Fracking: Friend or Foe?

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Introduction

You've seen the pictures — tap water in flames. You've probably read the stories of family well water contamination. You may even have heard the songs. "Fracking" or hydraulic fracturing, a method used in natural gas extraction, is in the news and for good reason. We need clean, reliable energy and natural gas fits the bill, but at what cost? The issues surrounding fracking are many and range from potential ground water contamination and air pollution to increased traffic and noise related to the actual drilling. Communities, particularly those that are new to the natural gas industry, are facing competing interests of jobs and economic growth vs. potential threats to human health and safety, the environment, and way of life. The answers are not easy.

From the viewpoint of sustainable investing, we at Sentinel seek companies that are operating responsibly in their given field. With industry best practices, reporting requirements and regulatory framework evolving, we have taken a case-by-case approach to companies involved in hydraulic fracturing. While not intended as an exhaustive discussion of the shale gas industry or the practice of hydraulic fracturing, this paper does explore the issues considered when determining suitability for Sentinel's sustainable portfolios.

Background

Natural gas or methane (CH_4), an abundant resource in the US, is seen as an important element of our national energy portfolio over the next 25 years. It is key to our energy future as it achieves the dual goals of reducing our reliance on foreign oil and reducing our greenhouse gas emissions. The questions arise not from the use of natural gas, but rather from the methods used to extract that gas from unconventional or tight formations. That's where hydraulic fracturing comes into play.

Hydraulic fracturing or "fracking" is a process used in enhanced oil recovery as well as in extracting natural gas from shale or other tight formations.

> The key component of hydraulic fracturing, and what gives the technique its name, is creating or enlarging cracks in subterranean rock formations. Drill shafts are sent deep into the ground. Then, large quantities of water (millions of gallons per well), along with chemicals and "proppants" (sand, ceramic beads, or other small particles that hold open the cracks) are injected into the shaft at high pressure, cracking open fissures into rock. The proppant holds the fissures open, allowing the natural gas to flow into the well shaft where it can flow up to the surface.[1]

Fracking has been used since the late 1940s in enhanced oil recovery in conjunction with vertical drilling. In the 1980s, it was combined with horizontal drilling for extraction of gas and oil from unconventional formations, including shale, coalbed methane reservoirs, and tight sands. More recently, this process has garnered attention with the development of the Marcellus shale field in the eastern US and the protests related to numerous environmental concerns nationwide.

National Energy Outlook: The Role of Natural Gas

According to the US Energy Information Administration's (EIA) 2011 Annual Energy Outlook, natural gas will be playing an increasingly important role in US energy use. In addition to being an abundant resource in the lower 48 states, it is considered a cleaner energy source as it burns about 40% cleaner than coal and almost 30% cleaner than oil.[2] It is also sometimes referred to as a bridge fuel as we transition from coal and oil to renewable energy sources.

> In a carbon-constrained economy, the relative importance of natural gas is likely to increase even further, as it is one of the most cost-effective means by which to maintain energy supplies while reducing CO_2 emissions. This is particularly true in the electric power sector, where, in the US, natural gas sets the cost benchmark against which other clean power sources must compete to remove the marginal ton of CO_2.[3]

