Unconventional Natural Gas: Industry or Bridge

Unconventional Gas Technology Issues

> **EIA Energy Outlook and Modeling Conference**

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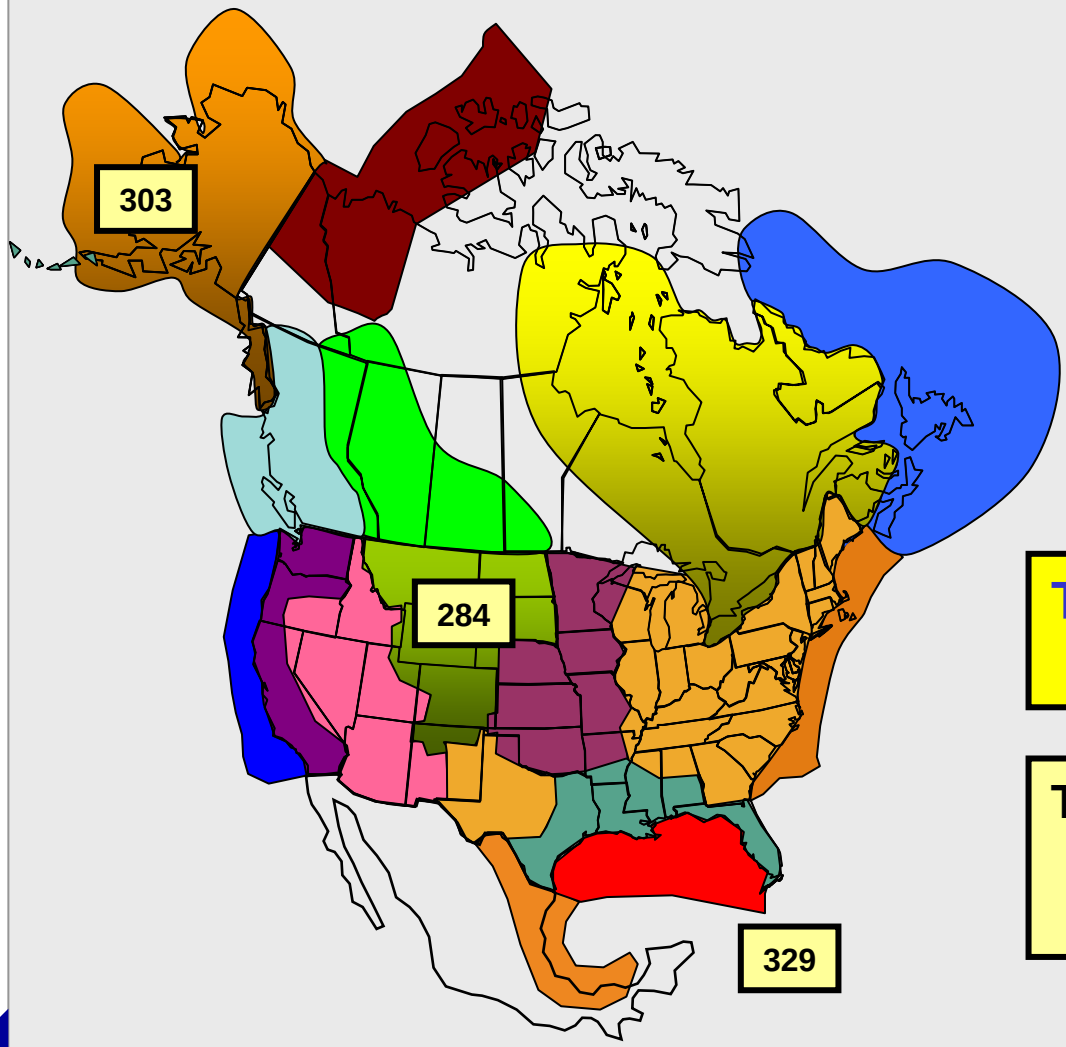
Gas Technology Institute

Unconventional Gas Issues and Trends

- Large Resource
- Resource is of Extreme Complexity
- Technical Approach - Precision is Replacing Horsepower
- Lower Reserves Per Well Over Time
- Many Wells Required
- Significant Drilling Cost Reductions
- New Strategies Need/Being Developed
- Environmental Issues Ongoing

Large Gas Resource



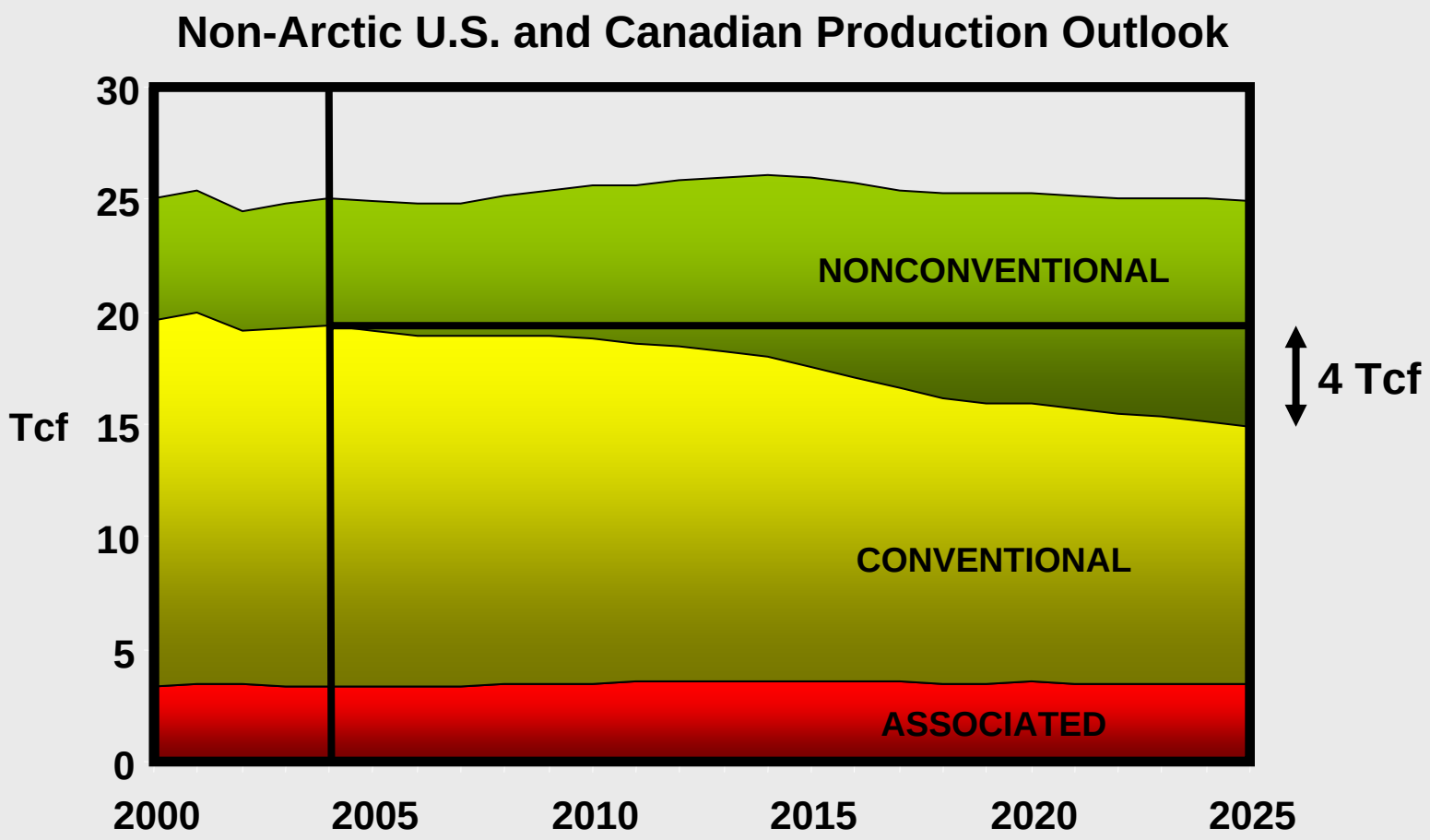
But:

