy

## ▶ Technology development for mitigation



# Richness controls CO<sub>2</sub> release

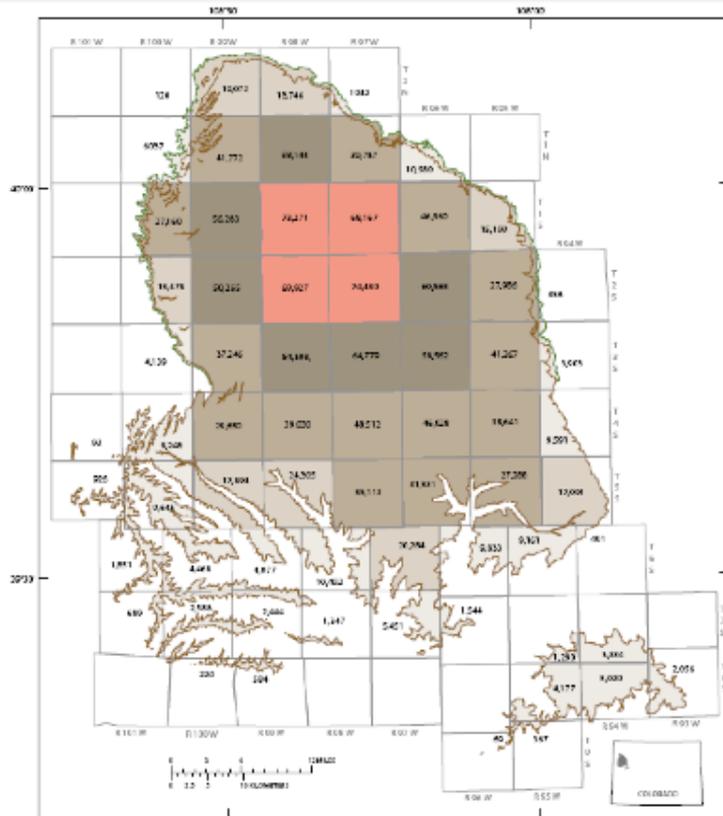


# Economic viability

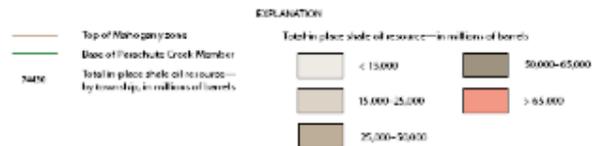
- ▶ Affected by all other listed issues
  - Access – time is money
  - Technology – energy, water, CO<sub>2</sub> efficiency
  - Environment – emissions, consumption, disruption
- ▶ Oil price, supply, demand, infrastructure
- ▶ Competing energy alternatives
  - Heavy oil
  - Global gas market
  - Renewable resources