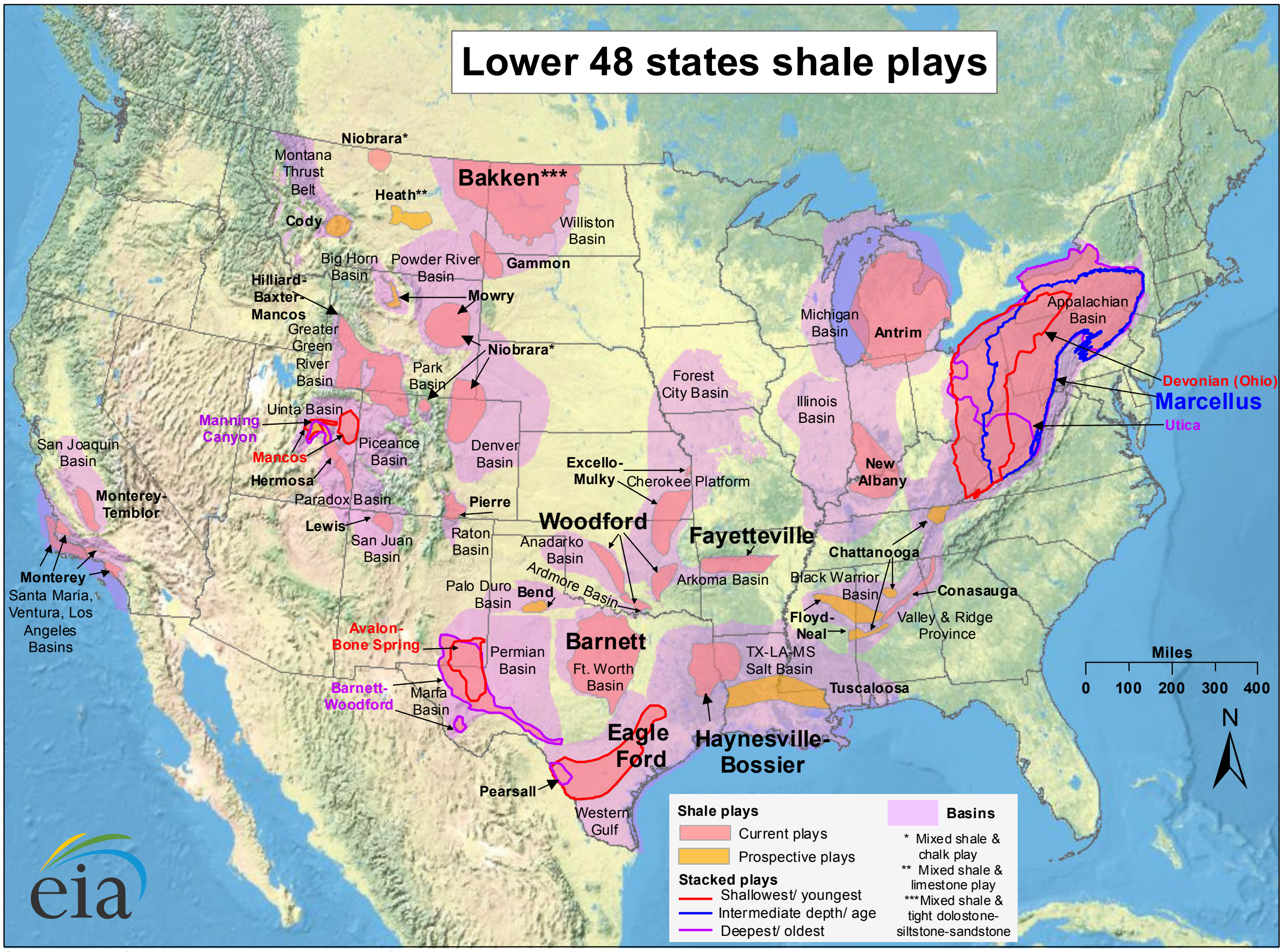
Abundant Natural Resource

Natural gas is an abundant resource in the US, and with technological advances such as hydraulic fracturing, extraction from unconventional resources is becoming more economically feasible. The largest shale play is the Marcellus which spans Pennsylvania, New York, West Virginia, and Ohio.

