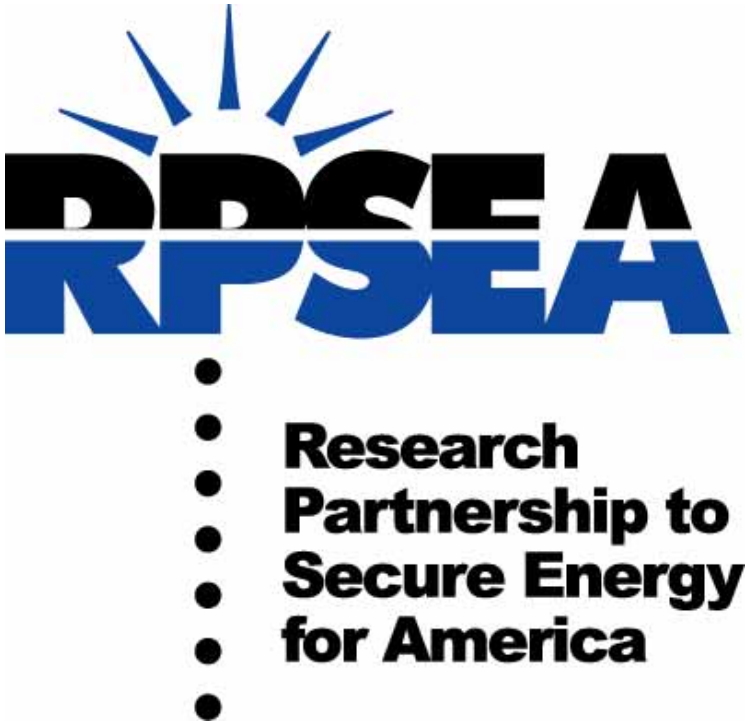


Money for Research:
New Technology on the Horizon

South Texas Section of the American Institute of Chemical Engineers
September 4, 2008

Secure Energy For America

Energy Policy

- "El Dorado" complex
  - Edgar Allan Poe
  - Elusive "El Dorado" vs. step by step change & discovery – example: horizontal drilling
  - The energy mix - hydropower, nuclear, photovoltaics , wave & tidal power, biofuels, hydrogen, wind, fossil fuels, etc…
- Energy Myths
  - The United States can become energy independent within 10 years
  - Renewable energy will replace fossil fuels within the next 10 years
  - Energy efficiency is the total answer to all of our energy problems
  - ExxonMobil controls the price of oil and makes obscene profits
  - All fossil fuels are dirty

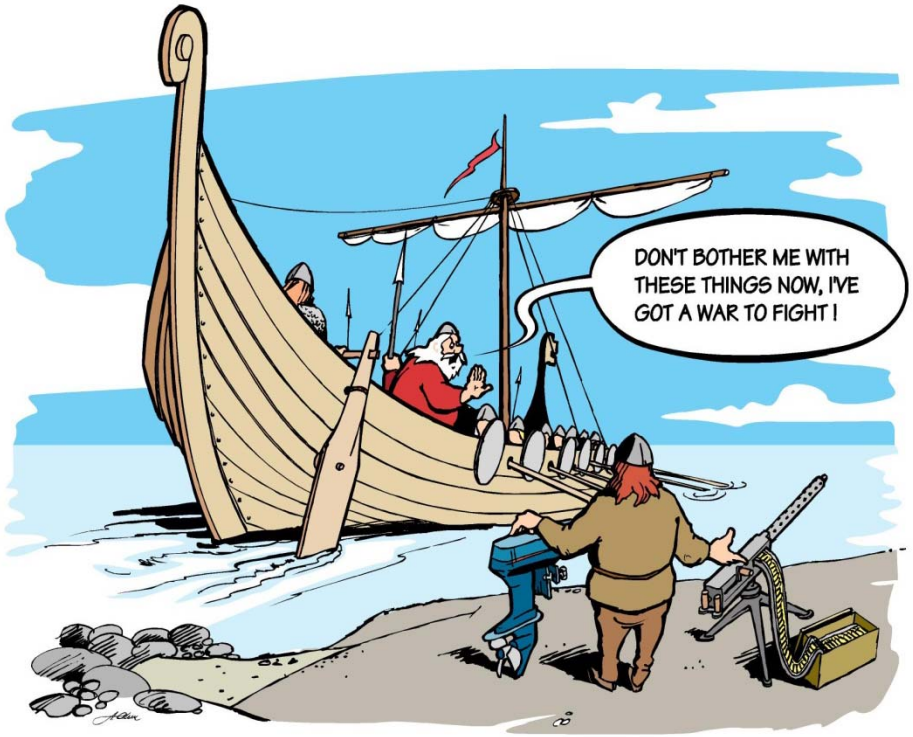
The Energy Policy Act of 2005

- Comprehensive Roadmap for our country's energy future
  - addresses secure, affordable and reliable energy sources
- 1724 pages
  - 18 titles; 64 subtitles; 1840 sections
- Energy Efficiency, Renewable Energy, Oil & Natural Gas, Coal, Nuclear, Vehicles, Hydrogen, Electricity, Ethanol & Motor Fuels, Climate Change and Other Energy Matters
- History
  - 1980's and 1990's

Massive New Funding Program Announced!

The Energy Policy Act of 2005
Subtitle J: Section 999

An Industry led Public/Private Partnership for R&D in the Ultra-Deepwater in the Gulf of Mexico and in Unconventional Onshore Natural Gas and Other Petroleum Resources of the United States.



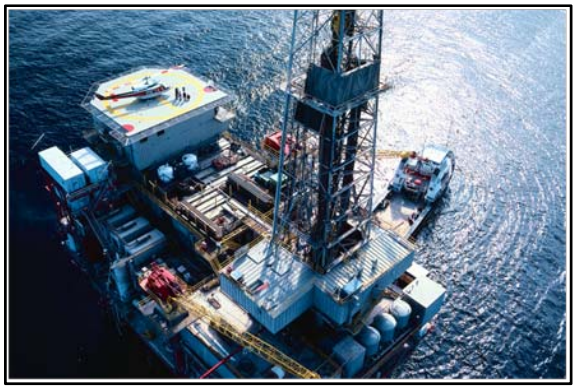
What is Subtitle J: Section 999?

Specifically, the law directs –

- Research, development, demonstration, and commercial application of technologies for ultra-deepwater and unconventional natural gas and other petroleum resource
- Maximize the U.S resource value by:
  - Increasing supply
  - Reducing the cost
  - Increasing E&P efficiency
  - Improving safety and minimizing environmental impacts

What is the Program's Focus?

The Program has four program elements:



- Ultra-deepwater 35%

  (> 1500 Meters water or

  15,000' OCS drilled depth)

- Unconventional Onshore 32.5%

  (Economic accessibility)

