A New Golden Era?
Unconventional Oil and Gas Regulation in the US: Implications for Korea

Edited by J. James Kim and Shin Chang-Hoon
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About

The Asan Institute for Policy Studies is an independent, non-partisan think tank that undertakes policy-relevant research to foster domestic, regional, and international environments that promote peace and prosperity on the Korean Peninsula, East Asia, and the world-at-large.

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Executive Summary

The widespread use of new technology enabling the extraction of natural gas and oil from tight underground shale formations (i.e. hydraulic fracturing or “fracking”) has ushered in a new era of rapidly changing landscape in the global energy supply and production. While the US Geological Survey estimates that there is an abundance of untapped energy from this source in various locations around the world, much of the recent activity associated with extracting oil and gas from deep underground tight formations has been concentrated in North America (i.e. United States and Canada). Estimates and projections vary, but the latest figures issued by the US Energy Information Administration (EIA) indicate that there are approximately 58 billion barrels of recoverable shale oil and 665 trillion cubic feet (tcf) of recoverable shale gas in the United States (See Figure 1).1

What this has meant, of course, is that there is now an abundant supply of natural gas and oil in North America and this remains likely to be the case for the foreseeable future. As far as the economy of the global energy market is concerned, this also means a significant drop in the price of these resources. For the time being, this trend has largely been localized around the price of natural gas in the United States with the Henry Hub price dropping from approximately US$9 per million British Thermal Units (BTU) in 2008 to US$2 to US$3, which is comparable to rates not seen since the late 1990s. One interesting observation is the divergence in the price of gas between North American and non-North American counterparts since 2008/9 (See Figure 2).

It is hardly surprising that the drop in price has coincided with the rise in natural gas production. According to the EIA’s latest estimate, 95 percent of
natural gas consumed in the United States as of 2011 were produced domestically. Another important point to note is the pace and scope with which this development is currently taking place in the United States. According to the EIA, US shale gas production increased at an annual average rate of 17 percent during 2000-2006 and at 48 percent during 2006-2010. As a comparison, the annual average growth rate of overall natural gas production in the United States since 2007 has been +4.7 percent as compared to the same figure for 1970-2006 which is -0.3 percent. Finally, the latest projection suggests that the overall share of shale and other forms of tight gas is likely to increase into the future (See Figure 3).

As far as the broader economic impact is concerned, the evidence is generally positive. A recent set of reports published by IHS, for instance, indicates that shale development is responsible for over 600,000 jobs in 2010 and approximately 1.7 million jobs as of 2012. This figure is expected to more than double by 2035. In terms of value added contribution to gross domestic product (GDP), shale development is projected to add more than US$400 billion to the US economy by 2020. Between 2012 and 2035, the estimated impact on the federal and state revenue will approximately be about US$2.5 trillion.

There are some studies that refute the validity of these assessments and outlook; however, other signs suggest that there is no early end in sight as far as fossil fuel extraction from tight formations is concerned. One observable trend is the rise in the level of foreign investments in the US shale industry. According to the EIA, total investments in the US shale plays totaled US $133.7 billion during 2008-2012 with about 20 percent of this figure coming from joint ventures involving foreign corporate entities. A trade press report released by the EIA in early 2012 lists about 11 companies from seven different countries that have made significant investments in eight different shale plays.

This trend is not likely to change any time soon given the rise in the number of export permit applications pending the approval from the US Department of Energy (DOE); thus far, the DOE has only approved two of 23 applications that it has received to permit overseas export of natural gas. However, it is clear that preparations are well underway to begin full-fledged export of both liquefied natural gas (LNG) as well as liquefied petroleum gas (LPG) from the United States. Consumer nation-states like Japan and South Korea, two of
Secondly, we also know that public concerns about well-bore integrity, transparency, and water management have pushed various federal agencies, such as the BLM, to adapt new rules which themselves are subject to change depending on negotiations with various social interests. In short, what this suggests is that there is some room for uncertainty about the direction of regulatory controls as we speculate on the future of unconventional oil and gas development on federal parcels.

With respect to state-level regulation, we found significant variations in enforcement as well as pre-conditions on various drilling sites across different states. The single greatest challenge appears to be the lack of comprehensive regulatory framework as far as fracking is concerned; however, development of a one-size-fits-all policy with respect to unconventional gas and oil development is problematic given that geological specificity and variations in climate as well as topography largely determine the method and technology used to extract resources from tight formations. Given also that certain regulatory environments are more favorable for certain types of extraction methods and technology, the impact that more or less stringent regulation can have on overall productivity is likely to be cushioned by the variation in regulation, holding all else (i.e. recoverable supply) constant. However, spots of poor regulation can potentially be areas of risk whereby a single environmental or public health fallout can prove to be the basis for harsh regulatory backlash against the industry as was the case in the recent BP Deepwater Horizon drilling rig disaster and the restrictions on drilling that followed shortly thereafter.

While the discussion suggests that state-level regulation, in conjunction with federal, regional, and local regulations, perform relatively well in addressing many concerns, it also appears to be the case that existing regulations are

the largest importers of LNG and LPG, are looking to step up imports of both products from the United States within the next three to four years. If these trends continue, the EIA projects the United States to be a net exporter of natural gas and oil by 2020 and 2025, respectively.

There is little left to doubt that change in this area has been vast and rapid; however, there is also much left to understand about the range of impact that these developments can and will have on the environment and the broader community. With increasing use of new methods and technology for extracting valuable resources from tight formations, there is a growing concern about the possible externality implications of fracking. One obvious suspect is the impact that fracking will have on surface and groundwater supply. Availability of water for other uses, impacts on the aquatic life, contamination from flowback, spills or leaks, as well as the handling of wastewater are all concerns that have been raised by various members of the civil society and government. Some have even questioned the possible connections between seismic activities in and around the injection wells and drilling pads.

As concerns about the environmental and social impacts of fracking continue to grow, there is an increasing potential for the kind of regulatory intervention that may pose severe restrictions on unconventional oil and gas development. Discussions in the preceding chapters reveal several important lessons that may prove useful in estimating the likelihood for this kind of shift.

We know, for instance, that there are extensive regulatory controls on licensing, planning, leasing, development, and reclamation on federal lands, but we also know that these existing regulations may not be adequate given that drilling operations vary according to subsurface geology and technology.
dated in relation to the change in technology and methods. Some potential problems point to a lack of adequate information about the state of regulations across different states as well as personnel resources to enforce existing regulations. Clearly, it seems to be the case that there is room for improvement on this front meaning this is an area in flux and much like federal regulation can change for better or worse.

The question about the kinds of regulation that we may see developing across different states may depend, in part, on how well the industry or the market may manage public concerns as well as the risks associated with drilling. The evidence from the above discussion suggests that there are improvements in at least two fronts in addition to changes in government regulation. One is on the technological front. Innovative approaches to managing water use along with the utilization of multi-well pads and green completion technology have assuaged some environmental concerns. Second area is in inclusive cooperative engagement. Multi-stakeholder approach, which brings together players from the industry, academia, government, as well as other interest areas, have allowed for better problem identification, greater transparency and more effective solutions to potential problems in unconventional oil and gas development. Finally, we also see the emergence of best industry practice which incorporates all of these elements along with effective regulation in order to minimize well construction failures and other potential fallouts. Whether these market-based developments will be able to adequately address public concerns and thereby preclude the need for a comprehensive regulatory control remains to be seen.

Aside from the above non-market factors, there are other critical dimensions that cannot be overlooked. First and foremost is the supply of oil and gas in shale and other tight formations. According to the EIA, estimates of technically recoverable resource (TRR) are a function of land area, well spacing, percentage of area untested, percentage of area with potential, and estimated ultimate recovery (EUR) per well. Unproved TRR refers to estimates of resources that can be recovered using current technology without concern for additional economic or operating conditions. As wells are drilled and resources are extracted, unproved TRR become proved TRR and then ultimately catalogued as production. The problem is that the projection figure has a high degree of variance (See Figures 4 and 5). The EIA reasons that since the economics and timing of development can affect production, TRR does not necessarily reflect projected production. One of the criticisms against the development of shale and tight formations, however, is that the projected...

![Figure 4: Unproved Technically Recoverable Shale Gas Estimates Outlook by Basin](attachment://figure4.png)
structure development itself poses a whole new set of questions with respect to regulation and environmental as well as public health concerns.

Implications for South Korea

Short-term trends in US shale gas and tight oil should not be underestimated. Some recent estimates suggest that the exploitation of shale oil, for instance, will boost GDP of large net oil importers, such as Japan, by around 4 percent to 7 percent by 2035. The impact on South Korea, which stands as the world’s second largest importer of LNG and the seventh largest importer of oil, is significant. As shown in Figure 6, the price of crude oil and natural gas imports in South Korea has consistently increased over time. Similar to the Japanese counterparts, both the Korea National Oil Corporation (KNOC) and the Korea Gas Corporation (KOGAS) have responded by increasing their investment in US shale plays. The Korean Ministry of Knowledge has long

supply is grossly overestimated. Whatever may be the case, volatility in projected estimates of supply should be weighed in towards decisions about future investments in unconventional oil and gas.

