

# Unconventional Resources Technology Advisory Committee

Advisory Committee to The Secretary of Energy

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November 1, 2012

The Honorable Dr. Steven Chu  
Secretary of Energy  
Washington, DC 20585

Dear Mr. Secretary:

On behalf of the Unconventional Resources Technology Advisory Committee (URTAC), it is my pleasure to submit our findings and recommendations based on our review of the Unconventional Resources Technology and Small Producers' portion of the *2013 Annual Plan* for the *Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Research Program*.

- We find this program has been remarkably successful in meeting its objectives.
- Research into oil and gas resources is still needed to meet the future demand for domestic energy. We strongly recommend continuing the *Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Research Program* beyond the current 2014 termination date. It is important that technology transfer and public outreach regarding the program's research results continue.
- We continue to seek efficient development and production technologies that increase oil and gas supplies while reducing environmental and safety impacts.

These key findings are addressed in the report along with other observations and recommendations made by the Committee members. As experts and professionals in our areas of expertise, we believe that they are worthy of consideration and implementation.

The URTAC recommends proceeding with the continued implementation of the *2013 Annual Plan* consistent with the guidance outlined in our report.

Respectfully submitted,



Jessica J. Cavens, Chair

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**Unconventional Resources Technology  
Advisory Committee**

**Comments and Recommendations  
2013 Annual Plan**

**November 2012**

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## 1.0 INTRODUCTION

The Unconventional Resources Technology Advisory Committee (URTAC) was formed in accordance with provisions of Title IX, Subtitle J, Section 999D(a) of the 2005 Energy Policy Act (EPACT).

The Committee consists of:

- A majority of members who are employees or representatives of Independent Producers of natural gas and other petroleum, including small producers;
- Individuals with extensive research experience, operational knowledge or unconventional natural gas and other petroleum resource exploration and production;
- Individuals broadly representative of the affected interests in unconventional natural gas and other petroleum resource exploration and production, including interests in environmental protection and safe operations;
- Individuals with expertise in the various geographic areas of potential supply of unconventional onshore natural gas and other petroleum in the United States.

The provisions of EPACT excluded from eligibility to participate in URTAC the following: Federal employees and board members, officers and employees of Research Partnership to Secure Energy for America (RPSEA).

The duties of the URTAC under EPACT Section 999D(a) are to advise the Secretary of Energy on the development and implementation of programs related to unconventional natural gas and other petroleum resources and to review the draft annual research plan.

The Committee members were appointed by letters from the Secretary in July, 2012. Key milestones for the Committee included:

- Committee members received the initial Draft 2013 Annual Plan on September 18, 2012.
- Committee members met on September 25, 2012 in Houston, Texas. The agenda included a status update and overview of the onshore elements of the Section 999 Complementary Research Program by NETL, and an overview of the Section 999 Program cost-shared research portfolio by RPSEA. The Chair appointed sub-groups to work on sections of the plan.
- During the period from September 18<sup>th</sup> through October 24<sup>th</sup>, the appointed sub-group members conducted several meetings by teleconference and E-mail to develop and consolidate recommendations regarding the draft annual plan.
- The Committee met on October 24<sup>th</sup> and 25<sup>th</sup>, 2012 in Houston, Texas to receive sub-group reports and to draft the final recommendations of the Committee.
- The Committee met via teleconference on November 1, 2012 in Washington, D.C. to complete final approval of the Committee report in accordance with the deadline set by the Secretary and conveyed through the Designated Federal Officer.

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EPACT Subtitle J Section 999H sets the funding for the overall program at a level of \$50-million-per-year over 8 years, provided from Federal lease royalties, rents, and bonuses collected by the Department of the Interior. Of this, \$37.5 million is awarded for the consortium research and development program administered by RPSEA and \$12.5 million for the Complementary Program administered by NETL. The RPSEA-administered program is broken into the Ultra-Deepwater (\$14.493 million), the Unconventional Gas (\$13.854 million), the Small Producer Program (\$3.562 million) and funding for administration and oversight (\$5.437 million).