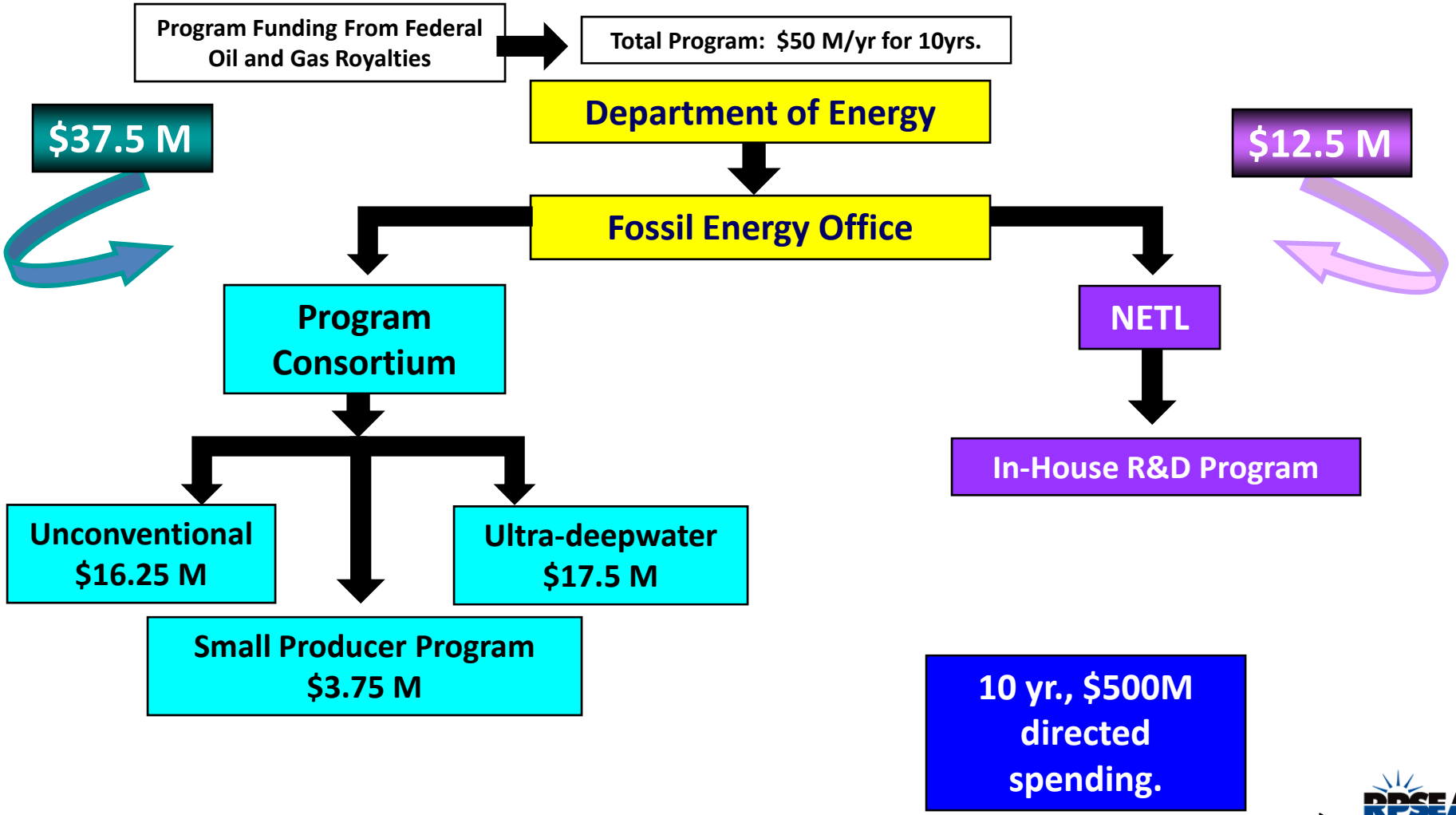
- Small Producers 7.5%

  (< 1000 BOEPD)

- Complementary Program 25%

  Managed by NETL

Current Program Structure: Directed Funding

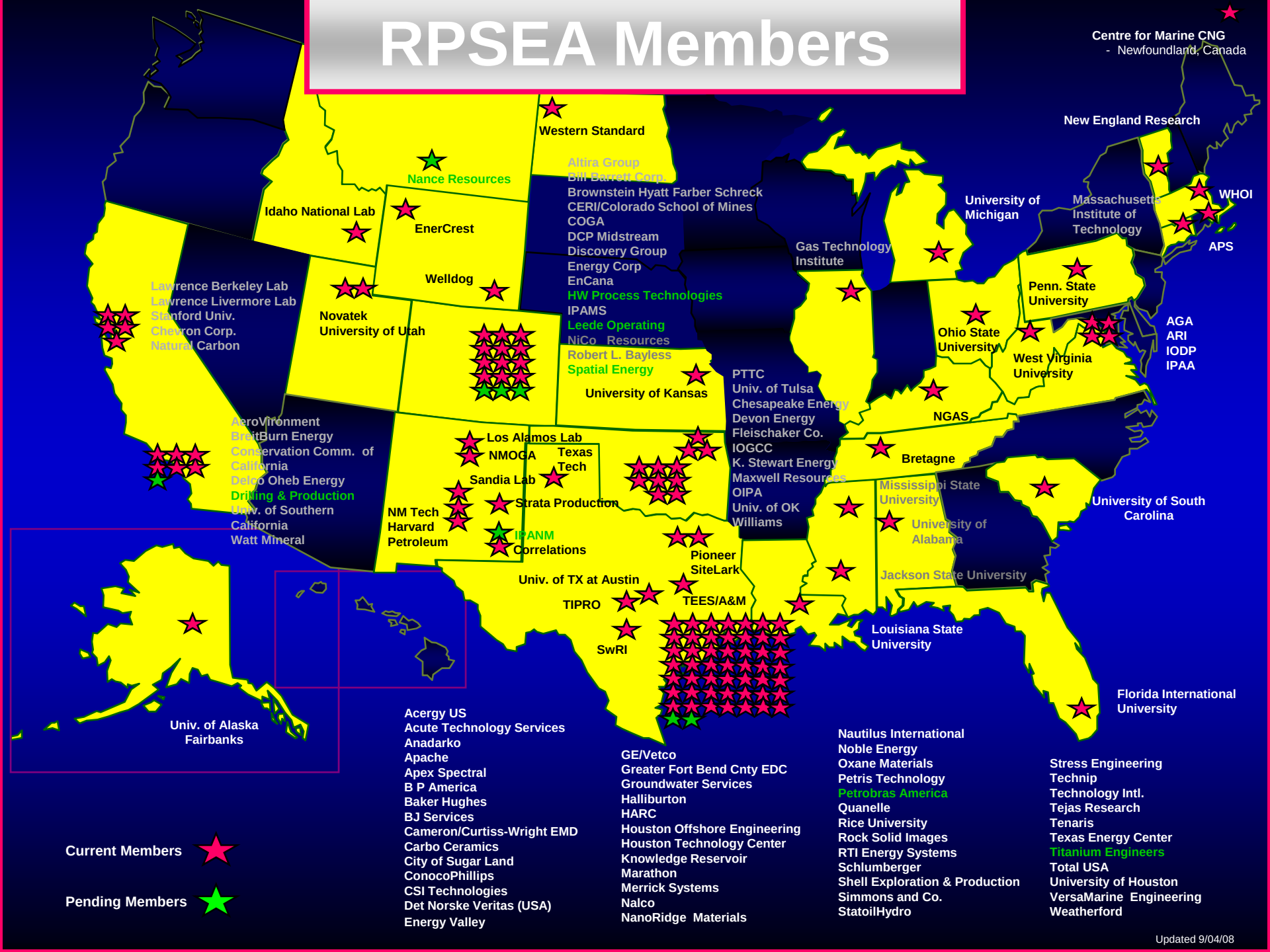


The RPSEA Organization

- A Research Partnership
- A Research Co-op
- A 501(c)3 not for profit
- Competitively selected by DOE as the Section 999 Consortium Manager
- 135 Members and growing

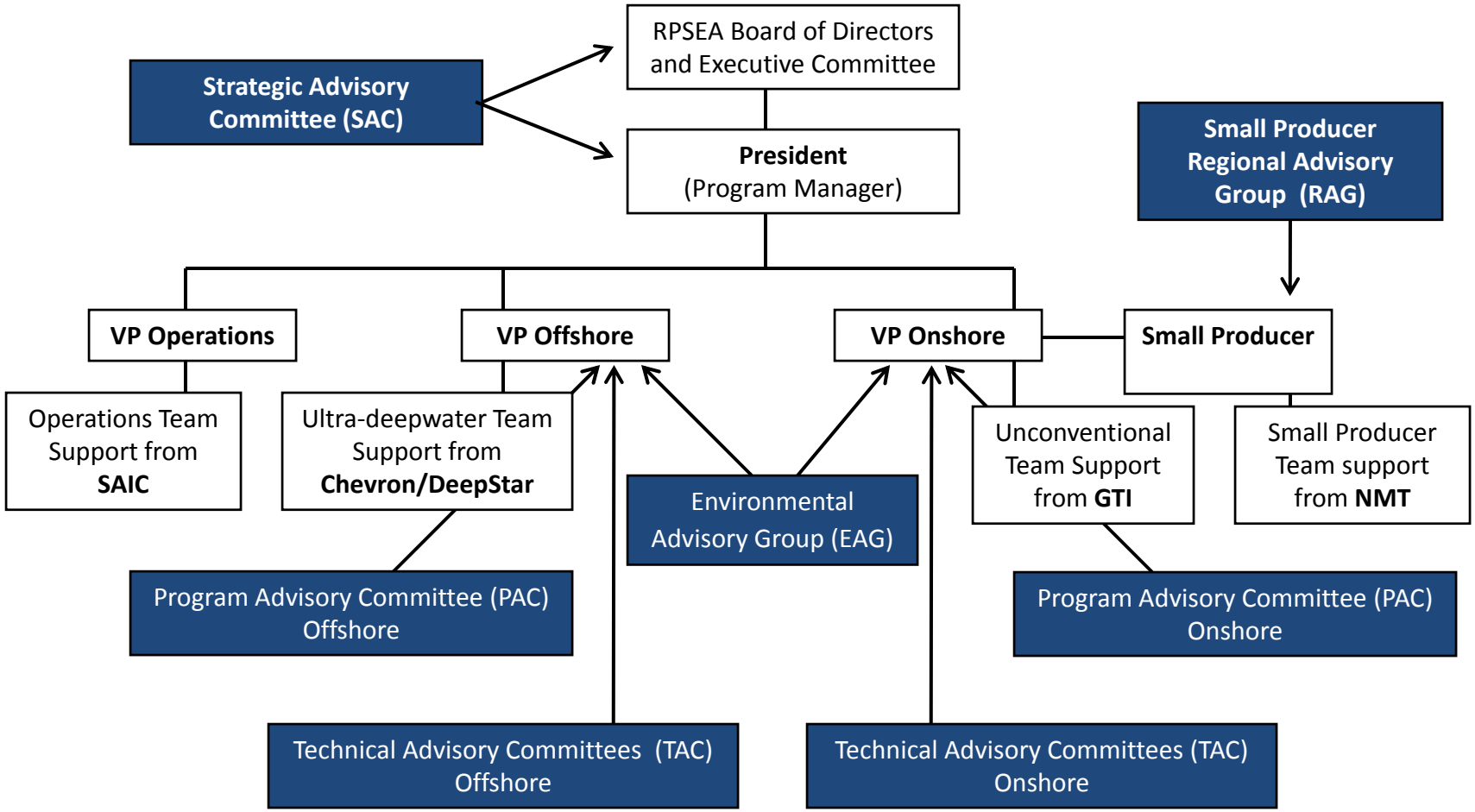
For more information visit www.rpsea.org

RPSEA Members



Updated 9/04/08

A Small Organization, A Large Network



Well over 1,500 experts have participated in this process!