- Deeper on Land
- Tighter Rocks
- Unconventional
- Deeper in Water
- Less Accessible
- Heavily Explored

Therefore Technically Challenging

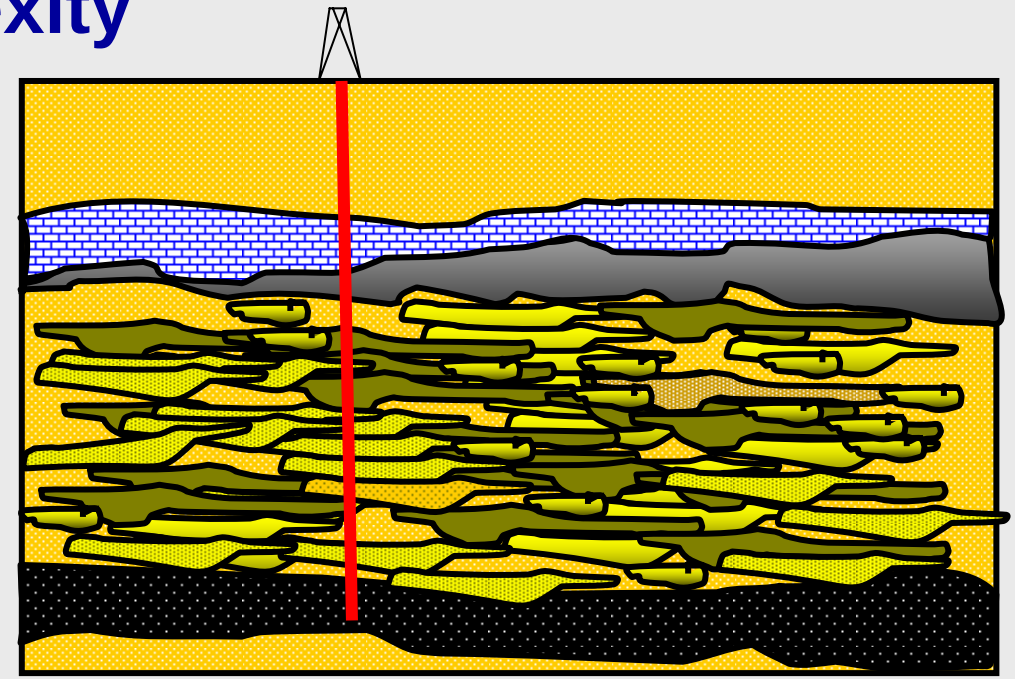
Technically Recoverable Resource Base 1,969 Tcf

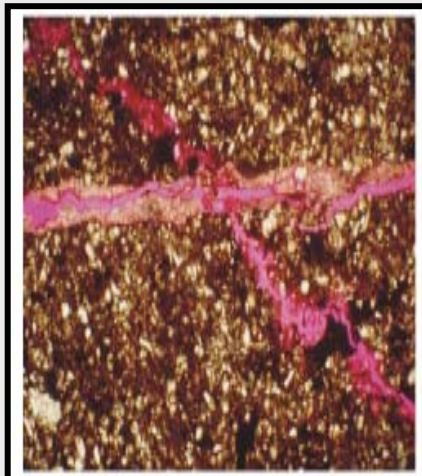
Nonconventional Gas Growth

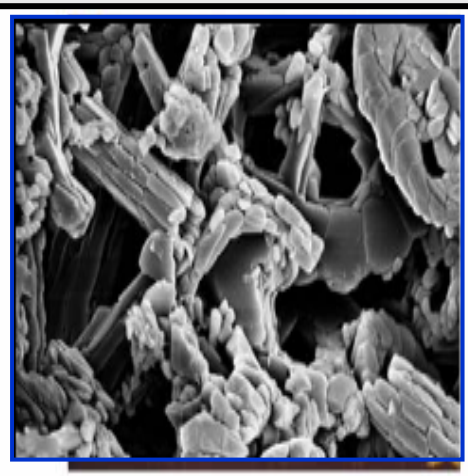


Extreme Complexity

Small Compartments
Low k
Natural Fractures
Lenticular
Produced Water
Gas Content
Stimulation Challenges
Depth
Over/Under Pressured