Infrastructure conditions are also critical in processing and delivering natural gas for domestic as well as foreign consumption. LNG terminals and storage facilities as well as pipelines will be required to prevent bottlenecking and stranded supplies from areas that previously were not considered as a resource base for natural gas. Some estimates suggest that the cost of new natural gas transmission infrastructure and processing facilities will require about US$160 billion of infrastructure investment by 2035. Of course, infra-

Figure 6: Import Price of Crude Oil and Natural Gas in South Korea, 1988-2014

Source: KITA
maintained that it will promote the expansion of shale gas imports to 20 percent of all natural gas imports by 2020. Private companies, such as the E1 Corporation and SK Innovation have announced that the import of LPG from US shale source will begin as early as 2014, timed to the Panama Canal expansion project. At the moment, the price of LPG produced from shale formations in the United States is 10 percent to 20 percent cheaper than the imports from the Middle East. As the number of stakeholders from other countries for unconventional oil and gas development in the United States grows, South Korea finds itself with a particular edge that some of these other players do not yet possess. As a recent signatory of the free trade agreement with the United States, South Korea has the ability to sidestep the time-consuming licensing process for US exports of natural gas and oil.

These conditions, however, do not necessarily imply unabashed optimism as far as energy prospects for South Korea are concerned. As discussed in the previous section, there are many risks and unknowns with respect to long-term outlook on unconventional oil and gas in the United States. Perhaps a more forward looking approach that problematizes risk management could prove useful. A step in this direction is strategic emphasis on optimal energy mix. As of today, nuclear power stands as one of the most important sources of electricity generation in South Korea and this is not likely to change into the future (See Figure 7). Dependence on coal, which currently stands to account for little over a third of electricity generation, will decrease into the future. In its place, LNG has emerged as an important alternative. As of 2001, only 8 percent of all electricity generated in South Korea came from LNG. This figure is more than doubled by 2010. Given that much of this energy source cannot be homegrown and the geopolitical risks associated with over-dependence on Middle East sources have gone up, South Korea is likely to shift its attention to the development of unconventional oil and gas in North America. The exact measure of how much South Korea will rely on this energy source, however, should be tempered with the outlined risks as it forges ahead.

Source: Korea Statistical Information Service
Chapter 1. Lessons and Implications from Non-Market Considerations in the Development of Unconventional Oil and Gas in the United States

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The widespread use of new technology enabling the extraction of natural gas and oil from tight underground shale formations (i.e. hydraulic fracturing or “fracking”) has ushered in a new era of rapidly changing landscape in the global energy supply and production. While the US Geological Survey estimates that there is an abundance of untapped energy from this source in various locations around the world, much of the recent activity associated with extracting oil and gas from deep underground tight formations has been concentrated in North America (i.e. United States and Canada). Estimates and projections vary, but the latest figures issued by the US Energy Information Administration (EIA) indicate that there are approximately 58 billion barrels of recoverable shale oil and 665 trillion cubic feet (tcf) of recoverable shale gas in the United States (See Figure 1.1).¹

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Figure 1.3: US Dry Natural Gas Production by Source, 1990-2040

Source: EIA

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These factors are critical as we look to the future of unconventional gas and oil in the United States. Aside from the challenges posed by commercial/market as well as infrastructure lags, regulation and industry practice can be a barrier as well as a catalyst for sustained shale rig production. The purpose of this report is to explore this aspect of shale gas and oil development in the United States. This report is a product of a day-long workshop that brought together experts from the industry and policymaking community from both the United States and South Korea to discuss the current state of regulations and industry practice with regard to shale developments.

In Chapter 2, entitled “Managing Oil and Natural Gas Development on Federal and Indian Lands in the United States,” Lonny Bagley provides a broad sweeping overview of the US Department of the Interior, Bureau of Land Management’s regulations of onshore land use with respect to oil and natural gas developments on federal and Indian lands in the United States. Aside from detailing a fairly extensive set of regulations for application, inspection, and enforcement of oil and natural gas development on federal lands, Bagley’s discussion also suggests some areas for possible improvements. For instance, the BLM currently employs about 190 certified inspectors to cover 33,000 inspections per year, which amounts to about 173 inspections per year per inspector. Increasing concerns about the surface and subsurface environment arising from fracking and directional drilling has also pushed the BLM to develop a new set of rules that would seek to improve wellbore integrity, increase transparency, and elevate water management standards. The concern here, of course, is how quickly this new set of proposed rules will go into effect.

In Chapter 3, which is entitled “US Regulation of Unconventional Oil and Gas Development: Progress and Challenges,” Hannah Wiseman provides a more thorough account of existing regulations on unconventional oil and gas devel-
opments at the state level. In particular, Wiseman points to three challenges with respect to regulation at the state level: One is the significant amount of variation on regulation and enforcement across different states; second is the overlapping jurisdiction in those areas where the directional drilling will be such that it will require crossing a state boundary; finally, the timing of regulation is such that it typically lags industry development and growth. What all of this means is that there is a significant level of uncertainty surrounding the regulation of shale oil and gas industry on non-federal lands for the foreseeable future. On the other hand, this can also be viewed as an opportunity for the industry to work in coordination with the civil society and government to develop the kind of standards and practices necessary to match the advances in technology and methods utilized in drilling rigs.

James Slutz covers this issue in Chapter 4, entitled “Challenges for Shale Oil and Natural Gas: Environmental Stewardship and Opportunities through Innovation.” Slutz points out that there are several innovations that stand to reduce negative externalities arising from fracking and directional drilling. One is wastewater disposal and reuse. By removing suspended solids and reusing clean brine, there can be a saving of about 50-80 percent of water used in a single well. There are also efforts to make use of Environmentally Friendly Drilling (EFD) systems, which promote multi-well pads, modular compact drilling rigs, and low impact access roads as well as green completion technology. Multi-stakeholder engagement as well as efforts to combine best practices and regulation, as in the case of the North Dakota Industrial Commission, stand as effective benchmarks for the rest of the industry.

In sum, the discussion shows that there are areas for improvement when it comes to the regulation of unconventional oil and gas development. One challenge seems to be the high level of variation in state-level regulation as well as a lag in regulatory standards across numerous state and federal jurisdictions. These are serious concerns since lack of timely development on these fronts may fail to assuage public concerns about the potential environmental and health problems arising from unconventional oil and gas development. However, it is precisely the lack of a uniform standard that can also provide an impetus for industry experts and government regulators to coordinate an effective pragmatic response that makes use of an innovative combination of best industry practice with existing policy.
The importance of the BLM oil and natural gas program is significant in terms of its contribution to domestic supply and revenues to the American economy. Domestic production from more than 92,500 federal onshore oil and natural gas wells accounts for 14 percent of the nation’s natural gas supply and 6 percent of its oil. The sales value of the oil and natural gas produced from public lands exceeded US$22.6 billion in 2012. Royalties, rentals, and bonus payments vary from year to year. In fiscal year 2012, these contributions totaled US$4.3 billion from federal onshore energy leasing and production. Half of this money is sent back to the states and half goes to the US Treasury.

A significant portion of funding in the BLM oil and natural gas program is used to fulfill the federal government’s trust responsibilities to American Indian tribes and individual Indian mineral owners. The BLM supervises operational activities on 3,700 Indian oil and natural gas leases, and provides advice on leasing and operational matters to the Bureau of Indian Affairs, Indian tribes and Indian mineral owners.

The Secretary of the Interior (Secretary) has the authority under various federal and Indian mineral leasing laws to manage oil and natural gas operations on federal and Indian (except Osage) lands. The Secretary has delegated this authority to the BLM, which issues onshore oil and natural gas operating regulations codified at 43 CFR part 3160. These statues include, but are not limited to, the:

- Mineral Leasing Act, 30 U.S.C. 181 et seq., which authorizes leasing and development of leasable minerals, including oil and natural gas, on public lands and on lands having federal reserved minerals;
- Mineral Leasing Act for Acquired Lands, 30 U.S.C. 351 et seq.;
- Federal Land Policy and Management Act, 43 U.S.C. § 1701, which establishes...
criteria for unnecessary or undue degradation, multiple resource management, sustained use for present and future generations and land use planning;

- National Environmental Policy Act, 42 USC § 4321 provides for disclosure of impacts from development;
- Federal Oil and Gas Leasing Reform Act of 1987, 30 U.S.C. § 181 requires quarterly lease sales wherever eligible lands are available for leasing;
- Title III of the Energy Policy Act of 2005, 42 USC § 15801 streamlines permit processing timelines;
- Federal Oil and Gas Royalty Management Act, as amended, 30 U.S.C. 1701 et seq., establishes the authorities and responsibilities of the Secretary of the Interior for royalty management for oil and natural gas leases on Federal lands and the enforcement practices for ensuring collection of oil and natural gas revenues owed to the United States.