The URTAC Committee focused on the Unconventional Gas and the Small Producer Programs of the Consortium Program and the applicable portions of the NETL Complementary Program.

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## 2.0 EXECUTIVE SUMMARY AND RECOMMENDATION HIGHLIGHTS

The Committee reviewed the *2013 Annual Plan* and identified major areas requiring further discussion. Sub-groups were formed to submit findings and recommendations for these areas. The sub-group reports were distributed to the entire Committee and each was discussed by the Committee as a whole. Following this discussion, the entire Committee agreed on and drafted the findings and recommendations included in this report.

The Committee wishes to note that steps have been taken by both NETL and RPSEA to implement many of the past recommendations of the URTAC, specifically in the areas of program and technology transfer.

For the 2013 Annual Plan, the Committee has the following comments:

- Due to the time frame necessary for field demonstration projects to yield reliable scientific data and to develop innovative solutions required to continue to develop affordable clean energy from unconventional reservoirs, URTAC recommends continuing the RPSEA program beyond the current 2014 termination date.
- Long-term R&D is valuable and necessary. This often cannot be done by independent producers who are responsible for a large portion of the current oil and gas development in the United States. Subtitle J of the Energy Policy Act of 2005 has provided steady funding for the long-term cooperative research required to make progress toward safe and efficient development of the gas shale resource base. We believe this approach to be much more efficient than intermittent funding which depends on annual appropriations.
- Technology transfer associated with the Subtitle J research program has been extremely valuable in achieving production, environmental, and safety goals. If Subtitle J program concludes, it is important that technology transfer and public outreach regarding the program's research results continue beyond the sunset date.
- Refocus the R&D component of Subtitle J to include other unconventional resources such as tight oil, and oil shale. Also include projects on increasing reservoir recovery in existing reservoirs.
- Research should be conducted to improve well construction that ensures long-term well bore integrity during and beyond the operational life of the well. Laboratory and/or field techniques that simulate long term barrier integrity are important. Focus areas may include: sealants/materials, equipment, accessories, installation processes, verification/monitoring, etc.
- Pursue research and communication among multiple government agencies and industry that addresses air quality concerns specific to the exploration and production of natural gas from shale deposits and other unconventional resources.

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- Improving safety and minimizing environmental impacts is synergistic with improving operational efficiency and reducing the cost of oil and gas production. Providing sound science contributes to the optimum development of a domestic energy supply while enhancing the safety of its operation, and protecting the environment. Technical innovations that support all of these goals should be more rapidly adopted.

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### **3.0 TOPICAL REPORTS**

The Advisory Committee developed their analysis of the 2013 Annual Plan through a series of meetings and sub-groups (as outlined in Section 5.0: Sub-Group Topics and Member Assignments). There are five areas of findings and recommendations:

- Policy
- Research & Development
- Technology Transfer and Public Outreach
- Environmental & Safety
- Appendix
  - Program Review Subcommittee Report

#### **Treatment of Non-Consensus**

All findings and recommendations reached consensus.



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### 3.1 POLICY FINDINGS AND RECOMMENDATIONS

#### ***Finding: SUNSET***

The landscape in Unconventional Resources is such that:

- A long-term balanced and sustainable energy supply for the United States is needed;
- Long-term field research projects and attendant basic research projects are needed to yield reliable scientific data;
- Continuity of research funding is necessary to achieve maximum benefits;
- There is a strong need to address continued public concerns and perceived challenges;
- There is a need to educate and train a skilled workforce to ensure continuity; and
- Innovative solutions are required to continue to develop affordable clean energy from unconventional reservoirs.