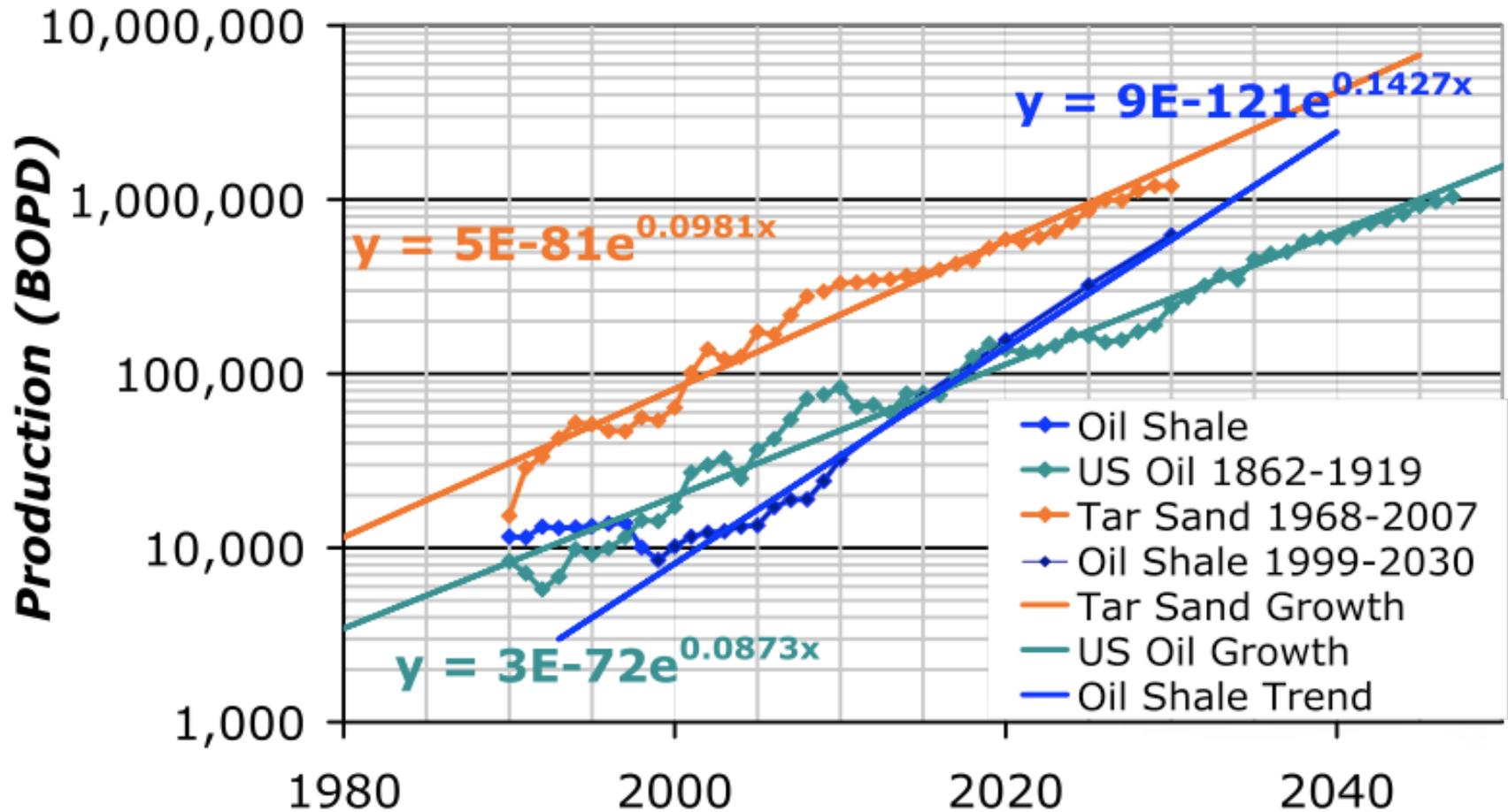
# Importance of resource estimates



- ▶ Resource estimates based on Fischer Assay,
  - Surface retort surrogate
  - New designs for retorts
  - In-situ methods
- ▶ Need for common basis of resource description
  - National interest in open databases for estimation
  - Technologic and economic factors will be more closely held



# Historic comparisons



# Oil Shale Conclusions

- ▶ Oil shale resources are widely distributed
- ▶ A great deal of excitement in the revived oil shale industry
- ▶ Countries & companies that sustained effort benefit by their leadership
- ▶ Both surface and subsurface processes are being employed
- ▶ New advances offer promise for the future
- ▶ Environmental challenges are significant
- ▶ Globally significant production still decades away
  - Even at 15% annual growth 1 MMBOPD takes ~25 years
  - Barring significant technological advances
  - Technology may not be rate limiting step
- ▶ Same is true for most alternative fuels
- ▶ Stable growth can provide time to enable carbon management