Within the operating regulations at 43 CFR 3160, detailed operating requirements are further developed through Onshore Oil and Gas Orders and Notices to Lessees when necessary to implement and supplement the operating regulations.

Not all lands with energy potential are appropriate for development. The BLM is a land and resource management agency with a multiple use mission. Through its land use planning process, the BLM has discretion in determining lands to lease for oil and natural gas development.

Land use plans are completed and updated periodically and identify various uses of public lands and analyze impacts to resources resulting from development, like oil and natural gas. If necessary, it provides measures to protect other resources that could be affected by exploration and development activities, basically setting the stage for site-specific permitting decisions.

The public is encouraged to participate and provide a key role regarding the use of lands. The bureau works with local communities, the states, industry, and other federal agencies in this process to ensure all views are heard. Numerous opportunities for public involvement during land use planning and then during environmental review of specific projects help ensure that development is both efficient and environmentally responsible, which includes restoring the land for other uses for current and future generations.

Lands are nominated for lease through an expression of interest process. Using the land description provided in the expression of interest, BLM consults the land use plan to determine if the lands are available for leasing. Once BLM confirms that lands are available, they are offered through an open competitive bidding process. Minimum bids begin at a US$2.00 per acre. Lease sales are held on a quarterly basis.

A lease is a contract to explore and develop (all horizons) for a period of 10 years. If production is established, the lease is held by production until production ceases. The lessee pays an annual rental ranging from US$1.50 to US$2.00 per acre. The royalty rate is set at 12.5 percent.

**Application for Permit to Drill**

Once a lease is obtained, an operator submits a site-specific proposal known as an Application for Permit to Drill, or APD, to begin exploration and development of their lease rights. Operators submit their application following com-
The comprehensive procedures that have been established through various regulatory processes by the BLM. Their application will have two parts: 1) a drilling plan and 2) a surface use plan of operations.

To cover the BLM’s cost for processing the APD, operators are required to pay a US$6,500 fee for each permit. Operators are also required to have a bond in place before beginning operations. Bonds help assure sound operations, proper royalty payment, and protection of the environment. Current minimum bond amounts are set at US$10,000 for an individual lease bond; US$25,000 for a statewide bond; and US$150,000 for a nationwide bond. The BLM can require additional bonding based on the operator’s performance and liabilities.

The drilling plan portion of their application addresses the geology of the area and anticipated formation tops; anticipated pressures they expect to encounter and the pressure rating of well control equipment they plan to use; various casings they plan to use, size, weight and grade, and setting depth; volume, type, and grade of cement they plan to use in setting casings; mud systems (fresh water, salt based, inverted, additives, and weight) they will utilize during the drilling of the entire well; any testing or logging they plan to conduct; pressures and potential hazards they may encounter while drilling the well; and directional or horizontal designs they plan to utilize. Upon submission, BLM performs an extensive review of their application to ensure their plans meet our minimum requirements.

The BLM will be looking to ensure wellbore integrity. The BLM’s first priority when reviewing a permit to drill on public and Indian land is to ensure the wellbore is constructed in a manner that will protect the environment and public safety. Our review to this regard will be to ensure that the proper casings (size, weight, grade, and setting depth) are used; proper type, grade, and volume of cement is used to secure the casing in the wellbore; appropriate pressure rated well control equipment is used; and testing procedures of casings and well control equipment are outlined to ensure they are functioning properly. Protections for other important minerals and water zones are another critical area where the BLM pays close attention. Using the geology and other information sources we will ensure these resources are isolated through sound casing and cementing practices. A third aspect of the review is the assurance that the public is protected. This is achieved by making sure the casing program is adequate; well control measures are in place; any expected hazards are addressed; and warning signs are in place.

In the second part of the application, the operator addresses how they plan to use the surface during all phases of the project. Based on a given set of criteria, the operator identifies surrounding surface resources and uses; then proposes how they will utilize the surface for their needs. The BLM will conduct an analysis of the proposed use to determine if it is appropriate. This includes conducting a site visit of the proposed location with the operator. This visit is designed to ensure the well is placed in a good location and to discuss any initial issues the operator should address in their permit application.

Based on the size (number of wells and facilities) and scope (surface impacts; resources affected and conflicts; etc.) of the project, the BLM determines the appropriate level of environmental review. The types of review consist of: 1) Environmental Impact Statement (EIS); 2) Environmental Assessment (EA); 3) Determination of NEPA Adequacy (DNA); or 4) Categorical Exclusion (CX). Each of these processes has varying degrees of analysis and time to complete. The selection of one over the other depends on the degree of resource
cantly reduced and can eliminate the need to construct additional well pads, roads and utility corridors. Instances in Pinedale, Wyoming, the number of wells drilled from one well pad has reached 64 wells.

The feasibility of directional drilling is dependent on the subsurface geology and the depth of the hole. Drilling costs are typically greater and may add risk to the operation. However, the benefits of reducing habitat fragmentation are significant and allow an operator to explore more resources that would otherwise be restricted. Options like directional drilling allow the BLM to be more responsive to resource conflicts; help operators in securing future leasing and permits; reduce our protests and litigation costs; and lead to improved efficiency and program effectiveness.

Inspection and Enforcement

Our stewardship mandate requires the BLM to manage the valuable assets of our public lands. A critical aspect of that responsibility as it relates to oil and natural gas development is to make sure operations are sound and ensure compliance with operational and environmental requirements during all phases of development. The BLM’s Inspection and Enforcement Program is designed to ensure: 1) compliance with all lease terms, conditions of approval in the drilling permit, and all other applicable laws and regulations; 2) production is properly handled, accurately measured; and reported correctly; 3) protection of the surface and subsurface environment; and 4) protection of the public health and safety.

On an annual basis the BLM prepares a strategy that identifies inspection priorities. Priorities are based on a number of criteria including, operator compliance; production rates; reporting violations; and environmental and
Inspections for production facilities are performed to ensure production is properly handled, accurately measured, and reported correctly. Inspection activities include: Site security, witness measurement activities, and ensuring measurement devices are functioning properly and are calibrated as per BLM and industry standards. Independent measurements are conducted and compared to the results taken by the operator. Audits of operator records ensure proper accounting of production. Accurate measurement and reported volumes leads to the proper revenue collection. 50 percent of the oil and natural gas proceeds collected from federal lands are disbursed to the states to support schools, hospitals, and other local needs.

In cases where theft or fraud is suspected, BLM's law enforcement arm is called upon to further investigate the case. Environmental inspections are conducted to ensure operators take appropriate measures to protect the environment. Inspections include observation for erosion concerns; topsoil stock piling, location, road, and pit construction and use, spills, water disposal methods, spill prevention and containment measures, surface hazards, and interim and final reclamation.

Hydraulic Fracturing

Hydraulic fracturing (known as "fracking") practices used to develop oil and natural gas resources are drawing much attention across the county from proponents and opponents alike. Hydraulic fracking is a process that uses high pressure to create small fractures in the hydrocarbon formation that aids extraction of oil and natural gas deposits that could not be recovered previously. Hydraulic fracturing is a 60-year-old process that is now being used more commonly as a result of advancements in technology. The BLM estimates that roughly 90 percent of wells currently drilled on BLM-managed
lands (approximately 3,100 per year) are stimulated using hydraulic fracturing techniques.

Fracturing fluid is typically more than 98 percent water and sand, with small amounts of additives used to control the chemical and mechanical properties of the water and sand mixture. The increased use of hydraulic fracturing in recent years has generated concern about its potential effects on both water quality and availability, particularly with respect to the chemical composition of the fracturing fluids, and wellbore integrity.

As previously discussed, when permitting a well on federal or Indian lands, wellbore integrity is the first and most important component to ensure measures are in place to protect fresh water, other resources and the public. When operators submit an Application for Permit to Drill they are required to describe their plans for drilling and completing the well. As part of the review process, the BLM identifies the risks and ensures the appropriate protective measures are in place to ensure fresh water and other resources are protected. This includes all potential safety or health risks that may need special protection measures during drilling, or that may require specific protective well construction measures. Once this analysis is completed, the BLM reviews the company’s proposed casing and cementing programs to ensure the well construction design is adequate to protect the surface and subsurface environment. Once drilling commences, the BLM conducts inspections throughout the operation to ensure they are in compliance as previously discussed.

As a result of concerns raised by the public, the BLM developed the proposed rule to address hydraulic fracturing practices. The proposed rule would strengthen the requirements for hydraulic fracturing performed on federal and Indian lands.