RPSEA Research Partnership to Secure Energy for America

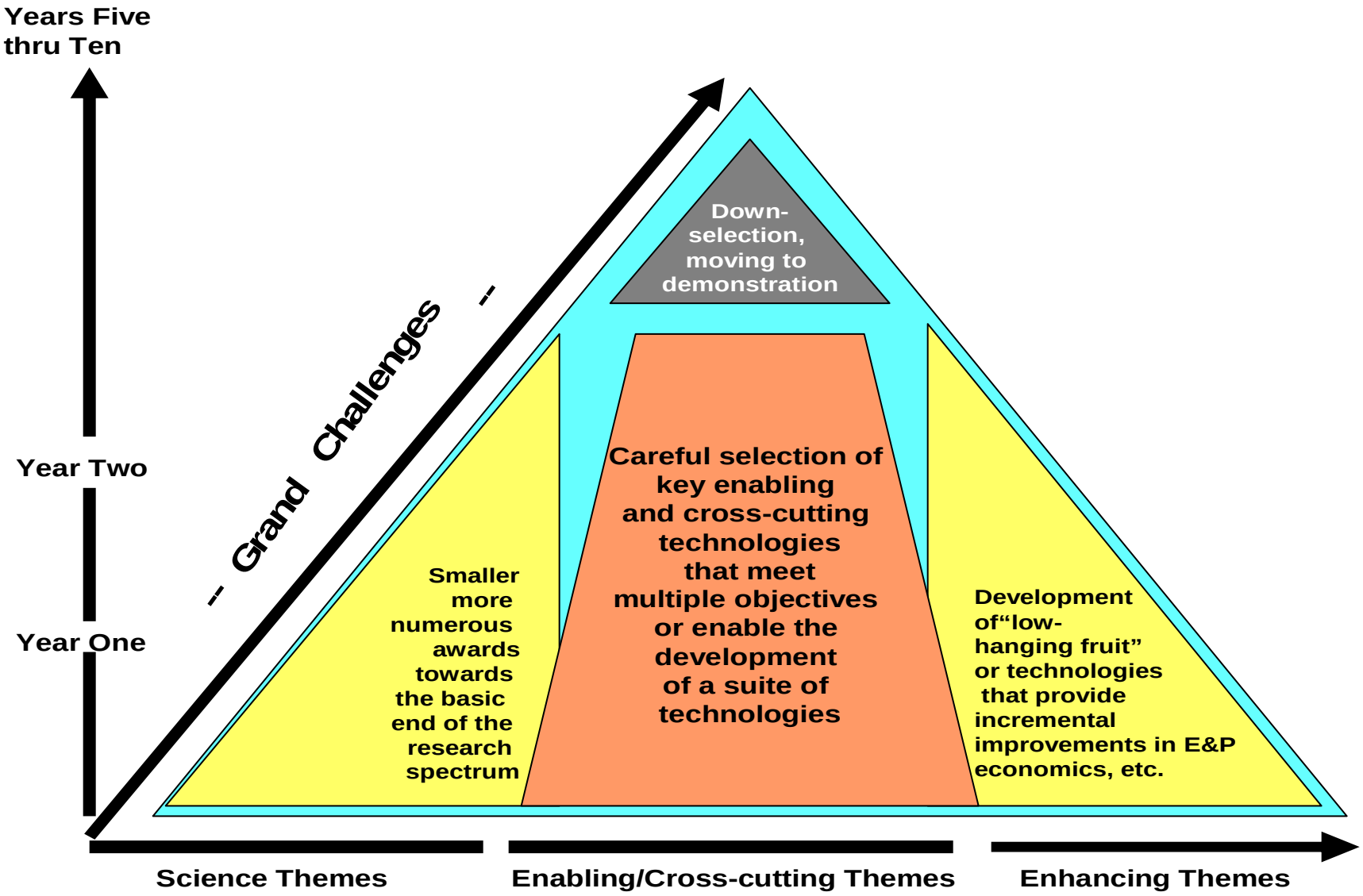
Environmental Advisory Group (EAG)

Name	Organization
Dr. Rich Haut, Chair	Houston Advanced Research Center
Scott Anderson	**Environmental Defense Fund**
Dr. Steve Bryant	University of Texas at Austin
Sharon Buccino	**National Resource Defense Council**
Dr. David Burnett	Texas A&M University
Assheton Carter	**Conservation International**
Bob Gordan	Stress Engineering Services
Russ Johns	University of Texas at Austin
Joe Kiesecker	**The Nature Conservancy**
Roy Long	National Energy Technology Laboratory
Pam Matson	Stanford University
Chuck Newell	GSI Environmental
Scott Reeves	Advanced Resources International
Oyvind Strom	Statoil Hydro
Mason Tomson	Rice University

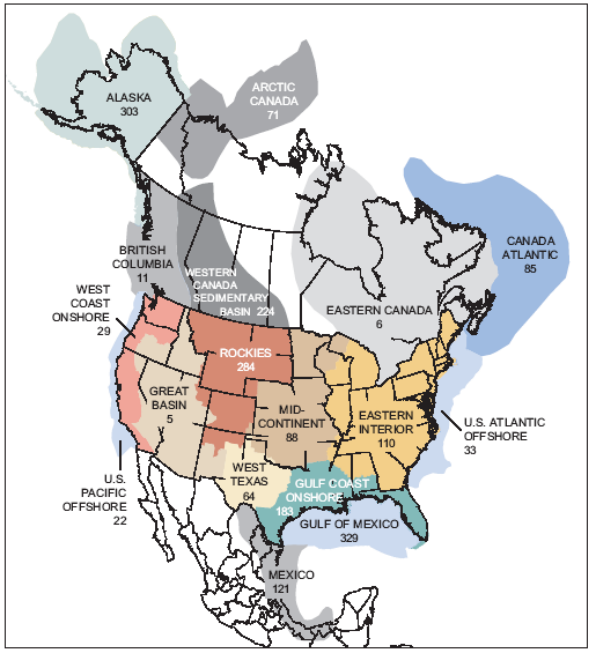
Some General Attributes of the Program

- Research should create leverage on
  - Funding, personnel, equipment, operations, and other resources
- Integration is a key to create synergies
  - Make 1+1=3
- Research should be cumulative to mitigate risk and build upon itself
  - Build in multiple time scales for the research plan
  - Allow for failure
  - Leave more legacies than one time projects, and plan for follow on funding
- Focus on short to mid term applied projects
  - Integrate with the NETL complementary program for more basic longer term projects
- Identify opportunities industry can't tackle or are impractical for industry to tackle
- Avoid many small projects which minimizes the potential for high impact

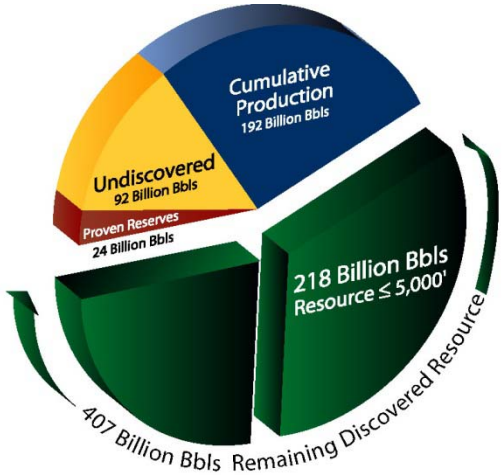
General Attributes of the Program



The Resources



NPC Technical Resources (TCF)



