TAPPING AMERICA'S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

FRIDAY, NOVEMBER 30, 2012

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Appendix II: Additional Material for the Record

TAPPING AMERICA'S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT

FRIDAY, NOVEMBER 30, 2012

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 9:34 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Andy Harris [Chairman of the Subcommittee] presiding.

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CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Energy & Environment

Tapping America's Energy Potential Through Research and Development

Friday, November 30, 2012
9:30 a.m. -11:30 a.m.
2318 Rayburn House Office Building

Witnesses

Dr. Anthony Cugini, Director, National Energy Technology Laboratory, Department of Energy

Mr. David Martineau, Chairman, Texas Independent Producers and Royalty Owners Association

Dr. Daniel Hill, Interim Department Head, Professor and Holder of Noble Chair in Petroleum Engineering, Texas A&M University

Mr. Michael Hagood, Director of Program Development, Energy and Environment Science and Technology, Idaho National Laboratory

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Tapping America's Energy Potential Through Research and Development

Friday, November 30, 2012
9:30 a.m. -11:30 a.m.
2318 Rayburn House Office Building

PURPOSE

On Friday, November 30, 2012 at 9:30 a.m. in Room 2318 of the Rayburn House Office Building, the Science, Space, and Technology Subcommittee on Energy and the Environment will hold a hearing titled, "*Tapping America's Energy Potential Through Research and Development.*" The purpose of the hearing is to receive testimony on research needs and priorities relating to unconventional oil and natural gas resources. The Subcommittee will also receive testimony on H.R. 6603, the *"Tapping America's Energy Potential Through Research and Development Act of 2012."*[1]

WITNESS LIST

- **Dr. Anthony Cugini**, Director, National Energy Technology Laboratory, Department of Energy
- **Mr. David Martineau,** Chairman, Texas Independent Producers and Royalty Owners Association
- **Dr. Daniel Hill**, Interim Department Head, Professor and Holder of Noble Chair in Petroleum Engineering, Texas A&M University
- **Mr. Michael Hagood**, Director of Program Development, Energy and Environment Science and Technology, Idaho National Laboratory

BACKGROUND

The United States currently ranks second and third in global natural gas and oil production, respectively.[2] The International Energy Agency (IEA) predicts the U.S. will overtake Saudi Arabia to become the world's largest oil producer by 2020 (Figure 1).[3] Domestic natural gas production is also projected to increase substantially, due to an anticipated 170 percent increase in shale gas production (Figure 2). America's resurgence as a leading global oil and gas producer can be credited in part to the development of specific enabling technologies, particularly the combination of horizontal drilling and hydraulic fracturing.

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[1] See Appendix A for the Section by Section Analysis of the *"Tapping America's Energy Potential Through Research and Development Act of 2012."*
[2] CIA World Factbook. Accessible at: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2249rank.html
[3] International Energy Agency, World Energy Outlook 2012. Accessible at: http://www.worldenergyoutlook.org/

Figure 1. World Oil Production Outlook (source: Wall Street Journal; data from International Energy Agency).[4]

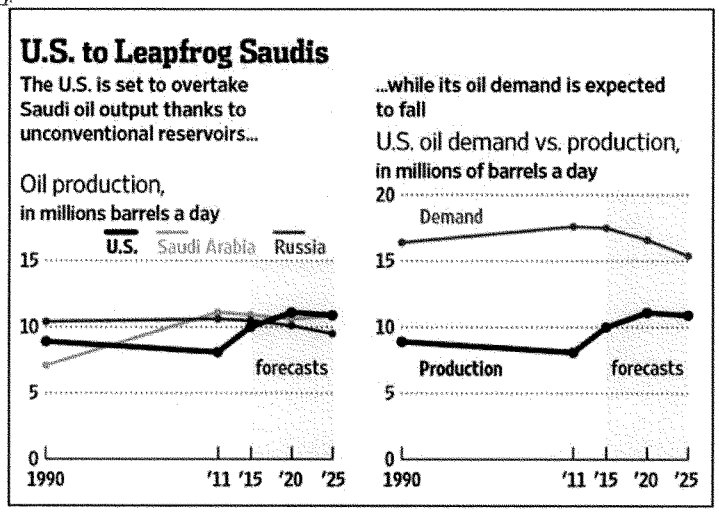
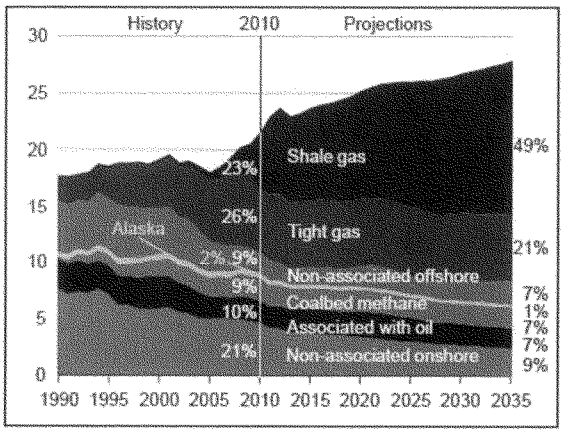


Figure 2. U.S. Natural Gas Production, 1990-2035 (trillion cubic feet).[5]



[4] http://online.wsj.com/article/SB10001424127887323894704578114492856065064.html
[5] http://www.eia.gov/forecasts/aeo/er/pdf/0383er%282012%29.pdf

Historically, conventional deposits have provided most of the oil and natural gas produced in the United States.[6,7] Conventional resources are generally considered to be resources recovered from a reservoir in which oil, natural gas, and water accumulate in a layered arrangement. Thus, unconventional resources can be defined as what they are not; they are those resources that cannot be produced, transported, or refined using traditional techniques. An unconventional deposit is one in which the distribution of oil and gas is throughout a geologic formation over a wide area, rather than within a discrete deposit. This category encompasses heavy oil, oil shale, and oil sands, as well as oil and natural gas produced from shale formations and methane hydrates.

- *Oil shale* refers to geologic deposits in which the petroleum component, kerogen, has not been fully transformed into oil or gas and must be heated to transform it into an upgraded hydrocarbon.

- *Tight oil or oil from shale formations (shale oil)* is produced using a combination of horizontal wells and fracturing to unlock hydrocarbons locked in low permeability and porosity siltstones, sandstones, and carbonates, or shale plays.

- *Shale gas or natural gas from shale formations* refers to natural gas trapped in fine grain sedimentary rock formations characterized by low permeability and porosity.

Department of Energy Unconventional Oil and Gas Programs

The Department of Energy's (DOE) Office of Fossil Energy (FE) manages research, development, and demonstration (RD&D) activities for oil and gas technologies. Specifically, FE's Office of Oil and Natural Gas "supports research and policy options to ensure environmentally sustainable domestic and global supplies of oil and natural gas."[8] The National Energy Technology Laboratory (NETL) serves as the lead FE RD&D facility and manages much of FE's oil and gas technology research.

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[6] Whitney, Gene; Behrens, Carl E.; Glover, Carol. Congressional Research Service, "Us Fossil Fuel Resources: Terminology, Reporting, and Summary." November 30, 2010. Accessible at: Accessible at: http://budget.house.gov/UploadedFiles/CRS_NOVEMBER2010.pdf

[7] For more information on oil and gas resources, see Committee on Science, Space, and Technology Hearing Charter, *"Tapping America's Unconventional Oil Resources for Job Creation and Affordable Domestic Energy: Technology and Policy Pathways,"* April 17, 2012, accessible at: http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/HHRG-112-SY-20120417-SD001.pdf and Subcommittee on Energy and Environment Hearing Charter, *"Supporting American Jobs and the Economy Through Expanded Energy Production: Challenges and Opportunities of Unconventional Resources Technology,"* May 10, 2012, accessible at: http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/HHRG-112-%20SY20-20120510-SD001.pdf

[8] U.S. Department of Energy, Office of Oil & Natural Gas, updated May 7, 2012. Accessible at: http://www.fossil.energy.gov/programs/oilgas/index.html

Table 1. Department of Energy Unconventional Oil and Gas Funding (dollars in millions).

Program	FY 2012 Enacted	FY 2013 Request	H.R. 5325, the "Energy and Water Development and Related Agencies Appropriations Act, 2013."	S. 2465, "Energy and Water Development and Related Agencies Appropriations Act, 2013."
Unconventional FE Technologies From Petroleum – Oil Technologies	$5.0	$0	$0*	$5.0
Natural Gas Technologies	$5.0	$12.0	$10.0**	$12.0**
Gas Hydrates	$10.0	$5.0	$5.0	$10.0

*House Appropriations committee mark recommended $25 million "to be used to support both research to improve the economics of oil productions from shale oil, as well as to reduce the health, safety, and environmental risks associated with shale oil extraction"[9] By a vote of 208-207, the funding was removed during floor consideration.[10]

** Funding to support DOE/EPA/USGS Interagency Collaboration. See "Interagency Effort on Shale Development."

Federal Unconventional Oil Research and Development Activities and Legislative History

Efforts to economically produce various sources of unconventional oil and gas were undertaken throughout much of the last century.[11] Recently, significant technology advances and high crude oil prices have regenerated interest in unconventional fuels production. The development of horizontal drilling permitted the use of hydraulic fracturing to economically produce shale oil and gas. Shale oil production enabled the development of the Bakken fields in North Dakota. North Dakota is now the second largest oil producing state, producing over 674,066 bpd, up from 45,000 bpd in 2007.[12]

[9] House Appropriations Committee Report, "Energy and Water Development Appropriations Committee Report, FY 2013." P. 97. Accessible at: http://appropriations.house.gov/UploadedFiles/EW-FY13-FULLCOMMITTEEREPORT.pdf

[10] Roll no. 340 on House Amendment 1186

[11] INTEK, Inc., Prepared for the US Department of Energy, Office of Petroleum Reserves, "*Oil Shale Research in the United States: Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies,*" Third Edition, September 2011. Accessible at: http://www.unconventionalfuels.org/publications/reports/Research_Project_Profiles_Book2011.pdf

[12] North Dakota Petroleum Council, *North Dakota Oil and Gas Industry Facts and Figures*, September 17, 2012. Accessible at: http://www.ndoil.org/image/cache/Facts_and_Figures_2012_9.17.pdf

Energy Policy Act of 1992

Section 2012 of the Energy Policy Act of 1992 (EPACT '92) established a five year program to support research and development of oil shale extraction and conversion.[13] The program intended to support the development of economically competitive and environmentally acceptable technologies to produce oil shale in both the eastern and western oil shales. Section 2013 of EPACT '92 also created a five year program to increase the recoverable natural gas resource base through more intensive recovery of conventional natural gas, as well as the extraction of natural gas from tight gas sands, Devonian shales, or other unconventional resources.[14]

Energy Policy Act of 2005

Section 369 of the Energy Policy Act of 2005 (EPACT '05) also contained provisions to facilitate the development of unconventional fuels.[15] For example, EPACT '05 directed the Bureau of Land Management (BLM) to begin leasing Federal lands for the purpose of oil shale and tar sands research and development (R&D) activities. The first round of research, development, and demonstration leases were awarded in 2006. A second round of leases were offered in 2009, resulting in two awards.

Recent Federal Oil Shale-Related Activities

Section 369 of EPACT '05 declared oil shale and other unconventional resources as strategically important domestic energy resources that should be developed to mitigate the nation's dependence on foreign sources of oil and directed the Secretary of Interior to develop a commercial leasing program for these resources. Accordingly, in 2008, BLM formulated the Final Oil Shale and Tar Sands Programmatic Environmental Impact Statement (PEIS).[16] The final PEIS analyzed the environmental and socioeconomic impacts of amending 12 land use plans in Colorado, Utah, and Wyoming to designate public lands administered by BLM as available for commercial leasing and development.

In response to a 2009 lawsuit challenging the PEIS, BLM re-examined the land allocations, stating it would "reassess the appropriate mix of allowable uses with respect to oil shale and tar sands leasing and potential development in light of Congress's policy emphasis on these resources."[17] Following this review, BLM released a revised PEIS, which makes approximately 677,000 acres available for commercial oil shale leasing, and emphasizes R&D activities before the leases can be utilized for commercial development.[18] This new proposal amends ten BLM

[13] P.L. 102-486
[14] Ibid.
[15] P.L. 109-58
[16] See Department of Energy, "Oil Shale and Tar Sands Programmatic EIS Information Center." Accessible at: http://ostseis.anl.gov/
[17] 2012 Final Oil Shale and Tar Sands Programmatic Environmental Impact Statement: Introduction. Accessible at: http://ostseis.anl.gov/documents/peis2012/chp/OSTS_Chapter_1.pdf
[18] Ibid.

resource management plans, and represents a signification reduction from the 2008 plan, which made available more than 2 million acres for commercial oil shale leasing.[19]

Recent Federal Shale Oil and Gas Efforts

On April 13, 2012, President Obama issued an executive order establishing a "high-level, interagency working group to facilitate coordinated Administration policy efforts to support safe and responsible unconventional natural gas development."[20] As outlined in the order, the interagency working group includes representatives from nine different agencies and four offices of the White House, and will work to support the safe and responsible production of domestic unconventional natural gas.

The group is tasked with coordinating agency policy activities and sharing scientific, environmental, and related technical and economic information. The group is also to engage in long-term planning and coordination among the appropriate Federal entities with respect to research, resource assessment, and infrastructure developments, and is required to consult with other agencies and offices as appropriate.

Multi-Agency Collaboration on Unconventional Oil and Gas Research

To execute the Executive Order, the Environmental Protection Agency, Department of Interior and DOE signed a Memorandum of Understanding (MOU) in which they pledge to develop a multi-agency program directed toward a focused, collaborative interagency effort to address high priority challenges associated with unconventional shale gas and tight oil resources.[21] The stated goal of this effort is to:

> "address timely, policy relevant science directed to research topics where collaboration among the three Agencies can be most effectively and efficiently conducted to provide results and technologies that support sound policy decisions by state and federal agencies responsible for ensuring the prudent development of energy sources while protecting human health and the environment."[22]

The interagency program is also to address and respond to the White House's 2011 "Blueprint for a Secure Energy Future" and recommendations made by the Secretary of Energy Advisory Board Subcommittee on Natural Gas.[23]

The agencies will identify research priorities and collaborate to sponsor work that improves understanding of the impacts related to development of our unconventional resources. The collaboration is intended to focus each Agency on its area of core competency, foster collaboration on research topics as appropriate, and bring coordination and consistency to the

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[19] Taylor, Phil, Oil Shale: Cheers, jeers for final Interior plan for Colo., Wyo., and Utah. E&E News PM. November 9, 2012. Accessible at: http://www.eenews.net/eenewspm/2012/11/09/2

[20] President Barack Obama, "Executive Order—Supporting Safe and Responsible Development of Unconventional Domestic Natural Gas Resources," April 13, 2012. Accessible at: http://www.whitehouse.gov/the-press-office/2012/04/13/executive-order-supporting-safe-and-responsible-development-unconvention

[21] See Appendix B for the Memorandum of Understanding.

[22] Memorandum of Understanding, DOE, DOI, EPA, April 13, 2012. Accessible at: http://www.epa.gov/hydraulicfracture/oil_and_gas_research_mou.pdf

[23] Ibid.

annual budget process. The three agencies have established a steering committee and are currently in the process of formalizing a research plan, which is anticipated to be published in January of 2013.

The Administration requested $12 million annually for three years for DOE's portion of the Interagency collaboration. The House Committee on Appropriations provided $10 million in the Fiscal Year (FY) 2013 Energy and Water Appropriations bill to fund DOE's portion of the collaboration and the Senate Committee on Appropriations provided $12 million in the FY 13 Energy and Water Appropriations bill.

APPENDIX A

Section-by-Section Analysis

H.R. 6603 *"Tapping America's Potential Through Research and Development Act of 2012"*

Purpose: To authorize research, development, and demonstration activities that increase energy security and affordability be enabling the safe and responsible production of the United States vast domestic unconventional oil and gas resources.

Section 1: Short Title

The Tapping America's Energy Potential Through Research and Development Act of 2012.

Section 2: Activities

This section expresses the purpose of the activities authorized in the legislation.

Section 3: Oil Shale Research and Development Activities

Section 3(a) authorizes research, development, and demonstration (RD&D) activities to facilitate commercial application of energy technologies related to the exploration, development, and production of oil shale resources.

Section 3(b) states that RD&D objectives are to address scientific and technological barriers to enable economically feasible production of oil shale and minimize potential associated environmental impacts.

Section 3(c) directs the Secretary of Energy to provide Congress an implementation plan that details constraints and opportunities affecting oil shale development, identifies strategies to enable such development, and identifies and prioritizes research, development and demonstration activities and requires the Secretary to transmit this report to the House Committee on Science, Space, and Technology, and the Senate Committee on Energy and Natural Resources 9 months after enactment.

Section 3(d) allows the Assistant Secretary for Fossil Energy to conduct research and directs the Assistant Secretary to make awards to eligible entities for RD&D activities in areas that include (1) oil shale resource characterization; (2) modeling and simulation of oil shale exploration and production technologies including advanced diagnostics and imaging systems and advanced computing applied to the physics and chemistry of oil shale production; (3) minimization and re-use of water, including benchmarking of current water use rates for multiple production methods, potential reduction in water volume needed for operations, and recovery utilization, reduction, and improved management of produced water from exploration and production activities; (4) efficient use of energy in exploration and production activities; (5) utilization and exploration and production methods and materials that reduce the potential impact of such activities on the environment, including improved production methods for in-situ mining and ex-situ mining.

Section 3(e) requires the Secretary of Energy to provide Congress a report on the progress of oil shale research and development activities to the House Committee on Science, Space, and Technology and Senate Committee on Energy and Natural Resources 3 years after enactment.

Section 3(f) authorizes $10,000,000 is authorized for each fiscal year from 2013 through 2017 for activities described in this Section.

Section 4: Shale Gas Extraction Research and Development Activities

Section 4(a) authorizes RD&D activities to facilitate commercial application of energy technologies related to the exploration, development, and production of oil, natural gas, and other liquid resources from shale formations.

Section 4(b) states that RD&D objectives are to maximize the benefits of the United States' shale oil and natural gas resources by advancing safe and responsible exploration, development, and production of shale oil and gas resources; minimize surface impacts from activities related to shale oil and natural gas production; focus on areas that provide benefits to the public and to industry; and advance the scientific and technological foundation available to producers, federal and state government agencies, and other stakeholders in identified research areas.

Section 4(c) allows the Assistant Secretary for Fossil Energy to conduct research and directs the Assistant Secretary to make awards to eligible entities for RD&D activities in areas that include (1) water use and demand, which may include potential reduction in the volume of water utilized for shale oil and natural gas production, and alternative materials, substances, or ingredients for use in shale oil and natural gas operations that could mitigate the need for or volume of water used; (2) water sourcing, which may include expanding options for sources of water used in shale oil and natural gas operations, and alternatives to groundwater or freshwater, such as but not limited to water recovered from other industrial or agricultural operations, brackish water, or surface water unsuitable for human or agricultural use in areas with water supply concerns; (3) materials used in shale oil and natural gas operations which may include increasing the efficiency of these operations by minimizing fluid use, improving the understanding of the relationship between additives used in fracturing and the chemical and physical properties of different shale formations, and enhancing permeability through improved proppants and other materials; and (4) diagnostic imaging and monitoring, which may include increasing understanding of the propagation of fractures within target zones, and advancing fundamental technologies that enable improved tracking and enhanced understanding of fracture movements.

Section 4(d) authorizes $12,000,000 for each fiscal year from 2013 through 2015 for the activities described in this Section.

Section 5: Produced Water Utilization Research and Development Activities

Section 5(a) authorizes RD&D activities for environmentally sustainable utilization of produced water for agricultural, irrigational, recreational, power generation, municipal, and industrial uses, or other environmental sustainable resources.

Section 5(b) allows the Assistant Secretary for Fossil Energy to conduct research and directs the Assistant Secretary to make awards for RD&D activities, including improving safety and minimizing environmental impacts of activities, in areas that include (1) produced water recovery, including research for desalination and demineralization to reduce total dissolved solids in the produced water; (2) produced water utilization for agricultural, irrigational, municipal, and industrial uses, or other environmentally sustainable purposes; and (3) Re-injection of produced water into subsurface geological formations to increase energy production.

Section 5(c) authorizes $5,000,000 for each fiscal year 2013 through 2017 for activities described in this Section

Section 6: Eligible Entities

Section 6 specifies entities eligible to receive funding for activities authorized by the bill. Those entities include an institution of higher education, a national laboratory, a private sector entity, a nonprofit organization, or a consortium thereof.

Section 7: Program Administration

Section 7 provides authority to the Secretary of Energy to enter into an agreement with a consortium to carry out research, development, and demonstration activities.

Section 8: Coordination

Section 8 requires the Secretary of Energy to coordinate with, and avoid duplication of, research, development, and demonstration activities with other DOE and Government programs.

Section 9: Cost Sharing

Section 9 requires all activities funded through the legislation follows cost sharing guidelines established by Section 988 of the Energy Policy Act of 2005.

Section 10: Limitations

Section 10(a) prohibits the Department of Energy from funding research, development, and demonstration activities in technology areas that industry by itself is not likely to undertake because of technical and financial uncertainty.

Section 10(b) prohibits any activities funded through the legislation from supporting the establishment of regulatory standards or requirements.

Section 11: Definitions

Section 11 provides definitions, including: Assistant Secretary, Institution of Higher Education, National Laboratory, Oil Shale, Produced Water, Secretary, and Shale Oil and Natural Gas.