The proposed rule would address three main areas: 1) improving assurances on wellbore integrity so we know fluids going into the well aren’t escaping; 2) requiring public disclosure of chemicals used in hydraulic fracturing, with appropriate protections for trade secrets; and 3) ensuring companies have a water management plan in place for fluids that flow back to the surface.

Some states have started requiring similar disclosures and oversight for oil and natural gas drilling operations under their own jurisdiction. This proposal seeks to create a consistent oversight and disclosure model that will work in concert with other regulators’ requirements while protecting federal and tribal interests and resources.

The proposed rule would require that disclosure of the chemicals used in the fracturing process be provided to the BLM after the fracturing operation is completed. This information is intended to be posted on a public web site, and the BLM is working with the Ground Water Protection Council to determine whether the disclosure can be integrated into the existing website known as FracFocus.org.

The final release of these rules is still pending. For more information, visit: www.blm.gov/wo/st/en/info/newsroom/2012/may/NR_05_04_2012.html or www.blm.gov/wo/st/en/prog/energy/oil_and_gas.html.
which is often sand or a similar substance, holds open the fractures, allowing natural gas to flow through them and up the well.\footnote{8}

Slickwater fracturing is different from previous types of fracturing used in the United States because it employs larger quantities of water and, in some cases, different chemicals.\footnote{9} The chemicals used in this process serve several purposes. An acid injected before the fracturing treatment cleans the shale around the wellbore. Substances mixed into the fracturing fluid help to reduce the friction generated by water forced down the well at high pressure, and other substances help to carry the proppants and then release the proppants into the fractures. Further, biocides mixed with the injected water kill bacteria in the shale that could interfere with the fracturing process.

In recent years, oil and gas operators have applied horizontal drilling and slickwater fracturing techniques to tight formations in several regions of the United States and have produced surprising quantities of natural gas and oil. The International Energy Agency (IEA) estimates that the United States will be nearly “self-sufficient” in energy by 2035\footnote{10} and will be an exporter of natural gas; the country will also produce large quantities of oil—possibly leading the United States to become the world’s largest oil producer.\footnote{11} This “renaissance” in energy, as the IEA calls it,\footnote{12} will have important environmental implications, which could potentially lead to investment uncertainty—particularly because the risks of this type of development cannot yet be fully quantified. This paper explores and briefly assesses the laws, including statutes, regulations, and agency directives, that govern the environmental impacts of fossil fuel development in the United States, including development that uses hydraulic fracturing.

Most oil and gas laws do not address hydraulic fracturing specifically, but

Chapter 3.
US Regulation of Unconventional Oil and Gas Development: Progress and Challenges

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Development of natural gas from “tight” formations in the United States, which include densely-packed, low permeability sandstones, shales, and coalbeds,\footnote{7} has recently expanded. Two key technological changes have enabled this expansion. First, entities that develop oil and gas wells, which are called operators, began drilling horizontal wells\footnote{3} that extend laterally through a formation. After drilling straight down into a formation—often up to one mile beneath the earth’s surface—the operator angles the drill bit to cut horizontally through the formation from which oil or gas will be extracted, thus exposing more surface area. Second, in the late 1990s in the State of Texas, energy companies with the help of the US government\footnote{4} perfected a technique called “slickwater” hydraulic fracturing.\footnote{5} Although hydraulic fracturing has occurred since the 1950s,\footnote{6} slickwater fracturing of multiple well segments is a specialized technique. After the operator drills a well into a formation that contains petroleum and lines the well with steel tubing and cement, the operator sends an instrument down the well that discharges electric charges or bullets at a particular point underground. This perforates the portion of the well around which fracturing will occur. The operator then injects between one and seven million gallons of water,\footnote{7} mixed with a small quantity of chemicals, down the well at high pressure. The water is forced out of the perforations in the wellbore and fractures the formation. A “proppant” injected with the water,
The Stages of Unconventional Well Development

The process of developing an unconventional well in a tight formation begins with testing for the presence of petroleum underground. Engineers typically estimate the presence of underground petroleum resources through a process called seismic testing, in which scientists drive trucks over the surface. They use equipment on the trucks to strike the ground; this creates sound waves underground, and the waves bounce back to a computer; data about the velocity of the signal traveling through the formation suggest the location of petroleum resources underground. Based on these data, operators select a surface location at which to drill; after obtaining the property rights (called “mineral rights”) and regulatory permits necessary for drilling, operators then begin the well development process—a temporary yet intensive industrial operation.

To develop a well, operators construct a well site and well pad—the flat surface on which all surface operations occur, and an access road to the site and the well pad. Operators then bring to the site drilling rigs and other materials required for drilling, including drilling muds that cool the drill bit as it cuts far underground. During and after the drilling process, the operator temporarily stores wastes either in surface pits or tanks; these wastes include salty produced water, which comes up naturally out of the formation, and drill cuttings—rocks and soil that emerge from the wellbore as it is being drilled. Both produced water and drill cuttings can contain low levels of naturally-occurring radioactive materials. In addition to the natural wastes from drilling, operators also store used drilling muds and fluids on the surface before permanently disposing of them. Surface storage of wastes poses some of the greatest environmental challenges, as improperly-lined pits or leaking tanks can pollute soil and groundwater beneath soil.

In light of these risks, improved regulation is important, and much of the regulatory landscape in the United States is rapidly changing. This paper begins by introducing the general legal approach to controlling the environmental impacts of oil and gas development in the United States and then explores the details of certain regulations. It concludes with an assessment of the need for further changes in some areas, suggesting how the legal landscape should continue to evolve.
As with drilling wastes, operators store this water on site in a pit or tank. Depending on the availability of disposal sites and the state regulations defining available disposal operations, operators then dispose of these wastes by injecting them underground in an underground injection control (UIC) well, sending them to a wastewater treatment plant, or reusing or recycling them. These many stages of well development pose several environmental risks. Diesel spills on well sites from construction equipment during the well site development phase and from rigs and other diesel-powered equipment during drilling and fracturing. Drilling and flowback wastes also spill when being transferred from the well to storage, or they leak from tanks and pits. Construction equipment and rigs on site release air pollution, and the flowback water that flows up out of a well after fracturing emits volatile organic compounds. Methane that flows from the well before the well is fully producing and connected to gathering lines is sometimes released into the air in a process called venting, which is problematic because methane is a highly-potent greenhouse gas. Methane also may be flared off (burned), which produces certain air emissions.

Several rare yet somewhat dramatic environmental incidents associated with oil and gas production also have occurred during the waste disposal stage. One underground injection control well in Texas, which appears to have only accepted wastes from conventional—not fractured—wells, leaked into an aquifer, polluting large volumes of drinking water. Other underground injection disposal wells in Ohio and elsewhere have caused small earthquakes. A variety of regulations attempt to mitigate these risks, as discussed in the following sections.
include the Endangered Species and Migratory Bird Treaty Acts (where certain species are present), small portions of the Clean Water and Clean Air Acts, and the Comprehensive Environmental Response, Compensation, and Liability Act, which makes operators liable for cleaning up contaminated sites (other than sites contaminated solely with oil or gas substances, which are not covered by the Act). For drilling and fracturing on federal lands, the Bureau of Land Management (BLM) also has developed draft rules for fracturing. Federal courts impact how these statutes—and regulations issued by agencies in order to implement the statutes—apply to oil and gas development. Parties challenging agency interpretation or application of a statute or regulation, or a federal civil penalty or criminal enforcement action, use the federal courts.

Despite federal laws that apply to certain stages of oil and gas development, states are responsible for controlling the core potential environmental impacts of drilling and fracturing. This is because oil and gas development and fracturing enjoy certain key exemptions, or simply omissions, from federal statutes. Operators need not disclose their annual emissions of toxic substances, for example, unlike a number of other industries. Operators that fracture with substances other than diesel fuel need not obtain a permit under the Safe Drinking Water Act, thus leaving states to ensure that drilled and fractured wells do not contaminate underground sources of water. Perhaps most significantly, most wastes associated with oil and gas development are exempt from federal regulation of hazardous waste handling and disposal, despite the fact that these wastes sometimes contain low levels of hazardous substances. This exemption allows states, rather than the federal government, to regulate the operation of surface pits and tanks as well as certain waste disposal methods, such as landfills that accept oil and gas wastes.
In light of these federal exemptions, and the fact that federal regulatory authority over oil and gas is often delegated to state environmental agencies, states play a key regulatory role. Most states, for example, are responsible for administering federal Clean Water Act and Clean Air Act regulations, including the issuance of permits under these Acts. And for the stages of oil and gas development that are not federally regulated, states have the primary regulatory authority in the following areas: disclosure of fracturing chemicals (if states choose to require disclosure, as many have begun to), the use of certain types and depths of well casing and cement, the use and maintenance of surface pits and tanks to store drilling and fracturing wastes, the prevention of surface spills during oil and gas drilling, disposal of oil and gas wastes, and the withdrawal of water from surface or underground sources. State oil and gas and/or environmental agencies write regulations governing many of these areas, and state legislatures also write statutes that impose certain requirements on regulatory agencies and oil and gas operators. Furthermore, state courts review agency interpretations of statutes and regulations as well as the constitutionality of statutes and regulations. In Pennsylvania, for example, a court recently struck down a state statute that would have required municipalities to allow gas development in most areas; the court concluded that the statute violated the state constitution. The highest court of Pennsylvania is now reviewing this decision.