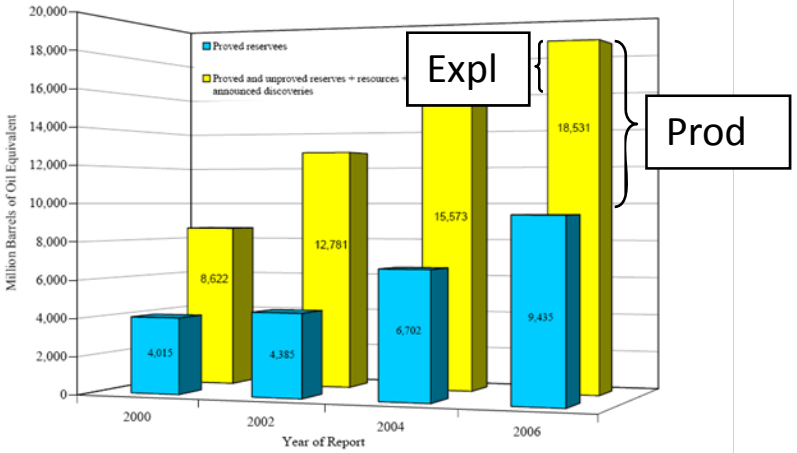
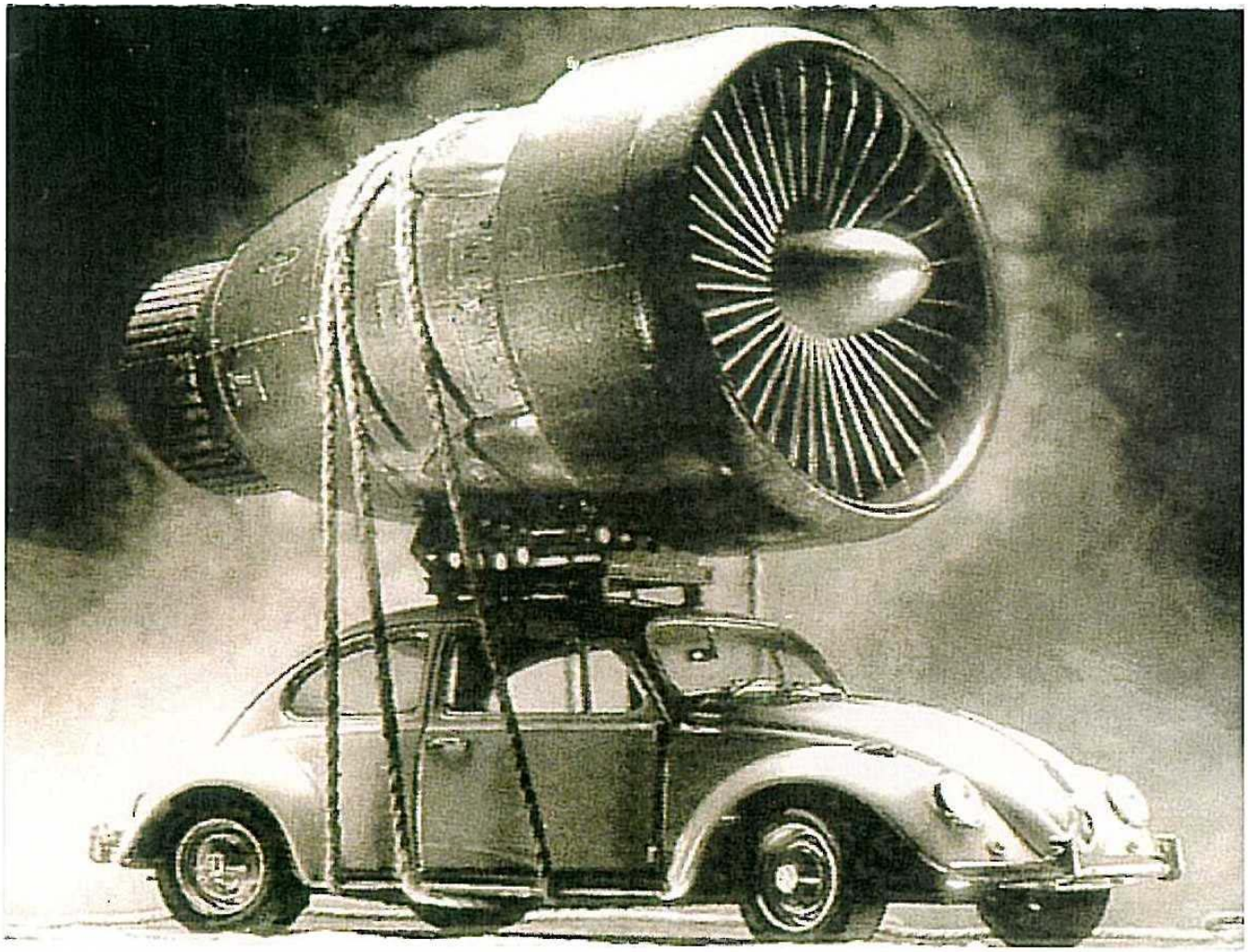


Figure 78. Comparison of 2000, 2002, 2004, and 2006 deepwater GOM reports: successive increases in deepwater BOE.

What is technology?



2007 & 2008 Unconventional Onshore Themes

- Gas Shales
  - Rock properties/Formation Evaluation
  - Fluid flow and storage
  - Stimulation
  - Water management
- Coalbed Methane
  - Produced water management
- Tight Sands
  - Natural fractures
  - Sweet spots
  - Formation Evaluation
  - Wellbore-reservoir connectivity
  - Surface footprint

Cost Reduction in All Aspects of Operations

The Technology Challenges of Small Producers

Focus Area – Advancing Technology for Mature Fields

- Target – Existing/Mature Oil & Gas Accumulations
  - Maximize the value of small producers' existing asset base
  - Leverage existing infrastructure
  - Return to production of older assets
  - Minimal additional surface impact
  - Minimize and reduce the existing environmental impact
- Lower cost and maximize production

Onshore Program

	Unconventional		Small Producer	
	Submitted	*Selected**	*Submitted*	*Selected**
Total Cost ($MM)	**$102.0**	**$34.3**	**$12.6**	**$6.0**
RPSEA Share ($MM)	**$49.5**	**$19.6**	**$6.3**	**$3.2**
Number of Proposals	**47**	**19**	**13**	**7**
University	**25**	**13**	**7**	**6**
Research Institution	**2**	**1**		
National Lab	**3**	**2**	**2**	**1**
Industry	**13**	**1**	**3**	
State Organization	**4**	**2**	**1**	

***Selections subject to approval and negotiation**

Significant Producer and Service Industry Involvement
– Crucial for Program Relevancy

- Anadarko
- Chevron
- Pioneer Natural Gas
- Williams E&P
- ConocoPhillips
- ExxonMobil
- Newfield Exploration
- Encana
- BP
- Bill Barrett Corp.
- Pinnacle Gas Resources
- Coleman Oil & Gas
- Ciris Energy

- Devon Energy
- Unconventional Gas Resources Canada
- Whiting Petroleum
- CNX Gas
- Trendwell
- Diversified Operating Corp
- Noble Energy
- Jones Energy
- Aurora Oil & Gas

- Schlumberger
- Halliburton
- Pinnacle Technologies
- BJ Services
- Carbo Ceramics

Unconventional Onshore Program
2007 Projects

- Several specific resources targeted
  - New Albany Shale
  - Rockies Tight Sands
  - Potential Shale Resources in Alabama, Utah
- Projects addressing unconventional gas fundamentals
- Vision – Use targeted resources as field laboratories for work leading to fundamental understanding of factors controlling unconventional gas production

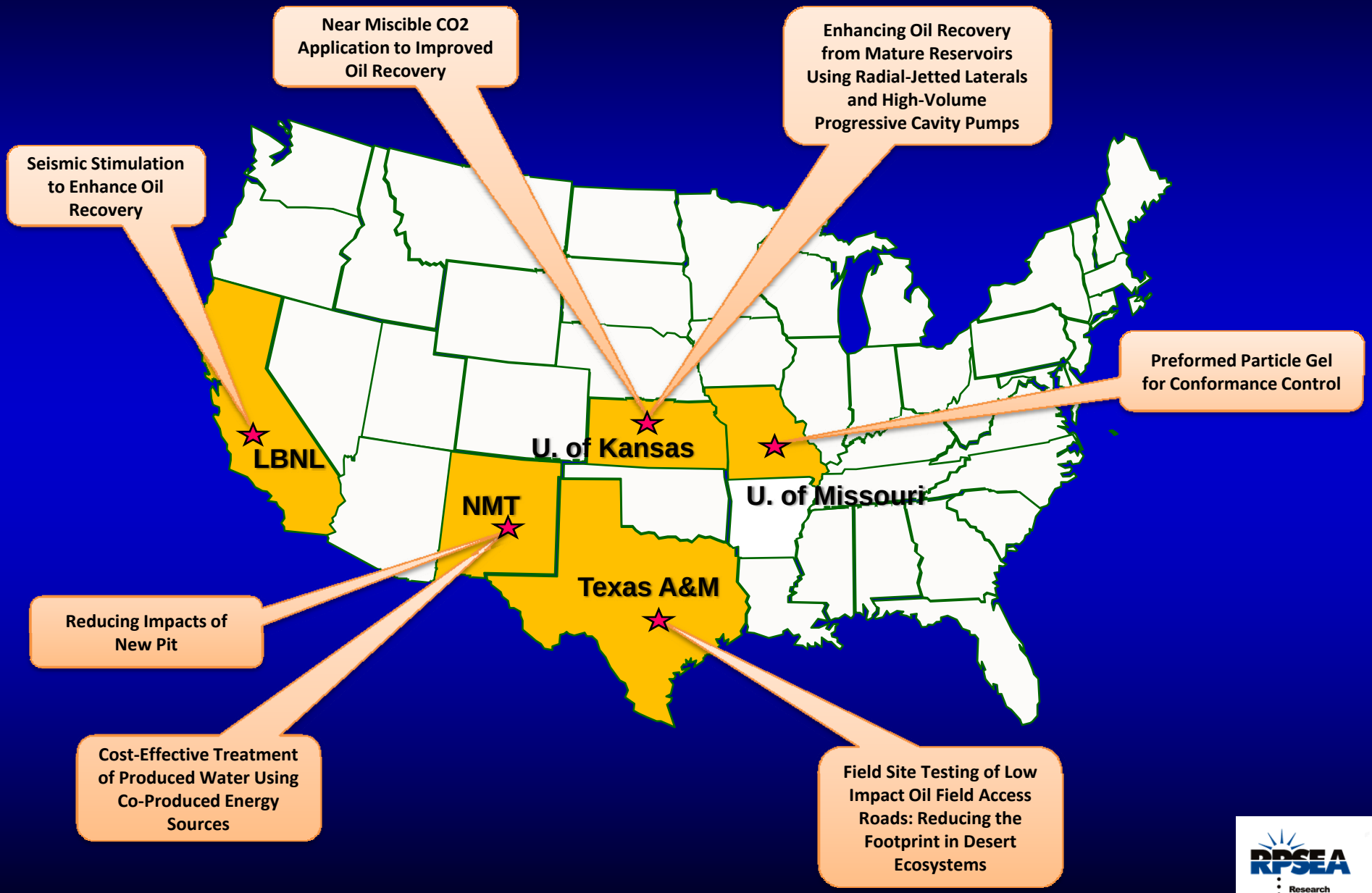
Unconventional Onshore Project Selections