#### ***Recommendation:***

- The advisory committee again proposes continuation of the program beyond the current 2014 termination date. The existing Subtitle J model, or a similar program, should be authorized for another 10 years.
- Features of the program that should be preserved include maximizing hydrocarbon recovery, safety and environment, public/private collaboration, and technology transfer. Areas that may require additional modification include responsibility for the award/approval process and more resources dedicated to technology transfer.
- A sub-committee has been established to provide specific recommendations at a later date.
- In the event that the program reaches conclusion, the value of the program should be continued through the recommendations located in the Technology Transfer and Outreach section.

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***Finding:* ENSURE THAT OTHER PETROLEUM RESOURCES ARE INCLUDED**

The focus on unconventional gas resources has resulted in significant advances in the production of this resource. While there are challenges that remain to be addressed, there are other unconventional resources that would greatly benefit from the research, development and technology transfer of the DOE R&D programs.

Under the current program, only a limited number of projects address oil reservoirs. Focusing on R&D projects in these areas would help reduce dependence on imported foreign crude oil.

Some examples are:

- The Monterey unconventional shale formation in California: The DOE Subtitle J research program has not focused on any West Coast resource during this program; yet one of the largest reservoirs is located in California.
- Identifying bypassed oil in older fields; developing improved recovery methods.

An increase in recovery efficiency in existing reservoirs by just 10 percent would greatly add to the oil reserves base at minimal cost.

***Recommendation:***

DOE should:

- Refocus the R&D component of the Subtitle J program to include other unconventional resources such as tight oil, and oil shale.
- Enhance the Subtitle J funding beyond unconventional resources to include projects on increasing reservoir recovery in existing reservoirs.

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## 3.2 RESEARCH AND DEVELOPMENT FINDINGS AND RECOMMENDATIONS

The three major reasons for continuing to recommend research are to:

- Influence the current solicitation that will be funded between now and September 30, 2014.
- Suggest research topics for the Subtitle J program that would be extended beyond the Sunset. The committee strongly recommends extension beyond the Sunset.
- Provide guidance on potential research topics for additional DOE R&D programs.

### ***Finding:* SAFETY AND ENVIRONMENTAL SUSTAINABILITY**

As stated in the 2013 Annual Plan Executive Summary, “This plan reflects the program’s focus on safety and environmental sustainability that was initiated in the last plan . . . . Onshore, research on Unconventional Resources focuses on protecting groundwater and air quality, understanding rock and fluid interactions, and integrated environmental protection, including water treatment technologies and water management.”

We find this overarching objective is synergetic with improving operational efficiency and reducing the cost of oil and gas production. A few of many examples are:

- Reduction of fresh water demand for hydraulic fracturing reduces the environmental impacts of obtaining and transporting water while reducing the cost of its provision.
- Reduction of fugitive methane emissions reduces the greenhouse gas footprint of hydrocarbon production while potentially minimizing loss of valuable product, thereby increasing efficiency and reducing costs.

We further find that technical innovations that improve safety and minimize environmental impacts will be more rapidly adopted by industry if they also improve operational efficiency and/or reduce costs.

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***Recommendation:***

DOE should:

- Direct RPSEA to associate operational efficiency improvements and cost reduction with safety and environmental objectives:
  - In preparing the RFP; and
  - In determining the evaluation criteria.

***Finding: FUNDAMENTAL RESEARCH NEEDS***

Understanding the fundamentals of fluid flow in gas shale and tight oil formations, and the interaction of hydraulic fractures with rock, are required to develop realistic reservoir simulators that use “hard data”<sup>1</sup> measured and collected during the operation instead of current practices of using interpretive “soft data”<sup>2</sup> to match production history and predict production performance. Such models are essential for the safe, efficient and environmentally responsible production and recovery.

Past research has resulted in valuable insights into the fundamentals of storage and fluid flow in the matrix of the shale reservoirs. Issues requiring further investigation are: the impact of the hydraulic fracturing on the rock matrix; the disposition of injected water; the relationship of microseismic events to production; the interactions between natural fracture networks; the rock fabric and induced fractures. Successful predictive models will facilitate optimization of hydraulic fracturing and well spacing in order to maximize production and recovery with minimum environmental footprint.