MEMORANDUM

APR 13 2012

TO: Assistant Secretaries, National Laboratories
Department of Energy

Assistant Secretaries, Bureau Directors
Department of the Interior

Assistant Administrators, Regional Administrators
Environmental Protection Agency

FROM: Arun Majumdar, Acting Under Secretary of Energy
Department of Energy

David J. Hayes, Deputy Secretary
Department of the Interior

Bob Perciasepe, Deputy Administrator
Environmental Protection Agency

SUBJECT: Multi-Agency Collaboration on Unconventional Oil and Gas Research

OVERVIEW: In March 2011, the White House released a "Blueprint for a Secure Energy Future" (Blueprint) - a comprehensive plan to reduce America's oil dependence, save consumers money, and make our country the leader in clean energy industries. The Blueprint supports the responsible development of the Nation's oil and natural gas, with the specific goals of promoting safe practices and reducing energy imports. The Department of Energy (DOE), the Department of the Interior (DOI), and the Environmental Protection Agency (EPA) each will have a critical role to play in this mission.[1]

To this end, the DOE, DOI, and EPA will develop a multi-agency program directed toward a focused collaborative Federal interagency effort to address the highest priority challenges associated with safely and prudently developing unconventional shale gas and tight oil resources. The goal of this program will focus on timely, policy relevant science directed to research topics where collaboration among the three Agencies can be most effectively and efficiently conducted to provide results and technologies that support sound policy decisions by state and Federal agencies responsible for ensuring the prudent development of energy sources while protecting human health and the environment. This program responds to the Blueprint and to relevant recommendations of the Secretary of Energy Advisory Board Subcommittee on Natural Gas.[2]

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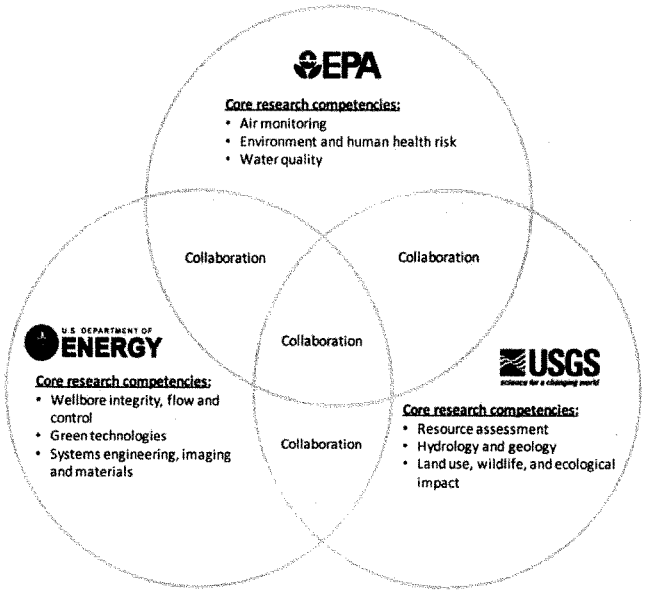
[1] The 31 March 2011 *White House Blueprint for a Secure Energy Future* instructed the Federal Government to "conduct research to examine the impacts of fracking on water resources," directing the EPA and DOE to sponsor research ..."

[2] The Secretary of Energy Advisory Board recommended that "the federal government has a role especially in basic R&D, environment protection, and safety" and recommends that the DOE, DOI and EPA "all have mission responsibility that justify a continuing, tailored, Federal R&D effort." http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf

Interagency Collaboration

The DOE, DOI, and EPA will identify research priorities and collaborate to sponsor research that improves our understanding of the impacts of developing our Nation's unconventional oil and gas resources and ensure the safe and prudent development of these resources. Through enhanced cooperation, the Agencies will maximize the quality and relevance of this research, enhance synergies between the Agencies' areas of expertise, and eliminate redundancy. The Agencies remain responsible for implementing their own authorities and internal priority-setting processes.
The goals of this interagency collaboration are as follows:

1. Focus each Agency on its area of core competency. Each Agency has a different combination of experiences, research strengths, personnel, resources, and mission mandates leading to complementary research core competencies.



The Venn diagram summarizes the core research competencies of each of the three Agencies. Further details can be found in the appendix to this memorandum.

2. Collaborate on research topics as appropriate. While each Agency will focus on its areas of core research competency, there will be tasks for which the combined capabilities of more than one Agency will be necessary to address a particular research topic.

An example of collaboration is research on water use for hydraulic fracturing, in which the EPA focuses on the impacts and effectiveness of current technology, DOE focuses on improvements that future technological innovations may yield, and USGS focuses on stream gage and groundwater monitoring to determine water availability, use, and groundwater flow modeling. Another example is the ongoing prospective case study in the Marcellus Shale that the three Agencies are currently collaborating on in support of the EPA's congressionally mandated study on hydraulic fracturing. Where practical and advisable, efforts will be made among the Agencies to apply common and/or consistent monitoring, sampling, and analytical protocols. These and other topic areas are represented by the green areas in the Venn diagram and will be further defined in the research plan discussed in the section below.

3. Bring coordination and consistency to the annual budget process. Effective research requires a sustained, well-planned effort. The three Agencies will work to ensure that the annual budget process is part of a coordinated multi-year effort with targeted results.

Forming the Partnership

The three Agencies will take the following steps:

Interagency management structure: The three Agencies will create a Steering Committee to coordinate the Agencies' activities for unconventional oil and gas research. Each Agency will contribute two members to the Steering Committee: one member focused on policy and one member focused on research and technology. The Office of Science and Technology Policy (OSTP) will also provide a member to serve on the Steering Committee. The lead agency of the Steering Committee will rotate annually among the three Agencies in alphabetical order: DOE, DOI, EPA. The Steering Committee will provide leadership, coordinate the activities of the three participating Agencies, and reach out to other relevant Federal, state and local organizations.

Formalizing a research plan: Within 9 months of formation, the Steering Committee will publish a formal multi-year Research Plan that will:

a. analyze and synthesize the state of knowledge of unconventional oil and gas research to assist in identifying and prioritizing new research directions;

b. identify, categorize, and prioritize research topics relevant to the safety and environmental sustainability of unconventional oil and natural gas exploration and production;

c. identify gaps in available data and appropriate activities to address these topics;

d. identify research milestones and deliverables;

e. describe steps to promote transparency and maximize stakeholder participation and notification;

f. establish specific mechanisms for cooperative relationships among the three member Agencies in planning and conducting research and reviewing the results; and

g. determine future plans, goals and objectives.

Within 6 months of formation the Steering Committee will have a draft of the research plan prepared for public comment.

As part of establishing the research plan, the Steering Committee will solicit comments from the scientific community, public and relevant stakeholders and will hold periodic workshops for this purpose, as appropriate.

Ongoing collaboration: The Steering Committee, augmented by appropriate staff, will meet on a quarterly basis to discuss research efforts being conducted under the research plan, track key milestones, identify and address any implementation challenges, and ensure that work in the priority areas is carried out efficiently and effectively.

Initial engagement: The Steering Committee will hold its inaugural meeting within one month of the effective date of this memorandum. In this meeting, the three member Agencies will nominate members to serve on the Steering Committee, and will further refine as necessary the steps outlined in this memorandum.

Progress Report: The three Agencies will issue an annual public progress report in conjunction with the budget process providing an update on the status of research under way in the previous year, including significant findings, progress toward milestones set forth in the research plan, and any changes in research direction or focus planned for the following year.

Appendix: Agency Roles and Core Competencies

- Department of Energy

  The DOE has research experience and capabilities in wellbore integrity, flow and control; green technologies; and complex systems, imaging, materials, earth science and engineering. Practices employed by companies engaging in exploration and production of shale gas evolve rapidly. An understanding of these technologies and practices is critical if the Federal Government is to accurately quantify the risks of these activities.

  Wellbore integrity, flow and control: The DOE capabilities in this area include experience and expertise in quantifying, evaluating, and mitigating potential risks resulting from the production and development of the shale gas resources, to include multi-phase flow in wells and reservoirs, well control, casing, cementing, drilling fluids, and abandonment operations associated with drilling, completion, stimulation and production operations. The DOE has experience in evaluating seal-integrity and wellbore-integrity characteristics in the context of protection of groundwater.

  Green technologies: The DOE has experience and expertise in the development of a wide range of new technologies and processes, to include innovations which reduce the environmental impact of exploration and production such as greener chemicals or additives used in shale gas development, flowback water treatment processes and water filtration technologies. Data from these research activities assists regulatory agencies in making a science-based cost-benefit analysis of requiring producers to adopt new technologies to mitigate environmental risks.

  Systems engineering, imaging and materials: The DOE specializes in the development of complex, engineered systems, high-speed computing and predictive modeling, and has experience in quantifying and mitigating low-frequency, high-impact risks. This includes evaluating human factors which potentially contribute to failures. The DOE has developed and evaluated novel imaging technologies for areal magnetic surveys for the detection of unmarked abandoned wells, and for detecting and measuring fugitive methane emissions from exploration, production, and transportation facilities. The DOE also has experience in understanding of fundamental interactions caused during the drilling process, such as the equation of state research that investigates the relationship between pressure, temperature, and viscosity of multi-phase fluids at the high temperatures and pressures associated with deep drilling and hydraulic fracturing. The DOE's experience in engineered underground containment systems for CO2 storage brings capabilities that are relevant to the challenges of safe shale gas production, such as evaluating cement-casing integrity in corrosive environment to characterize long-term wellbore integrity for CO2 sequestration.

- Department of the Interior:

  The United States Geological Survey (USGS) has research experience and capabilities in resource assessments; natural systems, geology, hydrology; and evaluation of effects on land use, wildlife and ecological systems.

  Resource Assessment: The USGS conducts research and assessments of the undiscovered, technically recoverable oil and gas resources of the United States (exclusive of the Federal Outer Continental Shelf). The USGS assessments use a geology-based assessment methodology that characterizes the total petroleum system considering source rock richness, petrophysical properties, thermal maturation, petroleum generation, migration, and reservoir rock as important factors in evaluating the hydrocarbon accumulation. Assessments incorporate uncertainty, are fully risked, and are reported as statistical estimates of gas, oil, and natural hydrocarbon liquids content. They support analyses to determine those resources that are economically recoverable. These assessments play an important role in Federal policymaking and land management and also support decision making at tribal, state and local levels.

  Geology and Hydrology: Understanding the stratigraphy, physical trapping mechanisms, petroleum geochemistry, and stress conditions of unconventional basin gas and oil-bearing formations is critical to determining local and regional variations in gas and oil abundance, composition, and quality that identify rock formation targets and guide operational plans for drilling and hydrofracturing, and for understanding and forecasting the composition of produced waters. The USGS expertise in earthquake seismology, geothermal systems, and geologic carbon sequestration is appropriate for induced seismicity evaluation. Down hole rock composition, native and flowback fluid composition, borehole temperature and pressure, and in situ stress levels are used to generate groundwater flow models and geochemical models that provide estimates of solute transport and rates and the potential fate of injected waters and their constituents. The USGS operates more than 7,700 of the Nation's surface water streamgages and groundwater monitoring wells each of which provide data critical for assessing and modeling water availability and water quality important to understanding water use, contaminant occurrences, flood hazards, and ecological flows. Cooperative agreements with state and local agencies provide additional data. Water quantity and quality are potentially affected by energy production activities. The USGS maintains an extensive, nationwide water monitoring capability and conducts assessments of surface and groundwater availability throughout the Nation, including both fresh and brackish groundwater resources.

  Land Use, Wildlife, and Ecologic Impact: The USGS has diverse capabilities to evaluate potential impacts to biological resources and the water resources available to sustain them due to activities associated with shale gas and tight oil production. Landscape scale research is important to quantifying the response of key species and habitats to land disturbance, contaminants, and other potential impacts resulting from development of shale gas and tight oil resources and to develop best management practices to mitigate impacts. Remotely sensed airborne imagery is used to assess forest fragmentation and effects of shale gas activities on land use patterns, wetlands, and migratory bird populations. The USGS also assesses the effects of habitat change on key aquatic species including endangered species affected by hydrocarbon production.

- Environmental Protection Agency:

  The EPA has research experience and capabilities across a wide range of scientific and technical disciplines that support the Agency's mission of protecting human health and safeguarding the environment. This includes core competencies in the areas of environmental and human health risk assessment, air quality, and water quality. The EPA has the unique ability to conduct research that spans the characterization of sources and emissions, to pollutant fate and transport, to ecosystem and human exposures, health effects and risk assessment, and to the prevention and management of environmental risks.

  Environmental and Human Health Risk: The EPA has extensive capabilities to characterize the effects of contaminants and environmental stressors on ecosystem integrity and human health for air and water contaminants and mixtures associated with gas extraction practices. Ecological research capabilities that support risk assessments focus on evaluating potential physical, chemical, and biological changes to ecosystems, disruptions of ecological flows in headwater rivers, and impacts on terrestrial wildlife, stream macrobenthos, and fish. The Agency also has the expertise to evaluate landscape pattern changes in terms of available habitat and changes in vulnerability for rare or unique ecosystems. The EPA research capabilities that support human health risk assessments include conducting field measurements and other types of studies to characterize exposures, performing laboratory and computational toxicology studies for hazard identification and dose response assessments, and developing and applying risk assessment methods to evaluate human health risks posed by environmental contaminants.

  Air Quality: The EPA possesses expertise in the measurement and modeling of air pollutants from sources related to all phases of gas extraction, processing, storage, and distribution. This includes using mobile and fixed air monitoring systems to estimate local, regional, and national exposures to air pollutants.

  Water Quality: Groundwater protection research capabilities at the EPA include quantifying the effects of exploration and production activities on ground water quantity and quality, conducting subsurface hydrogeological and geochemical modeling, evaluating well integrity issues, and assessing the potential for releases to groundwater from wells or surface impoundments during drilling, completion, operation or post closure.

Chairman HARRIS. The Subcommittee on Energy and Environment will come to order.

Good morning, everyone. Welcome to today's hearing entitled "Tapping America's Energy Potential through Research and Development." In front of you are packets containing the written testimony, biographies and Truth in Testimony disclosures for today's witness panel. I now recognize myself for five minutes for an opening statement.

Let me begin by noting that this is expected to be the last Energy and Environment Subcommittee hearing of this Congress. I would like to thank Ranking Member Miller and the members of the Subcommittee for working together to consider and address issues of great importance to the future of our country.

As we have highlighted throughout this Congress, the United States has a wealth of untapped unconventional energy resources. In fact, the International Energy Agency recently predicted the United States will overtake Saudi Arabia to become the world's largest oil producer by 2020, largely due to the potential for development of U.S. unconventional energy resources. The significant positive economic benefits associated with development of unconventional energy resources are widely acknowledged. Tapping America's unconventional oil and gas resources will additionally provide sorely needed stimulation of our economy, restore our manufacturing sector and create high-paying middle-class jobs. Citigroup predicts the cumulative impact of new oil and gas production could create as many as 3.6 million new jobs by 2020. Unfortunately, the degree to which the United States will pursue and realize these much-needed benefits remains in doubt, primarily due to politics.

Under Chairman Hall's leadership, the Science, Space, and Technology Committee and this Subcommittee in particular have explored a broad range of energy production-related issues, from the lack of transparency and weak scientific foundations underlying EPA's job-killing regulations to the waste and imbalance in Department of Energy's research and development activities. Unfortunately, time and again, a massive disconnect between the President's words and his Administration's actions are evident. While President Obama continues to claim he supports an all-of-the-above energy strategy, the plain facts tell a different story. This was clearly illustrated in May when DOE's Assistant Secretary for Fossil Energy testified to this Subcommittee that oil shale was a component of the Administration's all-of-the-above energy strategy. Yet when pressed, he acknowledged that DOE was not spending any funding on oil shale R&D, and could not identify anything the Administration was doing to actively advance oil shale. In fact, despite the President's prominent call for an all-of-the-above energy strategy in this year's State of the Union speech, just recently the Administration finalized a plan effectively reducing lands available for oil shale production by two-thirds.

Unfortunately, the Administration's rhetoric on energy production is similarly empty when it comes to shale gas and hydraulic fracturing, where the EPA is leading 13 federal agencies and offices in pursuit of new ways to regulate this incredibly beneficial and safe technology.

Chairman Hall's legislation, the "Tapping America's Energy Potential Through Research and Development Act of 2012," addresses the obvious imbalance in DOE research priorities. It restores a true all-of-the-above R&D focus at DOE through authorization of limited and targeted research and development activities that develop key technologies relating to oil shale, shale oil and gas, and produced water utilization.

[The prepared statement of Mr. Harris follows:]

PREPARED STATEMENT OF SUBCOMMITTEE CHAIRMAN ANDY HARRIS

Good morning and welcome to this morning's hearing entitled *Tapping America's Energy Potential Through Research and Development.*

Let me begin by noting that this is expected to be the last Energy and Environment Subcommittee hearing of this Congress. I would like to thank Ranking Member Miller and the Members of the Subcommittee for working together to consider and address issues of great importance to the future of our country.

As we have highlighted throughout this Congress, the United States has a wealth of untapped unconventional energy resources. The International Energy Agency recently predicted the U.S. will overtake Saudi Arabia to become the world's largest oil producer by 2020, largely due to the potential for development of U.S. unconventional energy resources. The significant positive economic benefits associated with development of unconventional energy resources are widely acknowledged. Tapping America's unconventional oil and gas resources will additionally provide sorely needed stimulation of our economy, restore our manufacturing sector and create high-paying middle class jobs. Citigroup predicts the cumulative impact of new oil and gas production could create as many as 3.6 million new jobs by 2020. Unfortunately, the degree to which the U.S. will pursue and realize these benefits remains in doubt, primarily due to politics.

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Chairman HARRIS. At this time I would like to yield to the Chairman of the Science, Space, and Technology Committee for three minutes for him to describe his legislation. Chairman Hall.

Chairman HALL. Mr. Chairman, I thank you very much, and you have done a very good job of your opening statement. You just about said it all. I say to you good morning, and I thank you for yielding the time you have given me.

I want to thank the witnesses for being here to talk about an issue that is very important to me and to all of us, and in particular, I would like to recognize and thank Dr. Daniel Hill, the Chair of Texas A&M Petroleum Engineering Department, and I had a good visit with your president two Saturdays ago, I think, when they created Johnny Football down there and we are waiting to see what they do with it, and Dr. Martineau, the Chairman of the Texas Independent Producers and Royalty Owners Association, TIPRO, a great organization that I am very familiar with, and I think that you started out with Frank and Shelby Pitts and they are still with the Pitts organization. Is that correct?

Mr. MARTINEAU. Yes.

Chairman HALL. How many?

Mr. MARTINEAU. Forty years.

Chairman HALL. Well, you are probably getting old to do things like that.

But energy policy is and has always been one of my very top priorities, both as a Member, and as Chairman of this Committee. I believe strongly that for young people today, the importance of energy and how important energy is and the fact that nations including our Nation will fight for energy if we don't have energy and we shouldn't have to because we have plenty, and I am very hopeful for this next two years that we can use what we have and be users of our own and salespeople of some will have in addition if we just do what we ought to do like all of the above. A lot of people talk all of the above and do none of the above, and that is what our problem is. I think after "prayer", "energy" is probably the most important word in the dictionary to youngsters that are graduating from high school, grade school or college. It is the foundation upon which our Nation has prospered, and the key to our quality of life and standard of living.

That is why I introduced H.R. 6603, which would increase energy security through support for research and development to enable prudent development of U.S. domestic energy resources. The legislation builds on the record of the Science, Space, and Technology Committee during our tenure here this last two years.

The United States is blessed with a wealth of unconventional energy resources and we are currently experiencing a revolution in oil and gas production thanks to those resources. This increased production is not only increasing our energy security, it is stimulating our economy and creating much-needed jobs. In 2010, unconventional natural gas development alone supported over a million jobs in this country, and this number is expected and could more than double by 2035.

This bipartisan legislation promotes the development of oil shale instead of restricting it, and ensures that we maximize the benefits of our unconventional oil and gas resources. The bill directs the Department of Energy to undertake R&D activities to address the scientific and technological barriers to oil shale development. It also supports R&D to minimize water use and maximize efficiency in shale oil and gas operations. The legislation includes language from the Produced Water Utilization Act, a bill I sponsored and others that was sponsored in the 111th Congress and passed through the House with unanimous consent.

In 2005, we worked together on and I authored Section 999 of the Energy Policy Act, which created a very successful Department of Energy unconventional oil and gas research and development program. The bill before us today is intended to complement the ongoing 999 program, which is a program that we knew energy was there in the Gulf but we couldn't get it up, couldn't get it to the top. We needed technology to get it to the top. We traded with a lot of universities. They would give us the technology, and we would pay them with the energy they got to the top. If we didn't get their technology, it didn't go to the top. If we did get their technology, it did, and it has worked very well. They take shots at it every year but it is so valuable that I am hoping—it is currently set to expire in 2014 and I hope they are going to continue it beyond that, and I think they will, as well as provide direction for the DOE oil shale R&D activities and the Administration's proposal for an interagency R&D collaboration on unconventional energy resources. The only thing that can stop this amazing story from continuing is politics, specifically, the Environmental Protection Agency's thinly veiled campaign to restrict access to these resources.

In closing, I will just say the bill I am introducing today will help to provide a check against EPA's war on energy by addressing environmental challenges through technological solutions instead of job-killing regulations.

I would like to ask unanimous consent to enter into the record a letter from the American Geosciences Institute in support of H.R. 6603, and I look forward to hearing from our witnesses today, and I yield back, and Mr. Chairman, I ask unanimous consent to enter into the record that letter.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF COMMITTEE CHAIRMAN RALPH M. HALL

Good morning and thank you Chairman Harris for yielding me time. I want to thank the witnesses for being here to talk about an issue that is very important to me. In particular, I would like to recognize and thank Dr. Daniel Hill, the Chair of Texas A&M Petroleum Engineering Department, and Mr. David Martineau, the Chairman of the Texas Independent Producers and Royalty Owners Association (TIPRO).

Energy policy is and has always been one of my top priorities, both as a Member, and as Chairman of this Committee. I believe strongly that, after prayer, energy is the most important word in the dictionary. It is the foundation upon which our nation has prospered, and the key to our quality of life and standard of living.

That is why I introduced H.R. 6603, which would increase energy security through support for research and development to enable prudent development of U.S. domestic energy resources. This legislation builds on the record of the Science, Space, and Technology Committee during my tenure as Chairman.

The U.S. is blessed with a wealth of unconventional energy resources and we are currently experiencing a revolution in oil and gas production thanks to those resources. This increased production is not only increasing our energy security, it is stimulating our economy and creating much needed jobs. In 2010, unconventional natural gas development alone supported over a million jobs in this country, and this number is expected to more than double by 2035.

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In 2005, I helped author Section 999 of the Energy Policy Act, which created a very successful Department of Energy unconventional oil and gas research and development program. The bill before us today is intended to complement the ongoing 999 program-which is currently set to expire in 2014 but I hope will continue beyond that-, as well as provide direction for the DOE oil shale R&D activities and the Administration's proposal for an interagency R&D collaboration on unconventional energy resources.