Some effects of industrial development (including oil and gas development) cross state boundaries, and some states have therefore developed regional coalitions to address interstate issues. In the United States, the federal Congress has the authority to govern interstate issues; state coalitions therefore must receive federal permission to conduct regional governance across state boundaries, which intrudes into traditional federal authority. In the Northeastern United States, several states have formed “compact commissions” (regional governing coalitions) with Congress’s permission. These commissions, which are comprised of governors from states and one federal voting member, address the quantity and quality of water in shared rivers. The Delaware River Basin Commission and the Susquehanna River Basin Commission have been most active in addressing drilling and fracturing issues—requiring that operators withdrawing water for fracturing obtain a permit prior to obtaining water, for example, and do not harm aquatic life during the water withdrawal process.

Finally, local governments—boroughs, towns, townships, cities, and counties—have important land use authority over fracturing. Local governments only have as much authority as is delegated to them by states, however. Under the US constitution, states retain what are called “police powers”—the power to regulate to protect health, safety, and welfare of their citizens, and states delegate certain of these powers to local governments. Through zoning, which divides municipalities into various areas (zones) and designates the types of land uses allowed in each zone, local governments can sometimes prevent oil and gas development altogether, or constrain its location. They also can govern nuisance-like activities—requiring fencing around well sites, for example, constraining the time of day during which fracturing and drilling may occur, and requiring operators to obtain insurance for environmental liability. In some states, like Pennsylvania, states are attempting to retrace some local powers over oil and gas development because they are concerned that too many municipalities will block fracturing. In other states like Texas and New Mexico, municipalities have exerted relatively broad control over drilling and fracturing. Here, too, state courts play a role: In Pennsylvania and New York, state courts have been very active in determining whether state statutes, which preempt (prohibit) certain municipal control over fracturing, are valid and prevent certain types of local oil and gas regulation. The following section
describes the content of local, state, regional, and federal regulations in more detail.

The Content of Oil and Gas Law

In most industrial areas, the federal government has relatively broad authority to regulate environmental impacts; as introduced in the second section, this authority is narrower for oil and gas, although several federal laws apply. If an oil and gas operator conducts operations in the habitat of a species listed as endangered, for example, the Endangered Species Act[50] would require him or her to obtain a permit from the Fish and Wildlife Service. This permit would constrain the activities of the operator or require certain mitigation efforts in order to limit the number of species “taken” (harmed) by oil and gas activities. The Migratory Bird Treaty Act (MBTA)[51] also prevents operators from killing migratory birds, although there is currently a disagreement in the federal courts as to the reach of the Act. In North Dakota, a federal district court determined that the simple maintenance of surface waste pits at a Bakken Shale site was not a violation of the MBTA; the fact that migrating ducks appeared to have been attracted to the pits and died in or near them did not make the operator criminally liable for the deaths. In contrast, a district court in Texas held that an oil refinery maintaining open tanks in which migratory birds were killed was covered by the Act.[53]

Limited federal water quality laws also apply to oil and gas operators. The Clean Water Act applies to the quality of surface waters of the United States, and operators constructing access roads and well sites—and thus disturbing soil through excavation—must obtain a stormwater permit under the Clean Water Act. In most states, the federal Environmental Protection Agency (EPA) has delegated to state environmental agencies the authority to issue Clean Water Act permits. In the case of stormwater permitting, state environmental agencies issue permits that include best management practices for preventing soil erosion and sedimentation during the construction of oil and gas sites. Although Congress and the EPA attempted to limit stormwater permitting requirements for oil and gas operators, a court decision made clear that oil and gas operators still must obtain stormwater permits. Beyond erosion control, the Clean Water Act further prohibits operators from dumping oil and gas wastes into waters of the United States without a permit.[56] And finally, the EPA is writing specific wastewater treatment standards for flowback from fractured oil and gas wells; draft standards likely will be available in 2014.[57]

The federal Safe Drinking Water Act (SDWA), like the Clean Water Act, protects water quality, but the Act primarily addresses underground water quality. Oil and gas operators that dispose of wastes by injecting the wastes underground must ensure that the underground injection control (UIC) well is properly permitted under the SDWA. A UIC permit—which is typically issued by a state environmental agency acting under authority delegated to it by the federal EPA—is designed to prevent the contamination of underground waters. Operators injecting fluids as part of the fracturing process (with the exception of fracturing with diesel fuel) do not have to obtain a UIC permit under the Safe Drinking Water Act, however.[58] The EPA has developed draft SDWA guidelines for fracturing that uses diesel fuels.[59]

Moving from water to air, the federal Clean Air Act, as recently revised by the EPA, controls the emissions of volatile organic compounds (VOCs) from newly fractured and refractured gas wells.[60] The Act requires operators to
install “green completion technologies,” which capture most of the VOCs emitted from flowback water that comes out of the well after fracturing.61

In addition to new Clean Air Act regulations, the EPA has recently attempted to apply other federal environmental statutes to fracturing. In Pennsylvania, the agency expressed concern that flowback water being sent to wastewater treatment plants was not being adequately treated prior to being discharged into rivers.62 The agency sent several letters to the Pennsylvania environmental agency discussing this concern,63 and Pennsylvania eventually agreed to strongly discourage the disposal of flowback through wastewater treatment plants.64 Also, as mentioned above, the EPA is drafting treatment standards for wastewater from shale development,65 and the agency—as directed by Congress—is conducting a detailed study of the impacts of fracturing on water quality and quantity.66 Further, the BLM has proposed guidelines for fracturing that occurs on federally-owned and tribal lands; these would require disclosure of the chemicals used in fracturing, the completion of cement logs that show adequate cementing in well casing, and other measures.67

Despite some federal efforts to expand regulation—and one prominent law professor’s proposal that fracturing be federally regulated68—most regulatory control over oil and gas development remains with the states. As introduced in the first section, states both implement federal regulations and apply a number of their own regulations to drilling and fracturing. Most importantly, most states set standards for the casing and cementing of wells; set minimum distances between wells or well sites and natural resources; describe how surface pits for oil and gas waste must be constructed and managed; require operators to implement plans for preventing spills at the surface; require the disclosure of fracturing chemicals (in some cases); govern the quantity of water that may be withdrawn from surface and underground sources for fracturing; and, aside from the federal SDWA, determine how oil and gas wastes may be disposed of. Many state regulations are highly variable, though, despite recent state efforts to update certain regulations. The following tables show some of this variability.

As introduced in the second section, one of the states’ most important regulatory functions is to ensure that oil and gas operators properly line (“case”) their well and cement this casing in place. This prevents the contamination of underground water resources with oil, gas, salty brine that flows back up out of the well, or chemicals. A number of states, including, for example, Pennsylvania recently updated casing requirements,69 and Texas has proposed to do so.70 Others, though, have not, and many of the casing regulations vary—particularly in their requirements for how far casing must extend below underground water resources.

Table 3.1: Examples of State Regulations Requiring Casing to be a Minimum Depth Below Groundwater71

<table>
<thead>
<tr>
<th>State</th>
<th>Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>“Surface casing shall be set and cemented at least . . . 100 feet below the deepest encountered freshwater zone.” 2014 Ark. Stat. Ann. § 21-1102.26 (Westlaw 2014). All Fayetteville Shale fields: min. 500 ft. of surface casing.72</td>
</tr>
<tr>
<td>CO</td>
<td>50 ft. if “unanticipated fresh water aquifers are encountered.” Casing must be set “in a manner sufficient to protect all fresh water and to ensure against blowouts or uncontrolled flows; individual casing program adopted for each well.” 2009 Colo. Admin. Regs. 4.24.1003 (Westlaw 2009).</td>
</tr>
<tr>
<td>KY</td>
<td>30 ft. (surface, intermediate, or long string). 805 KY. ADMIN. REGS. 1:020 Section 3:1 (Westlaw 2012).</td>
</tr>
<tr>
<td>LA</td>
<td>Casing lengths and strengths differ depending on “total depth of contact”; standard lengths and strengths only apply “where no danger of pollution of fresh water sources exists.” LA. ADMIN. CODE tit. 43: XIX, § 109 (Westlaw 2011). Below 9,000 feet, more than 1,800 ft. of casing required and test pressure at least 1,000 lbs. per sq. inch. Id.</td>
</tr>
<tr>
<td>MD</td>
<td>100 ft. or deepest known workable coal, whichever deeper. MD. CODE REGS. 26.19.01.10 (c)(4) (Westlaw 2012).</td>
</tr>
</tbody>
</table>
In addition to protecting groundwater through various casing regulations, states, to varying degrees, prevent some contamination of natural resources by requiring that wells, well sites, pits, tanks, or oil and gas disposal locations be a minimum distance from these resources. By requiring these “setbacks,” as they often are called, states can help to prevent pollution from entering surface waters and other important natural resources. Some states appear to lack these regulations, however, and setback regulations differ widely, as shown in Table 3.2.