***Recommendation:***

DOE should:

- Encourage proposals that contribute to the fundamental understanding of storage and fluid flow characteristics of fractured shale reservoirs, and the development, testing, and validation of shale-specific models.

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<sup>1</sup> **Hard Data** refer to the field measurements. This is the data that can readily be, and usually is, measured during the operation. As far as hydraulic fracturing is concerned, variables such as fluid type and amount, proppant type and amount, proppant concentration, injection and breakdown pressure, injection rates and ISIP are considered to be “Hard Data”.

<sup>2</sup> **Soft Data** refer to variables that are interpreted, estimated or guessed. Parameters such as hydraulic fracture half length, height, width and conductivity as well as Stimulated Reservoir Volume (SRV) are used as tweaking parameters during the history matching process and cannot be measured directly.

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- Encourage proposals that incorporate measured field data into the development, testing, and validation of predictive models that optimize hydraulic fracturing and well construction, in order to maximize hydrocarbon recovery with minimum environmental impact.
  - Encourage research to characterize induced fracture networks through the coupling of measurements, such as microseismic and production data.

***Finding: GEOPHYSICAL RESEARCH***

Novel geophysical imaging technologies have the potential to better define the characteristics of stratigraphic intervals. The ability to define these characteristics offers benefits such as: the possibility of improving productivity, reducing the potential of communication between aquifers and production/saltwater zones, mapping shallow subsurface zones, and reducing the possibility of induced seismic activity.

***Recommendation:***

DOE should:

- Pursue novel geophysical imaging techniques that better detect natural fractures and subtle faults, and that help define spatial positions, geometrical shapes, and volumetric sizes of stratigraphic intervals.

***Finding: VARIATIONS IN ROCK MECHANICS AND COMPLETION TECHNIQUES***

The differences between plays are largely based upon unique mineral content due to the origins of sediments and tectonic history. Natural fracturing imprints along with stress environments affect how these reservoirs respond to stimulation. These combine to create variations in the way rocks behave requiring a wide variety of completion techniques. Dissemination of information regarding development techniques relative to local rock, fluid, and geologic properties will help to minimize waste associated with trial and error in development ramp-up.

***Recommendation:***

The DOE should:

- Support projects which summarize and categorize the key characteristics unique to various basins to illustrate key similarities and differences in rock, fluid properties geological framework and current development and completion methodologies.

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***Finding: WELL INTEGRITY INCLUDING CEMENTING AND ACCELERATED TESTING***

The number of wells in the US continues to grow. In all phases of a well's life 'barrier integrity' is important for proper producing zone isolation, protecting fresh or treatable subsurface water zones, surface waters and air quality. Well integrity primarily comes from the initial well construction and at times relies on multiple barriers between zones, pressure containment, corrosion protection, and flow isolation.

Wellbore design requires a proper barrier during well construction that includes: sealants, installation process and verification/monitoring. Past research and development has been focused on the tensile and compressive strength of cements and their relationship to pressure and temperature. Little research concerned with longevity issues has been done. Some monitoring and testing methods required by regulators can damage the well's working barriers. Pressure tests can cause a failure of the casing / cement barrier. Remedial or repair cement jobs have low success rates and typically must be performed multiple times. Typical cements may not be the best sealant for such repair jobs. New research may develop materials and installation methods that can be adopted by industry and regulators to improve lifetime performance.

***Recommendation:***

DOE should:

- Pursue research to improve well construction that ensures long-term well bore integrity during and beyond the operational life of the well. Laboratory and/or field techniques that simulate long term barrier integrity are important. Research areas may include: sealants/materials, equipment, accessories, installation processes, verification/monitoring, etc.