> The Marcellus Shale may contain 490 trillion cubic feet of gas — enough to heat US homes and power electric plants for two decades … That makes it the world's second-largest gas field behind South Pars, shared by Iran and Qatar.[4]

In addition to the Marcellus shale, there are other sizable shale fields in the lower 48 states:

- Barnett: north central Texas
- Eagle Ford: south Texas
- New Albany: Illinois, Indiana, and Kentucky
- Haynesville: northern Louisiana and eastern Texas
- Woodford: south central Oklahoma
- Fayetteville: northern Arkansas and eastern Oklahoma
- Antrim: Michigan



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

While the resource is abundant as evidenced by the map above, many estimates regarding the size and scope of technically recoverable shale gas resources are bandied about. The key words here are “estimates” and “technically recoverable.” Most of the public estimates are reported by private institutions, with methodology and specific formation details not known.[5] Adding to the uncertainty is the fact that each shale play is unique, often with unique characteristics within a given play, with reservoirs at varying depths and geology. Noting such variables, production rates among wells in a given formation may vary by as much as a factor of 10.[6] “Estimates of technically recoverable shale gas are certain to change over time as new information is gained through drilling and production, and through development of shale gas recovery technology.”[7]

With such questions surrounding the extent of technically recoverable reserves, and the fact that “public information is skewed toward high-production and high-profit wells,”[8] it is difficult to estimate accurately future shale play productivity. This has led to some legal and accounting issues which are covered at greater length below. (Please see **Legal Issues**.) While the exact amount of gas recoverable is unknown, what is not disputed is the fact that the potential for the US is significant.

Powering a Nation

The greatest demand and opportunity for natural gas over the next 25 years is in the generation of electricity. "The role of natural gas grows due to low natural gas prices and relatively low capital construction costs that make it more attractive than coal. The share generation from natural gas increases from 23 percent in 2009 to 25 percent in 2035."[9]

> In the US electricity supply sector, the cost benchmark for reducing carbon dioxide emissions lies with the substitution of natural gas for coal, especially older, less efficient units. Substitution through increased utilization of existing combined cycle natural gas power plants provides a relatively low-cost, short-term opportunity to reduce US power sector CO_2 emission by up to 20%, while also reducing emissions of criteria pollutants and mercury."[10]

Despite a lack of formal national energy policy, the US is moving to reduce its CO_2 emissions and towards greater reliance on renewable energy sources. Natural gas is the natural response, both as a cleaner burning fuel and as an energy bridge. "Gas-fired generation ensures steady power when the wind isn't blowing or the sun isn't shining."[11]

Economics of Natural Gas

With an abundant domestic supply of natural gas coupled with improving technology, we are in the midst of a "shale rush."

> The shale gas rush is creating thousands of jobs and reviving the economy in states such as Wyoming, Texas, and Louisiana. In Pennsylvania, where 2,516 wells have been drilled in the last three years, $389 million in tax revenue and 44,000 jobs came from gas drilling in 2009, according to a Penn State report.[12]

Whether the shale rush is sustainable depends on the productivity of wells over time. As noted in the EIA Annual Energy Outlook, 2011, "Most shale gas wells are only a few years old, and their long-term productivity is untested."[13] A recent *New York Times* article pointed to questions surrounding the economic potential of shale gas: "the amount of gas produced by many successful wells is falling much faster than initially predicted by energy companies, making it more difficult for them to turn a profit over the long run."[14]

Increased regulation and development of industry best practice may also have an economic impact on shale gas production. Given the evolving nature of the industry, we have only to wait and see about the true costs and value of shale gas production over time.

Environmental Risks

One of the central costs of shale gas production relates to environmental risks of drilling and hydraulic fracturing. These risks range from potential ground water contamination, surface water contamination, and excessive water use to natural habitat degradation and air pollution. To help assess these risks, both the Department of Energy and the Environmental Protection Agency are studying the impacts of natural gas production in general and hydraulic fracturing in particular.

The Shale Gas Production Subcommittee of the Secretary of Energy Advisory Board (SEAB subcommittee) was charged with "identifying measures that can be taken to reduce the environmental impact and improve the safety of shale gas production."[15] It released its initial 90-day report in August 2011 with recommendations for best practices. The subcommittee's second report is expected in early 2012.

To assess the potential threat of hydraulic fracturing to drinking water supplies, Congress charged the EPA with studying the impact of fracking on drinking water. In November 2011, the EPA issued its *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resource*.