<table>
<thead>
<tr>
<th>State</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI</td>
<td>100 ft. below all fresh water strata and at least 100 ft below based of glacial drift into competent bedrock. MICH. ADMIN. CODE pt. 615, r. 324.408 (Westlaw 2012). In certain portions of Antrim Formation, production casing must be set at least 50 feet below surface casing.</td>
</tr>
<tr>
<td>MT</td>
<td>“Sufficient surface casing must be run to reach a depth below all fresh water located at levels reasonably accessible for agricultural and domestic use.”</td>
</tr>
<tr>
<td>NM</td>
<td>“[A]s may be necessary to effectively seal off and isolate all water-, oil- and gas-bearing strata.” N.M. CODE R. § 19.15.16.10 (Westlaw 2012).</td>
</tr>
<tr>
<td>NY</td>
<td>75 ft. or 75 ft. into bedrock, whichever deeper (100 ft. primary and principal aquifers).</td>
</tr>
<tr>
<td>ND</td>
<td>“[A]ll sufficient depths to adequately protect and isolate all formations containing water, oil, or gas or any combination of these.” At least 50 ft. “below base of Fox Hills Formation.”</td>
</tr>
<tr>
<td>OH</td>
<td>50 ft.; no agency specific review if at least 500 ft. between highest perforated portion of casing and lowest groundwater.</td>
</tr>
<tr>
<td>OK</td>
<td>50 ft. or 90 ft. below surface, whichever deeper.</td>
</tr>
<tr>
<td>PA</td>
<td>50 ft. or 50 ft. into consolidated rock, whichever deeper; if encounters additional freshwater, centralizers required.</td>
</tr>
<tr>
<td>TX</td>
<td>“[S]et and cement sufficient surface casing to protect all usable-quality water strata.”</td>
</tr>
<tr>
<td>WV</td>
<td>“[30] feet below the deepest fresh water horizon (that being the deepest horizon that will replenish itself and from which fresh water or usable water for household, domestic, industrial, agricultural, or public use may be economically and feasibly recovered).” May require special casing and special review of drilling procedures in Karst terrain areas.</td>
</tr>
<tr>
<td>WY</td>
<td>“[B]elow all known or reasonably estimated utilizable groundwater.”</td>
</tr>
</tbody>
</table>

A number of other state regulations also differ. In many cases, these differences likely are justified by variable climate, topography, geology, and other conditions. Relatively dry areas of Texas, for example, contain fewer streams, and requiring minimum distances between wells and streams therefore may be less important than, setbacks of oil and gas drilling from streams in Penn-
sylana. In some cases, however, it is not clear that major gaps or omissions in state regulations are justified by these legitimate differences.

Some states have addressed this variability, making relatively broad revisions to their codes. Colorado, as part of comprehensive revisions to its oil and gas code, established “buffer zones” around water supplies, in which various protective measures, such as storage of drilling and fracturing wastes in steel tanks, are required. In 2013, the state also required testing of water wells near drill sites before drilling operations occurred (although capping the number of wells to be tested) and imposed new statewide setback rules for well sites. Pennsylvania has similarly completed several regulatory and legislative reforms, first updating its casing and cementing requirements and rules for treating total dissolved solids in wastewater, and later expanding setbacks between well sites and protected natural resources, among other protections. In this later amendment to its statutes, Pennsylvania also expanded the rebuttable presumption that contamination of a water supply—within a certain distance and time following oil and gas activity—was caused by the oil and gas activity. New York has embarked upon a full environmental review of hydraulic fracturing that uses large volumes of water and has avoided issuing Marcellus Shale drilling permits as it completes this review and proposes detailed environmental standards. West Virginia also has completed a relatively comprehensive revision of its oil and gas laws, requiring setbacks between wells and certain natural resources, a waste management plan for drilling and fracturing wastes, and a water management plan, among other protections.

Some regulations at the regional and local level also help to fill gaps. The Delaware River Basin Commission has proposed relatively detailed regulations for gas drilling and fracturing within the Delaware River watershed, includ-

ing stringent erosion control measures both during site construction and well operation within the watershed, testing of nearby water supplies prior to drilling, limits on where fracturing wastes may be disposed of, and other protections. These regulations have not yet been implemented, however.

At the local level, municipalities such as Arlington and Fort Worth, Texas, and Farmington, New Mexico, have enacted a number of measures to constrain the impacts of fracturing, although some of these measures focus more on local nuisances, such as the noise of drilling and fracturing rigs, than on environmental protection. Figure 3.2 provides an example of provisions in Arlington, New Mexico’s ordinance.

Figure 3.2: Code of City of Farmington, New Mexico, Chapter 19, Oil and Gas Wells: Examples of Environmental and Nuisance-Based Controls

- Requires operators proposing to drill wells within city limits to obtain a special use permit from the city council and a license and permit to drill from the city clerk. § 19-2-66.
- Requires operators to file a minimum $20,000.00 bond with the city clerk. § 19-2-101(b).
- Establishes a city Oil and Gas and Geologic and Engineering Hazards Advisory Commission (“Oil and Gas Commission”) to serve as an advisory body to the city on oil and gas-related zoning matters, drilling and maintenance and wells, and other oil and gas issues. §§ 19-2-31, 36.
- Prohibits wells within 200 feet of residences, commercial, and industrial buildings and 300 feet of buildings used for public assembly. § 19-1-3(a).
- Prohibits the construction or moving of a building within 100 feet of a wellhead. § 19-1-3 (c).
- Requires “all waste substances” to be “retained in watertight receptors.” § 19-1-5 (a).
- Places restrictions on excavations and use of public rights-of-ways for gathering lines and pipelines, establishes maximum allowed pressure for gathering lines and pipelines. § 19-2-72.
- Requires rigs, steel pits, and tanks to be removed from sites and pits to be emptied, dried, and leveled within 30 days after the well has been completed. §§ 19-1-4, 19-1-5 (a)-(b).
- Encourages the co-location of multiple wells on single well sites. § 19-1-8.
- Establishes maximum allowed decibel increase measured at 300 ft. from pumping units or at the...
Second, mere comparison of regulation may insufficiently incentivize states to change regulations, and some federal intervention may be needed. David Spence of the University of Texas has described when federal as opposed to state action is typically justified within the United States, and he suggests that federal regulation of oil and gas and fracturing should primarily be limited to areas in which impacts clearly cross state boundaries. Other professors, such as Professor Jody Freeman of Harvard Law School, have proposed more comprehensive federal standards for fracturing, which the states would implement. In light of states’ historic expertise in regulating areas such as the casing of oil and gas wells, as well as state regulators’ geographic proximity to regulated oil and gas operations, it is not clear that federal regulation in all areas of drilling and fracturing is the best solution, but it is certainly being debated—at least in the legal literature. Several bills for federal regulation also have been proposed but have so far failed.

Together, federal, regional, state, and local regulations play a very important role in regulating the environmental impacts of oil and gas drilling and fracturing. In light of the fact that federal regulation does not apply to certain stages of development, however, and that sub-federal regulations are variable, more action may be needed, as discussed in the following part.

Improving Regulation

A number of efforts will be needed to fill certain gaps in US regulation of the environmental impacts of oil and gas drilling and fracturing. First and foremost, states need means by which to compare the content of their regulations in a consistent manner. There is currently no database in the United States that comprehensively collects and directly compares US state oil and gas regulations. With improved means of comparing regulations, states could better identify the leaders in regulation—other states that have taken the most aggressive steps to limit environmental impacts, for example—and could identify the regulations that may be most relevant in particular climates and topographies.

Finally, states, which at least for now retain primary control over the environmental impacts of drilling and fracturing, must ensure that they have adequate staff, and adequately-trained staff, to inspect oil and gas sites. Table 3.3 demonstrates the low levels of staff numbers as compared to the total number of active oil and gas wells (not just fracturing wells) in selected states.