***Finding: AIR QUALITY***

Emission inventories of reactive hydrocarbons, NO<sub>x</sub>, SO<sub>x</sub>, and radionuclides on site at various shale gas productions sites are highly uncertain. Reactive hydrocarbons, NO<sub>x</sub>, and SO<sub>x</sub> are precursors to ozone, and Particulate Matter (PM)<sup>3</sup>, and air toxics. These emissions react in the atmosphere to form gas phase compounds that may endanger human and ecological health, and PM that affects health, visibility, and climate. Measurement protocols for these species at exploration and production sites have not been established. Consequently, measurements are not taken at fixed times or for fixed periods and without knowledge of the production process. Carefully designed sampling protocols that are tailored to shale gas applications are non-existent. As a result, uncertainties in emissions are large.

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<sup>3</sup> Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, soot or black carbon, metals, and soil or dust particles. EPA regulates particles that are smaller than 10 micrometers and larger than 2.5 micrometers (PM-10) and those that are smaller than 2.5 micrometers (PM-2.5).

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***Recommendation:***

DOE should:

- Pursue research and communication among multiple government agencies and industry that addresses air quality concerns specific to the exploration and production of natural gas from shale deposits and other unconventional resources. Such research may include:
  - Sampling protocols and measurement guidelines
  - State-of-the-art modeling studies to separate the effects of local emission from upwind sources in determining air quality at production sites
  - A study of the benefits and limitations of different emissions reduction strategies
  - Acquire field data and analyze the overall greenhouse gas footprint of the natural gas lifecycle

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***Finding: DETERMINE METRICS AND PROGRAM VALUE***

The Subtitle J research program has significant value that has encouraged exploitation of unconventional fossil fuel resources. In order to make a tangible assessment, quantitative metrics need to be developed and applied. The use of incremental production, or royalties from production on Federal lands, as sole measures of program success, is inadequate. We find that metrics like these are unduly narrow in light of the mandate from DOE for Subtitle J activities to improve the environmental sustainability and safety of exploration and production operations. These metrics do not adequately capture the value of many long term research projects and the educational value of the program.

***Recommendation:***

DOE should:

- Pursue a research project to develop appropriate metrics. The request for proposal could be formulated to attract proposals from the economics or business school communities, or others who have developed quantitative metrics for R&D programs.



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### **3.3 TECHNOLOGY TRANSFER AND OUTREACH PROGRAM FINDINGS AND RECOMMENDATIONS**

#### ***Finding: TECHNOLOGY TRANSFER IS CRITICAL***

Technology transfer associated with the Subtitle J program has been extremely valuable in achieving production, environmental, and safety goals. However, the Subtitle J program is approaching its end date of September 30, 2014. It is important that technology transfer and public outreach regarding the program's research results continue beyond the sunset date.

#### ***Recommendation:***

The DOE should:

- Summarize the results and learnings of each research and development project.
- Continue to disseminate results from the research and development projects.
- Engage in technology transfer that is both passive (using the DOE Knowledge Base Data Management System) and active with continued workshops and symposiums.

#### ***Finding: BROADEN TECHNOLOGY TRANSFER***

For the Subtitle J program to be effective it is necessary that the research be used by the oil and gas industry and the public at large. Often, material was presented to industry groups from the perspective of the researchers without regard to how it might be received. Many producer groups are more interested in learning about applied solutions in the near term rather than basic research and long term applications.

#### ***Recommendation:***

DOE should:

- Widen geographic audience by holding workshops in various regions of the country.
- Select research content to stimulate interest of the intended audience.
- Publicize the workshops and present material in a format that is appropriate to the audience.
- Work with producer groups (such as trade associations, lunch groups, and the Petroleum Technology Transfer Council) when workshops are developed so that it will focus on areas of specific interest to the producing community.
- Expand workshops to better include government, regulatory agencies, and citizen groups to discuss a broad range of topics including environmental and safety concerns.
- Develop a clear message of the value of the project.

