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Before the

Senate Committee on Energy and Natural Resources

Field Hearing on Marcellus Shale Gas Development and Production in West Virginia

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Thank you for the opportunity to speak to you today about the role of the U.S. Department of Energy research efforts related to. domestic shale gas resource and its development.

Background

Shale gas production in the United States has grown dramatically during the past decade. Early success in shale gas production in the Barnett Shale in Texas, coupled with additional technological improvements, has prompted producers to invest in similar plays in other sedimentary basins. In addition to the Barnett in the Fort Worth Basin of Texas, the U.S. is now realizing production from the Haynesville shale in Louisiana and Texas, the Fayetteville shale in Arkansas, the Woodford shale in Oklahoma, the Marcellus shale in Pennsylvania and West Virginia, and the Eagle Ford shale in Texas. Other emerging natural gas shale plays such as the Utica shale in Ohio, as well as formations in Alabama and the Rocky Mountain states, are the scene of robust leasing and drilling activity.

The Energy Information Administration (EIA) at the Department of Energy (DOE) projects that shale gas production will continue to increase through 2035 in the *Annual Energy Outlook 2011* Reference Case, growing almost fourfold from 2009 to 2035. While total domestic natural gas production increases from 21.0 trillion cubic feet in 2009 to 26.3 trillion cubic feet in 2035, shale gas production grows to 12.2 trillion cubic feet in 2035, when it is projected to make up 47 percent of total U.S. production—up considerably from the 16 percent share in 2009.

The EIA's estimate for technically recoverable shale gas resources in the Reference Case is 827 trillion cubic feet (Tcf). However, estimates of technically recoverable shale gas are certain to change over time as new information is gained through drilling, production, and technological development. A National Petroleum Council report published in September 2011 surveyed a wide range of producers and consultants opinions regarding domestic, technically recoverable shale gas volumes and reported a range from 700 Tcf to 1800 Tcf.[1] Further, estimates of the portion of this technically recoverable volume that is *economically* recoverable will certainly change, as energy supply choices are made and natural gas prices reflect those choices.

The benefits of this current surge and expected continued expansion in natural gas production are many. Increases in business activity, employment, personal income, and royalty payments and state tax revenues are being measured and estimated, and reported. Early projections of net job creation and incremental tax revenue vary in terms of impact, but they are universally positive.

However, as the level of drilling and production operations has increased, concerns have been raised by members of the public about the potential negative impacts of shale gas development. Citizen concerns have included: potential contamination of water supplies from hydraulic fracturing; increased road maintenance costs and risk of accidents due to increased truck traffic; increased emissions of air pollutants from diesel equipment or production operations; disturbances to ecosystems needed to support other economic activities such as hunting, fishing, and tourism; increased levels of noise from drilling, natural gas processing facilities, and compressor stations; and a fear that the drilling and construction activity will impact the lifestyle of rural America.

It is within the context of this rapidly changing resource picture and range of viewpoints that state and Federal regulators are being called on to make important decisions that will influence our energy supply choices for many years. The DOE provides data and analyses to inform those decisions and identifies technology solutions to help enhance environmental protection and increase the benefits to communities and the Nation of shale gas development.

The Department of Energy's Mission Related to Shale Gas

The Department of Energy's mission with regard to gas shale resource development activity, as implemented through the National Energy Technology Laboratory (NETL), has two primary aspects: *technology development,* and *data development, compilation, and analysis to assess technical risks.* DOE's

[1] NPC, "Prudent Development Realizing the Potential of North America's Abundant Natural Gas and Oil Resources", Page 1-39

technology development role includes helping to catalyze industry efforts to develop new technologies that can significantly reduce the potential for environmental impacts and improve the efficiency of gas production, and providing critical support for nascent technology concepts that can help advance them towards commercial development.

The other aspect of DOE's role is in generating, compiling, analyzing, and reporting data that can be used by regulators to craft science-based regulations, and by industry and the public to assess risks and accelerate decision making related to resource development. As an objective source of scientific data, DOE's early contributions to fundamental baseline information about unconventional formations such as shales, tight sands, and coal seams published in the 1980s, has been credited with playing an important role in today's growth in domestic natural gas supply. Currently, NETL is managing a multi-agency effort, in collaboration with a major independent producer, to acquire, analyze and publish environmental baseline data that can be used to quantify the net impact of Marcellus shale drilling and production activity on the air, water, land, flora, and fauna surrounding a western Pennsylvania drilling site. I'll speak more on this activity in a moment.