The only thing that can stop this amazing story from continuing is politics-specifically, the Environmental Protection Agency's thinly veiled campaign to restrict access to these resources. The bill I'm introducing today will help to provide a check against EPA's war on energy by addressing environmental challenges through technological solutions instead of job-killing regulations.

I would like to ask unanimous consent to enter into the record a letter from the American Geosciences Institute in support of H.R. 6603.

I look forward to hearing from our witnesses today, and I yield back.

Chairman HARRIS. Without objection.

[The information appears in Appendix II]

Chairman HARRIS. Thank you, Chairman Hall, and Mr. Chairman, it is of course been a pleasure to work with you the last two years, and I realize that the room has been brightened up a little bit by a new picture hanging on the wall opposite the Chairman's podium here. Yeah, that is appropriate.

Chairman HALL. Can I tell you something about it?

Chairman HARRIS. I will yield to the Chairman.

Chairman HALL. I don't know how long it took him to do it, but he looked at me for about an hour and a half and took a thousand pictures and then he brought the picture in a box down to my house in Rockwell and he opened it up, and I said "Oh, my God." I looked at it, and I said "It's terrible." He said, "Well, I have my things here. I can touch it up. What is your problem with it?" I said, "Well, I don't think you can improve on it." He said "I can do whatever you ask me to do. What is the problem with it?" I said, "The main problem, it looks just exactly like me." Anyway, he eased up a little bit, but he did a good job, and thank you, Mr. Chairman.

Chairman HARRIS. Thank you, Mr. Chairman Hall.

I want to again thank the witnesses here today and now yield to the ranking member, Mr. Miller, for an opening statement.

Mr. MILLER. Thank you, Mr. Chairman.

Before I begin, I would like the opportunity to welcome our newest member, David Curson. Congressman Curson occupies the seat left by Thaddeus McCotter representing the 11th District of Michigan. He will not be a Member of the new Congress so he will probably not have the opportunity Thad McCotter had to impress us with his distinctive personality. He brings long experience as a member of the United Auto Workers leadership and has a technical background in manufacturing, which is a welcome addition to this Congress. So we do welcome him.

Mr. Chairman, we obviously have some disagreement about what would constitute an all-of-the-above energy policy. The lesson for today's hearing is from the Book of Matthew: "For to the one who has, more will be given, and he will have in abundance, and from the one who has not, even what he has will be taken away." Or as many Americans put it colloquially, them that has, gets. That has certainly been the Republican policy on energy research.

Our efforts to assist emerging energy technologies like solar, geothermal, wind, and technologies to make our energy use more efficient are considered "green pork" to House Republicans. They have opposed efforts by the Department of Energy to promote research, demonstration projects, and commercialization of emerging technologies as picking winners and losers. The Republican's Views and Estimates for Fiscal Year 2012 gave deeply principled reasons for opposition to government investment in emerging energy technologies, and I quote: "Fundamentally, the act of providing individual firms with government money for the purpose of commercializing profitable technology is an inappropriate intervention in the market that may crowd out or discourage a greater amount of private investment."

So for emerging technologies that have not the economic and political power of incumbent fossil fuel and nuclear technologies, even what they have will be taken away. But incumbent technologies, which are already enormously profitable, will be given more, and will have in abundance, with none of the navel-gazing discussion about picking winners and losers or inappropriate interventions in the market.

The incumbent technologies have benefited from government research for generations, government subsidies for generations, including research. Hydraulic fracturing is the combination of technologies developed by federally funded research. We will obviously continue to depend on fossil fuel technologies for most of our energy well into the future. Many Democrats, including me, have supported government funding for fossil fuels research, and will likely support this legislation as well. The section of Chairman Hall's legislation on produced water is almost identical to legislation passed by the Democratic majority in the last Congress. The industries and yes, the specific individual firms that will benefit most directly from this legislation, already have far more public and private investment in applied research and commercialization of technologies than do firms developing alternative energy technologies, some of which may dramatically alter our energy future and some of which may never be commercially viable.

Even more important, continued support in abundance for incumbent technologies, often to the exclusion of alternative technologies, continues to base our energy future almost exclusively on hunting fossil fuels to extinction, leaving us woefully unprepared for our longer-term energy needs.

Mr. Chairman, I suspect that most Democrats will support this legislation if it comes to a vote, but I hope that Republicans will consider whether the arguments in support of this legislation will be equally applicable to research for alternative energy sources so that we can have truly an all-of-the-above energy policy.

I yield back the balance of my time.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF SUBCOMMITTEE RANKING MEMBER BRAD MILLER

The lesson for today's hearing is from the Book of Matthew: "For to the one who has, more will be given, and he will have in abundance, and from the one who has not, even what he has will be taken away." Or as many Americans put it more colloquially, them that has, gets.

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Mr. Chairman, I suspect that most Democrats will support this legislation if it comes to a vote, but I hope that Republicans will consider the arguments in support of this legislation as arguments for a truly "all of the above" energy policy.

I yield back the balance of my time.

Chairman HARRIS. Thank you very much, Mr. Miller, and I join you in welcoming Mr. Curson to the Science, Space, and Technology Committee, and I welcome him sitting in on the Subcommittee hearing today.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witness panel. Our first witness today is Dr. Anthony Cugini. Dr. Cugini is the Director of the National Energy Technology Laboratory for the Department of Energy. He previously served as Director of the Office of Research and Development at the National Energy Technology Laboratory. Before that position, Dr. Cugini served as the Focus Area Lead for NETL's Computational and Basic Sciences Focus Area. He has been at the laboratory since 1987.

Our next witness is Dr. David Martineau. Dr. Martineau is the Chairman of the Texas Independent Producers and Royalty Owners Association. Mr. Martineau has worked in the oil and gas industry for more than 50 years. He is an active member of the American Association of Petroleum Geologists, the Interstate Oil and Gas Compact Commission, and the Barnett Shale Water Conservation and Management Committee.

Our third witness is Dr. Daniel Hill, who is the Interim Department Head, a Professor and holder of the Noble Chair in Petroleum

Engineering at Texas A&M. Previously, he taught for 22 years at the University of Texas at Austin after spending five years in industry. He is the author of the Society of Petroleum Engineering monograph "Production Logging: Theoretical and Interpretive Elements", co-author of the textbook "Petroleum Production Systems", co-author of an SPE book, "Multilateral Wells" and author of over 150 technical papers and holds five patents.

Our final witness is Mr. Michael Hagood. Mr. Hagood is the Director of Program Development for Energy and Environment Science and Technology at the Idaho National Laboratory. He is responsible for developing programs advancing energy innovation and also for designing and implemented INL's regional energy sector strategy, notably the western energy corridor concept. Mr. Hagood joined INL in 2003 and previously has also supported INL national and homeland critical energy infrastructure programs.

Thank you all for appearing before the Subcommittee today. As our witnesses should know, spoken testimony is limited to five minutes each after which the members of the Committee will have five minutes each to ask questions.

I now recognize our first witness, Dr. Anthony Cugini, the Director of the National Energy Technology Laboratory at the Department of Energy, for five minutes.

STATEMENT OF DR. ANTHONY CUGINI, DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY

Dr. CUGINI. Thank you. Chairman Harris, Ranking Member Miller and members of the Subcommittee, I appreciate the opportunity to discuss the role that the Department of Energy's Office of Fossil Energy and National Energy Technology Laboratory continue to play in the safe and responsible development of the Nation's unconventional oil and natural gas resources.

As you know, since 2008, U.S. oil and natural gas production has increased each year. In 2011, U.S. crude oil production reached its highest level in nearly a decade. Natural gas production grew in 2011 as well, the largest year-over-year increase in history. Overall, oil imports have been falling since 2005, and our dependence on imported oil declined from 57 percent in 2008 to 45 percent in 2011, the lowest level since 1995.

There are a number of unconventional resources with the potential to support the President's all-of-the-above strategy and to further reduce U.S. reliance on foreign oil. These include U.S. oil reservoirs amenable to CO_2 EOR, heavy oil, oil shale, shale oil, and natural gas resources to include methane hydrates.

Studies indicate that 24 billion barrels of residual oil may be recoverable with current CO_2 EOR technologies and another 36 billion barrels with next-generation technology. For perspective, the United States currently produces about 2 billion barrels of crude oil per year and has proved reserves of about 23 billion barrels. The National Coal Council estimates that another 33 billion barrels of residual oil zone oil is recoverable at a crude oil price of $85 per barrel.

In combination with oil shale, heavy oil, oil sands and shale oil, EIA estimates that unconventional oil resources total more than

3,000 billion barrels of liquid hydrocarbons in place. Production of unconventional natural gas resources has also risen sharply during the past decade. Shale gas in 2012 in the United States is roughly 25 times what it was in 2000. EIA estimates that 482 trillion cubic feet of unproven but technically recoverable natural gas exists, more than 20 times 2011 annual natural gas consumption of 24 trillion cubic feet.

Even more abundant than shale gas is natural gas from methane hydrate. The Bureau of Ocean Energy Management, Regulation and Enforcement estimates in-place gas hydrate resources of 21,400 trillion cubic feet in the Gulf of Mexico, and the USGS estimates 85 trillion cubic feet on the North Slope of Alaska.

Implicit in the development of our unconventional oil and gas resources is that air and water quality and public health and safety are not compromised. To this end, the Department signed a memorandum of agreement with the EPA and the USGS to address the potential environmental, health and safety impacts of hydraulic fracturing and the development of other unconventional fossil resources. The DOE's NETL is also carrying out research to quantify and understand the risks of shale gas and shale oil development as well as improve related unconventional oil and gas characterization and extraction technologies under Section 999 of the Energy Policy Act of 2005, the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources program. Just this week, the selection of 15 new projects was announced as part of the Section 999 program.

Regarding methane hydrates, DOE's efforts have featured extensive interagency coordination and collaborations with leading international gas hydrate research organizations. Because of these efforts, hydrates have moved from a scientific curiosity in 2000 to a known resource today.

DOE and NETL have a long history of success in unconventional oil and gas research. Collaboration with industry in the 1970s and 1980s was a linchpin in the current shale gas revolution. Recent successes include completion of a large-scale field test of natural gas extraction from methane hydrates on the North Slope of Alaska. Also, Altela Incorporated will open two commercial water treatment facilities this year in Pennsylvania based on technology demonstrated under DOE's oil and gas program. NETL also conducts onsite research that complements its extramural portfolio and it leverages competencies and capabilities including expertise in resource characterization, technology development and environmental monitoring to inform responsible, sustainable exploration of production of the Nation's unconventional domestic gas resources.

Let me conclude by saying that the United States contains significant hydrocarbon wealth that can be extracted and used to provide economic benefits for all Americans. The Department is committed to developing the science and technology that will allow the Nation to use its abundant fossil energy resources in a way that balances the energy needs for sustaining a robust economy with continued environmental responsibility. I recognize the developed legislation that aids in supporting unconventional oil and gas research, and while we have not developed a position, I am pleased that this legislation is focused on this important energy resource.

Mr. Chairman, this completes my prepared statement. I look forward to addressing any questions that you or the other Subcommittee members may have.

[The prepared statement of Dr. Cugini follows:]

Statement of
Anthony V. Cugini
Director, National Energy Technology Laboratory
U. S. Department of Energy
Before the
Subcommittee on Energy and Environment
Committee on Science, Space, and Technology
U.S. House of Representatives
November 30, 2012

Chairman Harris, Ranking Member Miller, and members of the Subcommittee, I appreciate the opportunity to discuss the role that the Department of Energy's Office of Fossil Energy's National Energy Technology Laboratory continues to play in the safe and responsible development of the Nation's unconventional oil and natural gas resources.

As you know, since 2008, U.S. oil and natural gas production has increased each year. In 2011, U.S. crude oil production reached its highest level in nearly a decade. Natural gas production grew in 2011 as well – the largest year-over-year volumetric increase in history. Overall, oil imports have been falling since 2005, and our dependence on imported oil declined from 57 percent in 2008 to 45 percent in 2011 – the lowest level since 1995.

One of the factors enabling us to make such progress is that our country enjoys a bounty of oil and natural gas resources. Over the past century, Americans have applied their ingenuity towards extracting these resources, which in turn have helped to fuel our Nation's economic prosperity.

Domestic Unconventional Oil and Natural Gas Resources
There are a number of unconventional resources with the potential to support the president's all-of-the-above energy strategy and to help reduce U.S. reliance on foreign oil. These include U.S. oil reservoirs amenable to carbon dioxide enhanced oil recovery (CO_2 EOR), heavy oil, oil shale, shale oil, and natural gas resources including methane hydrates.

Studies have shown that 24 billion barrels of residual oil may be economically recoverable[1] with the application of current CO_2-EOR technologies and another 36 billion barrels with widespread application of "next generation" CO_2 EOR technology[2]. For perspective, the U.S. currently uses about 5.4 billion barrels of crude oil per year and has proved reserves of about 23 billion barrels[3]. In addition to the post-waterflood residual oil left behind in producing oil reservoirs, there are significant amounts of oil in "residual oil zones" or ROZs, the portion of an oil reservoir *below* its estimated oil-water contact. These zones can extend for hundreds of feet and

[1] Economically recoverable at a price of $85 a barrel and $40 metric ton of CO2.
[2] V. Kuuskraa, T. Van Leeuwen, and M. Wallace. June 2011. Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2 Enhanced Oil Recovery. DOE/NETL report # 2011/1504 Table EX-3.
[3] EIA production for 2011, http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm
EIA reserves for end of 2010, http://www.eia.gov/dnav/pet/pet_crd_pres_dcu_NUS_a.htm

could hold large volumes of previously undocumented oil amenable to recovery via CO_2 EOR. The National Coal Council estimates that 33 billion barrels of ROZ oil is recoverable at a crude oil price of $85 per barrel[4].

In addition to the residual oil and ROZs, oil shale, heavy oil, oil sands and shale oil (conventional oil in shale formations) offer a huge potential in the US. Taken together, these four unconventional oil resources total more than 3000 billion barrels of liquid hydrocarbons in place[5]. Even if one were to assume that only 10 percent of this oil could be recovered economically, it would mean a significant increase in the Nation's domestic energy supply.

The United States is equally well-endowed with unconventional natural gas resources. Production of natural gas from unconventional rocks, tight sands, coal seams, and organic shales, has risen sharply during the past two decades. Production of natural gas from shale source rock in 2012 in the U.S. is roughly 25 times what it was in 2000[6]. This rapid growth in shale gas production is recognized to be the result of the combined application of horizontal drilling and large-volume hydraulic fracturing technologies. EIA's 2012 Annual Energy Outlook estimates that 482 trillion cubic feet (Tcf) of unproven but technically recoverable natural gas exists in eleven major shale gas plays, more than 1.75 times the current total for U.S. dry gas proved reserves and more than 20 times the 2011 annual marketed dry natural gas production (23 Tcf).

Even more abundant than shale gas is natural gas from methane hydrate. In 2008, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement, released a preliminary assessment of the in-place gas hydrate resource in the Gulf of Mexico. The assessment, which does not consider whether the resource is technically or economically recoverable, estimated a mean value of 21,400 Tcf of methane-in-place in hydrate form. The assessment also determined that about 6,700 Tcf of this resource occurs in relatively high concentration accumulations within sandy sediments; the sort of reservoirs that would be more likely to permit gas flow. To put these enormous methane hydrate resources in perspective, the DOE EIA reports that the US consumed a little more than 24 Tcf of gas in 2011.

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[4] National Coal Council, 2012, *Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security,* p. 4

[5] NETL, 2011, "Domestic Unconventional Fossil Energy Resource Opportunities and Technology Applications Report to Congress," September, Table 3-4, p. 15 http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/2011-005539-unc-fe-report-congress-final-oct-2011.pdf

[5] NETL, 2011, "Domestic Unconventional Fossil Energy Resource Opportunities and Technology Applications Report to Congress," September, p. 13 http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/2011-005539-unc-fe-report-congress-final-oct-2011.pdf

[5] USGS, 2012, "Isopach and Isoresource Maps for Oil Shale Deposits in Eocene Green River Formation for the Combined Uinta and Piceance Basins, Utah and Colorado," http://pubs.usgs.gov/sir/2012/5076/

[5] EIA, Annual Energy Outlook 2012, Table 16, p.58 http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf

[6] EIA, Annual Energy Outlook 2012 Online Data, Table A-14, http://www.eia.gov/analysis/projection-data.cfm#annualproj for 2012 estimate of 7.67 Tcf per year and "Shale Gas and the Outlook for U.S. Natural Gas Markets and Global Gas Resources," a presentation by Richard Newell from June 21, 2011 http://www.eia.gov/pressroom/presentations/newell_06212011.pdf for a 2000 estimate of 0.3 Tcf per year

Also in 2008, the United States Geological Survey estimated that there is approximately 85 Tcf of undiscovered, technically recoverable natural gas resource within gas hydrates on the North Slope of Alaska. If methane hydrates can be proven to be technically and economically producible, this onshore resource located near existing oil and gas production infrastructure is likely to be the first methane hydrate deposit to be tapped.

Current Status of Research and Technical Challenges

Unconventional resources are much larger in volume than are our conventional resource stores. These resources, however, generally exist in more geologically complex settings or in more remote or environmentally sensitive areas and require more intensive production methods. The safe and responsible development of unconventional domestic fossil resources creates jobs and provides economic benefits.

Federal coordination and collaboration is critical to successfully addressing the environmental and safety challenges associated with unconventional oil and gas development so that the benefits highlighted above can be realized. To this end, the President signed an Executive Order on April 13, 2012, creating a new Interagency Working Group to Support Safe and Responsible Development of Unconventional Domestic Natural Gas Resources. On the same day DOE, the Environmental Protection Agency, and the Department of the Interior's U.S. Geological Survey signed a related Memorandum of Agreement initiating a Multi-Agency Collaboration on Unconventional Oil and Gas Research. The objective of this collaborative effort is to better understand and address the potential environmental, health, and safety impacts of shale gas activities, although the research is also applicable to the development of other unconventional oil and gas resources. Through the collaboration, a robust Federal R&D plan will be developed, taking into account high priority recommendations of the Secretary of Energy Advisory Board (SEAB) Natural Gas Subcommittee. DOE's role in this initiative will focus on priorities identified by the interagency collaboration in a research plan to be formed within its area of core research competencies.

The Department is carrying out research directed at quantifying and understanding the environmental and safety risks of shale gas and shale oil development, as well improving our understanding of emerging and developing shale plays, lowering the cost and increasing the efficiency of technologies for treating hydraulic fracturing flowback water, and optimizing the recovery of shale gas resource. These efforts are funded through Title IX, Subtitle J, Section 999 of the Energy Policy Act of 2005, the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Resources Program.

DOE's current CO_2 EOR research portfolio is focused on developing and demonstrating next generation technologies designed to accelerate the application of CO_2 EOR in those basins where it has not yet been applied, and in those reservoirs within areas with existing CO_2 EOR that have not been viewed as economic candidates.

While technology exists for producing heavy oil, there are challenges that still require research, although given the economic benefits from producing efficiently, industry has incentive to do most of this research themselves. A key challenge is mitigating the environmental and safety

risks inherent with heavy oil and oil sands development. Recent DOE efforts have been focused on heavy oil deposits in the Ugnu Formation on the North Slope; understanding the formation's geological complexity; and developing water soluble polymers suitable for waterflooding Ugnu heavy oil reservoirs.

Oil shale was a major topic of public and private research in the 1980s, but interest declined when other less expensive sources of oil became available. In 2007 and 2009 the Bureau of Land Management (BLM) leased Federal minerals in Colorado and Utah to private companies to permit them to conduct oil shale research projects, with the possibility that the projects could be followed by a commercial leasing program. At least seven companies are utilizing these leases or other privately held oil shale properties to test both surface retorting of mined shale and *in situ* retorting technologies. A key research challenge associated with oil shale is the need to develop and evaluate technologies for reducing or controlling the potential for surface and subsurface water contamination and other environmental impacts.

With regard to methane hydrates, the DOE has successfully finished a pilot production well. Because of this effort and past DOE efforts, hydrates have moved from a scientific curiosity in 2000 to a known resource today.

DOE Capabilities and Expertise

The DOE's Office of Fossil Energy (FE) with support by the National Energy Technology Laboratory (NETL) remains well-positioned to address appropriate research challenges related to environmental sustainability and safe development of these unconventional oil and natural gas resources. FE and NETL have a long history of successfully engaging industry and academia, forming collaborative partnerships that leverage individual strengths to achieve useful results. FE and NETL engage with a wide array of experts when formulating research plans, including Federal Advisory Committees, industry experts, members of NETL's academic research consortium, authorities at other National Laboratories, and on-site scientists and engineers.

NETL's 1970- and 1980-era contributions to the fundamental research that resulted in the current shale gas "revolution" have been reported in the press, but three examples of DOE research highlight recent contributions made by DOE.

First, as mentioned above, the Ignik Sikumi well on the North Slope of Alaska represents an unprecedented test of technology to safely extract a steady flow of natural gas from methane hydrates. DOE partnered with ConocoPhillips and the Japan Oil, Gas and Metals National Corporation to conduct a test of natural gas extraction from methane hydrate using a unique production technology, developed through laboratory collaboration between the University of Bergen, Norway, and ConocoPhillips. Between February 15 and April 10, 2012, the team injected a mixture of CO_2 and nitrogen into a hydrate bearing zone and demonstrated that this mixture could promote the production of natural gas. This test was the first-ever field trial of a methane hydrate production methodology whereby CO_2 was exchanged *in situ* with the methane molecules within a methane hydrate structure, and the 30 day-long production test was five times as long as any previous test.

Second, in 2010 DOE partnered with Altela Inc. to test the AltelaRain® fracturing water treatment process at a well site in western Pennsylvania. Over a 9-month period, 77 percent of the produced hydraulic wastewater was successfully treated onsite, resulting in distilled water as the effluent. Following the DOE-sponsored demonstration project, four AltelaRain modules were sold and installed at a facility in Williamsport, Pennsylvania, for treating Marcellus shale wastewater. Building on the success of this application, in 2012 Altela Inc. and its partners are opening two new wastewater treatment facilities in western Pennsylvania. Each facility is able to process up to 12,000 barrels of wastewater a day—about 500,000 gallons per facility. The purified water can then be reused for any number of purposes.