> The scope of the research includes the hydraulic fracturing water use lifecycle, which is a subset of the greater hydrologic cycle. For the purposes of this study, the hydraulic fracturing water lifecycle begins with water acquisition from surface or ground water and ends with discharge into surface waters or injection into deep wells. Specifically, the water lifecycle for hydraulic fracturing consists of water acquisition, chemical mixing, well injection, flowback and produced water (collectively referred to as "hydraulic fracturing wastewater"), and wastewater treatment and waste disposal.[16]

The study plan includes retrospective as well as prospective case studies and generalized scenario evaluations. The first phase of the study is expected to be completed in 2012, with the second phase completion expected in 2014. While this study is limited to evaluating the impact of fracking on drinking water quality only, the EPA acknowledges that there are other issues, such as air quality, ecological effects, seismic risks, public safety and occupational risks related to fracking that should be studied in the future.[17]

Water Use

Hydraulic fracturing is, by definition, water dependent. As outlined in the EPA study plan, the water use lifecycle is a critical point of study. Estimates of water use for fracking vary from one to five million gallons of water per well depending on the shale gas formation.

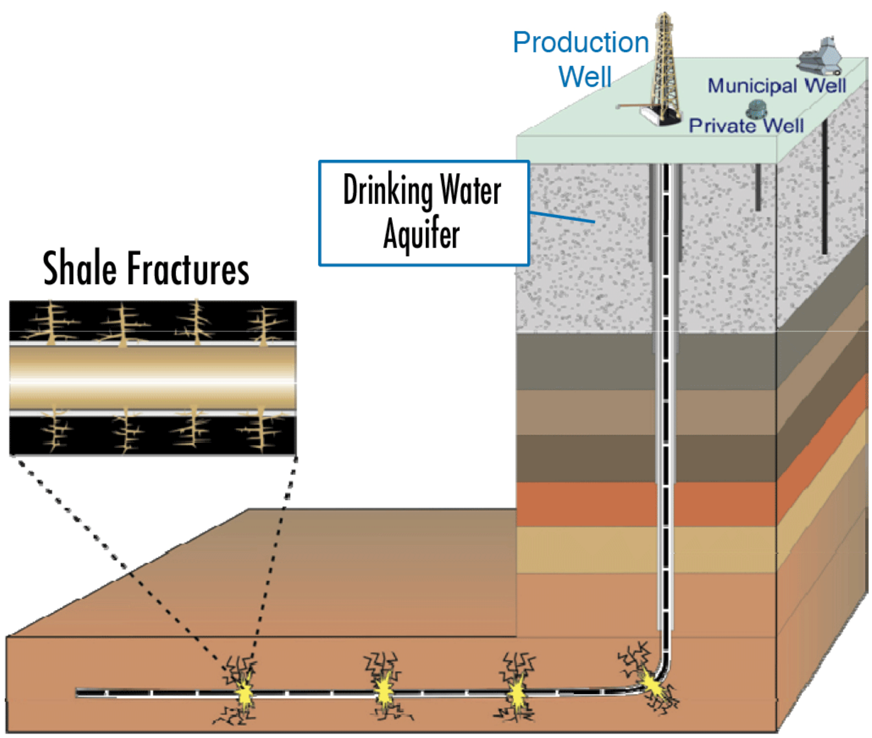
> While water availability varies across the country, in most regions water used in hydraulic fracturing represents a small fraction of water consumption. Nonetheless, in some regions and localities there are significant concerns about consumptive water use for shale gas development.[18]

For this reason, it is incumbent upon drilling operators to work closely with communities, particularly those in water-constrained regions, to ensure adequate water for all.

Ground Water Contamination

Besides water availability, another main concern is ground water contamination and its affect on drinking water. The famous image of tap water being ignited has become part of the rallying cry against fracking. *Gasland*, the Academy Award-nominated documentary on the natural gas industry, while making valid points about the potential dangers of hydraulic fracturing, may have overstated the issue of widespread water contamination.