It is also important to note what DOE does not do. DOE does not regulate oil and natural gas exploration or production activities, or manage Federal lands and the mineral estate.

Value of Department of Energy Work Products

The value of DOE's oil and natural gas research may be seen in more efficient production of these resources with less environmental impact. This research can support environmental compliance or increase the efficiency of equipment designed to reduce environmental impacts. Development of new hydraulic fracturing flowback water treatment technologies increases the number of options available to operators. As one example, NETL has partnered with a group led by West Virginia University to develop an on-site multi-media filtration system. Flowback water is the volume of fluid produced from a well in the short term whenever a well is "turned on" after being hydraulically fractured. Flowback is comprised mostly of the injected fluid and can be differentiated from produced water, which is fluid produced to surface along with natural gas over the life of a well.

Scientific data sourced by NETL is valued as objective information by state regulators seeking information on which to base regulations that can enhance environmental performance and community safety without stifling economic development. These data are also valuable to producers, particularly smaller independents without the resources to carry out their own research that are looking for data to inform their exploration and production strategies and development choices. A number of popular DOE research

products are online databases and decision-making tools that are used by both operators and regulators. Examples include the *Risk Based Data Management System*, *FracFocus*, the *Produced Water Management Information System*, and the *Fayetteville Shale Decision Support System*. Such tools, which would not be available without DOE support, and have already begun to play an important role in helping to mitigate problems associated with shale development. *FracFocus* has become an increasingly popular means for companies to voluntarily disclose the contents of fracturing fluids to myriad stakeholders.

How DOE Accomplishes its Mission through Research

DOE accomplishes its mission in three ways: (1) through cost shared research with industry, academia and governmental agencies; (2) through on-site research at NETL, including efforts through its regional university alliance; and (3) through strategic partnerships with other organizations.

Cost shared research is implemented via NETL open solicitations for research partnerships focused on topics where there is an appropriate opportunity to perform research that will yield a clear public benefit and that would not otherwise be carried out by industry. Cost share from an industry/academic partner is a minimum of 20 percent. NETL manages such research, development and demonstration projects with funds provided by Congressional appropriations and by Federal offshore royalty revenues.

NETL also conducts on-site research on topics that are complementary to the extramural research undertaken via competitive solicitation. This research is carried out by Federal employees and support professionals working as part of NETL's Office of Research and Development and in partnership with researchers who are affiliated with the NETL Regional University Alliance (NETL-RUA). This alliance is an applied research collaboration that combines NETL's fossil energy expertise with the broad capabilities of five nationally recognized, regional universities: Carnegie Mellon University (CMU), Pennsylvania State University (PSU), the University of Pittsburgh (Pitt), Virginia Tech (VT), and West Virginia University (WVU).

Finally, NETL forms collaborative partnerships with organizations whose missions are compatible with DOE's. For example, NETL, with the Ground Water Protection Council (GWPC) and the Interstate Oil and Gas Compact Commission, developed FracFocus, a landmark web-based national registry for disclosing the chemical additives used in the hydraulic fracturing process on a well-by-well basis. Similarly, NETL has coordinated with states through the GWPC to develop and maintain the *Risk-Based Data Management System* (RBDMS). The GWPC with DOE support has recently enhanced the RBDMS to track and record data related to hydraulic fracturing treatments.

DOE's Historical Role in Gas Shale Research

The DOE first began research into shale gas in the late 1970s when fears of dwindling domestic natural gas supplies spurred researchers to examine alternative sources of natural gas in unconventional reservoirs such as Devonian shales, coals, and low permeability or "tight" sands. DOE recognized the need for research and development to characterize these resources and developing ways to produce them.

During the period from1977 through 1992, through a suite of three programs focused on Eastern gas shales, Western gas sands, and methane from coal beds, DOE helped develop and stimulate the deployment of advanced exploration and production technologies for recovering new gas supplies from unconventional gas resources by increasing per well gas recovery efficiencies. NETL employed a detailed resource characterization and technology development approach that geologically partitioned each natural gas resource and matched technology to geology to chart a path for resource development. More than 25,000 feet of oriented core and well log data from 35 cored shale wells provided the basic rock and geologic data used to prepare the first, publicly available estimates of technically recoverable gas from Devonian Shales in West Virginia, Ohio, and Kentucky.