Third, DOE is currently collaborating with Petroleum Recovery Research Center at New Mexico Tech to develop a nanoparticle-stabilized CO_2 foam system that can improve the sweep efficiency of injected CO_2 in EOR projects. The research team has demonstrated for the first time that adding a small amount (30-50 parts per million) of surfactant to a silica nanoparticle solution significantly improves CO_2 foam generation and foam stability. Using nanosilica particle stabilized CO_2 foam rather than a straight CO_2 and water mixture, the researchers were able to recover up to 80 percent of the residual oil that remains after waterflooding. DOE and New Mexico Tech are continuing to quantify the performance of these foams in core flooding experiments under a variety of conditions and concentrations, but it is clear that cutting edge technologies utilizing next-generation materials like nanoparticles can dramatically improve oil recovery.

These three examples illustrate the range of approaches—international collaboration, field tests on new technologies with industry partners, laboratory experiments with academic researchers—that are reflected in DOE's unconventional oil and natural extramural gas research program.

Conclusion

The U.S. contains significant hydrocarbon wealth that can be extracted and used to provide economic benefits for all Americans. Developing our unconventional oil and natural gas resources in an environmentally sustainable and safe manner will require new technologies. DOE has demonstrated its ability to engage industry and academia to perform research that can help catalyze the development and application of these new technologies.

The research challenges are significant. Producing unconventional oil and natural gas requires that industry expend more energy, use more water, contact larger portions of the reservoir, and counteract more physical forces than when producing conventional oil and natural gas resources. It is important that we understand and minimize the unwanted consequences of unconventional fossil resource development. But as they have in the past, new technologies can provide ways to reduce or eliminate these barriers.

The Department of Energy is committed to developing, where appropriate, the science and technology that will allow the Nation to use its abundant fossil energy resources in a way that balances the energy needs for sustaining a robust economy with continued environmental responsibility. As we move forward on a multi-agency, collaborative research program with DOI and EPA, the Office of Fossil Energy will pursue its mission with the same commitment to excellence and innovation.

Mr. Chairman, this completes my prepared statement. I look forward to addressing any questions that you or other members of the Subcommittee may have. Thank you.

Chairman HARRIS. Thank you, Dr. Cugini.

I now recognize our second witness, Mr. David Martineau, the Chairman of the Texas Independent Producers and Royalty Owners Association.

STATEMENT OF MR. DAVID MARTINEAU, CHAIRMAN, TEXAS INDEPENDENT PRODUCERS AND ROYALTY OWNERS ASSOCIATION

Mr. MARTINEAU. Thank you very much. Good morning, Mr. Chairman and members. My name is David Martineau and I am representing the Texas Independent Producers and Royalty Owners Association, also known as TIPRO. TIPRO was founded in the East Texas Field in 1946. Since then, TIPRO has s grown to be a top-tier oil and natural gas trade association made up of over 2,500 members statewide. Our membership ranges from small, family-owned businesses to large publicly traded independent producers, and includes large and small royalty owners, mineral estates, and trusts. I currently have the pleasure of serving as the Chairman of the Board of Directors for TIPRO. I am a geologist. I worked for Pitts Oil Company for 40 years, as we said, and I am truly honored to be here.

Lately, much has been made of this country's looming fiscal cliff. The United States, however, is not only facing a fiscal cliff, but an energy cliff as well. Domestic independent producers are responsible for approximately 75 percent of the domestic natural gas production, and nearly 50 percent of the domestic oil production. However, threats to the framework that allows independents to maintain and grow their production levels exist in various forms. One, tax provisions like intangible drilling deductions, IDCs, and depletion allowance are crucial to the survival of the small independent producers and they are being attacked and mislabeled as big oil subsidies. Overreaching regulations from the EPA and U.S. Fish and Wildlife Service with no scientific backing pile additional unnecessary compliance costs onto the oil and natural gas producers. The Federal Government is attempting to go green and pick winners by focusing federal research and development monies on unproven, uneconomical and unreliable sources. They will not face the fact that 85 percent of the energy in the United States comes from fossil fuels.

What needs to be done to continue to tap the American energy potential that has been created by the new shale revolution? You need to, one, understand variations in subsurface properties to avoid drilling marginal wells and increase recovery efficiency, scientifically characterize risks and inform stakeholders, minimize surface impacts of unconventional oil and gas operations.

In the past, federal dollars have been spent on researching and developing improved methods of oil and gas extraction. Much of the resultant data and techniques combined with the forward thinking of some brilliant and creative private-sector minds resulted in some of the biggest energy successes in the country's history. Let me outline a few specific cases of worthwhile federal research conducted on oil and gas. In 1976 the U.S. Department of Energy initiated an eastern shale project to evaluate the gas potential of and enhance oil production from shales within the Appalachian, Illinois and

Michigan basins in the eastern United States. This project showed that we had enormous amounts of natural gas locked in these domestic shale formations, which are now the massive Marcellus and Utica shale plays. In 1982, the Federal Government began funding the research efforts of the Gas Research Institute, an industry-formed research and development program founded in 1978, which has since resulted in increased natural gas viability as a fuel source. In 1991, George P. Mitchell, the father of the Barnett shale, with financial help from the Department of Energy, drilled and completed his first Barnett Shale horizontal well. In 2005, the Energy Policy Act and a research program managed with the Research Partnership to Secure Energy for America called RPSEA has been a very successful program.

Recognizing the importance of oil and natural gas and investing federal money in its development should not be a thing of the past. In fact, never in history has it been more crucial to continue improving and enhancing our ability to recover domestic oil and natural gas. Domestic energy independence can be achieved, and federal research money can play a part.

In the State of Texas alone, since the shale revolution started in 2006, from 2006 to 2011 we have increased annual production of oil from 347 million barrels to 431 million barrels and natural gas from 6.3 trillion cubic feet to 7.7. This partially is why our imports have dropped from 70 percent to 45 percent in that same time period as we head toward energy independence.

Chairman Hall's bill 6603 is a good step in the right direction, and I compliment him for his efforts. Many areas where additional research could produce significant results are outlined in the bill, including hydraulic fracturing, development of improved proppants, water minimization, management, reuse and alternatives, improved modeling of formation, energy efficiency in exploration and production.

Hydraulic fracturing—the big item. The hydraulic fracturing process, as it has evolved over the past 50-plus years from vertical wells to long horizontal wells with multiple fracture treatments, has introduced many complexities. There is a need for research focus in this area to increase recovery efficiency. To do so requires focusing on the subsurface processes involved with fracturing, including modeling of the process, microseismic assessment, emissions, water usage and other research. Successful research will increase the efficiency of the process, significantly reducing the number of well bores required, resulting in a reduction in well sites, water usage, emissions, traffic, noise, dust and other factors, all while increasing oil and gas recovery per well. This area of research, the optics of which do not indicate direct environmental impact, can have an overwhelming environmental impact.

Water management is another big issue. According to data collected by the Texas Water Development Board, the volume of water used in hydraulic fracturing represents less than one percent of all the water consumed in the State of Texas. However, water management goes hand in hand with hydraulic fracturing, and the industry recognizes that there is still progress that can be made in this arena. Research and development are needed to address mitigation of the volumes of freshwater required in hydraulic fracturing; sig-

nificant volumes of water produced from oil and gas shale wells and associated concerns as to its composition when it comes back; the development of technology to process water, converting the industry's largest waste stream into a new, useful product; and assuring the ability to safely dispose of water in the subsurface by geologic characterization of potential disposal zones across the country because they vary from basin to basin.

Understanding the subsurface conditions and types of resource rock found within unconventional gas formations, in particular oil and gas shale, require ongoing research. Flow of fluids—gas, oil and water—through the low-permeability formations, particularly oil and gas shales, is not well understood. By increasing our understanding of subsurface geologic conditions, we can make progress toward effectively answering questions regarding economic recovery and environmental safety. Additionally, subsurface research can increase recovery efficiency from many unconventional oil and gas fields in the U.S., further unlocking minerals yet in place. These developed fields each have an entire infrastructure already in place with roads, well bores, metering facilities, marketing.

Thousands of small independents, many of whom are TIPRO members, do not have the resources to conduct their own research, yet cumulatively produce a huge portion of domestic oil and natural gas. This is an area where targeted and carefully disseminated federally funded research efforts can have a significant and immediate impact on production and the economy, and I urge you to revive federal research investments into this worthwhile industry.

Often efforts intended to impact major global oil and natural gas companies end up having a much larger impact on small, family-owned companies, many of whom live and work in your hometowns. These companies are a giant component in generating American jobs and resources for your state and this country, and they are worthy of your investment.

Thank you for your time.

[The prepared statement of Mr. Martineau follows:]

Energy & Environment Subcommittee
"Tapping America's Energy Potential Through Research and Development."
Testimony of TIPRO Chairman David Martineau
9:30 a.m. - Friday, November 30, 2012

Good morning Mr. Chairman and members. My name is David Martineau, and I am here representing the Texas Independent Producers and Royalty Owners Association, also known as TIPRO. TIPRO was founded in the East Texas Field in 1946. Since then, TIPRO has grown into a top tier oil and natural gas trade association, made up of over 2,500 members statewide. Our membership ranges from small, family-owned businesses to the largest publicly traded independent producers, and includes large and small royalty owners, mineral estates, and trusts.

I currently have the pleasure of serving as the Chairman of the Board of Directors for TIPRO. I am a Certified Petroleum Geologist, a licensed Texas Professional Geoscientist, and I work as exploration manager for Pitts Oil Company based out of Dallas, Texas. I am truly honored to have the opportunity to address you all today.

Lately, much has been made of this country's looming "fiscal cliff". The United States, however, is not only facing a fiscal cliff, but an "energy cliff" as well. Domestic independent producers are responsible for approximately 75% of domestic natural gas production, and nearly 50% of domestic oil production. However, threats to the framework that allows independents to maintain and grow these production levels exist in various forms:

1) Tax provisions like Intangible Drilling Cost deductions (IDC's) and depletion allowance that are crucial to the survival of small independent producers are being attacked and mislabeled as "big oil subsidies".
2) Overreaching regulations from the EPA and U.S. Fish and Wildlife Service with little to no scientific backing pile additional unnecessary compliance costs onto the oil and natural gas producers.
3) The federal government is attempting to go green and "pick winners" by focusing federal research and development monies on unproven, uneconomical, and unreliable energy sources. They will not face the fact that eighty-five percent of the energy in the U.S. comes from fossil fuels.

What needs to be done to continue to tap America's Energy Potential that has been created by the new Shale Revolution?

1) Understand variations in subsurface properties to avoid drilling marginal wells and increase recovery efficiency.
2) Scientifically characterize risks and inform stakeholders.
3) Minimize surface impacts of unconventional oil and gas operations.

In the past, federal dollars have been spent on researching and developing improved methods of oil and natural gas extraction. Much of the resultant data and techniques, combined with the forward thinking of some brilliant and creative private sector minds, resulted in some of the biggest energy successes in the country's history. A few specific cases of worthwhile federal research conducted on oil and natural gas development:

- In 1976 - the U.S. Department of Energy initiated the *Eastern Gas Shales Project* to evaluate the gas potential of, and to enhance gas production from shales within the Appalacian, Illinois, and Michigan basins in the eastern U.S. This project showed that we had enormous amounts of natural gas locked in these domestic shale formations, which are now the massive Marcellus and Utica plays.
- In 1982 - the federal government began funding the research efforts of the *Gas Research Institute* - an industry-formed research and development program, founded in 1978, which has since resulted in increased natural gas viability as a fuel source.
- In 1991 - George P. Mitchell, with financial help from the Department of Energy, drilled and completed his first Barnett Shale horizontal well.
- In 2005 – Energy Policy Act – is a research program with the Research Partnership to Secure Energy for America (RPSEA).

Recognizing the importance of oil and natural gas, and investing federal money in its development, should not be a thing of the past. In fact, never in

history has it been more crucial to continue improving and enhancing our ability to recover domestic oil and natural gas. Domestic energy independence *can* be achieved, and federal research money can play a part.

In the state of Texas alone, since the Shale Revolution started from 2006 to 2011 we have increased annual production of oil from 347 million bbls to 431 million bbls and natural gas 6.3 trillion MCF to 7.7 trillion MCF. This partially is why our imports have dropped from 70% to 45% in that same time period and we are headed toward energy independence.

Chairman Hall's H.R. 6603 is a good step in the right direction and I compliment him on his efforts. Many areas where additional research could produce significant results are outlined in the bill, including:

- hydraulic fracturing
- development of improved proppants
- water minimization, management, re-use, and alternatives
- improved modeling of formations
- energy efficiency in exploration and production

Hydraulic Fracturing

The hydraulic fracturing process, as it has evolved over the past 50+years from vertical wells to long horizontal wells with multiple fracture treatments has introduced many complexities.

There is a need for research focus in this area to increase recovery efficiency. To do so requires research focusing on the subsurface processes involved with fracturing, including modeling of the process, microseismic assessment, emissions, water usage and other research.

Successful research will increase the efficiency of the process, significantly reducing the number of wellbores required, resulting in a reduction in well sites, water usage, emissions, traffic, noise, dust and other factors, all while increasing oil and gas recovery per well.

This area of research, the optics of which do not indicate direct environmental impact, can have an overwhelming environmental impact.

Water Management

According to data collected by the Texas Water Development Board, the volume of water used in hydraulic fracturing represents less than 1% of all water consumed in the state of Texas.

However, water management goes hand-in-hand with the hydraulic fracturing process, and industry recognizes that there is still progress that can be made in this arena. Research and development are needed to address:

1) mitigation of the volumes of fresh water required for hydraulic fracturing;
2) significant volumes of water produced from oil and gas shale wells and associated concerns as to its composition;
3) the development of technology to process water – converting the industry's largest waste stream into a new, useful product; and
4) assuring the ability to safely dispose of water in the subsurface by geologic characterization of potential disposal zones which vary across the country – geologic basin to geologic basin.

Understanding the Subsurface

The subsurface geologic conditions and types of resource rock found within unconventional gas formations, in particular oil and gas shale, require ongoing research. Flow of fluids (gas, oil, water) through very low permeability formations (particularly oil and gas shales) is not well understood. By increasing our understanding of subsurface geologic conditions, we can make progress toward effectively answering questions regarding economic recovery and environmental safety. Additionally, subsurface research can increase recovery efficiency from many unconventional oil and gas fields in the U.S., further unlocking minerals yet in place. These developed fields each have an entire infrastructure already in place, i.e. roads, wellbores, metering facilities, marketing, etc.

Thousands of small independents, many of whom are TIPRO members, do not have the resources to conduct their own research, yet cumulatively produce a huge portion of domestic oil and natural gas. This is an area where targeted and carefully disseminated federally-funded research efforts can have a significant and immediate impact on production and the economy, and I urge you to revive federal research investments into this worthwhile industry.

Often efforts intended to impact major, global oil and natural gas companies end up having a much larger impact on small, family-owned companies, many of whom live and work in your hometowns. These companies are a giant component in generating American jobs and resources for your state and this country, and they are worthy of your investment.

Thank you again for the opportunity to address you today.

Chairman HARRIS. Thank you very much.

I now recognize our third witness, Dr. Daniel Hill, the Interim Department Head and Professor and holder of the Noble Chair in Petroleum Engineering at Texas A&M. Dr. Hill.

STATEMENT OF DR. DANIEL HILL, INTERIM DEPARTMENT HEAD, PROFESSOR AND HOLDER OF THE NOBLE CHAIR IN PETROLEUM ENGINEERING, TEXAS A&M UNIVERSITY

Dr. HILL. Good morning, Chairman and Committee members. I am Dan Hill. I am the head of the Petroleum Engineering Department at Texas A&M. I have been a faculty member for over 30 years after working in industry for about five years, and throughout my career I have conducted research on methods to improve oil and gas production. For the past ten years, I have been supervising research projects funded by the Department of Energy studying horizontal wells and hydraulic fracturing.

Unconventional oil and gas production has changed the U.S. energy game. In just a few years, applications of advanced technology have led to the most dramatic economic boost our country has seen in my lifetime. Production of natural gas and oil from unconventional reservoirs, primarily shale formations, is soaring, daily lessening this country's dependence on imported oil. Slide 1 is a history and forecast of the U.S. natural gas supply. In less than ten years, gas production from shale formations has grown to over 30 percent of the U.S. supply and continues to grow. This is great news in every possible way. Natural gas is the cleanest burning fossil fuel, it yields the least CO_2, and it is low cost, thanks to its newfound abundance in unconventional reservoirs.

Even more dramatic is the rapid increase in domestic oil production from unconventional reservoirs. Slide 2 shows that oil production from the Bakken formation in North Dakota is now close to 500,000 barrels per day. Forecasts are that Bakken production will reach a peak of 1 to 2 million barrels per day, equivalent to the peak production from the Alaskan North Slope. Production from the Eagle Ford formation in South Texas has grown from about 800 barrels per day to almost 300,000 barrels per day in only three years, as you see in this slide. These are just two examples. There are many other unconventional reservoirs in other parts of the country that are also rapidly adding to domestic production. Without question, there is a revolutionary change in U.S. energy supply underway, solely due to oil and gas production from unconventional reservoirs.

And how has this happened? This shale production revolution is a result of major advances in the technologies of horizontal drilling and hydraulic fracturing, and, in particular, the combination of these two technologies. These advances have been aided greatly by a modest level of research funding from the Department of Energy, funding that supported research primarily at universities, small businesses and the national laboratories.

Let me give you one example. Beginning in the early 1980s and through the mid-1990s, the Department of Energy, along with the Gas Research Institute, supported fundamental research on measuring the sounds made as hydraulic fractures are created. This re-

search, led by a team at Sandia National Laboratory, resulted in a commercial technique for mapping hydraulic fractures that is now called microseismic monitoring. This technique, which has now been applied to tens of thousands of fracture treatments, and which is now itself a multimillion-dollar industry, has allowed engineers to greatly improve hydraulic fracturing and well completion practices by providing a means to measure the extent of the fractured region. Slide 4 shows a microseismic map of the area affected by a multistage fracturing operation. The development of microseismic monitoring of hydraulic fracture treatments was clearly enabled by the Department of Energy-funded research that proved its viability.

Is the current domestic energy growth sustainable? The goal of energy security, and possibly energy independence for the United States, is no longer just political rhetoric, but is technically attainable. However, it will not be easy, and it will require two things: further developments in technology, and the trained engineers and geoscientists needed for continued growth.

On the technology side, although hydraulic fracturing methodologies have obviously been developed to the point that oil and gas are economically recoverable from very low permeability unconventional reservoirs, there is still a great deal of improvement that can be made to this technology. Major challenges include using less freshwater in fracturing and drilling fewer wells to contact the same amount of reservoir.

The Department of Energy has been funding fundamental research in conjunction with the Research Partnership to Secure Energy for America, or RPSEA, on topics like these for the past several years, and this research is having a visible impact on industry practices. It is important to continue supporting RPSEA as they have a proven track record of producing important research results using a unique public-private partnership model.

Perhaps most important is the role that Department of Energy funding for unconventional oil and gas research will have on the training of the engineers and scientists needed to sustain growth in unconventional oil and gas development. The research funded by DOE occurs primarily in universities and most of the money ends up in the pockets of graduate students. The research funding provided to universities through the proposed Department of Energy research program will help support the graduate students who will become the future technology leaders of our country.

Thank you.

[The prepared statement of Dr. Hill follows:]

Written Testimony

Committee on Science, Space, and Technology

U. S. House of Representatives

November 30, 2012

Good Morning. I am Dan Hill and I am the Head of the Petroleum Engineering Department at Texas A&M University. I have been a faculty member for over 30 years after working in industry for about 5 years, and throughout my career I have conducted research on methods to improve oil and gas production. For the past ten years, I have been supervising research projects funded by the Department of Energy studying horizontal wells and hydraulic fracturing.

Unconventional oil and gas production has changed the U. S. energy game.

In just a few years, applications of advanced technology have led to the most dramatic economic boost our country has seen in my lifetime. Production of natural gas and oil from unconventional reservoirs, primarily shale formations, is soaring, daily lessening this country's dependence on imported oil. Slide 1 is a history and forecast of the U. S. natural gas supply – in less than 10 years, gas production from shale formations has grown to over 30% of the U. S. supply, and continues to grow. This is great news in every possible way – natural gas is the cleanest burning fossil fuel, it yields the least CO_2, and it is low cost, thanks to its newfound abundance in unconventional reservoirs.

Even more dramatic is the rapid increase in domestic oil production from unconventional reservoirs. Slide 2 shows that oil production from the Bakken formation in North Dakota is now close to 500,000 barrels per day. Forecasts are

that Bakken production will reach a peak of 1 – 2 million bpd – equivalent to peak production from the Alaskan North Slope. Production from the Eagle Ford formation in South Texas has grown from about 800 bpd to almost 300,000 bpd in only 3 years (Slide 3). These are just two examples. There are many other unconventional reservoirs in other parts of the country that are also rapidly adding to domestic production. Without question, there is a revolutionary change in U. S. energy supply underway, solely due to oil and gas production from unconventional reservoirs.

How did this happen?

This shale production revolution is a result of major advances in the technologies of horizontal drilling and hydraulic fracturing, and, in particular, the combination of these two technologies. These advances have been aided greatly by a modest level of research funding from the Department of Energy, funding that supported research primarily at universities, small businesses, and the national laboratories.

Let me give you one example. Beginning in the early 80's and through the mid-90's, the Department of Energy, along with the Gas Research Institute, supported fundamental research on measuring the sounds made as hydraulic fractures are created. This research, led by a team at Sandia National Laboratory, resulted in a commercial technique for mapping hydraulic fractures that is now called microseismic monitoring. This technique, which has now been applied to tens of thousands of fracture treatments, and which is now itself a multi-million dollar industry, has allowed engineers to greatly improve hydraulic fracturing and well completion practices by providing a means to measure the extent of the fractured region. Slide 4 shows a microseismic map of the area affected by a multi-stage fracturing operation. The development of microseismic monitoring of hydraulic

fracture treatments was clearly enabled by the Department of Energy funded research that proved its viability. This basic research was greatly aided by research funding by GRI and the U.S. Department of Energy.