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- Showcase the “best of the best” to a larger more public audience. This should be part of a continuing DOE program.

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### 3.4 ENVIRONMENTAL AND SAFETY FINDINGS AND RECOMMENDATIONS

#### ***Finding: SMALL PRODUCER PROGRAM***

Small producers have played a significant role in the development of petroleum resources. However, the cost of meeting Environmental and Safety (E&S) requirements in operations threatens to become a barrier to entry for small producers to develop new resources. This is especially true of the operational cost of developing unconventional resources.

The 2013 Plan states that “the goal of this program is to carry out research, development, and demonstration efforts that will assist small producers in reducing the cost and increasing the efficiency of exploration and production while operating safely and in a manner which does not harm the environment.” The plan recommends that the upcoming solicitation focus on ways to “reduce cost and improve efficiency of well interventions and drilling”.

#### ***Recommendation:***

DOE should:

- Solicit projects that seek to identify Best Management Practices (BMPs) for small producers that can help reduce compliance costs while improving operational E&S performance.
- Solicit projects that will demonstrate technologies to reduce the burden of E&S compliance on small producers without compromising safety including Best Available and Safest Technologies (BAST).

#### ***Finding: SMALL PRODUCERS LACK REGULATORY RESOURCES***

Small producers and other stakeholders lack resources for becoming aware of newly released regulations, and understanding complex regulations. This makes compliance problematic for small producers.

#### ***Recommendation:***

DOE should:

- Provide resources to facilitate real-time understanding of complex and evolving regulatory frameworks.
- Work proactively with relevant agencies.

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***Finding:* UNCONVENTIONAL NATURAL GAS RESOURCES PROGRAM**

Understanding the environmental impacts of upstream oil and gas operations is difficult. Operations differ from play to play and even within plays. Much research to date has suffered from aggregation error which loses the nuances of regional and operational differences. As a result, many reports of environmental impacts are inadequate and/or misleading.

The 2013 Plan addresses E&S issues in unconventional operations through an extensive list of research topics on environmental impacts but does not consider how to systematically quantify impacts based on the unique characteristics of each basin.

***Recommendation:***

DOE should:

- Pursue projects that identify potential E&S impacts and mitigation strategies that recognize regional aspects.
- Include projects that systematically quantify play-specific air and water quality impacts of current operations. Understand the factors leading to the impacts, and develop methods to reduce them.

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## 4.0 COMMITTEE MEMBERS

<u>Title</u>	<u>Last Name</u>	<u>First Name</u>	<u>Employer</u>	<u>City</u>	<u>State</u>
Dr.	Brown	Nancy J.	Lawrence Berkeley National Laboratory	Berkeley	CA
Mr.	Camp	Wayne K.	Anadarko Petroleum Corporation	Woodlands	TX
Ms.	Cavens	Jessica J.	EnCana Oil & Gas (USA)	Denver	CO
Mr.	Daugherty	William S.	BlackRidge Resource Partners LLC	Lexington	KY
Mr.	Dwyer	James P.	Baker Hughes	Houston	TX
Mr.	Hall	J. Chris	Drilling & Production Co.	Torrance	CA
Dr.	Hardage	Bob	University of Texas at Austin	Austin	TX
Mr.	Harju	John A.	Energy & Environmental Research Center	Grand Forks	ND
Mr.	Kleinberg	Robert L.	Schlumberger-Doll Research	Cambridge	MA
Mr..	Lewis	Fletcher S.	Rainmaker Oil & Gas	Oklahoma City	OK
Ms.	Mordick	Briana	Natural Resources Defense Council	Washington,	DC
Dr.	Martin	John P.	JP Martin Energy Strategy, LLC	Saratoga Springs	NY
Mr.	Mason	Gregory	The Energy Cooperative	Newark	OH
Dr.	Mohaghegh	Shahab D.	West Virginia University	Morgantown	WV
Mr.	Nilson	Gary J.	Pioneer Natural Resources USA, Inc,	Irving	TX
Mr.	Oglesby	Kenneth D.	Acorn Resources, Inc.	Tulsa	OK
Mr.	Sparks	Don L.	Discovery Operating, Inc.	Midland	TX

