RPSEA Research Project Overview

IOGCC Annual Meeting
October 16-18 Buffalo, NY

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RPSEA

• A non-profit corporation formed by a consortium of premier U.S. energy research universities, industry and independent research organizations.

• Mission is to provide a stewardship role in ensuring the focused research, development and deployment of safe, environmentally sensitive technology that can effectively deliver hydrocarbons from domestic resources to the citizens of the United States.

• 3 programs
  – Ultra-Deepwater
  – Unconventional Natural Resources
  – Small Producer
Unconventional Resources Program Advisory Committee

- 15 members from Industry
  - Producing Companies,
  - Service Companies
  - Research Organizations

- Provide Direction to the Program
  - Solicitation Guidance
  - Proposal Evaluations and Selections Recommendations
  - Other Guidance
Unconventional Resources

- 38 projects have been undertaken – solicitation years 2007 – 2009
  - $72 MM total
  - $46 MM RPSEA
- 8 projects being negotiated from 2010
RPSEA Unconventional Gas Program Components & Approach – Built Over 2007-2010

- Resource Assessment
- Drilling
- Exploration Technologies
- Stimulation & Completion
- Reservoir Description & Engineering
- Environmental & Water Management

Integrated Basin Analysis

Technology Dissemination

Impact By Geologic Basin and Unconventional Resource

CBM Production (Bcf)

- Arkoma Basin
- Appalachian Basin
- Warrior Basin
- Emerging Basins
- San Juan Basin

e.g., CBM
<table>
<thead>
<tr>
<th></th>
<th>Gas Shales</th>
<th>Tight Sands</th>
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<tbody>
<tr>
<td><strong>Integrated Basin Analysis</strong></td>
<td>New Albany (GTI) $3.4</td>
<td>Piceance (CSM) $2.9</td>
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<td>Marcellus (GTI) $3.2</td>
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<td>Mancos (UTGS) $1.1</td>
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<tr>
<td><strong>Stimulation and Completion</strong></td>
<td>Cutters (Carter) $.09</td>
<td>Gel Damage (TEES) $1.05</td>
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<td>Frac (UT Austin) $.69</td>
<td>Frac Damage (Tulsa) $.22</td>
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<td>Refrac (UT Austin) $.95</td>
<td>Foam Flow (Tulsa) $.07</td>
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<td>Frac Cond (TEES) $1.6</td>
<td>Fracture Complexity (TerraTek) $.83</td>
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<td>Stimulation Domains (Higgs-Palmer) $0.39</td>
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<td>Fault Reactivation (WVU) $0.85</td>
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<td><strong>Reservoir Description &amp; Management</strong></td>
<td>HIRes. Imag. (LBNL) $1.1</td>
<td>Tight Gas Exp. System (LBNL) $1.7</td>
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<td>Gas Isotope (Caltech) $1.2</td>
<td>Strat. Controls on Penn (CSM) $0.1</td>
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<td>Marcellus Nat. Frac. Stress (BEG) $1.0</td>
<td>Fluid Flow in Tight Fms. (MUST) $1.2</td>
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<td>Frac-Matrix Interaction (UT-Arl.) $0.46</td>
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<td>Marcellus Geomechanics (PSU) $3.1</td>
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<td><strong>Reservoir Engineering</strong></td>
<td>Decision Model (TEES) $1.31</td>
<td>Wamsutter (Tulsa) $.44</td>
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<td>Coupled Analysis (LBNL) $2.9</td>
<td>Forecasting (Utah) $1.1</td>
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<td>Shale Simulation (OU) $1.05</td>
<td>Condensate (Stanford) $.52</td>
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<td><strong>Exploration Technologies</strong></td>
<td>Multi-Azimuth Seismic (BEG) $1.1</td>
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<td><strong>Drilling</strong></td>
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<td>Drilling Fluids for Shale (UT Austin) $0.6</td>
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<td><strong>Water Management</strong></td>
<td>Barnett &amp; Appalachian (GTI) $2.5</td>
<td>Frac Water Reuse (GE) $1.1</td>
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<td>Integrated Treatment Framework (CSM) $1.56</td>
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<td><strong>Environmental</strong></td>
<td>Environmentally Friendly Drilling (HARC) $2.2</td>
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<td><strong>Resource Assessment</strong></td>
<td>Alabama Shales (AL GS) $0.5</td>
<td>Rockies Gas Comp. (CSM) $0.67</td>
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<td>Manning Shales (UT GS) $1.43</td>
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**Coal Related:**
- Microwave Stimulation (Penn) $0.08
- Water Treatment (CSM) $1.56
- Microbial Methanogenesis (CSM) $0.86
Secure Energy for America