Is the current domestic energy growth sustainable?

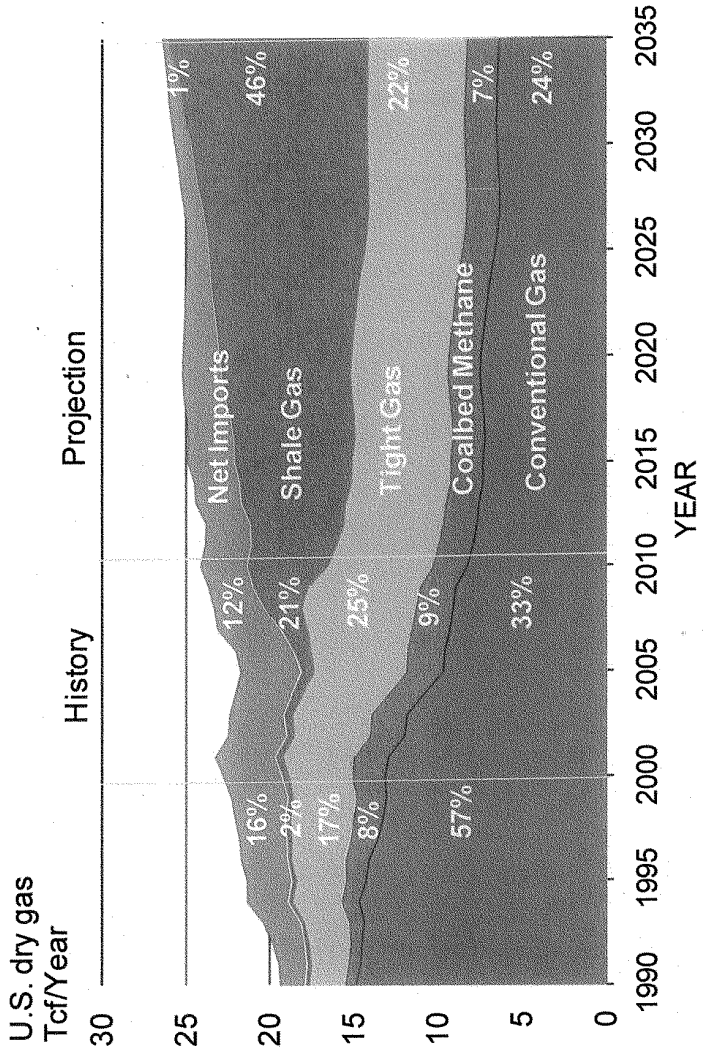
The goal of energy security, and possibly energy independence for the United States is no longer just political rhetoric, but is technically attainable. We know where the resources can be found, but we still need technical improvements to be able to produce much of the resource at prices that are beneficial to the public. However, it will not be easy, and it will require two things – further developments in technology, and the trained engineers and geoscientists needed for continued growth. The proposed Department of Energy research funding will be a great help with both of these needs.

On the technology side, although hydraulic fracturing methodologies have obviously been developed to the point that oil and gas are economically recoverable from very low permeability unconventional reservoirs, there is still a great deal of improvement that can be made to this technology. One of the major challenges is the development of various ways to lessen the environmental impacts of hydraulic fracturing operations, including using less fresh water in the process, and drilling fewer wells to contact the same amount of reservoir. Another challenge is the development of lower cost hydraulic fracturing techniques. Ironically, the success of the industry in rapidly developing huge new volumes of natural gas from shales has led to a low gas price, which has slowed gas drilling markedly. If the rapidly increasing oil production has a similar effect, unconventional oil development will inevitably slow down, unless lower cost methods can be applied to achieve the same results. The Department of Energy has

been funding fundamental research in conjunction with the Research Partnership to Secure Energy for America (RPSEA) on topics like these for the past several years, and this research is having a visible impact on industry practices. It is important to continue supporting RPSEA as they have a proven track record of producing important research results using a unique public – private partnership model.

Perhaps most important is the role that Department of Energy funding for unconventional oil and gas research will have on the training of the engineers and scientists needed to sustain growth in unconventional oil and gas development. The research funded by DOE occurs primarily in universities and most of the money ends up in the pockets of graduate students in the form of research assistantships. The demand for engineers in this field is huge – the COO of a major service company recently told me that his company alone hired 15,000 new employees in the U. S. in 2011. That is a lot of jobs, and many of them need to be highly trained engineers and scientists. Because of this booming demand for petroleum engineers to work in unconventional oil and gas development, we are receiving unprecedented demand for places in our graduate program. Other universities with graduate programs in Petroleum Engineering are also receiving numerous applications for graduate school. To attract and retain high quality graduate students, a university has to offer financial aid, and this is usually in the form of a research assistantship funded by an external grant. The research funding provided to universities through the proposed Department of Energy research program will help support the graduate students who will become the future technology leaders of our country.

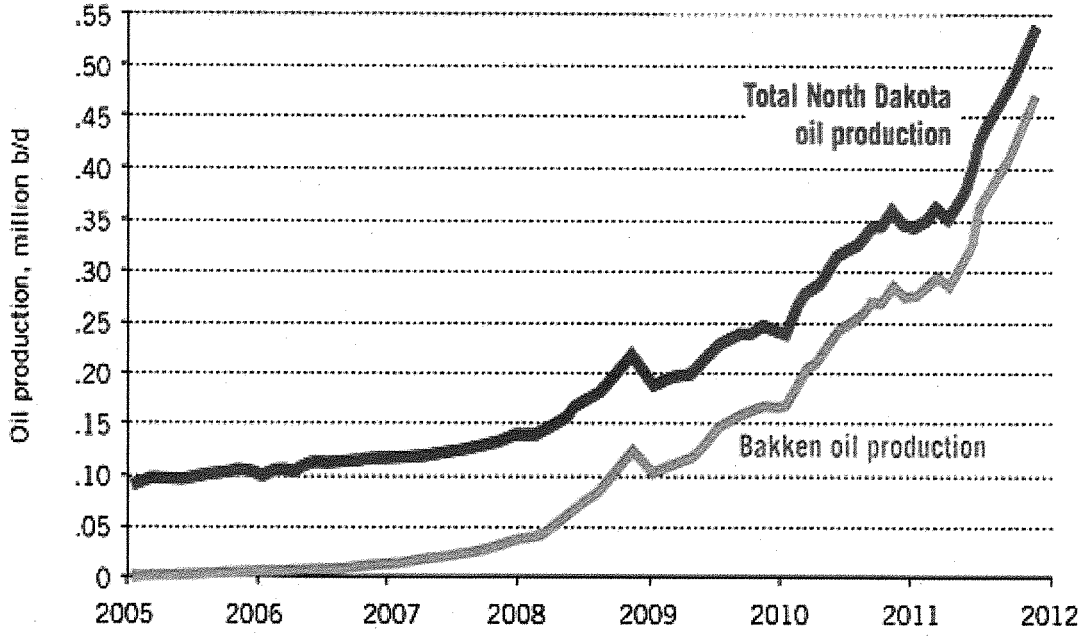
SLIDES PRESENTED DURING DR. DANIEL HILL'S TESTIMONY



EIA, *Annual Energy Outlook 2011*

NORTH DAKOTA BAKKEN OIL PRODUCTION

FIG. 2



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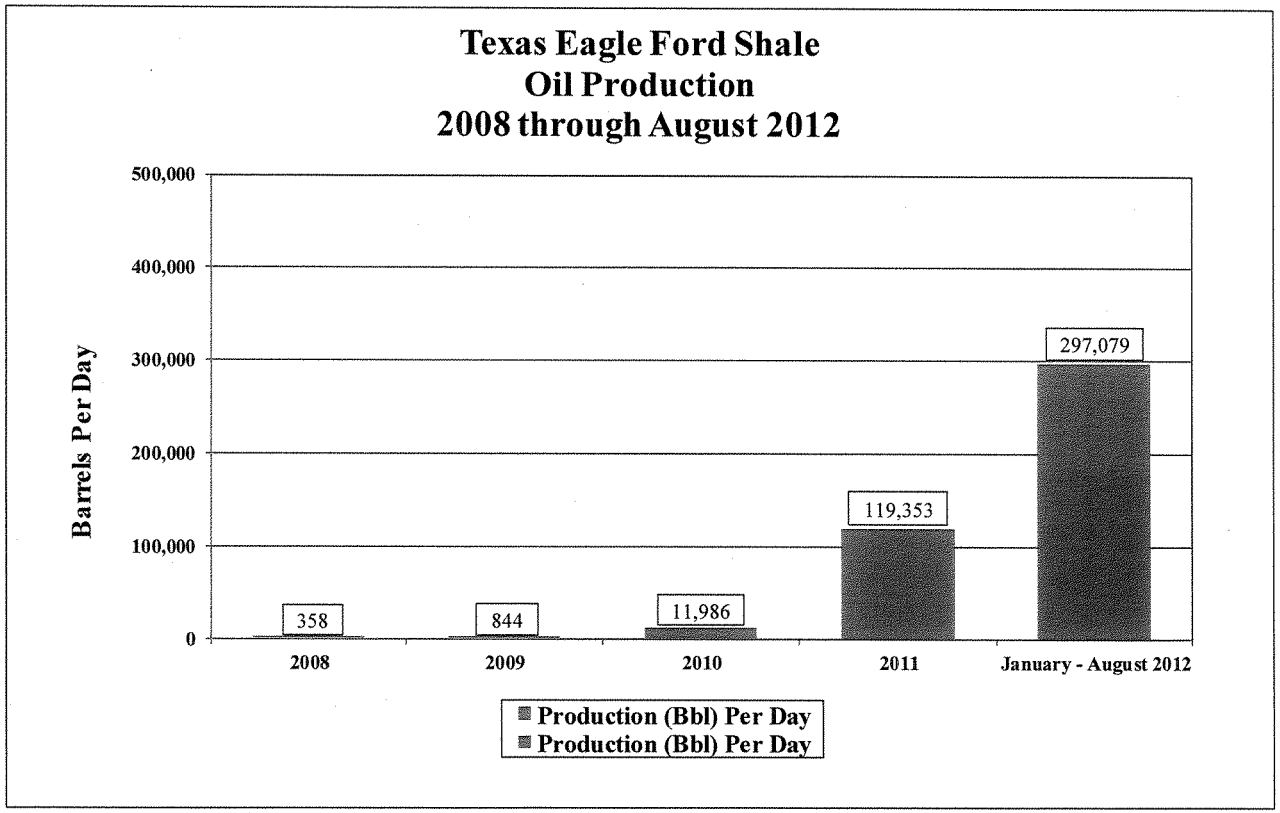

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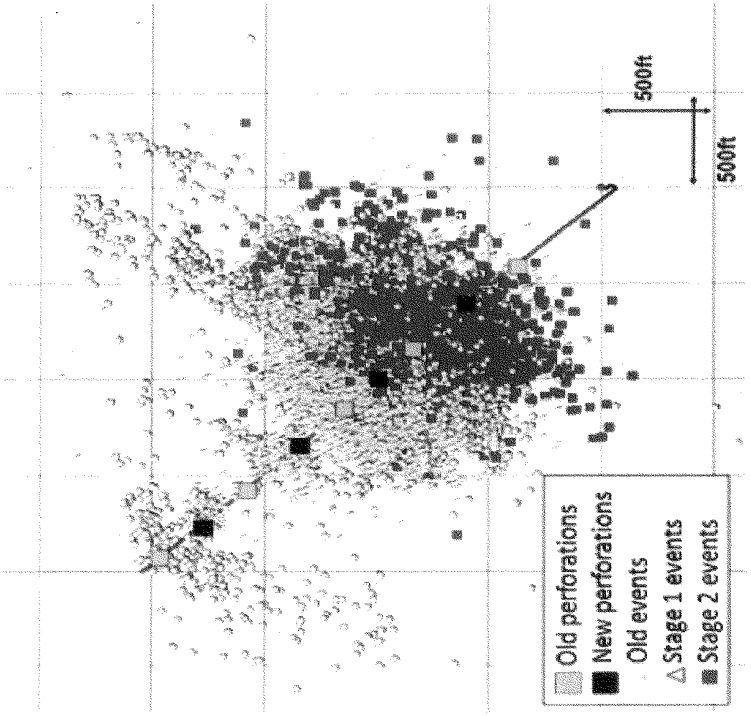

Potapenko et al., SPE 119636, Jan. 2009.

Chairman HARRIS. Thank you very much.

I now recognize our fourth and final witness, Mr. Michael Hagood, the Director of Program Development for Energy and Environment Science and Technology at the Idaho National Laboratory. Mr. Hagood.

**STATEMENT OF MR. MICHAEL HAGOOD,
DIRECTOR OF PROGRAM DEVELOPMENT,
ENERGY AND ENVIRONMENT SCIENCE AND TECHNOLOGY,
IDAHO NATIONAL LABORATORY**

Mr. HAGOOD. Chairman Harris, Ranking Member Miller and members of the Subcommittee, thank you for the opportunity to testify before the House Science, Space, and Technology Subcommittee on Energy and Environment.

I have been asked to provide a statement on aspects of U.S. oil shale resource development and the importance of associated research development and demonstration. The U.S. oil shale resource is immense in size with most of the resource located in the States of Wyoming, Utah and Colorado. Estimates from recent U.S. Geological Survey studies indicate that among these three states, approximately 4 trillion barrels of oil are estimated to be in place with a significant portion of this resource projected to be recoverable. To put that in perspective, some of those estimates are at 800 billion barrels of oil. To further put that in perspective, given 2011 estimates, the use of oil in the United States is approximately 6.8 billion. It is enormous.

A viable oil shale industry established on the foundation of these world-class western oil shale resources would help meet U.S. energy demands and reduce dependence on selected imports and their associated costs as well as reduce the risks associated with potential supply disruptions. On top of that, as already mentioned previously, this also has implications relative to the U.S. economy and not just directly but also in moving up the value chain associated with manufacturing.

An oil shale research and demonstration program can contribute significantly to unlocking some of the richest portions of the western oil shale resource and help achieve this in an environmentally responsible manner. Government and industry research development and demonstration investment in the Canadian oil sands and previous U.S. and current U.S. government investment in shale gas and oil development attest to the value of RD&D in developing unconventional fossil energy resources. In addition, several industry players are currently conducting R&D demonstration projects as part of the oil shale research and demonstration leasing program managed by the Department of Interior's Bureau of Land Management.

While a U.S. oil shale industry will likely be initiated with current technology such as with mining and surface retorts, aggressive research development and demonstration is also needed to explore and advance new approaches in innovation. Research development and demonstration offers to expand technology options, improve operability and efficiency, mitigate potential environmental impacts, and reduce costs of producing oil shale. The objective of a potential oil shale research development and demonstration program

should be to provide solutions that help achieve specific production and environmental performance goals. Such a program would have a near-term objective of supporting responsible development of an oil shale industry but also be sufficiently farsighted to anticipate and promote multiple next-generation technology advancements. Given the longevity of this resource, it is something important to keep in mind. This resource could last 100 or more years.

An oil shale research development and demonstration program should focus on challenges that exist at both a site operation scale and those that occur at industry-wide scale including addressing fuel logistics, integrated energy systems and address potential cumulative environmental effects. Relative to energy systems, these can include integration of renewable energy or even nuclear energy with fossil energy development.

Research development and demonstration associated with site operations should include enhancing production efficiency and environmental performance associated with in situ processing. Addressing environmental performance both at regional and operation scale needs to address surface and groundwater management, air quality, greenhouse gas, wildlife and land disturbance challenges. An effective R&D program should be guided by a strong, strategic plan developed working with diverse stakeholders and implementing R&D roadmap to ensure that the key research needs are identified and prioritized. Such a strategy can be built upon work already completed by U.S. Department of Energy in supporting and implementing the Energy Policy Act of 2005, Section 369.

Planning should also take advantage of decades of relevant research conducted in association with the Canadian oil sands as well as what is transpiring recently as part of the Department of Interior's oil shale leasing program. This effort should also incorporate assets and expertise that have emerged around western oil shale operations and research including by industry, regional universities, government agencies and laboratories.

The U.S. Department of Energy is a technical integrator that can bring together needed assets from both within and outside DOE to deliver an impactful RD&D program and can also act as an independent broker of technical information. DOE and its laboratories are well qualified to provide this leadership and to deliver a focused, solutions-oriented research program to address key challenges in developing long-term U.S. oil shale industry development.

Chairman and members of the Subcommittee, thank you once again for the opportunity to share my testimony with you.

[The prepared statement of Mr. Hagood follows:]

Testimony of

Michael C. Hagood

Director, Program Development

Energy and Environment Science and Technology

Idaho National Laboratory, Idaho Falls, Idaho

Before the

House Committee on Science, Space and Technology

Subcommittee on Energy and Environment

On

TAPPING AMERICA'S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT ACT OF 2012.

November 30, 2012

INTRODUCTION

Chairman Harris, Ranking Member Miller and members of the subcommittee, thank you for the opportunity to testify before the House Science, Space and Technology Subcommittee on Energy and Environment. Addressing United States (U.S.) energy security is extremely important and establishing an U.S. oil shale research and development (R&D) program is strategic, in my view, to securing our energy future.

My name is Michael Hagood. I am the Program Director for Energy and Environment Science and Technology at Idaho National Laboratory. I am a geologist by training and have worked in the energy and environment sectors for over 30 years.

My testimony will address the following:

- Background on Western U.S. oil shale resources;
- How safe and responsible production of oil shale contributes to U.S. security goals;
- Identification of selected technical challenges and R&D needs;
- Comments on strategy to identify and prioritize R&D;
- Comments on draft legislation titled "Tapping America's Energy Potential through Research and Development Act of 2012."

OIL SHALE RESOURCE BACKGROUND

The United States is currently experiencing an increase in domestic oil and gas production, primarily associated with its shale gas and tight light oil (shale oil) resources. Production from U.S. oil shale resources, as well, will likely emerge during the next several years as an important contributor to oil and gas production with the potential to ramp up into a substantial industry during the next few decades and lasting for most, if not all, of this century.

Oil shale is a fine-grained sedimentary source rock, containing organic matter called kerogen, an algae or marine based material that has not yet been converted into oil. When heated using a pyrolysis (retort) process, oil shale can be converted to either crude oil or gas. Crude shale oil is then processed in an oil refinery to produce gasoline, diesel and jet fuels.

Oil shale resources in the United States are immense in size, with most of the resource located in the states of Wyoming, Utah and Colorado. The richest oil shale was deposited in the north-central part of the Piceance Basin in Colorado and in the northeast corner of the Uinta Basin, located in parts of northeast Utah and northwest Colorado (Mercier and Johnson 2012). The Colorado deposits extend from approximately 1,000 feet to as much as 3,000 feet beneath the surface. Within the oil shale column are geologic formations that vary considerably in kerogen content and oil concentration. According to U.S. Energy Information Administration (EIA), the entire column ultimately could produce more than one million barrels oil equivalent per acre during its productive life, compared to Canada's oil sands deposits which are expected to produce about 100,000 barrels per acre (EIA 2009).

Estimates from recent U.S. Geological Survey studies indicate that between Colorado, Utah and Wyoming, nearly four trillion barrels of oil are estimated to be in place. Most of this resource is located on federal lands. Of the estimated four trillion barrels, it is not known how much oil is potentially recoverable and depends on technical and economic conditions. However, the Rand Corporation (Bartis et al., 2004) estimates that 30 to 60 percent of the oil shale may be recoverable. This is most significant, given that U.S. usage is approximately 6.8 billion barrels in 2011 (18.83 million barrels per day) and projected to be 7.3 billion barrels/yr. in 2035 (19.9 million barrels per day) (EIA 2012).

Oil shale development occurs by either in situ (in place) retorting or ex situ (at the surface) retorting. During the mid-1970s and early 1980s, the petroleum industry focused its efforts primarily on underground mining and surface retorting of oil shale. Today, mining and surface retorting is planned in areas where oil shale is located nearer the surface and more economical to mine. However, the higher concentrations of oil shale resources are located at depths where in situ processes may be more cost effective.

It is more likely that mining with ex situ retort operations will be initiated first by the U.S. oil shale industry and which will be primarily conducted on state and/or private lands. In situ retort operations within the richer formations will likely be initiated later. EIA estimates that the earliest date for initiating construction of a commercial project is 2017 for ex situ process and 2023 probably is the earliest initial date for first commercial production of in situ processes (EIA 2009). However, the Red Leaf Resources Eco Shale process, which is a modified surface retort method, may come on line as early as 2015.

Establishing an oil shale industry is heavily dependent upon economics and the price of a barrel of oil. According to industry representatives (represented by the National Oil Shale Association), it costs somewhere between $40 and $80 to produce a barrel of oil from shale, depending on the technology used. The price of oil, currently at ~$87 a barrel, has risen in the past over $100 a barrel.

HOW DOES SAFE AND RESPONSIBLE PRODUCTION OF OIL SHALE CONTRIBUTE TO U.S. SECURITY GOALS

A viable oil shale industry would help meet U.S. energy demands and reduce dependence on selected imports and associated costs, as well as reduce the risks associated with potential supply disruptions. New jobs directly related to oil and gas industry and the domestic production supply chain would arise from this industry, including those potentially associated with value-added industries, not yet identified. Development of an oil shale industry will also result in increases in tax and royalty payments to federal and state government for oil production on their lands and contribute to the U.S. gross domestic product (Unconventional Fuels Task Force 2004, 2006; GAO 2012).

Currently, it is not known what production rates may be achieved by an oil shale industry, however DOE provided a vision of a commercial oil shale projects that would range in size from 10,000 to 50,000 barrels per day for surface retorts to as much as 300,000 barrels per day for full-scale in situ projects. For the DOE study, a reasonable development scenario envisioned cumulative production of two to four million barrels per day by 2020 to 2030. The time to market, however, depends on the level of R&D support and other factors.