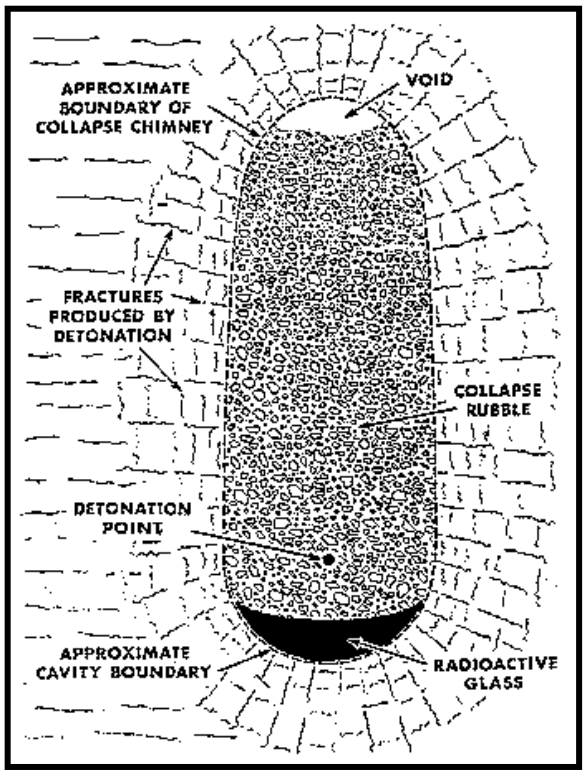






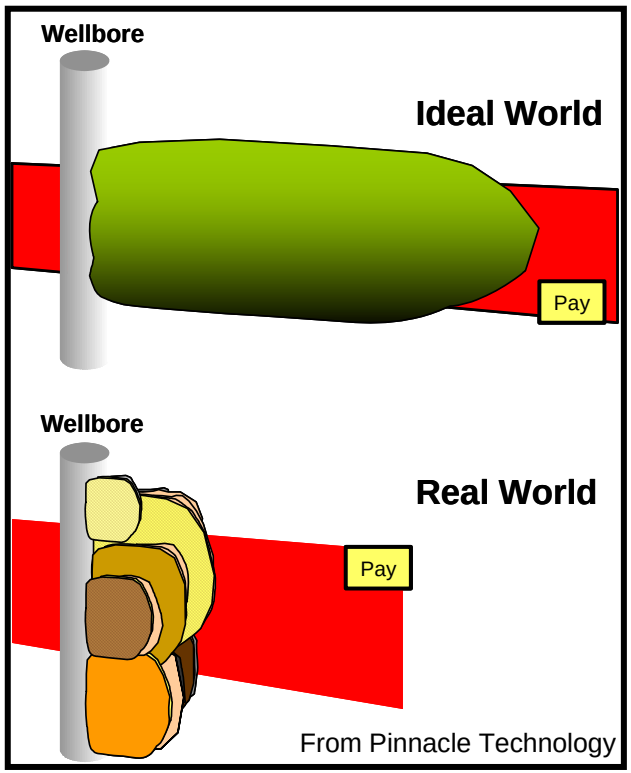
Precision Replaces Horsepower

1960's



Nuclear Stimulation

1980's

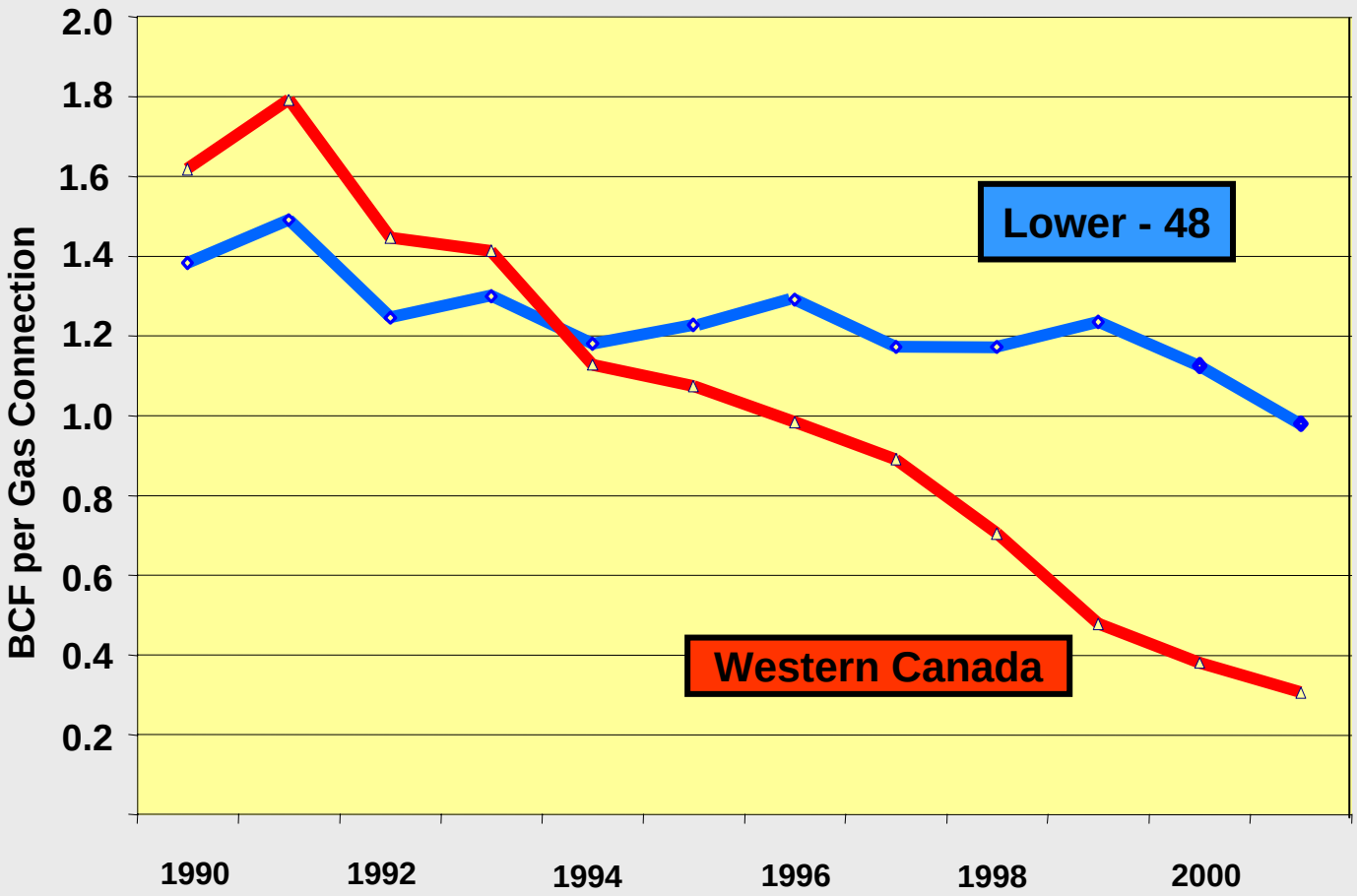


Massive Hydraulic Fractures

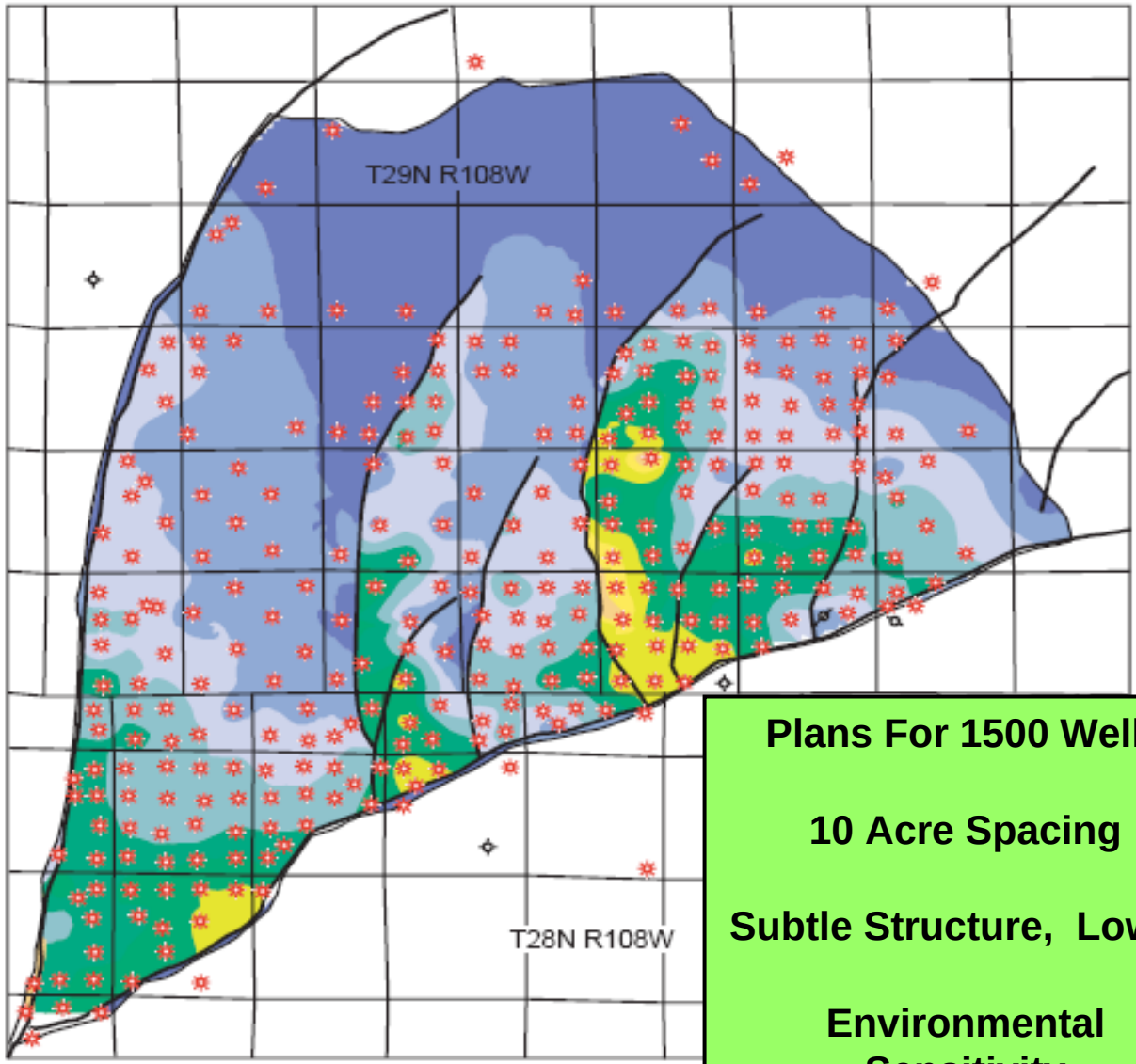
2000's

Microhole Wellbore Placement