RPSEA
Research Partnership to Secure Energy for America

Small Producer Program
2007 Projects

- Seven projects addressing concerns of small producers operating mature assets
  - Produced water treatment
  - Enhanced oil recovery (3)
  - Environmental impact (2)
  - Improve recovery and sweep efficiency
- Projects each involve a consortium of researchers and small producers
- Small Producer Research Advisory Group (RAG) actively involved

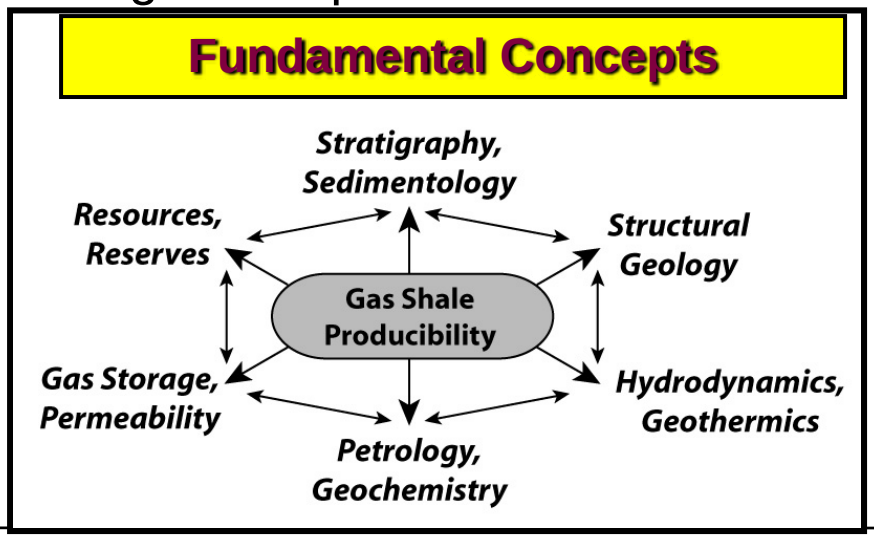
Small Producer Project Selections



RPSEA
Research Partnership to Secure Energy for America

Geological Foundation for Gas Production From Diverse Shale Formations

- Shale Prospects (Cambrian through Mississippian) are being developed in the Black Warrior Basin/Appalachian Thrust Belt of Alabama.
- Stratigraphic architecture and structural deformation differ significantly from established shale plays.
- Broadly applicable, multidisciplinary approach to geological characterization is being developed.



GTI New Albany Shale Research Project

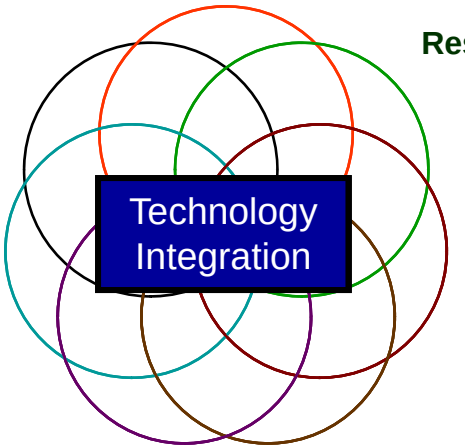
Resource Characterization - Well Stimulation - Well Cost

Geologic Studies
Bureau of Economic Geology

New Albany Consortium

Geochemical Analysis
Amherst & U Mass

Reservoir Engineering
Texas A&M



Formation Evaluation
ResTech

Fracture Modeling and Diagnositc
Pinnacle Technology and Texas A&M

Field Data, Environmental and Project Management

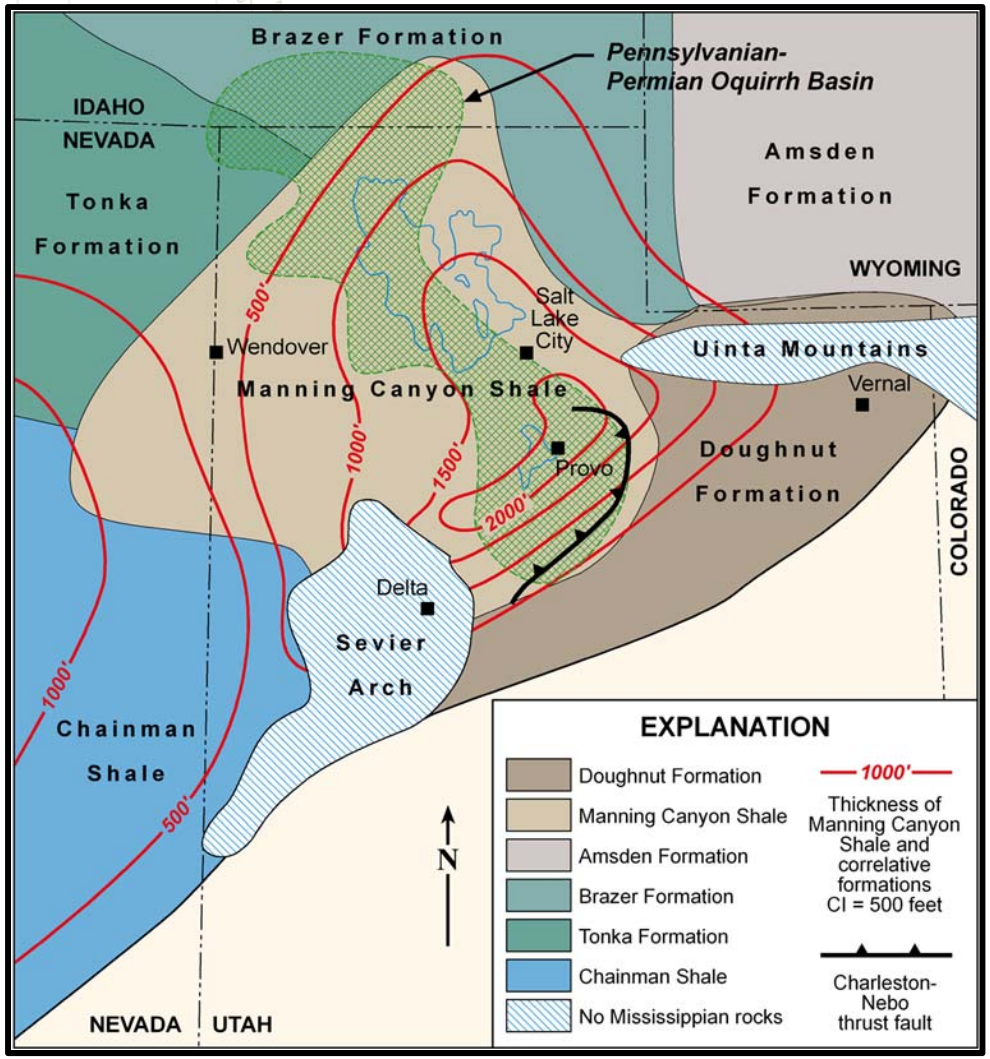
Best Practice Analysis
West Virginia University

Producer Participants

- >Noble Energy
- >CNX Gas
- >Trendwell
- >Rex Energy
- >Diversified Operating
- >Aurora Oil & Gas
- >Southwestern Energy