SELECTED TECHNICAL CHALLENGES AND ASSOCIATED RESEARCH AND DEVELOPMENT NEEDS PERTINENT TO CREATING AND SUSTAINING A U.S. OIL SHALE INDUSTRY

While an U.S. oil shale industry will likely be initiated on a small portion of the U.S. oil shale reserves using current technologies, an aggressive R&D program is required to help tap the largest and most valuable portions of the U.S. reserves. Specifically, R&D is required for in situ processes to explore and advance new approaches and innovative concepts. More research promises to expand technology options, improve operability and efficiency, mitigate potential environmental impacts and reduce costs of producing oil shale (DOE, 2004). Advancement of novel concepts and new approaches requires significant investment in long-term, high-risk R&D to reach proof-of-concept stages of development. Similarly, applied R&D is needed to develop and prove technology at bench or field scale prior to demonstration at a commercial scale (DOE, 2004).

Research and Development has already played a strategic role in the successful development of unconventional fossil energy resources, such the Canadian oil sands, U.S. shale gas and shale oil (light tight oil, e.g., Bakken Formation). All of these R&D programs took many years to bring new products to market. Relative to oil shale, a summary profile of oil shale technology and R&D can be found in various reports (U.S. DOE 2007, 2011; Unconventional Fuels Task Force, 2007). Research emanating from Canadian oil sands development is also an invaluable and relevant source of information, even though focused on a different type of hydrocarbon resource.

Ex situ retort of oil shale has already been deployed commercially, however most of the richer Western oil shale resources are located at depths requiring implementing in situ retort and recovery processes. Although the technical feasibility of in situ retorting has been proved, considerable technological development and testing are still needed. Of particular note, several industry players are conducting demonstration projects as part of the Oil Shale Research Development and Demonstration Leasing Program managed by the Department of the Interior's Bureau of Land Management (Crawford et al, 2012). Particular challenges include improving the economics of these operations by simultaneously attaining greater production efficiencies and mitigating environmental impacts. A number of associated research topics need to be addressed in a federal oil shale R&D program, including increasing the energy return on investment, fracture mechanics and heat transfer for enhancing recovery, materials performance in high-temperature subsurface environments, real-time subsurface process monitoring, water use reduction and post-retort subsurface environmental impact mitigation. Modeling and simulation can assist in addressing many of these topics but computer simulations must be supported by laboratory testing and field validation. In addition, there is significant opportunity for developing novel technology to support "smarter," environmentally-friendly oil shale development.

A number of challenges and opportunities also exist for an emergent oil shale industry as a whole. Collectively there are likely several pathways to develop Western oil shale, which goes beyond addressing individual site operations. Accordingly, it is worthy to consider conducting an oil shale industry fuels logistics analysis which would help better understand options for developing a power, refining and delivery infrastructure, within the context as well of a marketplace. Given the size and longevity of the resource, there is also opportunity to investigate application of hybrid energy systems approaches, including integrating renewable and/or nuclear

energy into oil shale development schemes for achieving greater carbon efficiency and reducing environmental impact. Understanding the development of a U.S. oil shale industry within the context of a greater bi-national regional energy corridor is also essential to enhancing long-term U.S. energy security and the economy. In addition, there will be cumulative environmental and socioeconomic effects in the region that need to be better understood and addressed, including within the context of competing needs (i.e., for agriculture, municipalities, industry, etc.).

Associated with both site operations and development of a larger oil shale industry is a need to ensure that oil shale resources are developed using environmentally suitable approaches. Increasingly, research is playing a role in better understanding the interdependencies between energy development and the environment and the development of innovations that mitigate environmental impacts. This requires significant investments in research to enhance environmental performance associated with water, air quality, wildlife, land (including land reclamation) and greenhouse gases. Water management, as an example, is critical in the arid west and there are concerns that adequate quantities are available to support an oil shale industry and whether there will be impacts on water quality and use elsewhere.

COMMENTS ON DRAFT LEGISLATION TITLED "TAPPING AMERICA'S ENERGY POTENTIAL THROUGH RESEARCH AND DEVELOPMENT ACT OF 2012."

A federal oil shale R&D program is critical to establishing a viable U.S. oil shale industry, focused on long-term responsible and safe oil shale production. Given the evidence from R&D investments made in similar settings, such as the Canadian oil sands, an oil shale program would provide a high return on investment. A well-organized federal R&D program can provide the backbone for coordinating research across academia, industry, and state and federal laboratories.

The objective of such an oil shale R&D program should be to provide solutions that help achieve specific production and environmental performance goals. It should have a strong strategic plan and a road map to better focus and prioritize R&D investments. Prescribing specific investment R&D directions without sufficient planning can be risky and potentially lead to disconnected R&D efforts that do not effectively achieve the desired end state. A significant body of work produced by DOE and the Task Force on Strategic Unconventional Fuels already exists upon which R&D planning can be built (see references) including a 2008 strategic plan for implementing portions of the Task Force's recommendations (Task Force's 2007 program plan), prepared by an Ad-Hoc group of approximately 35 representatives from private industry, academia, community representatives, and local, state and Federal agencies (DOE, 2008).

Stakeholder engagement in an R&D program is very important. Tapping diverse views and champions are essential for innovations in technology. A R&D network promoting "shared research" will improve technology development and have greater impact on technology development than isolated R&D.

The R&D program must consist of investments in both basic and applied research, given the nature of the industry and its longevity. In addition, a strong field demonstration aspect should be required to better facilitate technology deployment. Such a program would provide a greater understanding of the potential benefits and

impacts of oil shale development, while preparing the ground work for, and facilitating, commercialization of America's strategic oil shale resources.

The U.S. Department of Energy and its laboratories are well qualified to provide leadership to deliver a focused, solutions oriented R&D program to address key challenges in realizing a competitive U.S. oil shale industry. DOE is a technical integrator that can bring together needed assets and expertise from both within and outside DOE, including universities and industry, to provide a high-quality R&D program, and as well, act as a needed honest broker of technical information.

Chairmen and members of the Subcommittee, thank you once again for the opportunity to testify.

REFERENCES

Bartis, J.T., T. LaTourrette, L. Dixon, D.J. Peterson, G. Cecchine, 2005. "Oil Shale Development in the United States – Prospects and Policy Issues." Rand Corporation - Prepared for the National Energy Technology Laboratory, U.S. DOE.

Crawford, P.M., C. Dean, J. Stone, J. Killen, 2012. "Assessment of Plans and Progress on US Bureau of Land Management Oil Shale RD&D Leases in the United States." *http://www.unconventionalfuels.org/otherreports.html*.

General Accounting Office, 10 May 2012. "Opportunities and Challenges of Oil Shale Development: GAO-12-740T." General Accounting Office.

General Accounting Office, 2012. "Unconventional Oil and Gas Production: Opportunities and Challenges of Oil Shale Development GAO-12-7407." General Accounting Office.

General Accounting Office, 29 Oct 2010. "Energy-Water Nexus: A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development GAO-11-35." General Accounting Office.

King, C.W., and M.E. Webber, 2008. "Water Intensity of Transportation," Environmental Science & Technology, Vol. 42, No. 21, pp. 7866-7872 at *http://pubs.acs.org/doi/abs/10.1021/ec800367m*.

Mercier, T.J., and Johnson, R.C., 2012. "Isopach and Isoresource Maps for Oil Shale Deposits in the Eocene Green River Formation for the Combined Uinta and Piceance Basins, Utah and Colorado." *U.S. Geological Survey Scientific Investigations Report 2012–5076*, 85 p., 1 pl.

National Oil Shale Association, May 2010. "Oil Shale Update." *http://www.oilshaleassoc.org/documents/FinalUpdateMay2010.pdf*.

Task Force on Strategic Unconventional Fuels, December 2009. "Annual Report."

Task Force on Strategic Unconventional Fuels, September 2006. "Development of America's Strategic Unconventional Fuels Resources." Initial Report to the President and the Congress of the United States – Prepared in Response to Section 369(h) (5)(A) of the Energy Policy Act of 2005 (P.L. 109-58).

Task Force on Strategic Unconventional Fuels, September 2006. "Development of America's Strategic Unconventional Fuels Resources." Initial Report to the President and the Congress of the United States.

Task Force Strategy and Program Plan, 2007. "America's Strategic Unconventional Fuels." Volume I – Preparation Strategy, Plan and Recommendations, Volume II – Resource-Specific and Cross-cut Plans, Volume III – Resource and Technology Profiles."

U.S. Department of Energy Office of Naval Petroleum and Oil Shale Reserves, December 2004. "America's Oil Shale – A Roadmap for Federal Decision Making – Sustainable Development of Oil Shale Resources in the United States."

U.S. Department of Energy Office of Petroleum Reserves Office of Reserve Lands Management, Fourth Edition, September 2011. "Secure Fuels from Domestic Resources: The Continuing Evolution of America's Oil Shale and Tar Sands Industries - Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development: 5th Edition."

U.S. DOE Office of Naval Petroleum and Oil Shale Reserves, November 2008. "Strategic Plan - Unconventional Fuels Development within the Western Energy Corridor." U.S. Department of Energy, Ad Hoc Unconventional Fuels Working Group: U.S. Department of Energy.

U.S. DOE Office of Petroleum Reserves, September 2010. "Oil Shale Research in the United States: Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies." U.S. Department of Energy Office of Reserve Lands Management. Second Edition,

U.S. DOE, 2008. Strategic Plan - Unconventional Fuels Development within the Western Energy Corridor - produced by the Ad Hoc Unconventional Fuels Development Working Group.

U.S. Energy Information Administration Annual Energy Outlook Analysis. AEO, 2009. "Expectations for Oil Shale Production."

U.S. Geological Survey Oil Shale Assessment Team, 2011. "Oil Shale Resources of the Eocene Green River Formation, Greater Green River Basin, Wyoming, Colorado, and Utah." U.S. Geological Survey Digital Data Series DDS–69–DD, 6 chapters, pages variable.

U.S. Geological Survey, June 2011. "Assessment of In-Place Oil Shale Resources of the Green River Formation, Greater river Basin in Wyoming, Colorado and Utah." United States Geological Survey, June 2011.

SUMMARY

The U.S. oil shale resource is immense in size with most of the resource located in the states of Wyoming, Utah and Colorado. Estimates from recent U.S. Geological Survey studies indicate that among these three states, nearly four trillion barrels of oil are estimated to be in place, with a significant portion of this resource projected to be technically and economically recoverable. A viable oil shale industry would help meet U.S. energy demands and reduce dependence on selected imports and associated costs, as well as reduce the risks associated with potential supply disruptions.

An oil shale R&D program can contribute significantly to unlocking some of the richest portions of the western oil shale resource and help achieve this in an environmentally responsible manner. Government and industry R&D investment in the Canadian oil sands and previous U.S. government investment in shale gas and oil development attest to the value of R&D in developing unconventional fossil energy resources.

While an U.S. oil shale industry will likely be initiated with current technology, aggressive R&D is also needed to explore and advance new approaches and innovation. R&D offers to expand technology options, improve operability and efficiency, mitigate potential environmental impacts and reduce costs of producing oil shale. The objective of an oil shale R&D program should be to provide solutions that help achieve specific production and environmental performance goals. Such a program would have a near-term objective of supporting responsible development of an oil shale industry, but also be sufficiently far-sighted to anticipate and promote multiple "next generation" technology advancements.

An oil shale R&D program should focus on challenges that exist at both a site operations scale and those that occur at industry-wide scale, including addressing fuel logistics, integrated energy systems approaches (including renewable and nuclear energy options), and address potential cumulative environmental effects. R&D associated with site operations should include enhancing production efficiency and environmental performance associated with in situ processing. Addressing environmental performance, both at regional and operations scale needs to address surface and groundwater management, air quality, greenhouse gases, wildlife and land disturbance challenges.

An effective R&D program should be guided by a strong strategic plan working with diverse stakeholders and implementing a R&D road map to ensure that the key research needs are identified and prioritized. Such a strategy can be built upon work already completed by the Unconventional Fuels Task Force (www.unconventionalfuels.org) and DOE in support of implementing Energy Policy Act 2005, Section 369. Planning should also take advantage of decades of relevant research conducted in association with the Canadian oil sands. This effort should also incorporate assets and expertise that have emerged around western oil shale operations and research, including regional universities, government agencies and laboratories.

The U.S. Department of Energy is a technical integrator that can bring together needed assets from both within and outside DOE to deliver an impactful R&D program and can also act as an honest broker of technical information. DOE is well qualified to provide leadership and to deliver a focused, solutions oriented, R&D program to address key challenges in developing a long-term U.S. oil shale industry.

Chairman HARRIS. Thank you very much, and I thank the panel for their testimony, reminding members that Committee rules limit questioning for five minutes. The Chair will at this point open the round of questions, and I recognize myself for five minutes first.

Mr. Hagood, thank you very much for that testimony. Let me get those figures straight. There are estimates that of those 4 trillion barrels, 800 billion potentially recoverable, and if I do my math right, that is over 120 years at our current usage, and remember that our current usage of oil is actually declining over the past few years, so we have potentially over 120 years in that oil shale by those numbers?

Mr. HAGOOD. Yes.

Chairman HARRIS. That is what I thought. And who has the largest oil shale deposits in the world? It is us, and is it some other country also?

Mr. HAGOOD. Well, the United States has——

Chairman HARRIS. The United States, so let me see, I think I get it. Okay. So it is something we probably ought to be investing in.

Dr. Hill, do you realize that of the—oh, my gosh, let me see, $15 billion or so DOE budget, that only $5 million is spent on unconventional, none of it on oil shale or shale oil and gas?

Dr. HILL. I am well aware.

Chairman HARRIS. You realize that, right?

Dr. HILL. Yes.

Chairman HARRIS. Okay. I know you mentioned the importance of getting this money to graduates, but there is no money going to graduate students who are looking at oil shale from DOE, I anticipate.

Mr. Martineau, let me just run that one more time because even in the current discussion, we are hearing about Big Oil and all the rest of that. The intangible drilling cost deduction and depletion allowance doesn't go to Exxon, does it? The vast, vast, vast majority. I mean, the vast majority goes to small owners and drillers?

Mr. MARTINEAU. Yes and no. Exxon and major oil companies get to deduct 70 percent of their intangibles, but when they come back into this country and start drilling again, it is very important.

Chairman HARRIS. That they continue to do it because they are drilling here, not making money overseas.

Mr. MARTINEAU. Amortized over five years.

Chairman HARRIS. So when we are talking about that, that is about domestic manufacturing. That is what I thought, and I thought we all support domestic manufacturing. You mentioned that—it is interesting because you kind of mentioned the importance of investing in these technologies, and there are two ways you can invest. The government can invest in order to find ways to condemn the technology, or they can invest to find ways to further develop new technologies, and my fear is that some of the investment being done over at EPA, and I am going to get Dr. Cugini next about DOE, may be the former, that's what we want to do, is we want to do research to condemn current technologies, not realizing the future is to find the next technological breakthrough, and it would seem to me that that—and I am just asking if you share that opinion. It seems that that is the best way we should be spending our money is actually to find out how to increase pro-

duction through new technology, not finding problems with current production in order to just condemn it. I mean, that has no use if you are not going to also find ways to improve it. Is that correct?

Mr. MARTINEAU. I think you can improve the technologies that we currently have, and——

Chairman HARRIS. And that would do both things at once, right? It would increase production and help the environment.

Mr. MARTINEAU. Exactly.

Chairman HARRIS. Right, and I am still trying to figure out how drilling those wells at Pavilion by the EPA does the latter and not the former. I am still trying to figure it out. It is just to condemn current technology. It is incredible to me.

Dr. Cugini, let me end up with you in my last couple minutes because, you know, this is about getting money into the Department of Energy to do some things. Is that really true, that there is no money spent right now on oil shale R&D? I mean, that was the testimony before the Committee this year.

Dr. CUGINI. Well, I think there has been some historical——

Chairman HARRIS. Not historical—this year.

Dr. CUGINI. But those projects are still underway, so at the University of Utah, we have some small amount of work going on and——

Chairman HARRIS. And how much is a small amount out of the $15 billion DOE budget?

Dr. CUGINI. I don't have those numbers——

Chairman HARRIS. Can you get that number back to me? And I will ask the Committee to make sure we make that request of the doctor. Because I suspect it is really small, which is just amazing to me because we have testimony, we are looking at 120 years of oil, and I am not even counting the things that is in shale oil and gas. We are just talking about this one resource, 120 years. We are in the midst of—the whole world would like to buy our oil and we are sitting on it, and you are telling me there is one little project at Utah, and that is it for oil shale.

Dr. CUGINI. Well, I think there is also some work that we do with Bureau of Land——

Chairman HARRIS. Well, now, let me ask you——

Dr. CUGINI. —Management that you pointed out during your——

Chairman HARRIS. Let us pretend we start with a clean slate. What are some of the things we should be doing in order to move the development of oil shale along? What are some of the things the Department of Energy you think could do within the realm of possibility?

Dr. CUGINI. Well, obviously several of the projects would involve improving the efficiency of the process, looking at things like better water management and those type of technologies. I think those are the two key components of an oil shale program. The energy requirements and water requirements are such that it makes it difficult to extra the oil economically so I think a program that was addressing those two issues would allow us to look further at oil shale.

Chairman HARRIS. And do you think that Chairman Hall's bill moves us in that direction, or can?

Dr. CUGINI. I think added resources would have the opportunity to do it. I think that is the way I would say it.

Chairman HARRIS. Okay. Thank you very much for answering.

I now recognize the ranking member, Mr. Miller, for five minutes.

Mr. MILLER. Thank you, Mr. Chairman. I know what Emerson said about a foolish consistency but I am still struck by this discussion.

Dr. Cugini?

Dr. CUGINI. Yes.

Mr. MILLER. You said in your testimony that, not oil shale, but shale oil technology was a result—that we have now was a result of research in the 1970s and the 1980s, Federal Government research but closely working with industry in that. Is that correct?

Dr. CUGINI. That is correct.

Mr. MILLER. Okay. And how—we have heard the phrase "picking winners and losers", and the various technologies are in competition with each other as the coal industry has learned from the decline in natural gas prices, and I think most of the assumptions about oil shale is that the reason it is not commercially practical, although it has been researched within an inch of its life, it is not commercially viable at current prices. But how are we not picking a winner? How are we not picking winners and losers in the 1970s and the 1980s?

Dr. CUGINI. Well, I think in the 1970s and 1980s, the research was developed—was focused on developing technology, base sets of technology. So you heard testimony today about some of the work that resulted in seismic activity allowing us to draw seismic maps. It was somewhat fundamental in nature. We were also able to start asking industry to start looking at these technologies, providing information about the resource maps and other types of information related to resources, and working with industry, industry picked up a lot of the balls in looking at applying, as we found out, hydraulic fracturing and other types of technologies.

Mr. MILLER. And by the way, I support energy research, and I support energy research into any available form of energy. In the 1970s and 1980s, I think we were spending ten percent of all federal research funding on energy research, and I think now it is 3, and that seems foolish to me. I think we should be spending more on energy research, and it should include energy into alternative fossil fuels or unconventional fossil fuels. So the research in the 1970s and 1980s was for a fairly early stage that might or might not work. Is that correct? Is that why the industry wasn't just doing it by themselves without needing government to be part of that?

Dr. CUGINI. I think there were a lot of factors in play. I mean, part of it was the early stage of the resources—the research. It was also a lack of information relative to whether that resource was actively there and actively extractable. So part of the DOE's budget in research at that time was characterizing—working with USGS and others to characterize the available resource. So there were a combination of interests. I think one of them may have been the early stage of the technology development.

Mr. MILLER. I am struck by the arguments, the fairly dismissive arguments about alternative energy sources as being unreliable, uncertain, and the fossil fuel research that we have heard about today is described as a sure thing, a slam dunk. Mr. Martineau, that was your testimony, and you are nodding your head now, that yes, that is right. But if it is a slam dunk, if we know it is going to be profitable, why do we need to be funding it? Why is that not an ordinary business expense for the industry that will produce it? It seems like the more logical funding should be for early-stage research for technologies that might or might not prove to be commercially viable.

Dr. Cugini, could you walk me through that? Could you explain that to me?

Dr. CUGINI. Well, there still is somewhat risk factors associated with some of the technologies, so take for example exploiting the natural gas resource from shale development. Right now, there is incentive to exploit that resource because at about 20 percent extraction of the gas, which current technologies, give or take, give us, it is economically recoverable. But there is potential to access quite a bit more of that gas through novel techniques. There really isn't any incentive, I think, in industry or capital in the industry to go after improved extraction technologies. So that might be an example that I think addresses your question.

Mr. MILLER. Mr. Martineau, if this research is as sure as you say it is to produce recoverable energy, why is this not—why is our funding for this research not paying for just an ordinary business expense for the industry? Why is it not a direct, just subsidy?

Mr. MARTINEAU. A subsidy—well, of course, I have been an independent oil and gas operator, which I have been a geologist for 52 years now, and I just look back at what has happened in the shale itself. We used to drill wells all the time through shales, non-commercial, low permeability nanodarcy type thing, and you couldn't do it, and until they started the Barnett shale program in 1981, when George Mitchell drilled the first well, attempting to develop the gas, and you think how many years it took before the shale took over. Now we have a shale revolution all over the whole United States, but if it hadn't been for some of the research work, and I was involved somewhat when the first horizontal well that I mentioned here before that George Mitchell drilled, was funded somewhat by the Department of Energy to see if a horizontal well—at that time gas prices were so low, it didn't make sense to do it, and as the gas prices came up, we started doing it. But some of the research that us independents—because we don't have access to research. We strictly drill well, drill producers, dry holes and commercial wells, and so I think the research that has been done that I have been involved with through my years in the business has been a real asset for the small independents, because we don't have the research teams to come up with the different type of technologies that were advanced in fracking itself. Fracking has been around for 50 years. We have been fracking wells forever, but the technology of hooking a horizontal well with a frack job—and they used to frack them all with water in one stage—or no, gel, and then they switched to water, increased the production tremendously. The horizontal legs now, it used to be 2,000, 3,000 feet.

Now it is 6,000 to 7,000 feet but 50 fracks in it. In other words, the technologies and the mapping that he did showing where the frack job goes is really critical because nobody knew before. The microseismic work that we have done and the technology, that was backed by funded research from the Department of Energy and different people how to do—how do you trace where these frack jobs go.

The big issue, of course, is frack water contaminating the freshwaters, and that mapping that he showed, it only goes 150, 200 feet away from that well before. They go up into the freshwater zone. It doesn't happen. There has never been a well yet that has been contaminated by a frack job from the freshwater zones. They have been contaminated all right, but it is because of poor casing, cementing or the lack of integrity in the pipe, which has caused the water, but, you know, they have been opening water wells in homes forever and you could light a match to it and, you know, it is not the first time. Since fracking came around, everybody says, oh, they are caustic. That is not true. That has been happening forever in this United States.