A couple of related and noteworthy milestones include:

- In 1986, DOE collaborated with industry to mark the first air-drilled 2000 foot long horizontal Devonian shale well in the Appalachian Basin. This well also marked the first recovery of core from a horizontal, air-drilled shale well and the first successful use of external casing packers in an air-filled wellbore, and was the first horizontal shale well to complete seven individual hydraulically fractured intervals.
- Early DOE leadership in the development of fracture mapping—techniques for using seismic responses to identify the orientation and extent of hydraulically created fractures. The Department began support of fracture mapping as related to geothermal resources and through a series of technology advancements has become commercial with a number of companies successfully mapping hydraulic fractures, including many in the major shale gas plays.

SEAB 90 Day Report

In March 2011, President Obama directed Energy Secretary Steven Chu to form a subcommittee of his advisory board on natural gas to develop recommendations to improve the safety and environmental

performance of hydraulic fracturing. The Subcommittee produced a 90-day report on August 18, 2011, with 20 recommendations, and is scheduled to submit a final report this month.

The recommendations support an approach that relies on increased measurement, public disclosure, and continuous improvement. The subcommittee specifically acknowledges the need for data-driven processes with increased transparency and the development of industry-wide "best practices."

In several cases, the Subcommittee recommended actions that DOE, through NETL, has already begun or has been doing. For example, funding for RBDMS, and to collect and publish emission data such as is being done at the Marcellus shale Test Site. The Subcommittee also recommended that state and Federal regulators develop an integrated water management system; NETL has been supporting the development of a planning and water management tool for several states, which could serve as a building block for the referenced integrated system. In addition, the Subcommittee recommended the continued funding and expansion of *FracFocus*.

Within available funds, NETL also has planned research related to several topics highlighted by the Subcommittee: (1) basic research on the relationship of fracturing and micro-seismic signaling, (2) chemical interactions between fracturing fluids and shale, (3) development of "green" drilling and fracturing fluids, and (4) development of improved cement evaluation and tools for assuring casing and cementing integrity.

DOE's "Holistic" Approach to Environmental Risk Assessment

The Marcellus Test Site is an example of the "holistic" approach taken by the Department through NETL in the area of environmental baselining and risk assessment and an example of effective research coordination among federal agencies. NETL is leading a joint industry/government research project to monitor key aspects of shale gas development throughout its lifecycle. The research plan calls for one year of comprehensive environmental monitoring, followed by the drilling of two horizontal wells by Range Resources-Appalachia in July 2012 at a well pad site in southwestern Pennsylvania. Monitoring will continue through road and pad construction, drilling, and hydraulic fracturing, and for at least one year beyond the start up of subsequent production operations. This research project has been selected as one of the two "prospective case studies" for the U.S. Environmental Protection Agency's ongoing study of the potential impact of hydraulic fracturing on drinking water resources.

Comprehensive, scientifically acquired baseline environmental data from a well site *prior* to drilling and fracturing have not been rigorously acquired and analyzed. Pre-operation data are essential for quantifying

environmental impacts and for ascertaining what portion of the post-development environmental footprint is due to current natural gas development operations versus that which may be due to past energy development activity or concurrent industrial, agricultural, or recreational activities. Accordingly, these two prospective studies will provide important reference points for discussions regarding the need for further research and the development of regulatory policy at both state and federal levels.

At the Marcellus Test Site, the NETL lead team will be monitoring groundwater and surface water quality, and air quality; conducting soil gas surveys, hydraulic fracturing tracer studies, and electromagnetic induction surveys to identify any possible migration of natural gas, completion fluids, or production fluids. Quantifying potential risks and providing sound, unbiased and transparent scientific data is an important step in building a rationale, scientific approach to sustainable resource development. A Marcellus Test Site summary, which provides additional details of the research project, is being submitted for the record.

Summary

In summary, NETL has a technology development role in helping to catalyze industry efforts to develop new technologies that can significantly reduce the potential for environmental impacts and improve the efficiency of gas production and in providing critical support for nascent technology concepts that can help advance them towards commercial development. NETL also has a role in generating, compiling, analyzing, and reporting data that can be used by regulators to craft science-based regulations, and by industry and the public to assess risks and accelerate decision making related to resource development.

Responsible development of shale gas resources provides a significant national opportunity for regional economic growth, not only through drilling and production, but also along the entire natural gas value chain, including natural gas liquids, ethane feedstock chemical production, and natural gas-fired manufacturing processes. Increased domestic natural gas supplies have the potential to provide a significant source of transportation fuel, particularly for truck fleets.