Paleozoic Shales – Utah

Manning Canyon Shale

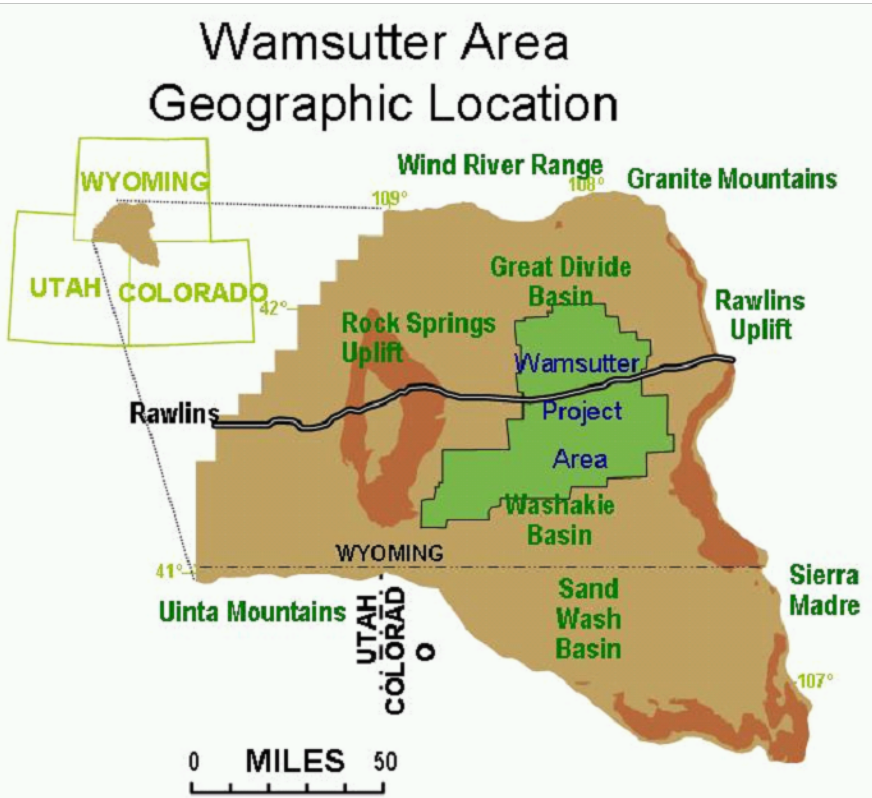


- **Characterize Geological Properties**
- **ID Greatest Gas Potential**
- **Best Completion Practices**

Optimizing Infill Drilling at Wamsutter

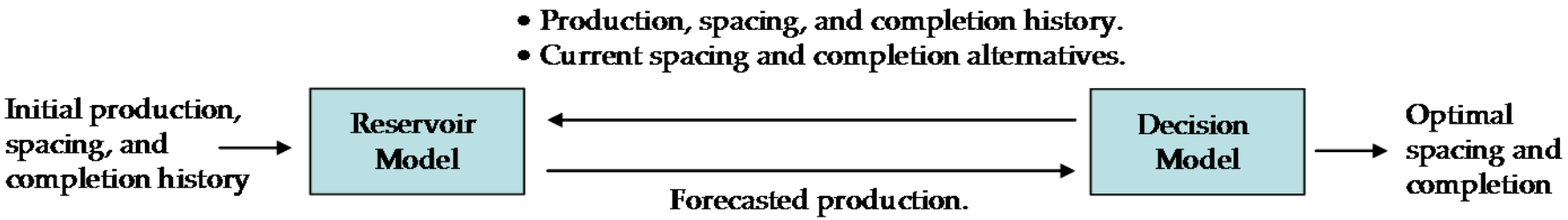
- **Over 2,000 square miles**
- **k < 0.1 md**
- **80 acre spacing**

- **Generate static reservoir descriptions of sands using geostatistical procedures**
- **History match 80 &160 acre spaced wells**
- **Project the future performance of 40 acre spaced wells & Identify Best Locations**



Optimizing Development Strategies to Increase Reserves in Unconventional Gas Reservoirs

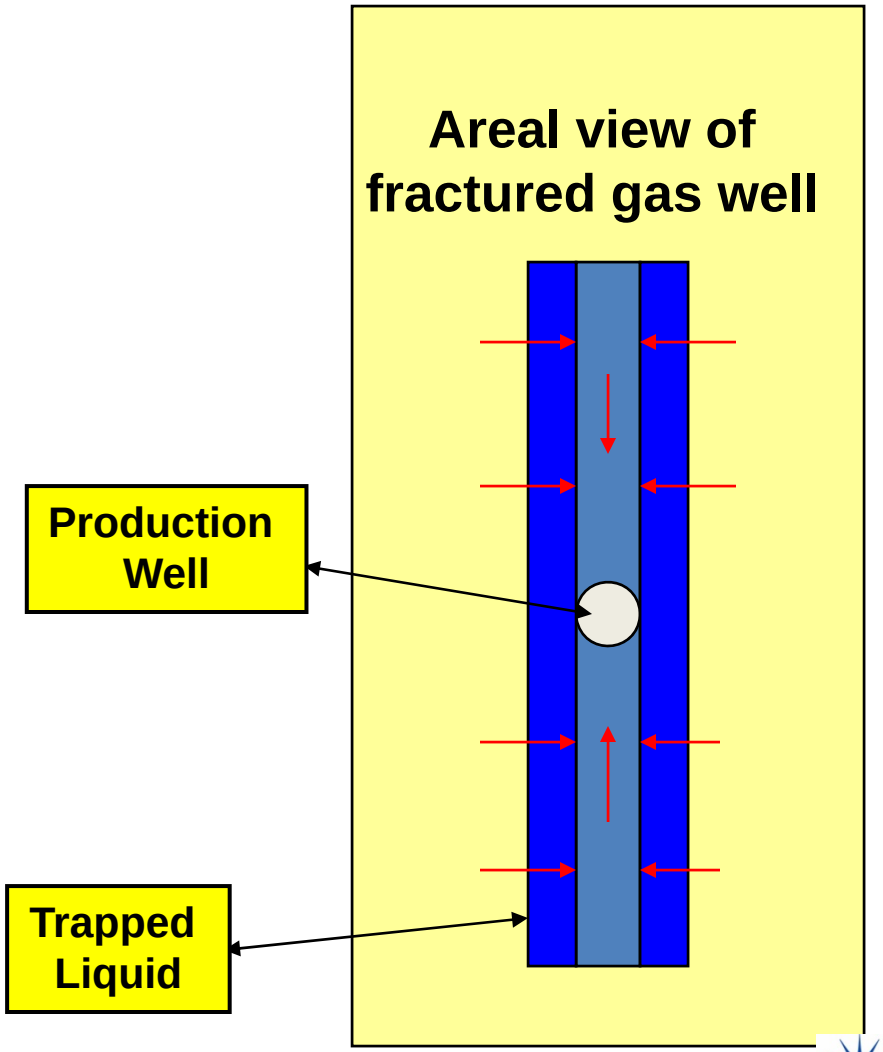
- Objectives: Develop new technologies for determining optimal development strategies in gas shale and tight sand reservoirs
- Core technology will be an integrated reservoir and decision model that fully incorporates uncertainty



- Project will determine optimal well spacing and completion methods in the Barnett Shale and a US tight gas reservoir
- Impact: Incorporating the technology into operators' development processes will enable reaching optimal spacing as quickly as possible, accelerating production and increasing reserves

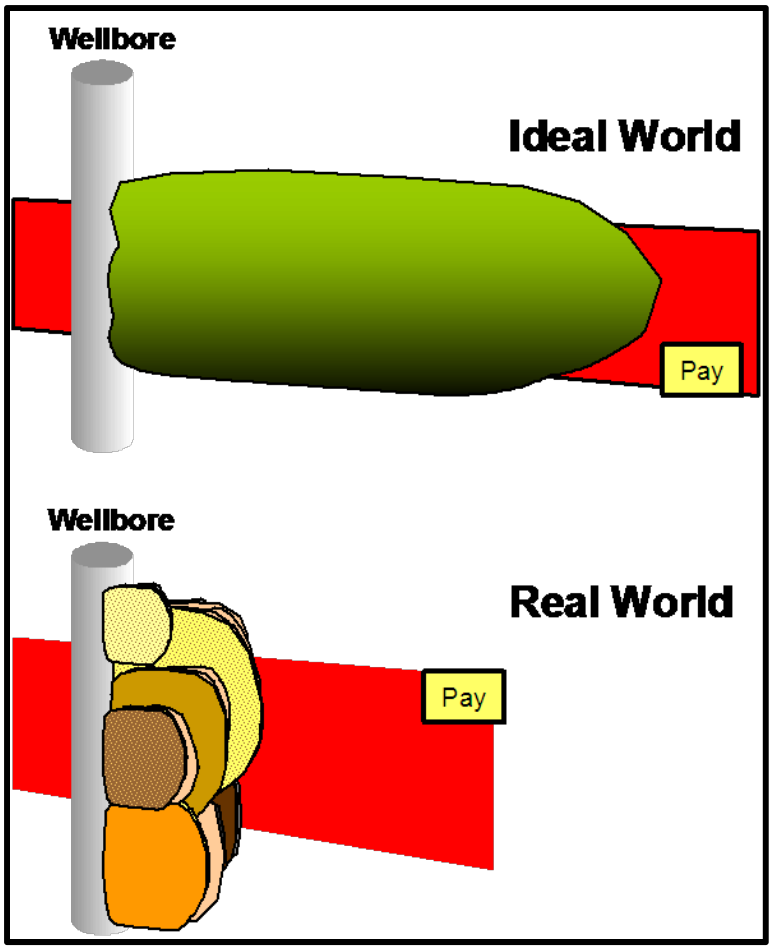
Productivity Loss Due to Fracturing Induced Damage

- Liquids Invade the Near Wellbore/Fracture Region
- Use of Polymer Gels Can Aggravate Loss in Well Deliverability
- We Aim to Understand Factors Affecting Cleanup of Gel Induced Damage
- Lab Testing – Model Development and Field Verification