Chairman HARRIS. Thank you very much, and the gentleman yields back his time.

Chairman Hall is recognized for five minutes.

Chairman HALL. I thank you, Mr. Chairman, and I think Dr. Cugini and Mr. Martineau and others of you there could also point out that independents seek and search for and majors buy it, and independents are the ones that take the chance and need some help, and years ago I think that the names of Frank Pitts and Shelby Pitts are well known to this Committee. They have been before this Committee and before Energy and Commerce many times, and thank you. It is a product of theirs for being here.

Mr. Martineau, I want to thank you also for impact on unconventional energy production in Texas. As you know, states currently have the authority to regulate hydraulic fracturing, though I am concerned that the EPA's activist regulatory agency and disregard for scientific methods, not taking a scientific approach to it, in their attempts to usurp this authority. How does the responsible regulatory agency for oil and gas production in Texas—that is the Railroad Commission—perform regulation and oversight of TIPRO members and their companies?

Mr. MARTINEAU. Well, the Texas Railroad Commission has been overseeing the development of oil and gas for many, many years, and they have got technical staff of engineers and geologists just like the oil companies do, and whenever a frack job is performed—of course, now with the new frack focus, you have to report exactly what has been pumped into the particular well and that information was somewhat started kind of by the Railroad Commission because everybody kept saying well, we don't know what is going into the well. But the Railroad Commission oversees all the development when you are drilling a well, how much surface casing you have to set to protect the freshwaters and how much cement you actually have and you have to report all of this information to the Railroad Commission. So they have been overseeing the operations of oil and gas in Texas forever, and had the EPA come in—and I testified—well, I didn't testify. I went over to a hearing where the

EPA was talking about trying to control fracking, and every state, every rock is a little bit different. You frack them all different. You can't come up with one rule that covers the entire United States. Each state has different types of rock and therefore each State has its own regulatory agency and therefore you don't need to have one massive rule by people who have never drilled a well in their life trying to tell you how to do it.

Chairman HALL. Well, Mr. Miller asked some questions, logical questions about why can't the success pay for the search, you know. It is probably true that the independents do take all the chances and the majors buy them after they are successful. That is the reason that they need some support as they go.

Before I yield back my time, I want to thank Mr. Miller for his service to this Committee. He has been a very valuable member. He goes back to my state, all my people came from North Carolina, to give his services there, and I want to wish him well there.

I yield back my time.

Chairman HARRIS. Thank you very much, Mr. Chairman, and the gentleman from California, Mr. McNerney, is recognized for five minutes.

Mr. MCNERNEY. Thank you, Mr. Chairman, and I thank the panelists for coming today and testifying. Most of my colleagues, I believe would be in favor in providing research dollars for development of energy resources but I just challenge my Republican colleagues to be as receptive toward spending dollars on clean energy as they are on fossil fuel energy. For example, the wind energy production tax credit is about to expire this year. That will throw about 40,000 people out of work, and this is an industry that has been developed in this country by American research dollars. These jobs are going to go overseas and they are going to be taken over—this industry is going to be taken over by our competitors. So I think it is important that we keep that in mind as we move forward.

Now, I think everyone on this panel agrees that the unconventional resources are massive, that there is a massive amount of energy and fossil fuels there. But what is the energy balance of the unconventional resources versus the conventional resources? Pick any one of them, tar sands or shale oil. What is the energy out versus the energy in compared to what it looked like when the oil was first being developed back in the early 1900s? Does anyone want to take a shot? Dr. Hill, do you want to take a stab at that?

Dr. HILL. All right. Well, certainly some energy is expended in creating these wells, and you could pretty much figure it out from the economics, you know, compare the value of the oil produced compared with the cost to create and complete the wells, and a typical good oil-producing well now from a shale formation, you know, that ratio might be two or three to one. In other words, two or three times—the value of the crude oil produced is two or three times the cost of the well. So that is a rough ratio.

Mr. MCNERNEY. I mean, that sounds about right. Back in the spindle oil well days, they were talking about 90 or so to one, so we are seeing a much bigger investment of energy into these wells than we ever saw before, and those of us that are concerned about CO_2 and global warming, and I am one of those people, we are

going to be putting two to three times as much carbon into the atmosphere per unit of energy delivered. So this is a very big concern for myself, for a lot of people across this country about what impact it is going to have on our global environment. And I think that is something we need to consider as we move forward and the research dollars that are spent in this program to understand that impact and to find ways to mitigate that impact if carbon sequestration is part of the solution.

Now, another question I have is, will the so-called energy independence that we are aiming at result in any lower cost for American consumers as opposed to the cost that it will reduce for foreign consumers? So what I am getting at is that, yes, this is going to produce a lot more energy, a lot more oil but this is fungible. This is an international market. Those products are going to go overseas just like they are to this country. It is not going to help our consumers any more than it is going to help any other consumer in the world. So to say that this is benefiting American consumers more than foreign consumers I think is not necessarily true. It is not necessarily a true statement. Does anyone care to respond? Mr. Martineau? Go ahead.

Mr. MARTINEAU. You know, one thing earlier that you said about the other resources, and I think of biofuels in particular, because it is kind of interesting, you hear a lot of conversation, you know, biofuels are, what, ten percent of the gasoline you have do now, and the cost of the biofuels, which is this third-party energy, green energy-type thing, comes from the corn that is grown, and they were talking about how much water it takes to keep that corn growing, which is the water that we are now talking about how do we use it, we are using up all the water in fracking. A lot of it is being used to grow the corn. The corn now goes into biofuels and doesn't go to the food and so our food prices have gone up. And so, you know, these are the third-party-type green energy things that I think are very expensive, that people don't put the real dollar to it what that ten percent cost is unbelievable——

Mr. MCNERNEY. I agree. There needs to be a fair look at all these sources, and I am not going to single out fossil fuels because corn-based ethanol has its problems, no question about it.

The last question I have is regarding to the industry's record for hiring veterans of this country. The wind industry has the best record of any industry of hiring veterans because of the transfer of skills. What is the record of the fossil fuel industry in this area?

Mr. MARTINEAU. I am not real sure, although I heard, and I am not sure which group, they are doing a program, I think it is Houston—I will have to find out—where they are bringing in all of the veterans because the job increases that have increased in the United States recently because of the shale revolution is unbelievable, and they are putting a program together, and I can find out the name of it but it is to ask veterans to come in, study how to be a roughneck, how to be a roustabout, you know, either that or can they go to college and become an engineer or a geologist. So there are programs that are using veterans because we can't find people to go to work in all these shale plays that are going on right now, and I think your group in the wind industry, they can go to

work in the oil industry. They are not going to have to go overseas. They can go right to work in the oil and gas industry.

Mr. MCNERNEY. Mr. Chairman, I would ask that you consider that a part of your bill, Mr. Hall, to give provisions, special provisions for training and hiring veterans if they are going to be used in this research.

Chairman HARRIS. Thank you very much, Mr. McNerney, and I now recognize the gentleman from California, Mr. Rohrabacher, for five minutes.

Mr. ROHRABACHER. Well, let me just note that when people in this country are forced to use energy resources that are more expensive than the alternatives that they could use otherwise because of some harebrained environmental theory that whatever that harebrained theory is, that that expense, which is usually hidden from the public, goes right out of the pool of money that we have to provide good jobs for our veterans and everybody else. So if wind costs five times as much to produce the same amount of electricity as natural gas, that is how much money less we have to provide good jobs for veterans and anybody else in this country because we are eating up resources that could be used, put to better use and are now just evaporated because that wealth no longer exists. I find wind to be one of the, and from what I have seen and heard from various sources, one of the most inefficient ways of producing electricity per cost and not to mention the fact that there are environmental costs to it as well, the thousands of birds that get killed. I am not necessarily a bird man here but I can just tell you that there are many more birds that are killed by windmills than there are by fracking from what I understand.

And by the way, wind energy is not anything new. My family came from a small farm in North Dakota and I used to go up there and work in the farm in the summertime, sometimes the wintertime. They had windmills back then. In fact, about 100 years ago, windmills were thought to be the potential use for electricity, especially on farms and places like that, but they decided not to go that direction because it was cheaper and it was a waste of resources not to go with the cheaper method of producing electricity, and if you don't go with the cheaper method, you are evaporating wealth, which could be put to use in improving people's standard of living.

And let us also note, the idea that we have not been financing "green energy research" as compared to what we are doing with oil and gas is just incredible. I mean, hundreds of times more money has been spent on green energy research than in oil and gas, and that is documented here.

And one other thing. I think the oil industry and the gas industry, one of the most vilified industries that have done so much good for our country. Having come from a family in North Dakota, I realize what our cities must have smelled like when we were relying on horses for our transportation system, and I will tell you that a hundred years ago, one of the biggest problems was horse manure, and the smell and the stench and the health-related things, and the oil industry saved us from all of that, and kids aren't even taught that now. They just think that it was hunky-dory back in those days.

One thing that I probably have disagreed with the industry about is about this whole research thing that we are talking about today. If we are putting money into research, which is what we are talking about, and we are talking about how fracking became, you know, a viable source, and there are certain technologies that were developed and certain government involvement in that. What is the American taxpayer getting out of that? Are we going to, as far as I am concerned, if we invest in the development technology for your industry, and that technology reaps a big reward because we are producing all this energy now and making billions of dollars doing it, shouldn't the taxpayers be the owners of that technology if we are investing in it, and how much have we gotten back from our investment in research, for example, in fracking and other things? Besides the fact the public is benefiting, there is no doubt about that, but we are talking about in the other industry and people input money into research and development, develop new technologies, they have the patent rights and they have the property rights to that utilization and they make money on it. Now, shouldn't the taxpayers make money for investing and developing your technology? Anybody can answer that. That is fine with me.

Dr. HILL. I guess the government could do that if they chose to, in other words, Department of Energy-funded research, the Department of Energy could own the intellectual property. In general, the way it has always been is that this type of research is done for the general benefit of the public and so that knowledge that is created is share with everyone.

Mr. ROHRABACHER. Mr. Chairman, just for the record and this hearing, that this is one Congressman that would insist that if we are going to invest taxpayer money and whether it is the oil industry or any other industry, that developing technology for them to make a profit, the taxpayers should have an ownership right of some kind on the technology that is being developed, and that is just for the record. Thank you very much.

Mr. MARTINEAU. Let me answer one thing there. If you think about the economy, the natural gas prices here in the United States, they are benefiting because we have so much natural gas now that gas prices are down so low and they are benefiting indirectly. If they want to move to Europe, they sure can and pay $11 in MCF over there as opposed to $3.

Mr. ROHRABACHER. You know any time you do something right in a free market economy, it means somebody is going to make some more money, right? So it is not just oil and gas, it is anybody, if we were paying the research and development costs for any other industry and then they were profiting from it, that would be different if that industry was using their own money and developing their own technology. They would actually own the rights to that particular technology and they would lease it out to other people and make money from it. Now, if the United States government is going to do this for your industry or any other industry, I might add, I just think that the taxpayers should own that share of the technology they are helping to develop and should go into the coffers of the taxpayer.

Chairman HARRIS. Again, I want to thank the gentleman from California, and the gentleman, the new gentleman on the Com-

mittee has been very patient waiting. It is my pleasure to recognize Mr. Curson for five minutes for questioning.

Mr. CURSON. Thank you, and being the newest member, I am probably the least knowledgeable about this issue, but I have studied the history of this Committee and these hearings, and first I want to agree with the previous speaker that I am glad that our automobiles aren't powered by horse manure, coming from the industry.

But in this particular issue, I know the question that the citizens of my district will ask is, we have got an industry that the government has participated in R&D. This is a for-profit industry. They provide the oil industry very generous tax rates and incentives. The three largest companies, oil companies in America, in 2011 made $80 billion in profits while the rest of the economy was struggling out of the worst recession that we have had in many, many years. Why would the government pay for R&D to create more profit for a profit company when these companies aren't making nickels and dimes, they are making huge dollars? I heard clearly that many of the smaller oil companies that don't make these type of profits are the ones that are the actual benefactors. Well, there is other ways for those companies to take advantage of this rate. I believe that—I would like to have an answer on why in the big picture with companies making this kind of profit should the government be rolling out taxpayer dollars to do your R&D, particularly these aren't new technologies. This unconventional resources have been around for years and the oil companies have decided not to pursue them because they weren't profitable in the end. So if now new technologies are making it more clear that they can be profitable, you would think that would be the responsibility of the oil companies to pursue it, and in previous hearings on this very subject when you get a member of the U.S. Chamber that says "I don't think you will find anybody in the industry that is saying we need more money from the federal government." I believe that is the same thing the citizens of my district would say.

So if there is a reasonable answer to that, I would like to hear that.

Dr. HILL. I would like to point out that again, as I said in my testimony, the majority of research funding of this type that goes to the Department of Energy in general, it is funding university research. Is it not going to Exxon Mobil. It is not going to these very profitable oil companies. It is being spent in universities, and this is how we were able to train the engineers that this country desperately needs, and so I would encourage you to think of it that way. Don't think of this as not money flowing directly to the industry, it is helping develop technology that anyone in the country is welcome to use but it is really being spent in support of education.

Mr. MARTINEAU. And that education goes to people like Apple. You notice where Apple is on their profits compared to Exxon? You need to look at that. It is four times higher than what Exxon is, and the engineering that he was just talking about from those students is what helped. Will you give up your phone? Will you give up your computer? Will you give up the plastic that you use every day in these water bottles? It all comes from the research done

originally by the oil and gas industry and utilized by other technologies like Apple.

Chairman HALL. Will the gentleman yield?

Mr. CURSON. I yield the rest of my time.

Chairman HALL. What percentage of the little independents that drill and hit to those who drill and miss?

Mr. MARTINEAU. You don't want to know the number of dry holes I have drilled in my lifetime.

Chairman HALL. I think that answers my question.

Mr. MARTINEAU. And you know, it kind of goes back, speaking of dry holes made me think about when we talk about intangible drilling deductions, and the reason that bill was put in place back in 1913 was because at that time if you drilled a bunch of dry holes or non-commercial wells, you were out of business, and if you didn't continue having some sort of resources, so that tax credit for intangible drilling was passed in 1913, 100 years ago, and because of that being able to continue if you drill dry holes and non-commercial wells, Mr. Hall, is what has kept our industry alive, and to be able to say you want to take away intangible drilling costs, you will put so many companies out of business, it is unbelievable because not everybody drills a producer, let me tell you. There can be non-commercial wells, and people forget about those, but you haven't got your money back. And it is not like making a washing machine or an automobile, you know. It comes out every day. You come and drill with me, you might not make a well every day.

Chairman HARRIS. Thank you very much, and I want to thank all the witnesses for your valuable testimony and to the members for their questions. The members of the Subcommittee may have additional questions for the witnesses, and we ask you to respond to those in writing.

Mr. ROHRABACHER. Mr. Chairman?

Chairman HARRIS. I am sorry. I yield to the gentleman from California.

Mr. ROHRABACHER. I would like unanimous consent for one minute.

Chairman HARRIS. Without objection.

Mr. ROHRABACHER. I would just like to thank Mr. Miller for the job that he has done with us. It has been a lot of fun kibitzing with you on various issues, and he is a very intelligent member and a very hardworking member of this Committee, and sometimes we have had disagreements, obviously, but the fact is, is that he is a very respected person here and we will miss him and wish him well in the years ahead. Thank you for the good job that you have done.

Mr. MILLER. Thank you, Mr. Rohrabacher. I am not aware of any instance in which either one of us has convinced the other of anything, but thank you.

Chairman HARRIS. I want to thank the gentleman from California and echo the gentleman's comments. It has been a pleasure working with the ranking member. And, you know, in the end, we all realize that we want what is best for the country and what is best for Americans, and do our little bit here on the Energy and Environment Subcommittee of the Science Committee toward that

end. I want to thank him for his service to the Congress and to his district.

Anyway, again, we will ask you to respond to any questions in writing that come from Committee members. The record will remain open for two weeks for additional comments from members.

The witnesses are excused and the hearing is adjourned.

[Whereupon, at 10:53 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Anthony Cugini

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Andy Harris
Tapping America's Energy Potential Through Research and Development

Dr. Anthony Cugini

1. What recommendations do you have to resurrect and develop a Department of Energy oil shale research and development program? What are key items and considerations to guide oil shale research activities?
2. Please describe the types of activities you anticipate DOE supporting as part of its contribution to the interagency shale gas study effort. Can you ensure the committee that activities focused on issues such as safety and the environment are designed not to find problems or excuses to regulate but rather are focused on developing technological solutions to enable increased production? Beyond environmental issues, what other governmentally-appropriate research and development activities can be undertaken to advance expanded development of domestic unconventional resources?

Responses by Mr. David Martineau

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Andy Harris
Tapping America's Energy Potential Through Research and Development

Mr. David Martineau

1. What sort of impact have shale plays, such as the Barnett and Eagle Ford, had on the local economy and unemployment rate? In addition to direct benefits, what increased professional demands in related economic sectors is Texas experiencing? What are some of the multiplier effects?

2. As you are aware, technological development in unconventional energy productions is providing extensive economic benefits in a time of sorely needed economic stimulation. Can you speak to the impact of energy development on average consumers? In addition to employment benefits, what other sorts of positive effects do people experience on a day to day basis?

3. Mr. Martineau, a recent report by Citigroup declared that "North America is the new Middle East. The only thing that can stop it is politics…" Can you describe potential hurdles politics could pose to the timely, safe, and economic recovery of our oil and gas resources?

4. The Wall Street Journal's CEO Council recently ranked the most important U.S. policy issues and concluded that promotion of shale oil and gas to be among the top five—right alongside deficit reduction, taxes, and immigration. This speaks volumes about the magnitude and importance of the broader spillover effects of the revolution in unconventional oil and gas development. Can you speak to the broader importance increased energy production can have? For example, what effects are cheap and abundant natural gas supplies having on the manufacturing and chemical industries?

Responses by Dr. Daniel Hill

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment

Hearing Questions for the Record
The Honorable Andy Harris
Tapping America's Energy Potential Through Research and Development

Dr. Daniel Hill

1. How can technology advances in water reuse and recycling improve operation efficiency and potentially mitigate stress on local water resources? Can you speak to what type of R&D needs to be conducted in order to enable treatment and re-use of fracking water for other purposes, such as agricultural?
2. Please identify some challenges associated with produced water management and the different nature of those challenges across different shale plays? How are recycling techniques and technologies different across shale plays and unconventional oil and gas resource types?
3. What are some of the potential alternatives to fracking with fresh water, such as non-potable or brackish water? Additionally, please comment on waterless options such as propane gel or compressed air, and discuss how University research and development might enable these sorts of options?
4. Can you comment on how the Produced Water Utilization research and development activities contained in H.R. 6603 address major challenges related to minimizing potential environmental impacts of shale operations?

Responses by Mr. Michael Hagood

RESPONSES TO HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy & Environment
Hearing Questions for the Record
The Honorable Andy Harris
Tapping America's Energy Potential Through Research and Development

RESPONDENT: Michael Hagood, Idaho National Laboratory

Question #1: What is the current state of global activity on oil shale research and production? Is there a risk of the U.S. falling behind to foreign countries and companies that are also pursuing development of oil shale?

Response: The world's oil shale deposits are located in more than 30 countries with more than 60% located in the USA (Allix et al, 2011; Knauss et al, 2010). Given historical precedents in evaluating oil and gas deposits, additional oil shale deposits will likely be discovered in the future. Most of the world's commercial oil shale development operations are currently focused on surface or subsurface mining approaches accompanied by less sophisticated surface shale retort processes.

Oil shale research and development (R&D) is primarily being applied to in situ development processes, i.e., for those deposits that are sufficiently deep and not economical to mine. Much of this R&D is funded by U.S. and international industry, primarily associated with Western U.S. oil shale development. The import of this particular R&D focus is significant given that some of the greater concentrations of oil shale resources are found at depth. Summary profiles of oil shale technology and R&D can be found in various reports (U.S. DOE 2007, 2010, 2011).

Of particular relevance to oil shale research, the Albertan government and industry have invested heavily in in situ processing R&D associated with developing Canadian oil sands, primarily located in Alberta. Although, oil sands differ compositionally from Western U.S. oil shale, oil sands research has spawned significant innovation, including some benefitting U.S. oil shale research. As a result of this investment, Canada maintains both an operational and R&D leadership position relative to in situ processing of unconventional oil resources.

Current R&D leadership derived from a combination of Canadian oil sands work, Western U.S. oil shale technology demonstrations, and hydraulic fracturing technology will have a revolutionary impact on unconventional oil development, worldwide. However, if incentives are insufficient to advance oil shale research domestically, international leadership opportunities may pass by U.S. stakeholders. Informally, there are indications that this may be occurring already, with certain major oil companies refocusing their situ processing/extraction R&D from U.S. oil shales to international locations.

References

Allix, Pierre, 2011: Coaxing Oil from Shale Oilfield Review, Winter 2010/2011. Allix, Pierre; Burnham, Alan K. (2010-12-01). "Coaxing Oil from Shale" (PDF). *Oilfield Review* (Schlumberger) **22** (4): 6. http://www.slb.com/~/media/Files/resources/oilfield_review/ors10/win10/coaxing.ashx. Retrieved 2012-04-18.

Crawford, P.M., C. Dean, J. Stone, J. Killen, 2012. "Assessment of Plans and Progress on US Bureau of Land Management Oil Shale RD&D Leases in the United States." *http://www.unconventionalfuels.org/otherreports.html*.

Knaus, E, Killen J., Bigiarbigi K, and Crawford P: "An Overview of Oil Shale Resources," in Ogunsola OI, Hartsetin AM and Ogunsola O (eds): Oil Shale: A Solution to the Liquid Fuel Dilemma. Washington, DC: American Chemical Society, ACS Symposium Series 1032 (2010): 3-20

U.S. DOE Office of Petroleum Reserves, 2007. Task Force Strategy and Program Plan, 2007. "America's Strategic Unconventional Fuels." Volume I – Preparation Strategy, Plan and Recommendations, Volume II – Resource-Specific and Cross-cut Plans, Volume III – Resource and Technology Profiles."