Shale Related Projects
Unconventional Onshore Program
**Shale Related Projects-2007 Program**

1. New Albany Shale Gas
3. An Integrated Framework for Treatment and Management of Produced Water
4. Geological Foundation for Production of Natural Gas from Diverse Shale Formations
5. Petrophysical studies of unconventional gas reservoirs using high-resolution rock imaging
7. Optimizing Development Strategies to Increase Reserves in Unconventional Gas Reservoirs
8. Improvement of Fracturing in Gas Shales
9. Improved Reservoir Access Through Refracture Treatments In Tight Gas Sands And Gas Shales
Shale Related Projects-2008 Program

1. Barnett and Appalachian Shale Water Management and Reuse Technologies
2. Novel Gas Isotope Interpretation Tools to Optimize Gas Shale Production
3. Environmentally Friendly Drilling
4. Defined Effort to provide Pretreatment and Water Management for Frac Water Reuse and Salt Production.
5. Sustaining Fracture Conductivity of Gas Shale Reservoirs for Enhancing Long-Term Production and Recovery
Shale Related Projects-2009 Program

1. Characterizing Stimulation Domains, for Improved Well Completions in Gas Shales
2. Marcellus Gas Shale Project
3. Prediction of Fault Reactivation in Hydraulic Fracturing of Horizontal Wells in Shale Gas Reservoirs
5. Simulation of Shale Gas Reservoirs Incorporating Appropriate Pore Geometry and the Correct Physics of Capillarity and Fluid Transport
6. Integrated Experimental and Modeling Approaches to Studying the Fracture-Matrix Interaction in Gas Recovery from Barnett Shale
8. Improved Drilling and Fracturing Fluids for Shale Gas Reservoirs
Completed Projects

Unconventional Onshore Program
Completed Projects
Unconventional Onshore Program
Final Reports Available on RPSEA website

- Novel Concepts for Unconventional Gas Development in Shales, Tight Sands and Coalbeds
- New Albany Shale Gas
- Geological Foundation for Production of Natural Gas from Diverse Shale Formations
- Enhancing Appalachian Coalbed Methane Extraction by Microwave-Induced Fractures
- Optimization Of Infill Well Locations In Wamsutter Field
Novel Concepts for Unconventional Gas Development in Shales, Tight Sands and Coalbeds

2000 ft² Planar Slots for Enhanced Productivity

Key Seat Slots Cut in Dogleg Hole
New Albany Shale

Resource Characterization - Well Stimulation - Well Cost

Geologic Studies
Bureau of Economic Geology

Geochemical Analysis
Amherst & U Mass

Formation Evaluation
ResTech

Field Data, Environmental
and Project Management

Technology Integration

Reservoir Engineering
Texas A&M

Fracture Modeling and
Diagnosis
Pinnacle Technology
and Texas A&M

Best Practice Analysis
West Virginia University

New Albany Consortium

Producer Participants
> NGAS
> Aurora Oil & Gas
> Noble Energy
> CNX Gas
> Trendwell
> Breitburn Energy
> Diversified Operating

Gas Technology Institute
Geological Foundation for Production of Natural Gas from Diverse Shale Formations
Enhancing Appalachian Coalbed Methane Extraction by Microwave-Induced Fractures

- Microwave energy have been shown to induce fractures.
- Can we in situ generate new macro and micro fractures with a microwave burst?
- What is the influence of these changes on methane permeability?
- Lab experiments will scan coal core, establish fracture/permeability baseline.
- A burst of microwave energy will be tested for permeability enhancement
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

Wamsutter Area
Geographic Location

University of Tulsa
Questions?