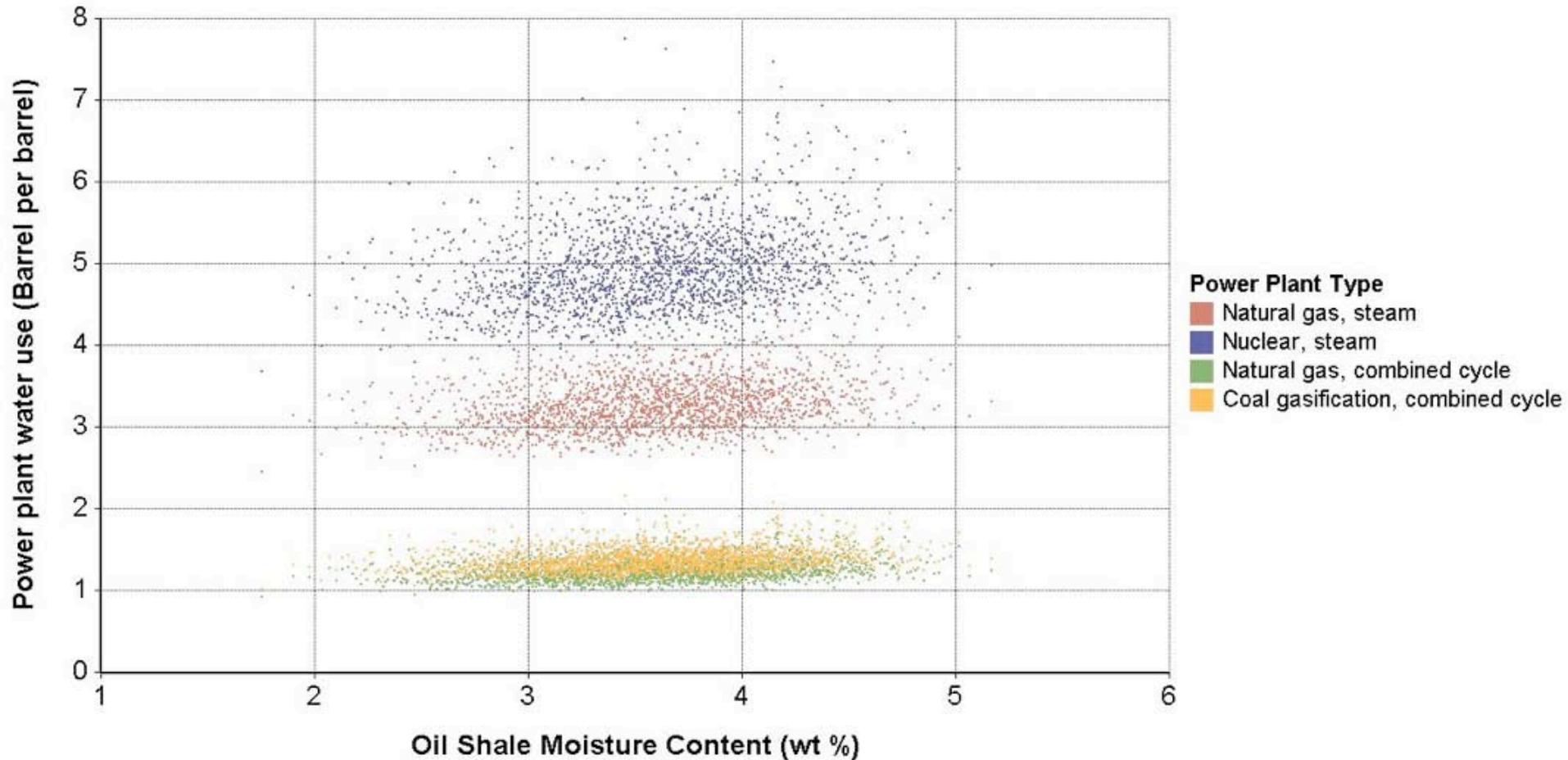


# COSTAR and the Oil Shale Symposium

- ▶ **Center for Oil Shale Technology and Research**
  - Membership - Total, Shell, ExxonMobil
  - Research Team - Colorado School of Mines, University of Wisconsin, Binghamton University (SUNY), National Center for Atmospheric Research
  - Initial tasks - rock mechanics, geology and stratigraphy, geochemistry, GIS database development
- ▶ **29<sup>th</sup> Oil Shale Symposium and Field Trip**
  - Symposium October 19-21, Mines Campus, Golden CO
  - Field Trip October 22-23, Western CO
  - 12 countries represented, most major players and many smaller companies
  - Water issues figure prominently on agenda