<table>
<thead>
<tr>
<th>State</th>
<th>2012 Inspectors</th>
<th>2012 Active Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado</td>
<td>36</td>
<td>49,062</td>
</tr>
<tr>
<td>Michigan</td>
<td>27</td>
<td>15,742</td>
</tr>
<tr>
<td>New Mexico</td>
<td>12</td>
<td>50,366</td>
</tr>
<tr>
<td>Ohio</td>
<td>40</td>
<td>55,083</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>76</td>
<td>92,392</td>
</tr>
<tr>
<td>Texas</td>
<td>153</td>
<td>279,856</td>
</tr>
</tbody>
</table>
Related to the need to ensure adequate staff for inspecting well sites and enforcing violations at sites is the need for states to better record enforcement actions. Only Pennsylvania and a handful or other states have an easily-searchable database of violations at well sites, including fractured well sites; information on enforcement is much more difficult to obtain in most other states, although some, like New Mexico, have limited information about incidents at well sites in a “spill database.” It is important to produce better enforcement data in order to better understand whether and how states are applying regulations to oil and gas development and to identify the types of incidents that occur at these sites.

Much progress remains to be made in US oil and gas regulation. As described in this paper, some states are changing their regulations, and the EPA and BLM have taken some actions at the federal level. Local and regional governments, too, have adopted certain regulations to address drilling and fracturing. Moving forward, it is unclear whether there will be more dramatic changes, such as more sweeping federal regulation. Overall, it appears that oil and gas development, including fracturing, will continue to occur at a relatively rapid pace, although there will perhaps be enhanced regulation of this development. As the United States rushes forward with the development of gas from shales, this country will likely continue to learn from and respond to incidents, and to explore ways of reducing environmental impacts while reaping the benefits of gas.

The greatest challenge moving forward may be the sheer abundance of oil and gas from shales: With large fossil fuel sources, the United States may be tempted to ignore needed investments in renewable energy. The IEA, although noting the US energy “renaissance,” has also noted the perils of this renaissance for efforts to mitigate climate change. Natural gas, although likely emitting fewer greenhouse gases than coal or oil, will not independently solve our climate problems. Yet it could distract from needed investments in renewables, which are the energy sources to which we must transition in the future. Treating fossil resources as an ultimate energy solution, rather than a bridge to a more sustainable energy future, would set us on a perilous course. Much work remains to be done to improve the regulation of unconventional oil and gas development and ensure that gas leads us to a more sustainable energy future.
Chapter 4.
Challenges for Shale Oil and Natural Gas: Environmental Stewardship and Opportunities through Innovation

James Slutz
Global Energy Strategies, LLC

The recent development of shale oil and natural gas in the United States has been called a game changer. One recent study estimated that by 2035, the US unconventional oil and gas industry would support three million jobs. While the economic and energy benefits are clear, the environmental and social impact of shale oil and natural gas development are areas of concern. These issues must be addressed to protect the environment and ensure public support for future development.

There are many issues when looking at the impact or trade-offs in oil and natural gas drilling and production. To understand the dynamics facing the industry and communities around the non-market issues of oil and natural gas development, it is helpful to understand the context of shale oil and gas development in the United States, including the key enabling technologies of horizontal drilling and hydraulic fracturing. Environmental issues need to be reviewed in the context of key areas of concern, such as ground water, surface water, land disturbance, and air quality. Community and social impacts are different but are related to environmental ones. Both environmental and community impacts can be mitigated through effective regulation and best practice, which may establish effective standards of operations and provide for innovation to improve future operations. Effective environmental and social stewardship in turn is important to maintain public confidence and financial performance.

Shale Oil and Gas Development in the United States

The shale oil and natural gas revolution have been critical to the US economy over the past five years. The United States is the largest natural gas producer and the third largest oil producer in the world. In 2011, natural gas production in the United States was 23 trillion cubic feet (tcf), 20 percent of global production. The EIA’s 2012 Annual Energy Outlook projects by 2022 that the United States will be a net exporter of natural gas. This is a complete change in outlook from just a few years ago when, the EIA projected that the United States would import about 20 percent of the US natural gas supply by 2030. This change is related to the significant increase in natural gas production from shale. EIA projects that from 2010 to 2035, natural gas production from shale formations will rise from 23 percent to 49 percent of the US gas supply. The nation’s natural gas resource base, which includes proved and unproved reserves, is now estimated at 2203 tcf, or almost 90 years of supply.

Regarding oil production, the United States for the past three years is increasing oil production and reversing a long-term decline. Perhaps the best example is the State of North Dakota, which has a significant portion of the Bakken shale within its borders. In six years, North Dakota’s oil production has increased 380 percent from 40 million barrels/year in 2006 to 153 million barrels/year in 2011.

These increases in production have been singularly important to the nation’s economy, creating more than 600,000 new jobs at a critical time when the
economy desperately needed new jobs. These energy developments have occurred on private property and under state regulation with effective stewardship of the environment and protection of public health and safety. Industry has drilled thousands of wells with relatively limited adverse environmental impact; however, there is still room for improvement in reducing environmental and community trade-offs.

**History**

The shale revolution is the culmination of the work by a committed visionary, George P. Mitchell. Geologists have known that the shale formations throughout the United States contained hydrocarbons. In fact, they are known to be the source rock (origin) of oil and natural gas that has accumulated in conventional oil and gas-bearing geologic zones. Mitchell’s vision was that he could figure out the technology necessary to commercially produce the natural gas, and he began drilling shale natural gas wells in the Barnett formation around Dallas, Texas in 1984. After many years and many attempts, Mitchell was successful in effectively applying hydraulic fracturing to the shale formations. The real breakthrough in shale gas production came with the application of both horizontal drilling and multi-stage hydraulic fracturing, which resulted in more wide-scale shale gas development beginning around 2005.

**Key Factors in Shale Oil and Gas Success**

Shale oil and gas development is both similar and different from conventional oil and gas. It is similar in that it uses advanced petroleum engineering and information technology to access difficult-to-reach resources. The oil and gas industry is one of the most high technology industries in the world. It takes a combination of advanced materials, supercomputing, and sophisticated communications to drill two miles deep and turn and drill horizontally another mile or more and stay on target in a vertical interval of just a few feet.

The oil and gas industry has made these developments look easy. However, shale oil and gas production is a high cost exploration and development activity. Where shale oil and gas development is different from conventional production is that success is critically tied to managing costs and maximizing productivity. Managing productivity is absolutely critical to continued investment. A key element of managing costs is effective planning of not just one well, but the entire drilling and production site. An industry measure of the effectiveness for a company is monitoring drilling rig utilization in terms of “days per well drilled.” The industry has dramatically reduced drilling time through technology and improved management. Regulations that cause delays or uncertainty will result in decreased rig efficiency. This is especially troublesome when regulatory delays do not contribute to environmental protection or public health and safety. Any reduction in rig efficiency will directly impact the number of wells drilled and will also have an impact on long term investment decisions.

**Environmental Implications and Mitigation**

The process of exploring, drilling, and extracting oil and natural gas impacts the environment. These impacts are manageable and long-term harm to the ecosystem can be prevented with a proactive and comprehensive approach. Effective environmental protection requires advance planning and operational processes designed to protect ground and surface waters, minimize land impacts, and manage methane and other air releases.
Effective environmental stewardship is critical for maintaining a social license to operate. It is also essential to effective long-term corporate financial performance. There are many aspects of environmental protection. For purposes of this discussion, the focus is on a primary set of environmental issues regularly found in shale gas development. On a site-specific basis, additional issues may need to be considered. For instance, endangered or protected flora and fauna may require additional measures. Archeological surveys may be necessary to protect historically important artifacts or cultural resources. The primary environmental impacts and mitigation common to all shale oil and natural gas development include ground water, surface land and water, land disturbance, and air emissions. Associated with waste disposal wells in a few instances, a relatively new issue of concern is induced seismicity. Following are reviews of the major environmental protection components and the mitigation measures generally used by the oil and gas industry.

**Ground Water**

One of the primary long-term risks in drilling oil and natural gas wells is potential impact to groundwater. The very process of drilling a well creates a potential pathway for lower quality water, oil, and natural gas to migrate from deeper geologic zones to the shallower freshwater bearing formations. To protect freshwater zones (sometimes referred to as underground sources of drinking water), wells are constructed using steel casing and cement to isolate the different geologic formations. In the few cases where contamination or degradation of freshwater zones have occurred, it has typically been because of a failure in one of the well construction components.

The protection of underground sources of fresh water is accomplished by first drilling through the freshwater zones. Before drilling further, a steel pipe called surface casing is set through the freshwater zone and cement is circulated through the casing and up around the outside, sealing the fresh water bearing rocks. The drilling is then continued through the inside of the surface casing. Additional strings of casing (pipe) are set to isolate other zones when necessary to protect the well or facilitate deeper drilling. A final casing is set and cemented through the oil and gas bearing target zone to isolate the oil and natural gas. This casing and cement must be properly engineered to hold the pressure of the fracture treatment as well as pressure created by the flowing oil and natural gas. Properly monitoring casing and cementing processes, pressure testing casing, and additional geophysical tools can be used to determine construction effectiveness.