In general, the drilling process goes well below ground water. Depending on the formation, there can be between 100 feet (New Albany) to 13,100 feet (Haynesville) of rock separating treatable water and natural gas reservoirs.[19]



Source: EPA

In their 2011 study, *The Future of Natural Gas*, researchers at MIT reviewed three key reports from various sources which covered 43 incidents associated with natural gas drilling reported from 2004 to 2010. Of the 43 incidents reported, 20 or 47% were related to ground water contamination by natural gas and appeared to be the result of faulty cementing of casing into wellbores. “It is noteworthy that no incidents of direct invasion of shallow water zones by fracture fluids during the fracturing process have been recorded.”[20]

It appears as though this claim can no longer be made as fracking fluid has just been detected in a Wyoming aquifer. The EPA announced that for "the first time it found chemicals used in extracting natural gas through hydraulic fracturing in a drinking-water aquifer in west-central Wyoming."[21] While the findings are not conclusive, there does appear to be a strong link with local fracking activities. Further study and analysis are underway to determine the exact source of the chemicals. Regardless of the final determination, it is clear that stronger regulation of hydraulic fracturing is warranted.

This issue of fracking fluid aside, there is "evidence of natural gas migration into freshwater zones in some areas, most likely the result of substandard well completion practices by a few operators."[22] In addition to this migration related to drilling, it is important to note that methane occurs naturally. In the case of methane being found in a well owned by the Brant family near Buffalo, NY, "state environmental officials have said that methane occurs naturally in well water in Brant's part of the state, and that the gas turned up in other water wells in the area before drilling began."[23]

This is not to suggest that contamination of ground water is not a concern. It does, however, point to the importance of monitoring environments through all phases of the drilling operation: before drilling and hydraulic fracturing begin, during production, and after well completion.

Wastewater

Another area of concern is that of wastewater, its treatment and disposal.

> The fluid that returns to the surface can be referred to as either "flowback" or "produced water," and may contain both hydraulic fracturing fluid and natural formation water… These wastewaters are typically stored on-site in tanks or pits before being transported for treatment, disposal, land application, and/or discharge. In some cases, flowback and produced waters are treated to enable the recycling of these fluids for use in hydraulic fracturing.[24]

Underground injection of wastewater into salt water disposal wells is considered a viable disposal option and is regulated by the EPA. In this process, wastewater is injected into disposal wells separated by thousands of feet of impermeable rock from treatable ground water.[25] The main shale plays in the lower 48 states use a combination of injection wells and fluid recycling.[26]

In the MIT review of 43 incidents associated with natural gas drilling operations, 18 were related to spills, including storage pit leaks and off-site disposal issues. In these cases, operators were fined and / or improved control measures were put in place.[27] In terms of best practice, the 90-day report of the SEAB subcommittee highlights the importance of adopting a lifecycle approach to water management, including monitoring and public reporting of the composition of the water stocks (e.g. wastewater in water ponds and collection tanks).[28]

Importance of Transparency

The idea of public reporting has become one of the key issues in hydraulic fracturing as the secrecy that surrounded the listing of chemicals used in fracking led to mistrust between drilling operators and the public. Fracking fluids are:

> water-based fracturing fluids mixed with friction reducing additives (called slickwater)… Overall, the concentration of additives in most slickwater fracturing fluids is a relatively consistent 0.5% to 2% with water making up 98% – 99.5%. Because the make-up of each fracturing fluid varies to meet the specific needs of each area, there is no one-size-fits-all formula for the volumes of each additive.[29]

With the goal of greater transparency, the industry has responded with voluntary reporting of chemicals used in fracking operations. The Web site www.fracfocus.org is operated by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission, and lists chemicals used by operator and drill site. The industry is also looking to more environmentally-friendly chemicals for use in fracking fluids.

Drilling Footprint

The size and scope of the drilling footprint is another area of concern. There is actually some good news here. The combination of hydraulic fracturing and horizontal drilling reduces the drilling footprint considerably.