# Oil shale water use a significant issue

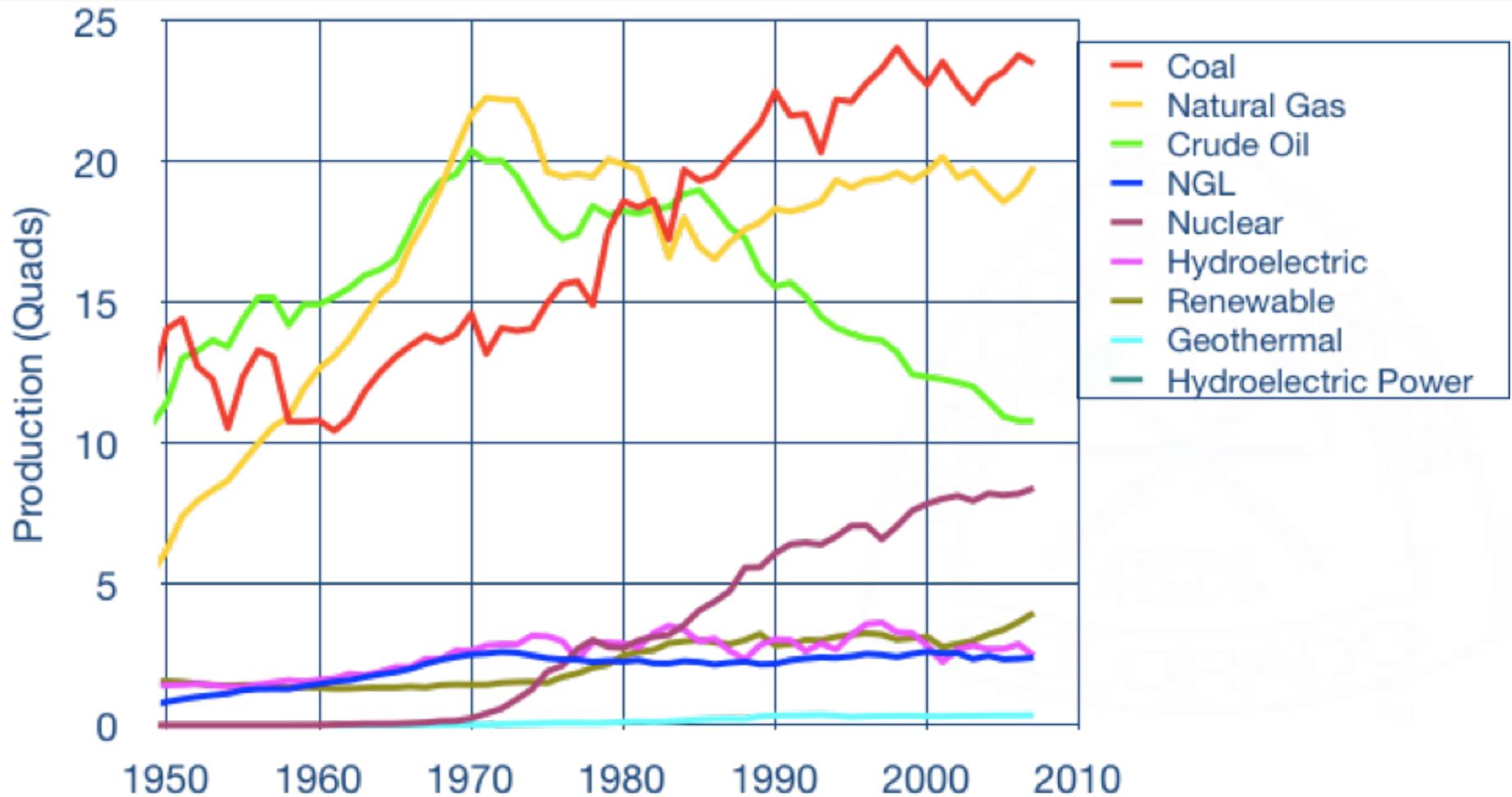


# Websites

- ▶ Oil Shale Symposium Proceedings:
  - <http://ceri-mines.org/oilshaleresearch.htm>
- ▶ DOE documents
  - <http://www.fossil.energy.gov/programs/reserves/npr/publications/>
- ▶ 29<sup>th</sup> Oil Shale Symposium program
  - <http://mines.conference-services.net/programme.asp?conferenceID=1729&language=en-uk>
- ▶ Tell Ertl Collection
  - [http://inside.mines.edu/Tell\\_Ertl](http://inside.mines.edu/Tell_Ertl)