Lower Gas Reserves Per Well



Jonah Field



Plans For 1500 Wells

10 Acre Spacing

Subtle Structure, Low k,

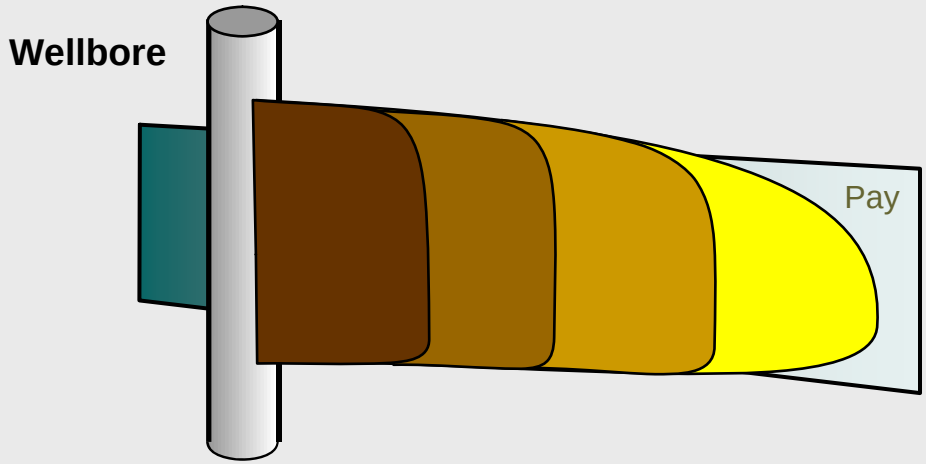
Environmental Sensitivity

Courtesy AEC

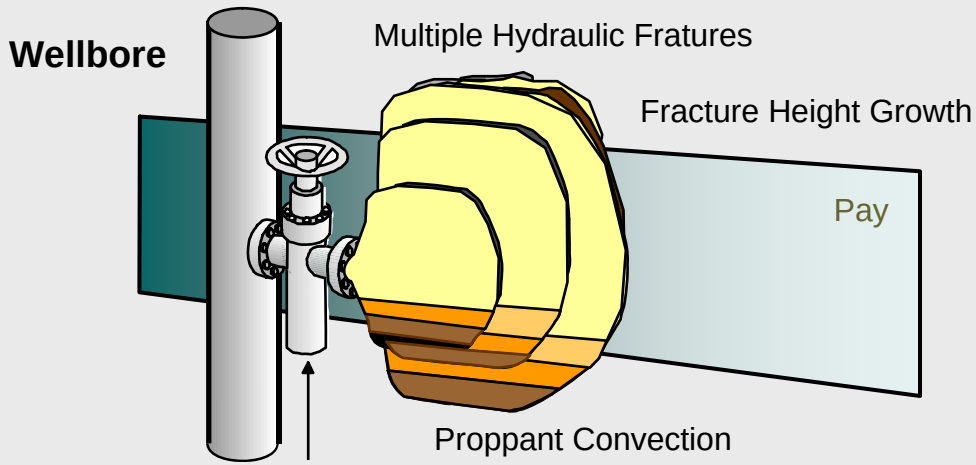
Hydraulic Fracturing and Fracture Diagnostics