> Six to eight horizontal wells drilled from only one well pad can access the same reservoir volume as sixteen vertical wells. Using multi-well pads can also significantly reduce the overall number of well pads, access roads, pipeline routes, and production facilities required, thus minimizing habitat disturbance, impacts to the public, and the overall environmental footprint.[30]

Air Quality

Although natural gas has lower GHG emissions and pollutants when burned, there are air quality questions surrounding drilling operations. Such questions relate to the extent and impact of emissions, including fugitive methane emissions, volatile organic compounds (VOCs), benzene, etc. While not considered a major contributor to air pollution and ozone depletion, natural gas development does have an impact on air quality which is regulated by the EPA.[31] In addition to the air quality issues of drilling itself, there are emissions from the vehicular traffic associated with drilling operations. As noted in the EPA study plan, these issues should be addressed in the future.

Health & Safety Risks

Most of the health and safety concerns are related to the environmental risks noted above. Other risks that have been raised relate to naturally occurring radioactive material (NORM) releases and occupational health and safety. NORM is not considered a significant risk to human health and safety as it is present in negligible amounts.[32] Regarding occupational health and safety risks, they are similar to those of more conventional drilling methods, and therefore require the same careful attention by drill operators and contractors. This area as well has been identified by the EPA for further study.

Community Relations Risk

Community education and public engagement are crucial components in building trust and understanding between industry players and the communities in which they operate. "An industry response that hydraulic fracturing has been performed safely for decades rather than engaging the range of issues concerning the public will not succeed."[33]

The importance of this community / industry dialogue is heightened in areas that are not used to drilling, such as those in the Marcellus shale region. In addition to the environmental and safety concerns that must be addressed in each community, there is also the change in way of life. The noise, increased traffic with heavy vehicles, and the presence of drilling rigs that accompany natural gas development are issues that must be part of the conversation. Open, honest and continuous communication is a foundational element of best practice for the industry going forward.

Regulatory Risk

Several agencies within the US government are looking into the impact of hydraulic fracturing. The EPA has created a study plan to evaluate the impact of hydraulic fracturing on water quality. The Department of Energy established the Shale Gas Production Subcommittee of the Secretary of Energy Advisory Board to review the industry and make recommendations for best practices. While these are steps in the right direction to evaluate and ultimately regulate the practice of hydraulic fracturing and drilling of unconventional natural gas resources, the current regulatory framework is a patchwork at best.

> Hydraulic fracturing for oil and gas production wells is typically addressed by state oil and gas boards or equivalent state natural resource agencies. EPA retains authority to address many issues related to hydraulic fracturing under its environmental statutes. The major statutes include the Clean Air Act; the Resource Conservation and Recovery Act; the Clean Water Act; the Safe Drinking Water Act; the Comprehensive Environmental Response, Compensation and Liability Act; the Toxic Substances Control Act; and the National Environmental Policy Act. EPA does not expect to address the efficacy of the regulatory framework as part of this investigation.[34]

This is a critical period as best practices are shaped by the industry and regulators in various jurisdictions. While there is some uncertainty regarding the final form of a regulatory framework, what is certain is that there will be regulatory changes in the future. The extent to which such changes could add to the cost of natural gas extraction remains to be seen.

Legal Issues

Although not directly related to hydraulic fracturing, there are two legal issues pertaining to shale gas currently garnering attention, and both are complex. One concerns mineral rights. The second involves the appropriate accounting for shale gas reserves.

Mineral Rights

In the case of mineral rights, at issue is whether the Marcellus shale constitutes a mineral under Pennsylvania law.

> For more than a century, Pennsylvania has required landowners to consider oil and gas rights separate from more general 'mineral rights' when transferring ownership of resources beneath the surface of their property. The defendants in the title dispute argued shale gas is different and should be considered part of the mineral rights because it is contained inside rock.[35]

The issue is working through the Pennsylvania courts, and may take up to two years to decide. For drillers with leases with landowners, this is not an insignificant issue. As shale development expands, more mineral rights issues are expected to emerge.