U.S. DOE Office of Petroleum Reserves, September 2010. "Oil Shale Research in the United States: Profiles of Oil Shale Research and Development Activities in Universities, National Laboratories, and Public Agencies." U.S. Department of Energy Office of Reserve Lands Management. Second Edition,

U.S. Department of Energy Office of Petroleum Reserves Office of Reserve Lands Management, Fourth Edition, September 2011. "Secure Fuels from Domestic Resources: The Continuing Evolution of America's Oil Shale and Tar Sands Industries - Profiles of Companies Engaged in Domestic Oil Shale and Tar Sands Resource and Technology Development: 5th Edition."

Question #2: What are the potential parallels between oil sands and oil shale in terms of development challenges and related Research and Development (R&D) needs? You noted in your testimony that Canadian oil sands production, which is currently at almost two million barrels of oil per day, was really enabled by strategic and targeted R&D supported by the Canadian government. Can you describe some of the R&D that was undertaken to make oil sands production a reality, and how that might serve as a model for U.S. activity on oil shale?

Relative to Canadian oil sands development, there is an estimated proven reserve of 169 billion barrels, which places Canada third in world oil reserves. Oil sands production reached ~1.6 million barrels per day in 2011 and is projected to reach five million barrels per day by 2030 (CAPP, 2012). Officially establishing these reserves and the current (and future) production rates have been built strongly on technology R&D investments.

There are a number of parallels between oil sands and oil shale development pertinent to R&D needs. Both resources can be extracted by mining or in situ processes, depending on the proximity of the resource to the surface. Unlocking the greater portions of these deposits (80% of oil sands reserves) will occur at depth using in situ processes, including potentially hydraulic fracturing techniques, horizontal drilling, heating, solvents and/or other processes. In addition, development of both resource sets requires management of process CO2, water, as well as addressing other environmental concerns.

In 1974, the Alberta government formed the Alberta Oil Sands Technology and Research Authority (AOSTRA) for promotion of the development of new technologies for oil sands and heavy oil production with a main target on finding technologies for that part of the resource that cannot be recovered using surface mining technologies. The Alberta government invested roughly $800 Million of government research funding over a period from 1975-1995, while the private sector has invested over $100 Billion in the Alberta oil sands since the Government of Alberta's original commitment. In March 2012 the Alberta government confirmed commitment of $150 million annually to AOSTRA 2 over an expected 20-year life of the new project with the intent to further development of the oil sands.

In 1984, AOSTRA initiated the Underground Test Facility as an in situ steam assisted gravity drainage (SAGD) bitumen recovery facility. AOSTRA also supported research at Canadian universities and research institutions by providing grants to inventors, funding the operation of a technical information system, promoting international co-operation in oil sands development, and providing scholarships and fellowships for educational assistance.

This foundational "first phase of R&D" is now leading to further developments, including the next generation of "in situ" extraction methods, decreasing energy intensity and the amount of natural gas deployed for steam generation, reducing water usage and reducing CO2 emissions, landscape, etc.

Reference

Canadian Association of Petroleum Producers (CAPP), 2012: Crude Oil: Forecast, Markets & Pipelines.

Question #3: What recommendations do you have to resurrect and develop a Department of Energy oil shale research and development program? What are the key items and considerations to guide oil shale research activities?

The U.S. Department of Energy and its laboratories are well qualified to provide leadership to deliver a focused, solution oriented, R&D program to help address key challenges in realizing a competitive U.S. oil shale industry. DOE is a technical integrator that can bring together needed assets and expertise from both within and outside DOE, including universities and industry, to provide a high-quality R&D program, and as well, act as a needed honest broker of technical information. It is critical to recognize that any role that DOE plays, here, should be complementary (not duplicative) to industry pursuits. The following are selected recommendations and guidance for resurrecting and developing a DOE oil shale research and development (R&D) program:

- Build off of existing work. The U.S. DOE Office of Fossil Energy has conducted extensive work in assessing and evaluating the development of a potential oil shale industry, including identifying technologies and R&D efforts relevant to establishing a DOE oil shale R&D program. The 2007 Task Force Report to Congress on Strategic Unconventional Fuels has details on needed R&D for Oil Shale. This would be a very good place to identify key items for consideration in resurrecting a U.S. Oil Shale Research Program.

- Establish a U.S. Western oil shale regional perspective and presence. A DOE oil shale R&D program should be focused primarily around the immense oil shale resources located within the Western United States, i.e., in Colorado, Wyoming, Utah. Along with this, a more regional presence by DOE, engaging with regional stakeholders, should be encouraged.

- Develop a solutions oriented R&D strategy. A well planned oil shale R&D strategy should be developed which is driven by the goal of establishing a long-term sustainable and environmentally responsible Western oil shale industry. As an example, such a strategy should be built around, in part, production and environmental goals.

- Develop an oil shale R&D road map. Once a strategy is developed, with end goals established, it is recommended to conduct an R&D road mapping exercise to identify various R&D pathways.

- Consult Alberta oil sands industry and government expertise. It is recommended to consult with Alberta oil sands industry, academic and government stakeholders (including provincial and federal governments) on strategic planning, research collaborations and designing an R&D model suitable for U.S. Western oil shale, as per Energy Policy Act 2005, Section 369 H(4).

- Address multiple scales of operations. An oil shale R&D program should focus on challenges that exist at both a site operations scale and an oil shale industry-wide scale, including addressing fuel logistics, integrated energy systems approaches, and potential cumulative environment effects.

- Address near-term and long-term R&D perspectives: The size of the Western U.S. oil shale resource, as well as its potential longevity, ideally requires both near-term and longer-term R&D approaches, the latter leading to multiple generations of innovation. This setting also broadens the perspective for considering R&D site demonstration, applied research and basic research phases.

- Promote collaboration across DOE Offices: Given the nature of oil shale development and trends being witnessed in energy development, there is an opportunity to realize significant synergy between the various DOE offices. Examples may include the Offices of Nuclear Energy and Energy Efficiency and Renewable Energy working with the Office of Fossil Energy to propose more integrated approaches that may lead to greater production efficiencies and lessening of potential environmental impacts.

- Engage diverse stakeholders in planning and implementation. Development of an R&D program should involve significant stakeholder involvement, including across DOE offices, other federal agencies (e.g., DOI, EPA, DoD), academia, universities, private industry and others. In particular, engagement with industry is paramount to reduce research redundancies. In addition, given the location of Western oil shale, there is a need to ensure regional stakeholder participation. Further, it is important that such a program is complementary to industry needs (not duplicative).

- Target in situ development R&D. Advancement of higher risk in situ concept R&D is needed to reach proof-of- concept stage of development (pre-competitive), i.e., addressing energy intensity, fracturing, heat transfer, materials performance, process monitoring, etc.

- Target environmental impact mitigation R&D. R&D is required to both understand existing and potential future impacts from oil shale development, as well as develop technology that can help mitigate environmental impacts.

- Provide an independent source of technical information. DOE can play a very important role in providing pedigreed technical information to various stakeholders, including the public, and be viewed as an "honest independent information broker", including addressing some more of the contentious environmental and technology topics.

Appendix II

Additional Material for the Record

LETTER SUBMITTED BY CHAIRMAN RALPH M. HALL FROM THE AMERICAN GEOSCIENCES INSTITUTE IN SUPPORT OF H.R. 6603

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a federation of societies advocating earth science

November 28, 2012

The Honorable Ralph Hall
Committee on Science, Space, and Technology
United States House of Representatives
Washington DC 20515

Dear Chairman Hall,

The American Geosciences Institute (AGI) supports the Tapping America's Energy Potential through Research and Development Act of 2012 (H.R. 6603). The research and development (R&D) programs included in this bill are essential to America's economy and national security. To be better prepared for the future, we need to begin research and development (R&D) on the formation, extraction, processing, and use of unconventional oil and gas and R&D on environmental issues relating to production and disposal of produced water.

Your forward-looking measure stresses the importance of fossil fuels for the United States in the years to come and the importance of the geoscience community in helping to meet the challenges of energy development in a delicately linked Earth system. AGI supports any effort to promote responsible exploration, production, and consumption of energy resources, including efficiency and conservation measures, through science and engineering advances. However, the United States can only achieve this through a healthy and well educated geoscience workforce. Data collected by AGI shows a decline in geoscience degrees granted over the past 40 years.[1] The public and private sectors face a dilemma of an aging workforce and a limited number of skilled new workers educated in the United States to fill the growing gaps. The R&D programs in H.R. 6603 will not only retain America's global leadership in responsible energy development but will also help support the next generation of geoscientists.

AGI supports the produced water utilization R&D program listed in H.R. 6603 as well. Clean water is our most precious commodity and our demand for it is increasing. Finding ways to reduce, reuse, or recycle produced water will benefit our economy, environment and public health.

AGI and the geosciences community stands ready to help meet the challenges of the twenty first century, such as providing reliable energy supplies in an environmentally conscious way. Thank you for introducing this legislation and for your leadership on the Science, Space, and Technology Committee.

Please contact us if you need any information regarding unconventional oil and gas or any other aspects of the geosciences.

Sincerely,

P. Patrick Leahy, Ph.D.
Executive Director, American Geosciences Institute

cc: Representative Eddie Bernice Johnson, Ranking Member

[1]Additional information is available online: AGI's publication "Status of the Geoscience Workforce 2011" [PDF online at http://www.agiweb.org/workforce/reports.html] highlights a growing disparity between supply and demand of trained geoscience professionals. AGI's Pulse of Earth Science [http://www.agiweb.org/education/statusreports/2007/index.html] surveys the limitations of inquiry-based Earth science education for grades K-12 in the United States. AGI's Critical Needs publication [http://www.agiweb.org/gap/criticalneeds/index.html] sets out federal policy directions that would help the U.S. meet the many challenges of the twenty first century.

The American Geosciences Institute is a nonprofit federation of geoscientific and professional associations that represents more than 250,000 geologists, geophysicists, and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resilience to natural hazards, and the health of the environment.

"THE NEW BOOM: SHALE GAS FUELING AN AMERICAN INDUSTRIAL REVIVAL," ARTICLE, WASHINGTON POST

The new boom: Shale gas fueling an American industrial revival

http://www.washingtonpost.com/business/economy/the-new-boom-shale-gas-fueling-an-american-industrial-revival/2012/11/14/73e5bb8e-fcf9-11e1-b153-218509a954e1_story.html

By Steven Mufson, Published: November 14

The shale gas revolution is firing up an old-fashioned American industrial revival, breathing life into businesses such as petrochemicals and glass, steel and toys.

Consider the rising fortunes of Ascension Parish, La.

Methanex Corp., which closed its last U.S. chemical plant in 1999, is spending more than half a billion dollars to dismantle a methanol plant in Chile and move it to the parish.

Nearby, a petrochemical company, Williams, is spending $400 million to expand an ethylene plant. And on Nov. 1, CF Industries unveiled a $2.1 billion expansion of its nitrogen fertilizer manufacturing complex, aiming to displace imports that now make up half of U.S. nitrogen fertilizer sales.

These companies all rely heavily on natural gas. And across the country, companies like them are crediting the sudden abundance of cheap natural gas for revving up their U.S. operations. Thanks to new applications of drilling technology to unlock natural gas trapped in shale rock, the nation's output has surged and energy experts almost unanimously forecast that prices will remain low or moderate for a generation. The International Energy Agency says that by 2015, the United States will overtake Russia as the world's biggest gas producer.

"The supply of natural gas and the price are the driving factors, and we're swimming in natural gas down here," said Mike Eades, president of the Ascension Economic Development Corp.

Ascension Parish falls inside the Haynesville geological region — one of the nation's big shale gas prospects.

"It has become clear to me that the responsible development of our nation's extensive recoverable oil and natural gas resources has the potential to be the once-in-a-lifetime economic engine that coal was nearly 200 years ago," U.S. Steel Chairman John Surma said in a speech this year.

Industrial companies are betting that the surge in the domestic production of natural gas is much more than a blip. Cheap and plentiful supplies of natural gas are flooding the U.S. market, and prices in the United States are as low as a quarter of what they are in Europe or Asia.

"For the foreseeable future, thanks to the recovery of vast U.S. underground gas deposits of shale, natural gas is likely to remain 50 to 70 percent cheaper in the U.S. than in Europe and Japan," said a recent report by the Boston Consulting Group.

"That will translate into significantly lower costs for electricity generation, for fuel used to power industrial plants and for feedstock used across many industrial processes," said Justin Rose, a BCG principal and co-author of the report.

Manufacturers have plans to invest as much as $80 billion in U.S. chemical, fertilizer, steel, aluminum, tire and plastics plants, according to Dow Chemical. And the main reason, said George J. Biltz, Dow Chemical's vice president for energy and climate change, "comes back to the massive competitive advantage the United States has with natural gas today."

A changing conversation

The shale boom has not just changed corporate plans. It has also altered the way we think and talk about oil and gas.

For decades, most of the conversation about U.S. oil and natural gas has revolved around the idea of scarcity, declining output and rising prices. The seminal work by M. King Hubbert — the Shell geologist who accurately predicted in the 1950s that U.S. oil production would peak in 1971 — defined this framework.

Natural gas supplies traditionally have been seen as limited and gas prices have been volatile — burning utilities that bet too heavily on gas-fired power plants in the 1990s.

But past assumptions have been challenged by new technologies — and new uses of old technology. Years of pioneering work on drilling techniques by an independent oilman, George Mitchell, paid off. Despite concerns about water pollution risks linked to hydraulic fracturing of shale, drilling and production have soared.

The United States is rife with these shale plays, some rich in natural gas and others rich in oil. The United States is still producing less oil than in 1971, and prices are high. But the country is producing more oil than in any year since 1994, and production is rising.

Meanwhile, natural gas production has jumped to record levels. In 2000, shale gas was 2 percent of the U.S. natural gas supply; by 2012, it was 37 percent.

Natural gas supplies suddenly look bountiful enough to last a century at current consumption rates, the National Petroleum Council said in a report last year. Some advocates of natural gas have called it a "bridge" to a clean-energy future because its greenhouse gas emissions are half those of coal and because gas plants can start up quickly and pair with wind and solar to provide a reliable alternative to coal.

Others call it a detour, since it is still a fossil fuel and it is undercutting nuclear, wind and solar energy as well as coal. "Bridge to clean future or U-turn to dirty past?" said a headline on the

blog of the environmental group Earthjustice. The United States has drilled more oil and gas wells than any other country, and the new wave of supplies has brought a new wave of rigs dotting the countryside and new crisscrossing pipelines.

For environmentalists, the abundance of shale gas poses a political and environmental dilemma. As new gas supplies fuel more and more industrial plants, new constituencies will have stakes in gas production, making it politically harder to impose new regulations. The Environmental Protection Agency is weighing whether to issue additional federal guidelines on various disruptive aspects of shale gas drilling, including the disposal of toxic water used to fracture formations and air pollution from drilling operations. The EPA might also issue rules requiring drilling techniques that would make contamination of water aquifers less likely.

But one thing is clear: Tumbling natural gas prices have changed every calculation and assumption about the energy business.

Petrochemical reaction

Perhaps no one benefits more from low natural gas prices than the petrochemical industry, which relies on natural gas as a feedstock and as a source of power. Natural gas, in turn, produces the building blocks for other products, including paints, solvents, plastics, packaging, inks, dyes and lubricants.

And no industry better demonstrates just how much has changed in a short period of time. Chemical-industry employment slid 17 percent from January 2002 through January 2011, according to the Bureau of Labor Statistics.

In October 2005, after Hurricane Katrina pounded Louisiana, the price of natural gas had spiked to $14 per thousand cubic feet. Supplies were scarce even before the storm, and Dow Chemical had temporarily shut down one of its biggest petrochemical plants.

"We say it unequivocally — the U.S. is in a natural gas crisis," Dow Chemical chief executive Andrew Liveris said in Senate testimony at the time. "The hurricanes have dramatically underscored the problem, but they did not cause it." Natural gas prices, once $2 per thousand cubic feet, had soared sevenfold. Gas accounted for half of Dow's costs, he said.

"We simply cannot compete with the rest of the world at these prices," Liveris added. "We and others are now investing in China and the Middle East, where energy is much cheaper, to our incredulity. Our industry will continue to grow. It's simply a question of where we will grow."

Among the deals it made: one with Kuwait and a $20 billion joint venture with Saudi Aramco to build facilities in Saudi Arabia using cheap gas found along with oil there.

Today, Dow Chemical is drawing up plans to construct a plant in Freeport, Tex., and is restarting a plant in St. Charles, La. And year-end nationwide chemical-industry employment has edged up for the first time in a decade, the Bureau of Labor Statistics says.

Methanex chief executive Bruce Aitken said natural gas prices made moving operations to Louisiana attractive.

"The proliferation of shale gas in North America has resulted in a structurally low natural gas price environment, which underpins the very attractive economics for this project," he told investors in a July 26 conference call.

He said moving the methanol plant from Chile to Louisiana will pay off in less than four years if gas prices stay around $4 per thousand cubic feet. He said the company was considering moving a second plant from Chile to Geismar, La.

CF Industries was also lured by the price and proximity of natural gas in Ascension Parish. Gas makes up about 70 percent of manufacturing costs at its ammonia and urea units. The company said the site is served by five pipelines at prices set at the nearby Henry Hub, which is the nationwide benchmark for spot gas prices.

Foreign companies are also eyeing U.S. natural gas.

In September, a large Egyptian construction company announced that it would build a new nitrogen fertilizer production plant in southeast Iowa to supply customers in the U.S. Corn Belt. Cairo-based Orascom Construction Industries, one of the world's largest fertilizer makers, said the $1.4 billion plant would be "the first world-scale, natural gas-based fertilizer plant built in the United States in nearly 25 years" and would reduce U.S. dependence on imported fertilizers.

After years of losing manufacturing jobs, most American communities are vying to lure industries.

Orascom chose Wever, Iowa, over Illinois because part of its investment will be funded by a tax-exempt bond. The Iowa Economic Development Authority approved an incentive package that is expected to provide tax relief "in the order of $100 million," the company said.

Royal Dutch Shell has unveiled plans for a $2 billion petrochemical plant northwest of Pittsburgh, where it can use natural gas supplies from the state's enormous Marcellus shale formation. It chose Pennsylvania despite being wooed by Ohio and West Virginia.

The broader effect

The economic growth from natural gas abundance extends to companies providing supplies to the drilling boom.

On Oct. 1, Honeywell announced that it paid $525 million for a 70 percent stake in Thomas Russell, a privately held provider of technology and equipment for natural gas processing and treatment. With the acquisition, Honeywell will offer technologies and products that allow producers of shale and conventional natural gas to remove contaminants from natural gas and recover high-value natural gas liquids used for petrochemicals and fuel.

Another example: U.S. Steel. The company is churning out new pipe for natural gas drilling rigs, wells and pipelines. And as a big consumer of power, it is paying less for fuel.

Surma, U.S. Steel's chief executive, said in a speech recently that the company used 100 billion cubic feet of natural gas in 2011, "so just a few dollars' difference in the price .□.□. allows us to realize important and significant cost savings." For every dollar change in the price of a thousand cubic feet, the company saves $100 million.

Surma said the company is also improving its North American blast furnaces to allow for increased injection of natural gas to reduce its consumption of coke, a fuel derived from coal. The reduction could cut blast furnace fuel costs by $15 per ton of hot metal produced — and U.S. Steel can produce more than 20 million tons of steel a year.

"In addition to these kinds of cost savings opportunities, natural gas should provide North American steelmakers with another operating advantage over our foreign competitors," Surma said.

Once some of these basic industries come home, companies further down the value chain could return, too.

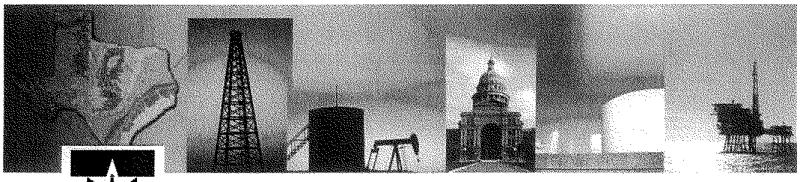
"If you make plastics in the United States, there are a bunch of things produced in China that might tip back to being produced in the U.S.," said Harold L. Sirkin, a senior partner at the Boston Consulting Group.

"You could think about toys," he said. "We talked to a few companies thinking, 'Does this mean I can re-shore some toy production to the U.S.?' The energy cost in plastic toys is reasonably high. And the labor content is relatively low because we're talking about automated injection molding facilities."

Chinese exporting factories could be vulnerable, especially given the risks of intellectual property theft, transportation costs and long supply chains.

"All of a sudden, the equations start changing about where you produce things," Sirkin said. "Even in industries where the cost structure includes only 1 or 2 percent electricity, that could make the difference."

"OIL AND NATURAL GAS GENERATE EMPLOYMENT AND TAX REVENUE,"
SUBMITTED BY MR. DAVID MARTINEAU



TIPRO

Texas Independent Producers and Royalty Owners Association

Oil and Natural Gas Generate EMPLOYMENT and TAX REVENUE

In FY 2011, the oil and natural gas industry paid **over $9.3 billion** in state and local taxes and royalties in the state of Texas. These payments are used by lawmakers to fund programs related to: education, Medicaid, children's health insurance programs, child protective services, roads, emergency services, and much more. Moreover, royalty payments serve as an important source of income for many Texans. Texas families are using royalty payments to put children through college that previously could not have afforded to go.

Additionally, oil and gas puts Texans to work and pays them exceptionally. Communities across Texas are being transformed into economic powerhouses by the oil and gas industry's investment in the development of Texas minerals. The numbers truly speak for themselves:

- ► Texans employed by oil and natural gas - 353,000
- ► Avg. salary of Texas oil and natural gas workers - $120,000
- ► Avg. salary paid by other private sector industries - $47,000
- ► Taxes paid to Texas per job:
  - o Oil and Natural Gas Industry - $28,000
  - o All other industries - $4,733
- ► Texas households receiving royalty payments - 570,000

*Figures provided by Texas Workforce Commission, Texas Comptroller of Public Accounts, James LeBas - Tax & Fiscal Consulting, Austin, TX, and the Joint Association Education Effort

Texas Independent Producers & Royalty Owners Association

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