The role for NETL is to support the realization of these opportunities through solid science and objective data-generation and analysis and effective efforts to accelerate the development of technologies that can help optimize the way we produce our natural gas resources in the most environmentally responsible manner possible.

Thank you for the opportunity to speak with you this morning. I look forward to answering any questions that you may have.

DOE Leads Collaborative Effort to Quantify Environmental Impacts of Shale Gas Development

DOE's National Energy Technology Laboratory (NETL) is leading a joint industry/government research project to monitor key aspects of shale gas development throughout its lifecycle. The research plan calls for one year of environmental monitoring before any development takes place, followed by the drilling of two horizontal wells in July 2012 at a Range Resources-Appalachia well pad site in southwestern Pennsylvania. Monitoring will continue through road and pad construction, drilling, and hydraulic fracturing, and for at least one year of subsequent production operations. This research project has been selected as one of the two "prospective case studies" for the U.S. Environmental Protection Agency's (EPA) ongoing study of the potential impact of hydraulic fracturing on drinking water resources.

As an important step in EPA's Congressionally mandated study, seven sites were selected to help inform the assessment. These sites were selected following input from the public, local and state officials, industry, and environmental organizations and include five "retrospective case studies" that will examine areas where hydraulic fracturing has already occurred to identify possible impacts to drinking water resources. The two prospective sites include the NETL-lead research project in southwestern Pennsylvania and a second location in Louisiana's Haynesville Shale play.

The critical importance of the two prospective case studies cannot be overstated. This is because comprehensive, scientifically acquired baseline environmental data from a well site prior to drilling and fracturing have not been rigorously acquired and analyzed. Pre-operation data are essential for quantifying environmental impacts and for ascertaining what portion of the post-development environmental footprint is due to current natural gas development operations versus that which may be due to past energy development activity or concurrent industrial, agricultural, or recreational activities. Accordingly, these two prospective studies will provide important reference points for discussions regarding the need for further research and the development of regulatory policy at both state and federal levels.

The NETL-lead Marcellus research effort is part of the laboratory's unconventional fossil energy research program, a larger effort that is focused on developing technologies that enable environmentally sustainable development of oil and natural gas resources. NETL will monitor air quality and surface water quality at the Range Resources-Appalachia site pre- and post-drilling to quantify the extent that these vital resources are impacted by shale gas production. Further, NETL will conduct soil gas surveys, hydraulic fracturing tracer studies, and electromagnetic induction surveys to identify any possible migration of natural gas, completion fluids, or production fluids.

NETL research chemist evaluating stream water quality.

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A Range Resources-Appalachia well pad location in southwestern Pennsylvania is the site for an EPA Prospective Case Study as part of a NETL-led field based research initiative. NETL's Mobile Air Monitoring Laboratory will be used to measure air quality.

NETL will deploy its mobile air emissions monitoring equipment at the location to monitor up to 52 volatile organic compounds (VOC's), ozone, sulfur dioxide, nitrous oxides, particulates, specific ions (e.g., sulfate, chloride, bromide), and radon. Soil gas concentration measurements are also an important part of site characterization, because they can provide an indication of gas migration from depth even before drilling or hydraulic fracturing has begun. Stable isotope measurements are important for distinguishing between methane migrating from a productive formation deep underground and biological and atmospheric background methane concentrations.

NETL will also conduct surveys aimed at identifying improperly abandoned natural gas and oil wells based on the magnetic response of the buried remnants of well casing. This "gas well archeology" is often the only way to locate old, unrecorded wells that can be the source of communication between a shallow underground source of drinking water (USDW) and historical producing formations. Such antique wellbores should be located and properly plugged to address historical methane migration problems.

In addition, NETL will coordinate a larger research team with specific tasks that includes the EPA and U.S. Geological Survey (groundwater monitoring), the U.S. Fish and Wildlife Service (wildlife acoustic monitoring), the U.S. Forest Service (landscape and soil monitoring), the U.S. Army Corps. of Engineers (regional stream water quality monitoring), the Pennsylvania State Department of Environmental Protection (terrestrial and aquatic systems monitoring), and the Pennsylvania Geological Survey (subsurface geologic monitoring).

This comprehensive, rigorously scientific collaborative effort among federal and state agencies and a natural gas producing company will provide valuable information that can be used to quantify the potential risks of environmental impacts from hydraulic fracturing during the development of shale gas resources. Quantifying potential risks and providing sound, unbiased and transparent scientific data is the first step towards building a rationale, scientific approach to regulating sustainable resource development.

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