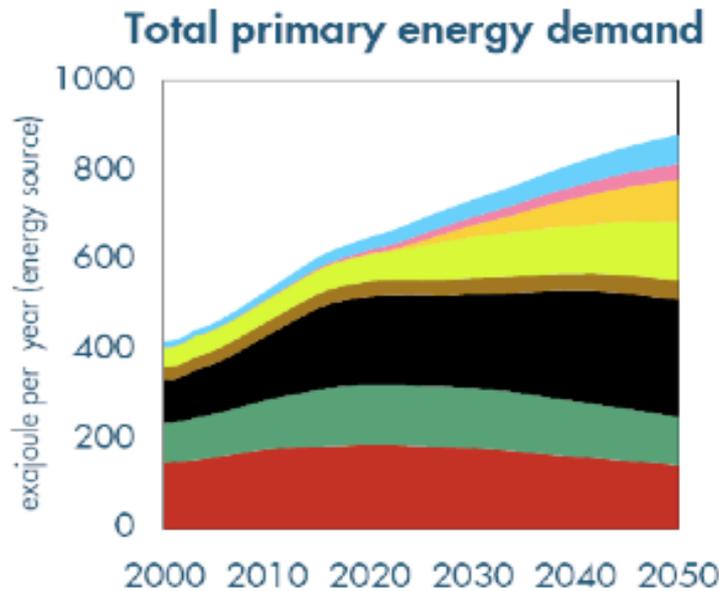


# U. S. Energy Production

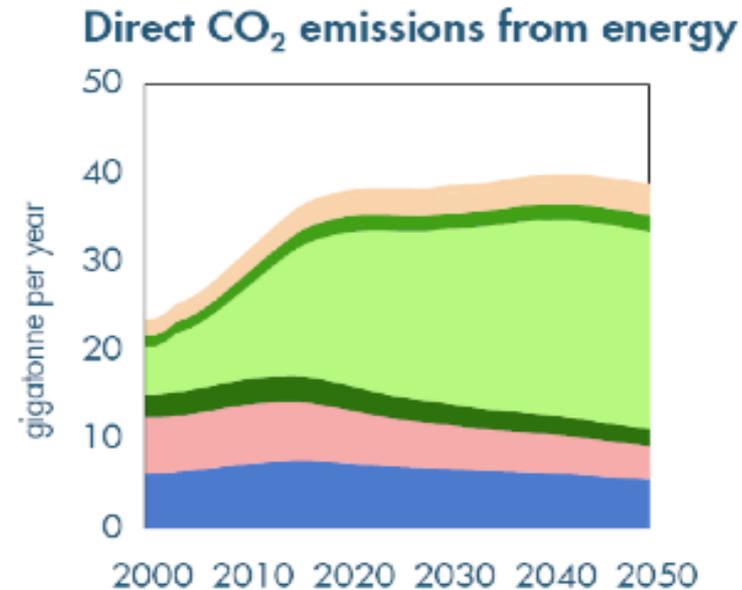


# Shell Energy Projections - 1

## Scramble – supply focus and late responses



- Oil
- Coal
- Biomass
- Wind
- Gas
- Nuclear
- Solar
- Other Renewables



- Middle East & Africa
- Latin America
- Asia & Oceania - Developing
- Asia & Oceania - Developed
- North America
- Europe

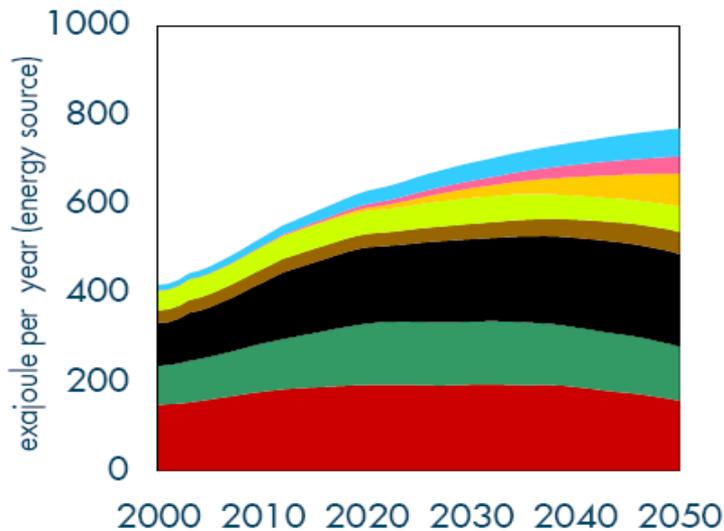
Sources: Shell International BV and Energy Balances of OECD and Non-OECD Countries © OECD/IEA 2006