Hydraulic Fracturing – More Complicated Than Once Thought

Ideal World

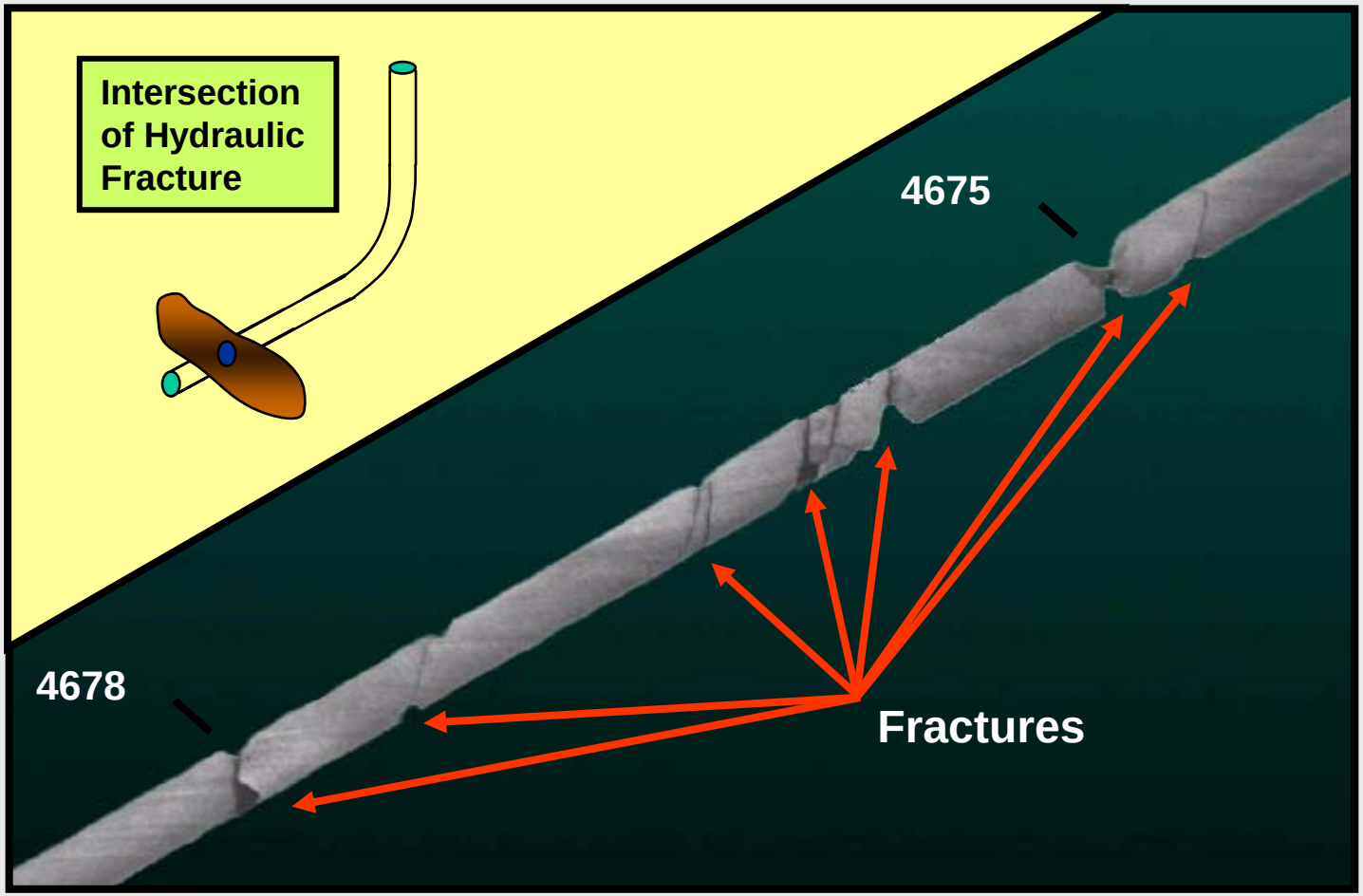


Real World

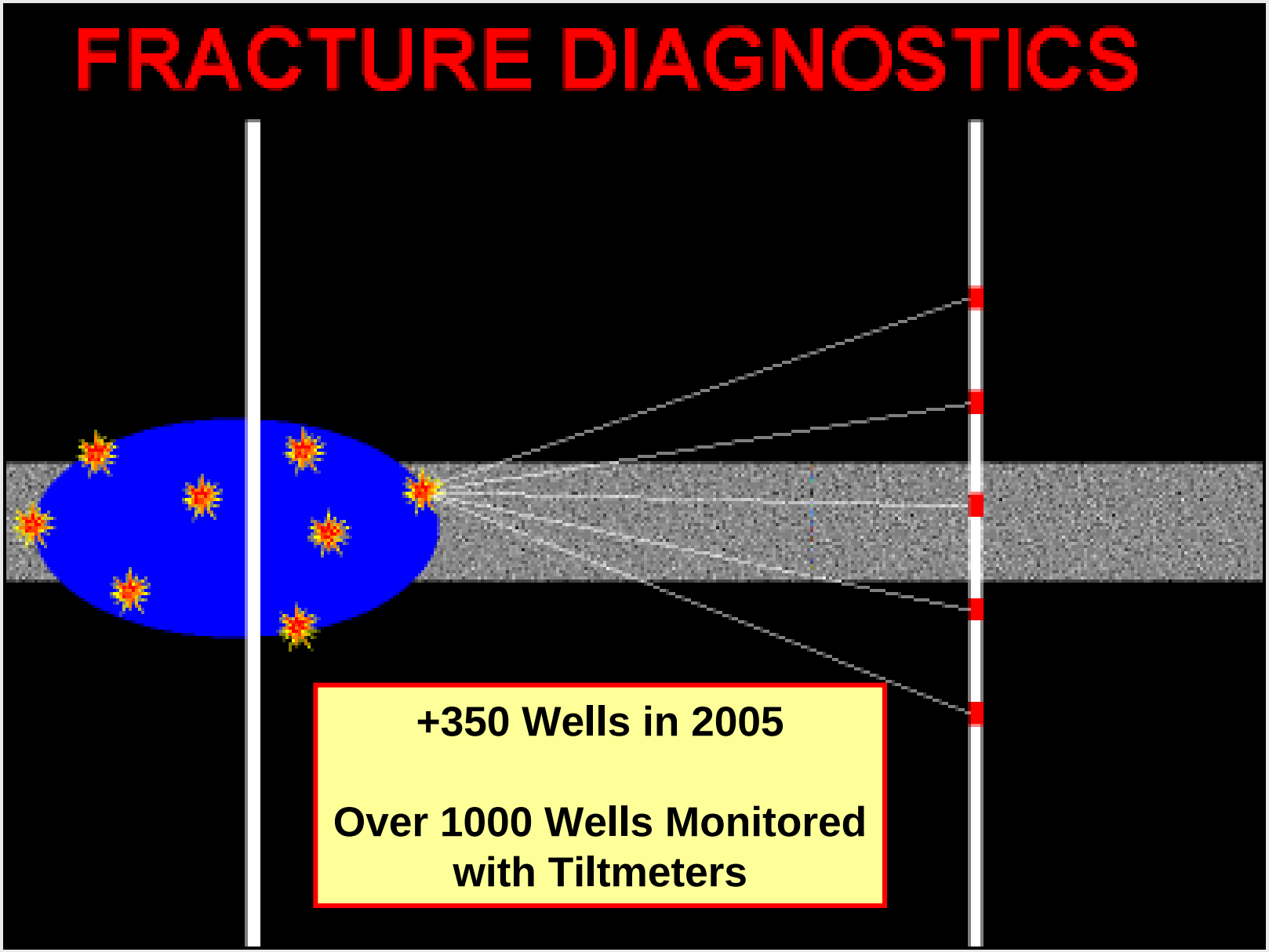


From Pinnacle Technology

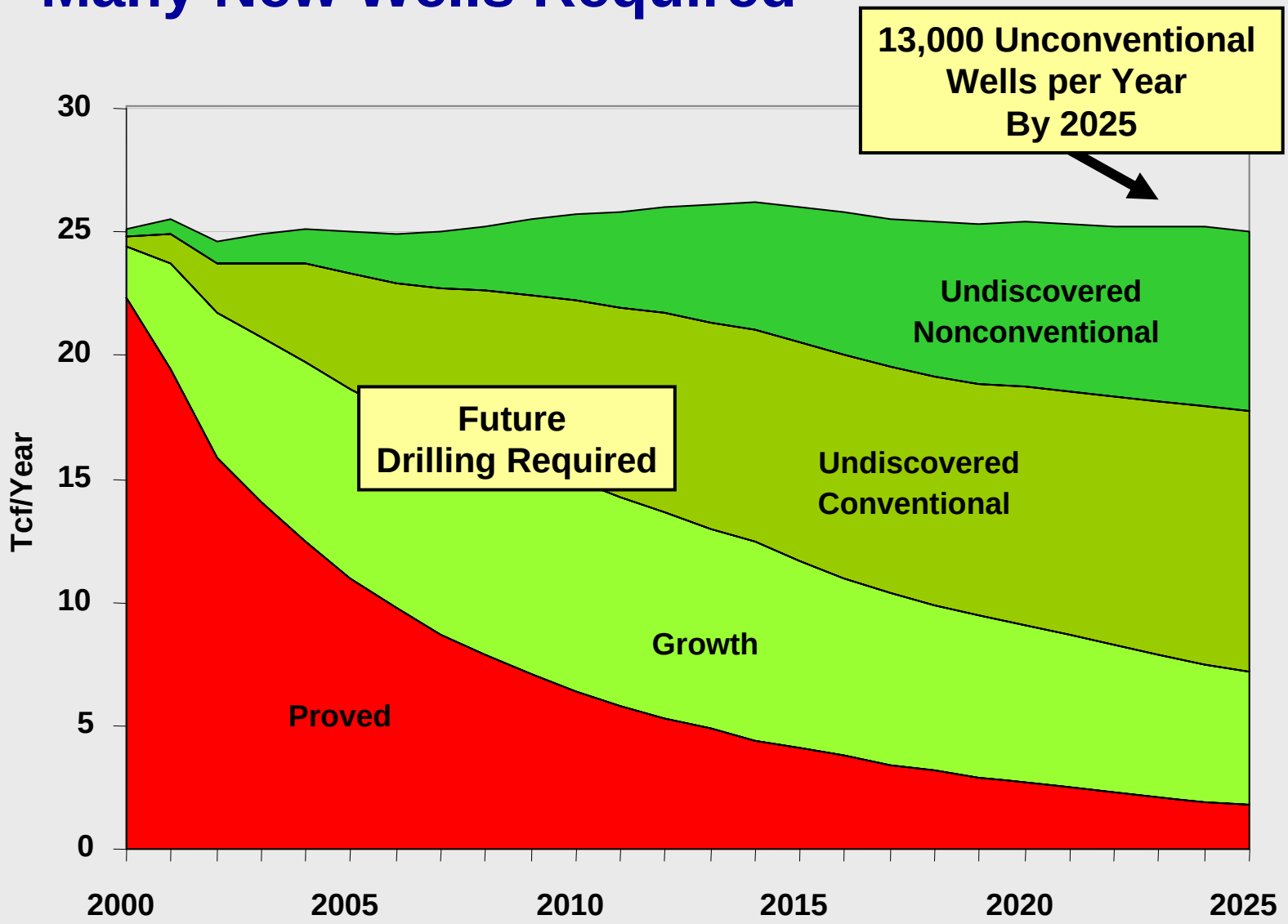
Piceance Basin Fracture Diagnostics Experiment