Accounting for Reserves

At the heart of investigations by the SEC, New York Attorney General, and members of Congress is the question of whether companies are overstating reserves in their financial statements and thus misleading investors.[36] As noted above, the EIA's 2011 report highlighted the problem of accurate reserve estimates:

> In emerging shale formations, gas production has been confined largely to 'sweet spots' that have the highest known production rates for the formation. When the production rates for the sweet spots are used to infer the productive potential of the entire formation, its resource potential may be overestimated. [37]

Per 2009 SEC rules, companies are allowed "to book proved reserves for undeveloped well sites that are situated more than one offset location away from a developed well, provided that certain criteria are met."[38] The question is how companies are interpreting these rules and actually booking reserves.

Best Practice

The need to identify best practice is essential, especially as we balance the concerns, risks and myriad issues associated with hydraulic fracturing with necessity of a relatively clean, abundant, domestic energy source. The industry, as represented by the American Petroleum Institute (API) with its nearly 400 members, has taken steps to develop best practices.

> Over the past year, API… has released several reports detailing best-practice recommendations, the most recent of which deals with water management from hydraulic fracturing, [Cathy] Landry [API spokeswoman] said. These standards are designed to minimize the environmental impacts of water usage, treatment and disposal of water and other fluids used in drilling.[39]

The 90-day report of the Shale Gas Production Subcommittee identified best practice opportunities and provided recommendations for further action. The subcommittee stressed the importance of continuous improvement (investment in R&D), cooperation between industry and regulators, monitoring and reporting, and community involvement. More detailed recommendations and actions are expected in the subcommittee's 180-day report in early 2012.

In general, best practices for hydraulic fracturing would address the following issues:

- well design / integrity
- water lifecycle management
- water quality monitoring (including baseline testing)
- air quality monitoring (including baseline testing)
- disclosure of drilling policies and procedures
- disclosure of chemicals used in fracking fluids
- development and use of environmentally-friendly alternatives to chemical additives used in fracking
- proper disposal of fracking fluid
- reduction of clean water use in fracking process, using recycled water whenever possible
- occupational health and safety
- minimizing impact on wildlife habitats, ecologies, and communities
- community engagement and education

"Sloppy drilling practices, inconsistent cementing and poor fluid management have caused the majority of negative attention on the shale gas industry."[40]

"Companies have economic incentives to adopt best practice, because it improves operational efficiency and, if done properly, improves safety and environmental protection."[41]

"The public deserves assurance that the full economic, environmental and energy security benefits of shale gas development will be realized without sacrificing public health, environmental protection and safety."[42]

"'Natural gas burns cleaner than coal, emits less in the way of greenhouse gases, and avoids mercury and other pollutants from coal,' [Fred] Krupp [president of the Environmental Defense Fund and member of the Energy Department's Shale Gas Production Subcommittee of the Secretary of Energy's Advisory Board] points out. 'So this could be a win-win, if — and this is a big "if" — we do it the right way.'"[43]

Conclusion

Natural gas will continue to play an increasingly important role in our energy future. As a relatively clean burning and abundant domestic fuel source, natural gas helps achieve many of our national goals, from energy independence and reduced CO_2 emissions to job creation and a transition to renewable energy. While the full extent of the technically recoverable shale gas reserves in the lower 48 states is still not known, and the technology and regulatory landscape are still evolving, the potential of shale gas is significant. So, too, are the risks, particularly those associated with hydraulic fracturing. The key is to tap into this resource responsibly, protecting our environment and our communities.

For Sentinel's sustainable funds, this means identifying strong companies that are committed to developing and employing best practices, and demonstrate this commitment through:

- rigorous health and safety programs and proven safety records,
- robust environmental management systems and positive environmental history,
- transparency,
- accountability, and
- continuous community engagement.

In short, we will continue to invest in companies that operate responsibly and sustainably.

ENDNOTES

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