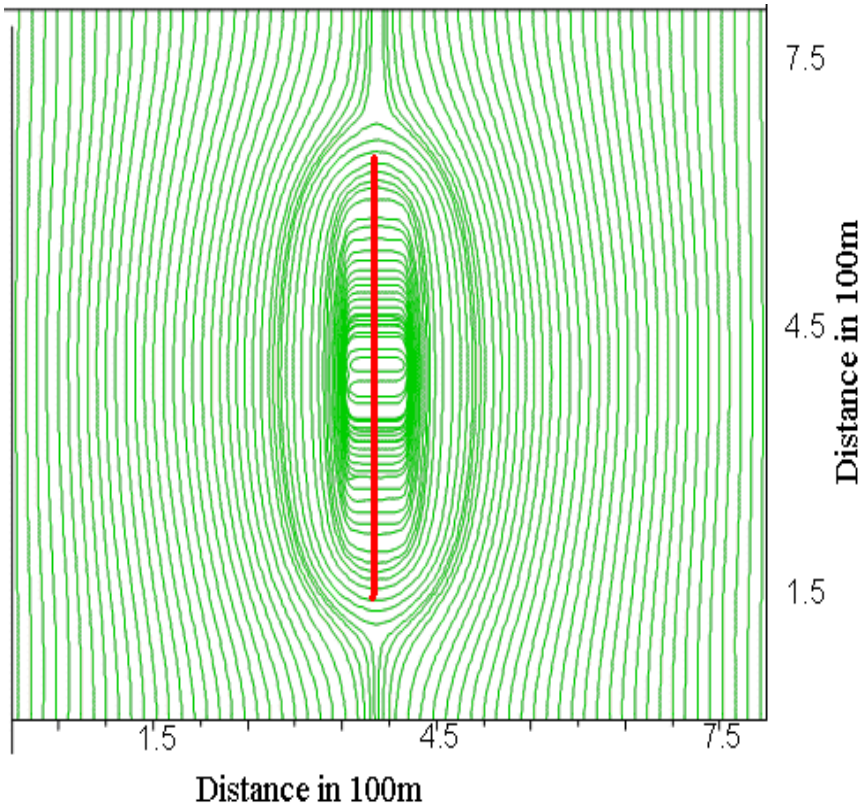
Improvement of Fracturing for Gas Shales

- Laboratory evaluation of ultra-light weight proppant based fracturing fluid.
- Laboratory evaluation of ultra-light weight proppant and foam based fracturing fluids.
- Fracture designs for a Barnett shale reservoir.
- Field test to evaluate the effect of new fracture fluids.



Identification of Refracturing Opportunities

- Methodology for candidate well selection based on poro-elastic models and analysis of field data.
- Recommendations for the time window most suitable for re-fracturing
- Re-fracture treatment design for horizontal and deviated wellbores



Stress Profile Created by Horizontal Producing Well

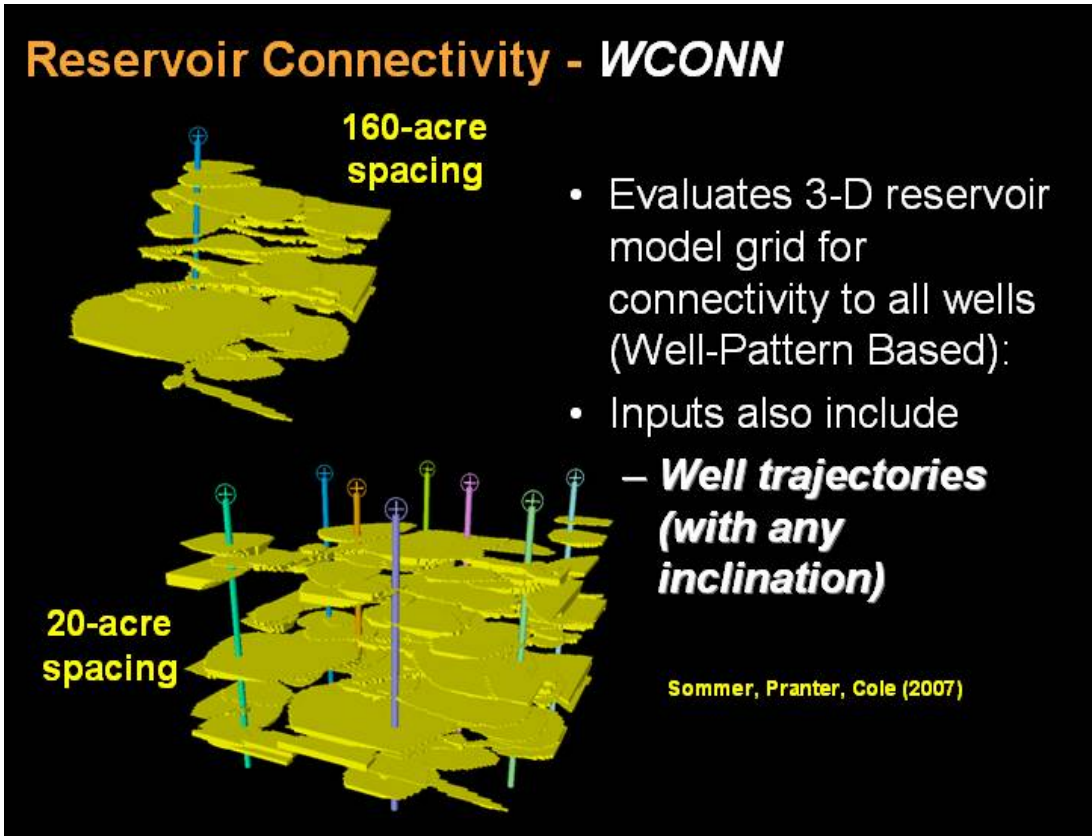
Reservoir Connectivity and Stimulated Gas Flow in Tight Sands

The Rocks

- *Basin-wide Stratigraphy*
- *Static reservoir models*
- *Regional structure*
- *Natural fractures*
- *Azimuthal AVO and attenuation*

The Fluids

- Reservoir flow simulation tied to rock properties
- Electrical methods to monitor subsurface flow
- Fracturing of rocks & Micro-earthquake location



An Integrated Framework for Treatment and Management of Produced Water

Research Objectives

- Compile data on quality and quantity of produced water associated with unconventional gas production
- Explore most appropriate and cost-efficient water treatment technologies
  - Assess requirements to minimize environmental impacts and reduce institutional barriers
  - Compile findings into a decision analysis framework for management of produced water

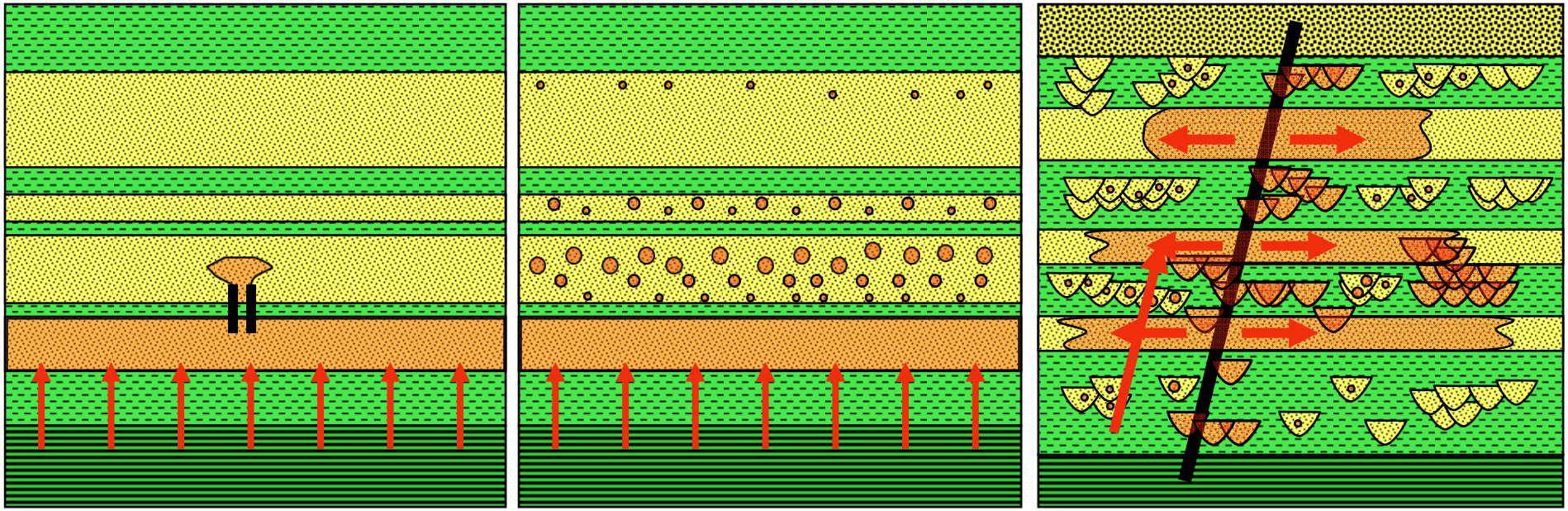
How Does Gas Migrate into and Fill Unconventional Reservoirs?