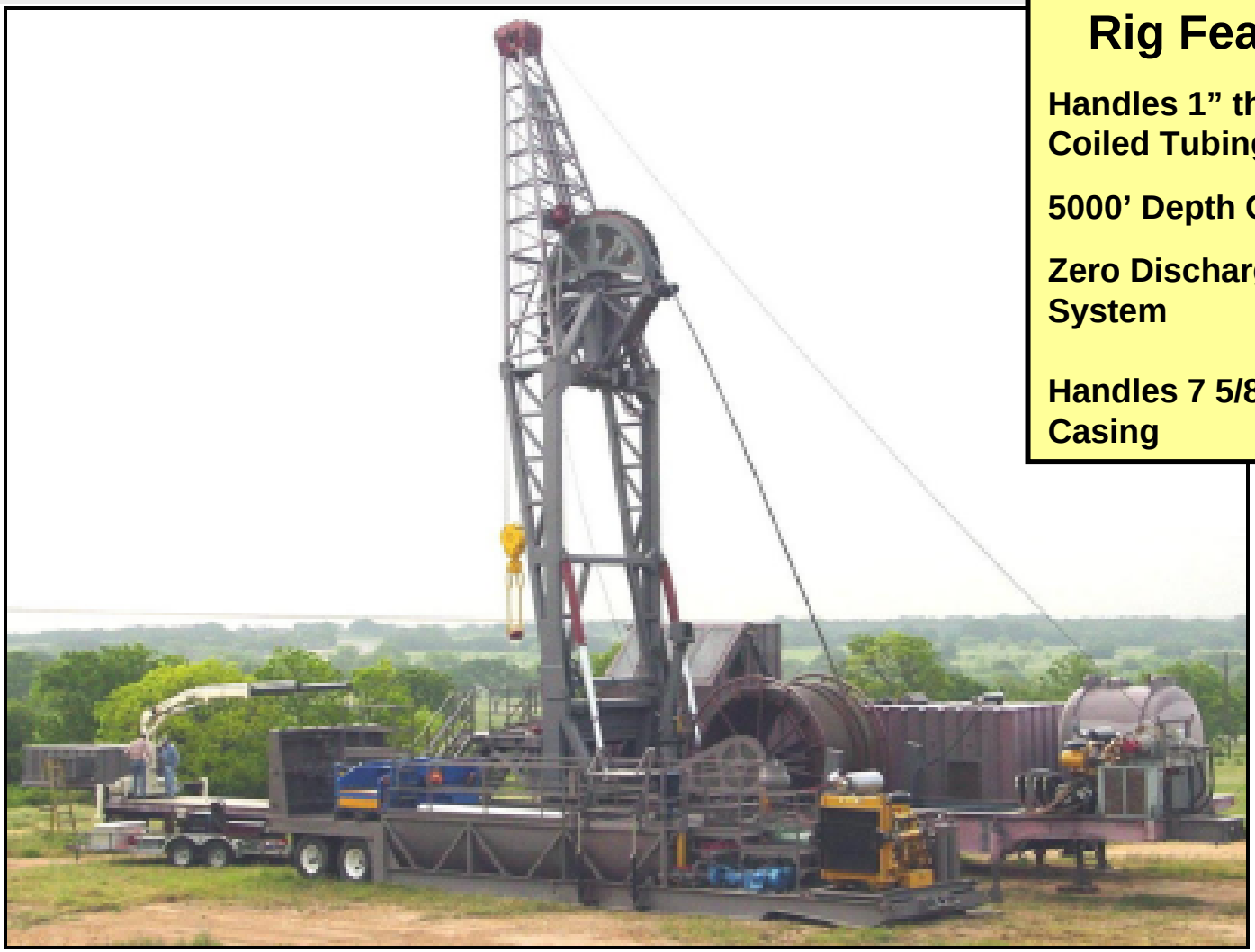
FRACTURE DIAGNOSTICS



Many New Wells Required



Fit For Purpose Drilling Rigs



Rig Features

Handles 1” thru 2 5/8 ” Coiled Tubing

5000’ Depth Capability

Zero Discharge Mud System

Handles 7 5/8” R3 Casing

Benefits of Rig Utilization

- Efficient Rig Mobilization
- Small Environmental Footprint
- Rapid Drilling
- Good Hole Quality and Cement
- Rig Capable of Drilling, Running Casing, Tool Handling, Logging
- Benefits of Continuous Tubing
- Low Noise, Emissions
- Mud Reuse and Minimum Cuttings and Zero Discharge if Required
- Improved Safety

Saves Money, Environment and Enables Marginal Resources

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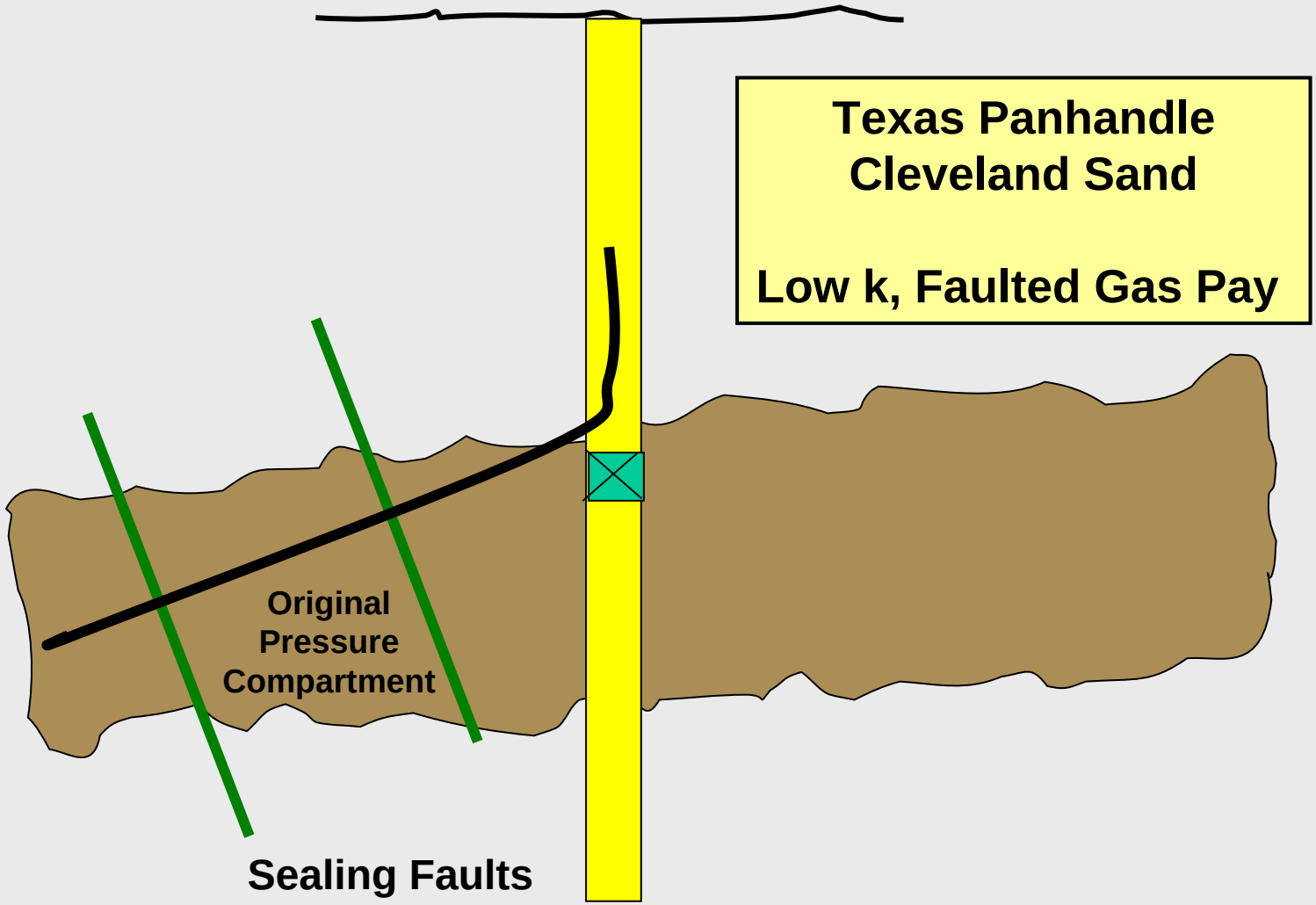
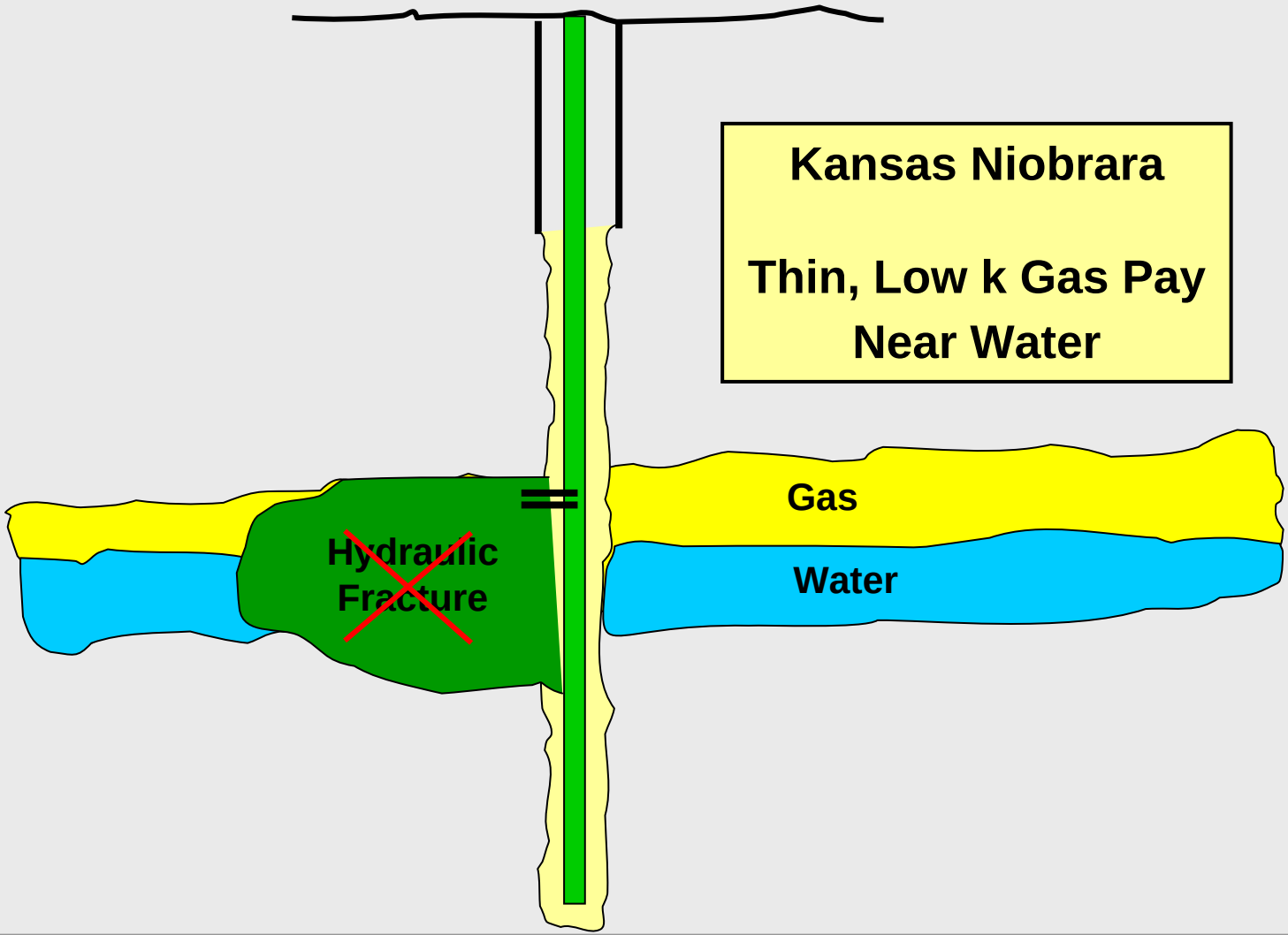
Activity Trend