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## **5.0 SUB-GROUP TOPICS AND MEMBER ASSIGNMENTS**

At the September 25th, 2012 meeting in Houston, Texas the following Subgroups and Schedule were established for developing the Subgroup analyses and reports. At the Committee meeting in Houston, Texas on October 24<sup>th</sup> and 25<sup>th</sup> the Subgroup reports were reviewed and incorporated into this final report.

### **Six Sub-Group Areas of Analysis and Member Assignments:**

#### **Policy**

Dwyer (chair), Brown, Daugherty, Hall, Lewis, Mohaghegh, Oglesby, Sparks

#### **Technology Transfer and Public Outreach**

Lewis, (chair), Hall, Daugherty, Dwyer, Mason, Camp

#### **Environmental & Safety**

Martin (chair), Hardage, Harju, Kleinberg, Mordick,

#### **Research and Development**

Brown (chair), Dwyer, Hardage, Kleinberg, Mohaghegh, Nilson, Oglesby, Sparks

#### **Program Review**

Hall (chair), Dwyer, Kleinberg, Nilson

#### **Editing**

Dwyer (chair), Cavens, Hall, Mason

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## **6.0 APPENDIX A: PROGRAM REVIEW SUBCOMMITTEE REPORT**

A sub-committee of the URTAC has attended the RPSEA Unconventional Project Review Meetings as well as some of the workshops given to producers. It was determined that many if not all of the project results are contributing to the efficient and environmentally sound production of unconventional resources.

- The projects span the range of exploration, production, and environmental subjects. The balance of projects reflects the real needs of stakeholders, including small and large producers, service companies, communities, and environmental advocates. The projects are also balanced with respect to short-term versus long-term vision.
- Many of the projects that might be nominally classified as production-oriented also have significant environmental benefits. For example, improvements in drilling and formation stimulation translate directly into reduced environmental impacts (land use, water use, water disposal, etc.). Thus, the present program is substantially in line with the Department of Energy's emphasis on environmental protection.
- Perhaps one of the greatest benefits of the Subtitle J programs is the direct exposure of undergraduate and graduate students to the real needs and capabilities of the oil and gas industry since they are directly involved in many of the projects. It has been widely noted that the workforce that came into the industry in the 1970's and 1980's is now retiring. The vitality of the domestic energy industry requires an infusion of young, well-trained scientists and engineers. Almost all the sponsored projects have a significant educational component, bringing together industry, academic workers, students, resources, and data. We believe these training opportunities alone justify the cost of this program.
- The technical information as presented was very good. The presentations stimulated excellent interaction among those attending in the form of discussions and questions. There was very good interaction between researchers and the producing community.
- The investment is worthwhile to the stakeholders, specifically in the outreach and public dissemination efforts carried out through the Technology Transfer mechanisms.
- Many of the projects are tied to in-field activities and weren't just limited to "laboratory research"; thus, there is good oil and gas producer involvement, which is very important.
- The presentations allowed for excellent collaboration among the many presenters, providing valuable feedback, input and even sharing of materials to facilitate the on-going research efforts.

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- While many of the workshops were excellent, some did not attract the number of producers that should have attended. This is believed to be both the result of how the workshops were described in publicity materials and how the material was presented.
  - The workshops are an essential element of the Technology Transfer component of the program. They are essential in order to reach out to the producing community with valuable information that has resulted from the R&D conducted by the program. This is especially important for small to mid-sized companies who otherwise might not be aware of the information that is being provided.

Recommendations based on the findings of this Subcommittee have been incorporated into recommendations of other portions of this report.