Different Mechanisms Should Leave Different Signatures in the Gas Composition; Assisting with Exploration Strategy

Gas pressure Produces Fractures

Gas Diffuses Through Seals

Gas Migrates Along Faults



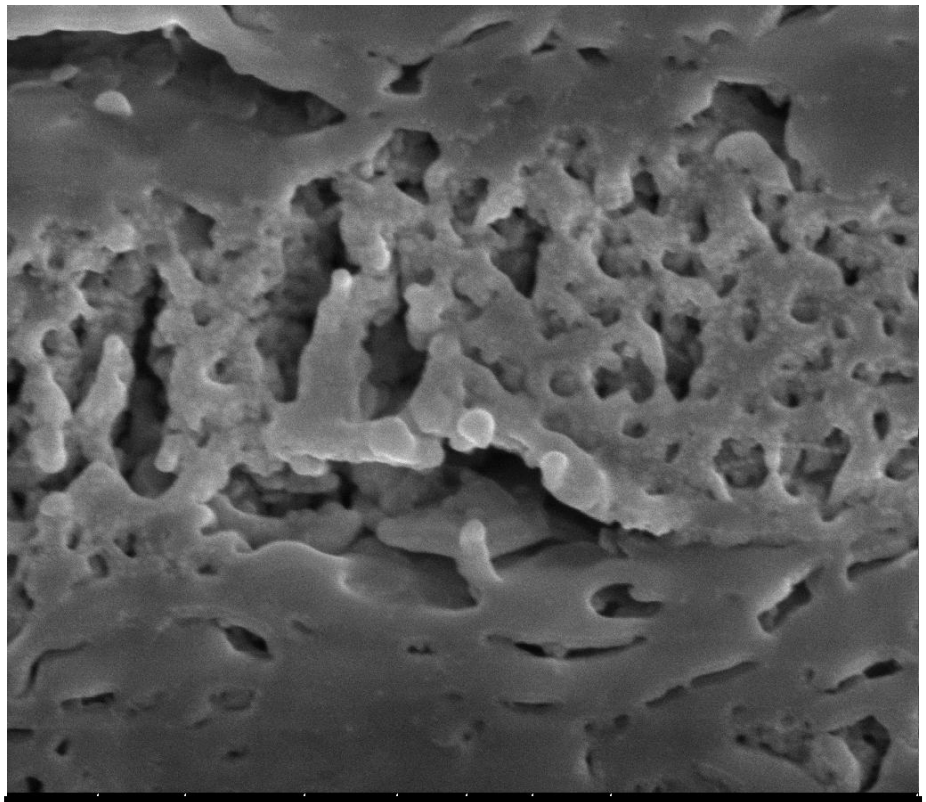
Petrophysical Studies of Unconventional Gas Reservoirs using High-Resolution Rock Imaging

Main Objectives

- ID Mechanisms Limiting Gas Recovery
- Means of Extending Well Productive Life

Technical Approach

- High-resolution images of low k rocks
- Analysis of flow properties from 3D pore space geometry
- Recovery strategies preventing condensate precipitation

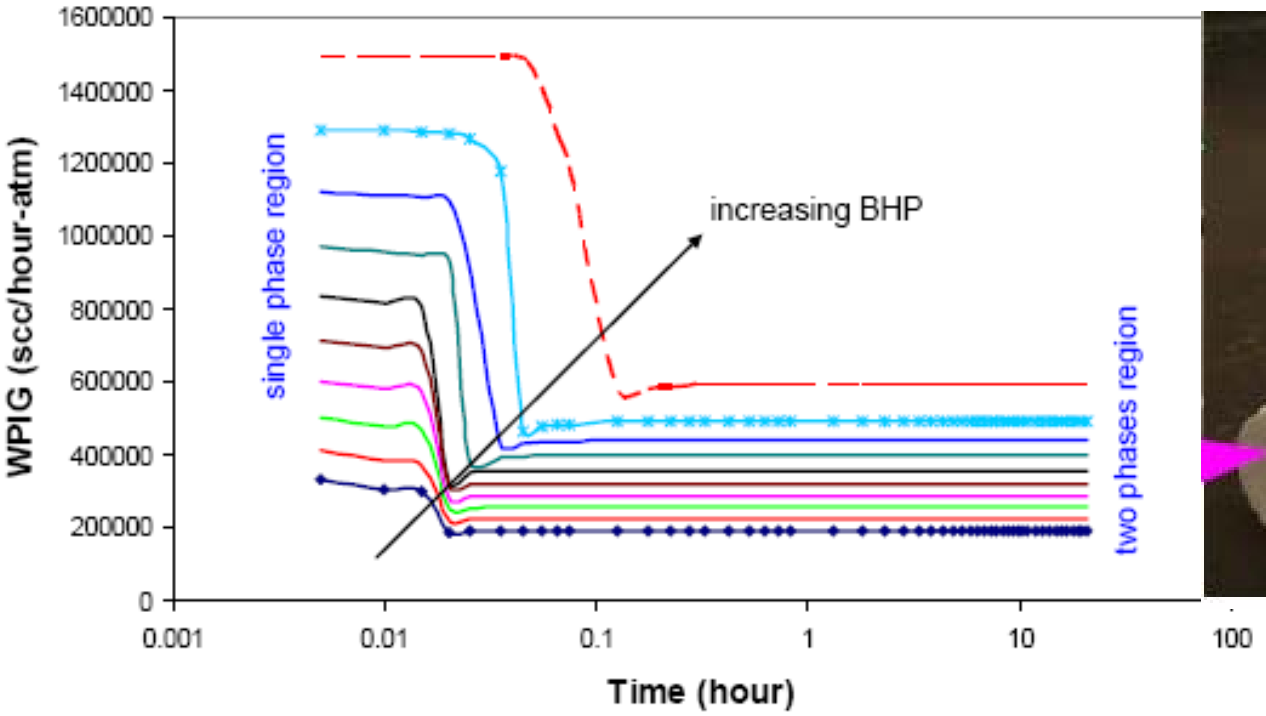


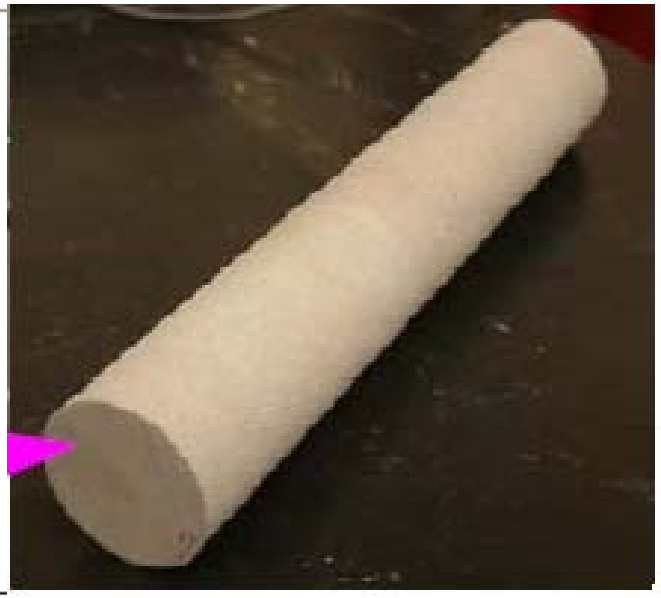
500 nm

Pore space geometry of a hydrocarbon-bearing shale. Nanometer-scale

Gas Condensate and Tight Gas Sand Productivity

Mitigating Productivity Loss Due to Sandface Precipitation





Gas Well Productivity Decreases Significantly Due to Condensate Precipitation

Gas Composition Changes Will be Investigated

Self-Teaching Expert System for Design and Prediction of Gas Production from Unconventional Gas Resources

•Incorporates Evolving
- geological,
- geophysical,
- fracturing,
- reservoir and
- production data

– From an continuously expanding database of unconventional extremely tight gas reservoirs

– Continuously updates the built-in database

– Makes recommendations about
- formation fracturing/stimulation,
- well location, orientation, design and operation

Permits the analysis of data from installed wells for parameter estimation and continuous expansion of the installed data base.

Deliverable

- A self-teaching expert system (available in the form of a computer program that is easily installed and executed on a wide variety of computational platforms)
- Offers predictions of the performance of proposed wells, and estimates of the corresponding uncertainty) in the stimulated formations

Key Seat Slots Cut in Dogleg Hole

2000 ft^2 Planar Slots for Enhanced Productivity

2009 Draft Annual Plan – Onshore Program

- Mission & Goal
  - Unchanged from 2007, 2008
  - Economically viable technologies to allow environmentally acceptable development of unconventional gas resources
    - Gas Shales
    - Tight Sands
    - Coalbed Methane
- Objectives
  - Near Term
    - Increase production & recovery from established unconventional gas resources, accelerate development of existing & emerging plays
    - Decrease environmental impact of unconventional gas development
    - Integrate project results & deliverables and engage in technology transfer to ensure application of program results
  - Longer Term
    - Technologies for high-priority emerging and frontier resources

"You miss 100% of the shots you don't take."

Wayne Gretzky

QUESTIONS?