- Rig Has Drilled + 220 Wells in 2005
  - Colorado – Kansas
- 3000 Ft. Wells Drilled in One Day
- Drilling Faster Than Permitting

New Strategies - New High Angle/Horizontal Wellbore From Existing Well



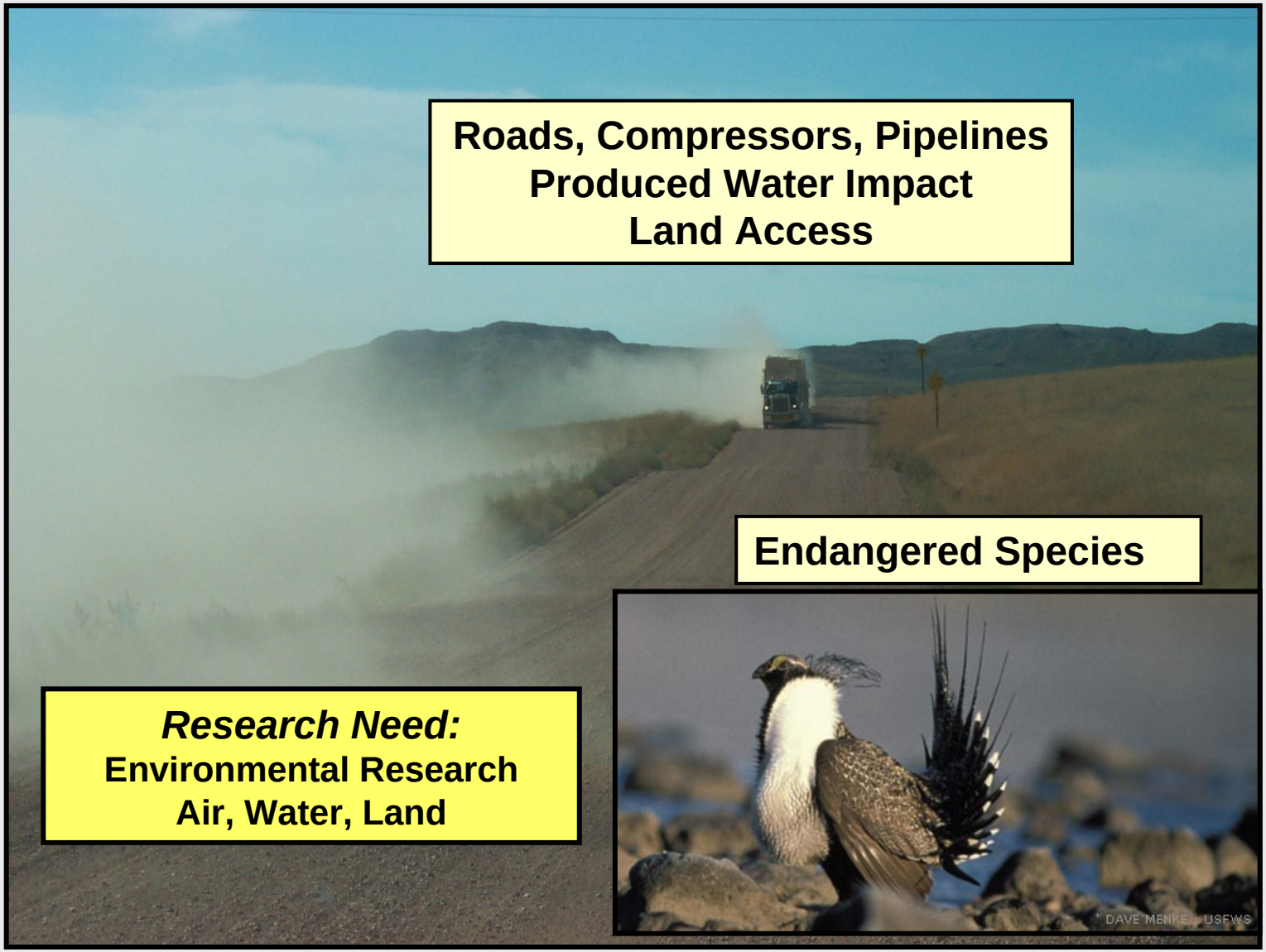
New Strategies - No-Frac Completion



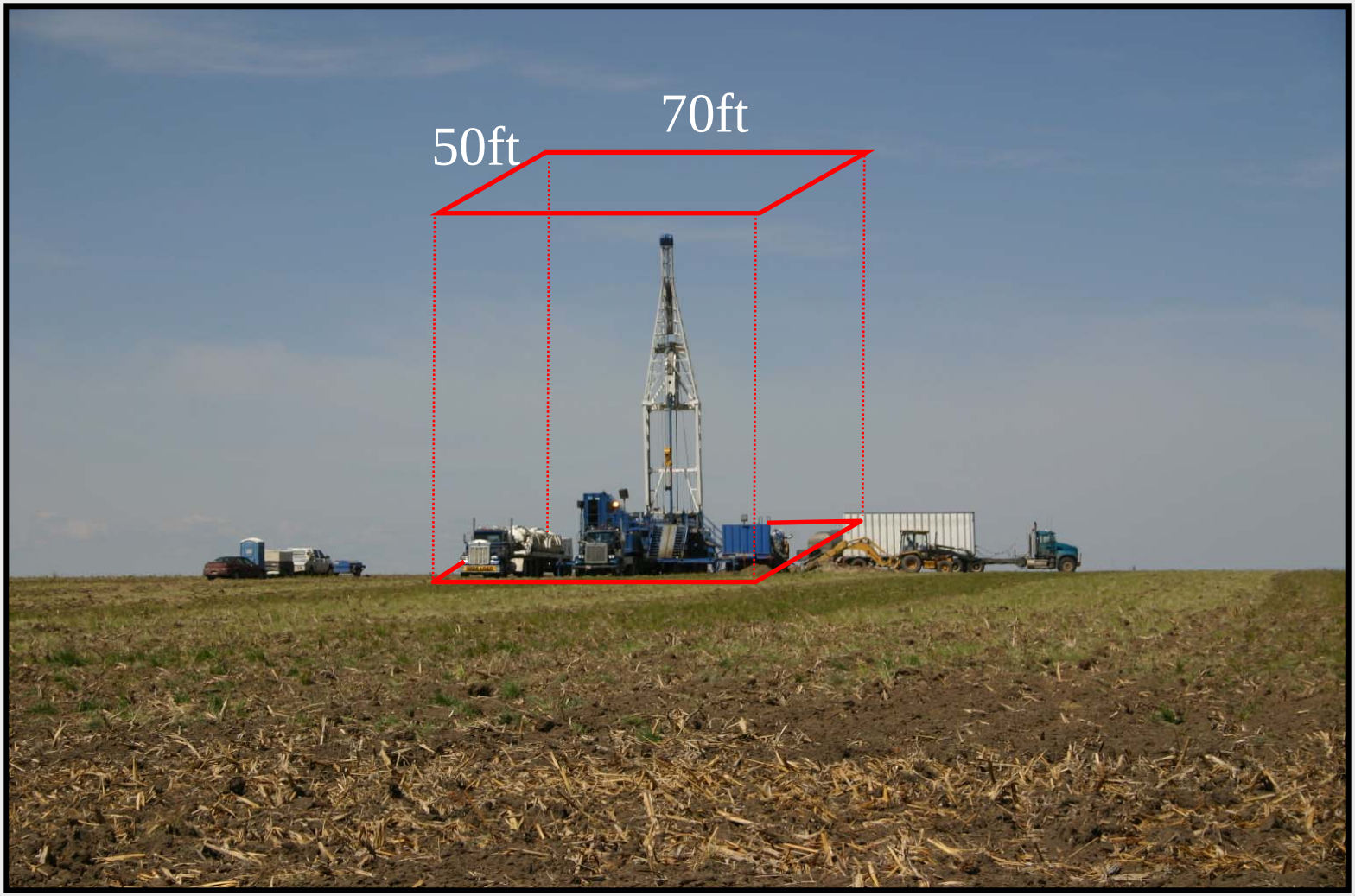
The Wind River Mountain Range and some of the Upper Green's pronghorn antelope population

From Wilderness Society

Environmental Concerns



Reduce Environmental Footprint



Top Ten Texas Gas Fields

	Field	Cum. year 2002 (BCF)
1.	Newark East (Barnett Shale)	220
2.	Carthage (Cotton Valley)	151
3.	Panhandle West (Permian)	99
4.	Tom East (13,800')	97
5.	Giddings (Austin Chalk)	80
6.	Oak Hill (Cotton Valley)	70
7.	La Perla (Lobo)	65
8.	Dew (Cotton Valley)	53
9.	Vaquillas Ranch (Lobo)	51
10.	Sawyer (Canyon)	49

Source: IHS Energy

Unconventional Gas - Top Ten Technology Needs

Shale

Low-k Sands

Coal Seams

San Juan

Permian

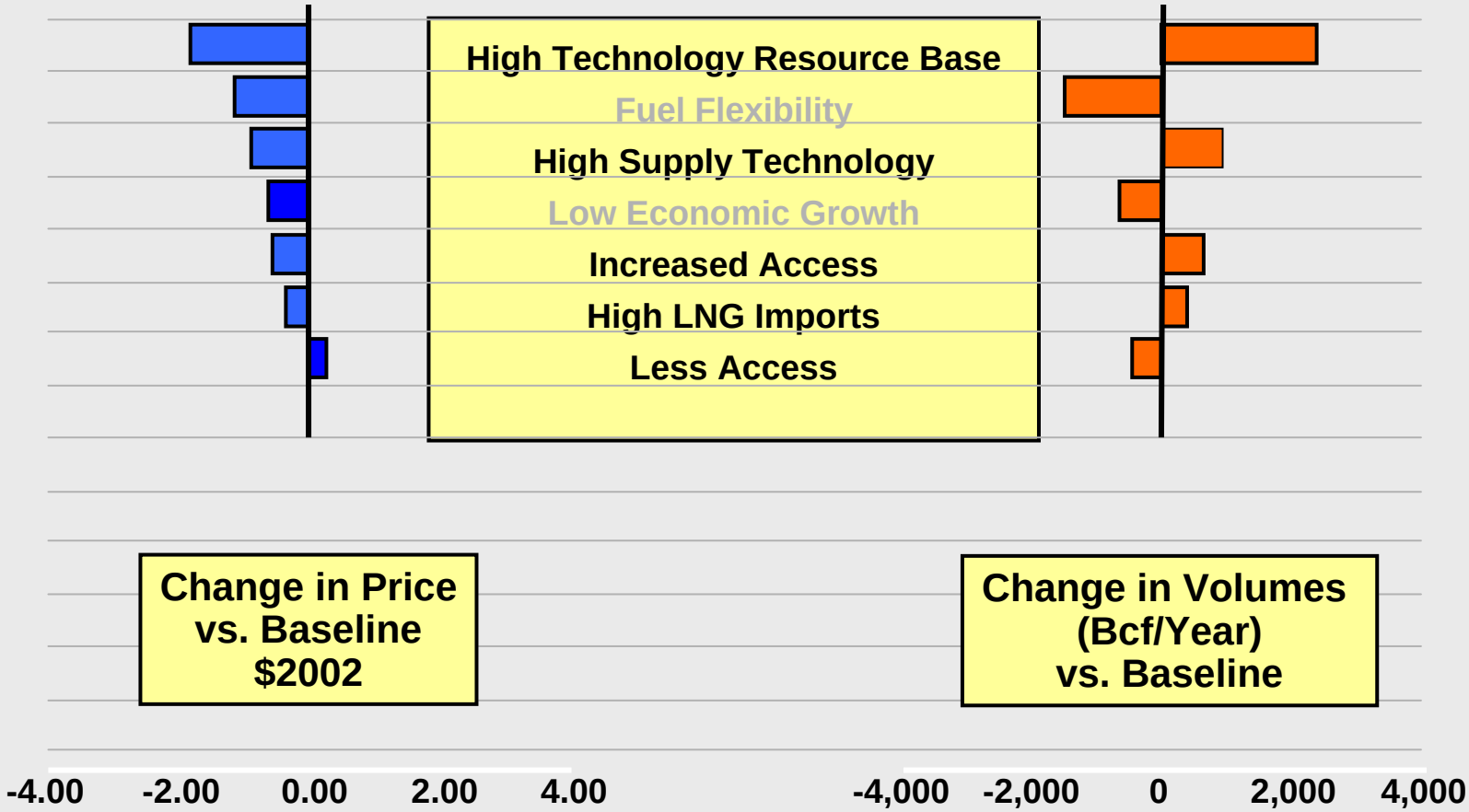
Mid-Continent

Appalachian

Rocky Mountains

- Reservoir Characterization, Imaging
- Stimulation
- Resource Assessment
- Data Mining
- Producibility Models
- Produced Water Handling
- Extending Well Life
- Drilling Cost Reduction
- Horizontal Well Completion
- Expert Systems

Technology Can Have a Significant Impact



Values shown are averages for the 2011 to 2025 period

Unconventional Gas Research

- **The Energy Policy Act of 2005**
  - **Research, Development and Demonstration Program for Unconventional Gas**
- **As Enacted: $50 Million/Year for 10 Years**
  - **$12.5 Million DOE In-House Research**
  - **$16.2 Million for Unconventional**
  - **$17.5 Million for Ultra-deep Water**
  - **$ 3.8 Million for Small Producer Program**
- **Program to Be Industry Advised/Managed Through Research Consortium**

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Summary

- Unconventional Gas Growing in Importance
- Large Resource
  - Technically Challenging
- New Approaches Require Innovative Thinking
- Integration of Technology Will Continue to be Important
  - Engineers, Geologists, Land Use
- Environmental Technology Response to Environmental Challenges Will Continue To Be Important
- Less Gas/Well…*Therefore*…More Wells...*Therefore*… Need for Well Cost and Environmental Footprint Control