# Shell Energy Projections - 2

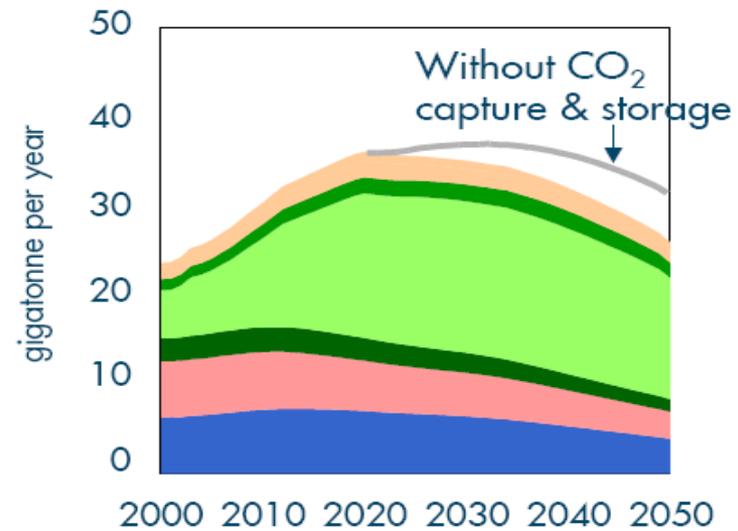
## Blueprints – multi-focus and early actions

Total primary energy demand



- Oil
- Coal
- Biomass
- Wind
- Gas
- Nuclear
- Solar
- Other Renewables

Direct CO<sub>2</sub> emissions from energy



- Middle East & Africa
- Latin America
- Asia & Oceania - Developing
- Asia & Oceania - Developed
- North America
- Europe

Sources: Shell International BV and Energy Balances of OECD and Non-OECD Countries©OECD/IEA 2006