Regulatory agencies and oil and gas developers have known about the need for adequate well construction for decades and all state regulatory programs in the United States have well construction requirements to protect freshwater sources. However, the advent of shale gas drilling introduced technology and subsurface environments, which in some cases exceeded the design standards that were anticipated by older regulations. For example, formation pressures from some shale zones have exceeded pressures encountered previously in some regions. Regulators have moved to update construction standards to solve these issues. While the well construction issue has largely been solved, this does illustrate the need to identify areas of potential changes in practice and regulation as a result of technology advancements.

**Surface Land and Water Pollution**

Material handling on the surface around the well site creates a potential for surface water and land pollution. The best mitigation is to prevent any releases of contaminates into the environment. Depending on the material released,
the cleanup may be difficult and have the potential to lead to ground water contamination. Historically, surface spills have been one of the greatest environmental threats related to oil and gas development.

A number of different fluids must be properly handled when drilling an oil or natural gas well. Fluids are required as part of the drilling process to circulate drill cuttings to the surface, fuel and lubricants to run the pumps and drilling rig, and chemical additives for the hydraulic fracturing process. When properly managed, these fluids have a minimal adverse impact on the environment. However, if an unintended release occurs, the potential for damage may be significant. To prevent damage from spills, mitigation measures involve containment systems, reducing the volume of fluids, and substituting less hazardous materials.

Containment systems are required for storing all materials that can cause environmental damage. This is in addition to the primary storage container or tank. A secondary containment system capable of holding the entire contents of the primary vessel is a critical component of spill prevention. In addition, the system must include design and procedures to prevent material loss during transfers of fluids. In areas with a high environmental risk, additional precautions such as requiring steel tanks for drilling operations instead of lined impoundments may be necessary.

Land Disturbance

A drilling site requires several acres of land for the drilling rig and equipment, as well as the land required for a road to each site. Historically, each well required a separate drilling site or pad. With the advent of horizontal drilling, however, one well pad is now able to accommodate four to six wells. This also means that protective measures, such as drilling rig secondary containment systems, drilling fluids storage, and drill cuttings storage systems, can all be used as part of the same operation. In many cases, hydraulic fracturing for all of the wells on one pad can be coordinated, also reducing surface land use.

Roads and pipeline corridors constitute a significant portion of the land impacted by oil and gas development. Multi well drilling pads have reduced the number of roads required for drilling and well servicing. In sensitive ecosystems, new technology is available for temporary road construction that minimizes impact and speeds restoration. New regions of oil and gas development require new pipelines to gather and produce oil and natural gas for delivery to transmission systems. One way to minimize land disturbance from multiple pipelines is to coordinate pipeline corridors among well operators in a region. Technology and practices regarding pipelines are an aspect of oil and gas development, which may warrant further review.

Air Emissions

Drilling oil and natural gas wells result in air emissions from engines and potential methane escape during the drilling and fracturing process. In addition, in areas where both oil and gas is produced, but the infrastructure to market the gas is under development, gas flaring can also be a problem. One of the challenges to setting more effective air emissions requirements is the lack of a clear baseline data on methane and other emissions during the drilling and production process. Several research and data collection projects are currently underway to obtain necessary baseline data.

There are several new approaches to reducing air emissions during shale oil and gas development and production. New engine technology that uses natu-
ral gas as fuel either fully or in combination with diesel fuel is one option. Several operators are using liquefied natural gas (LNG) engines to power drilling rigs. Services companies are developing and using combination natural gas and diesel engines to support pumps for hydraulic fracturing, thereby reducing engine emissions. There are regulatory hurdles to implementing these new measures, but the applications appear promising.

In developed natural gas fields, operators are implementing “green completion” technology to capture methane, which would otherwise be vented or flared during the well completion process. This requires a higher degree of coordination and in some cases may result in delaying well completion until the natural gas gathering pipeline is completed. In the area of gas flares resulting from gas associated with oil production, progress is being made. Gathering and transmission pipelines are being put in place and regulatory systems are stricter; however, the volumes flared are still high suggesting that there is yet more room for improvements. The answer is in commercializing gas associated with oil production. Both infrastructure development to connect gas production to the pipeline network and new technology, such as small-scale gas to liquids technology, are possible solutions. To expedite this process, more aggressive state regulations and standards may prove useful.

*Induced Seismicity*

Induced seismicity is minor earthquake activity that is caused by injection of fluids into a geologic formation. Induced seismicity has been observed in the vicinity of a few wells used for the disposal of oil and gas wastewater. No significant or long-term impact has been observed from induced seismicity; however, there is limited information on this issue. In cases where seismicity has been observed, regulatory agencies have restricted injection activity.

One effort to establish a scientific basis of induced seismicity is the University of Southern California’s Induced Seismicity Consortium (USC-ISC). The USC-ISC project seeks to bring a multi-stakeholder approach to understanding induced seismicity by engaging technical expertise from engineering, geology, geophysics, and other university departments to study sites around the country. The California Earthquake Center and public communication experts will assist in developing tools to communicate the very unique technical language of seismicity in an understandable way. The participation of environmental groups, regulators, and other stakeholders along with technical experts will guide the research and recommend risk mitigation strategies for induced seismicity.

**Public and Community Impacts**

While related to the environmental trade-offs, public and community impacts of shale oil and gas development are the specific effects directly linked to local residents in the vicinity of the oil and gas activity. Whether the residents consider these impacts significant varies from region to region. Not surprisingly, in those areas with a long history of oil and gas development, the impact is seen as less of a problem. Some of the primary public and community impacts are related to traffic, construction activity, and commercialization of rural areas.

**Vehicle Traffic and Road Congestion**

The equipment and materials for a single shale oil and gas drilling operation requires hundreds of truckloads per well. In addition, the material needs are concentrated during specific periods of development, such as rig mobilization and hydraulic fracturing. Many areas with oil and gas development are in rural or agricultural areas with low levels of truck traffic prior to drilling...
operations. Some of the community issues that arise include road congestion, traffic safety, and road maintenance. The roads, which are normally under the jurisdiction of the local government, may fall into disrepair because of the increased truck use. Failure of the oil and gas developers to work effectively with the local regulators and to identify benefits (direct or indirect) from oil and gas development can create negative perceptions within the community. In most areas, specific permits and bonding are required for very heavy equipment, such as drilling rigs, to ensure that roads are repaired when damaged. Oil and gas development companies should not underestimate the importance of road and traffic issues.

**Construction Activity**

Oil and gas drilling is a twenty-four hour a day and seven day a week industry. The cost of well drilling requires this around the clock operation. In rural areas, this activity dramatically changes the evening and nighttime hours. Needless to say, sound can travel long distances and disrupt traditional lifestyles. Sound barriers and careful use of lighting can minimize the impact of drilling operations. For long-term production operations, noisy equipment, such as compressors, can be housed in soundproof buildings to restrict noise impact to surrounding residents.

**Community Changes—Rural/Agricultural to Commercial Activities**

Oil and gas development is an industrial activity with positive and negative spillover effects. In high growth areas such as the Bakken shale in North Dakota, housing shortages and an influx of temporary workers can create problems for local residents. The new activity can drive up local prices of goods and services, lowering the standard of living for those who have not directly benefited from the oil and gas developments. But this is not to downplay the benefits derived from job creation and economic development, which have resulted in an unemployment rate of 3.2 percent in the case of North Dakota. The state can soften the negative impact by implementing the right kinds of policies, such as promoting housing growth.

**Technology Solutions—Illustrative Examples**

There are many innovations that are vying to solve problems and reduce environmental impact. Oil and gas companies have a primary objective of producing oil and gas, so it is not at all surprising that most environmental technologies emerge from service companies supporting the industry (rather than the oil and gas industry itself). One challenge is the environmental trade-offs between solutions. For example, a more intensive water treatment program may improve water quality from wastewater treatment processes, but at the expense of increased air emissions. This is just one of the challenges of implementing new technology for reducing environmental trade-offs. In addition, new technology takes time to demonstrate capability in the field, at scale. Even with the challenges, new technology to support reduction of negative externalities is moving from laboratories to field applications. Below are just two examples of areas where technology is playing an important role mitigating environmental trade-offs.

**Water Use/Wastewater Disposal**

Technologies around water management are becoming an important area of innovation in shale oil and gas development. These technologies range from reducing water requirements for hydraulic fracturing to methods for treating wastewater for reuse or recycling. While research is ongoing in different
areas, following is a discussion on two specific areas of development: water reuse and water recycling.

Water reuse refers to the practice of reusing fracture treatment flow back water for other fracture treatments. Hydraulic fracturing requires a significant amount of water, along with sand and some additives, which is pumped under high pressure into the oil and natural gas bearing shale formation to crack the shale formation. After the fracture treatment is completed, water is recovered from the well, usually 20 to 50 percent of the original volume pumped into the well. The recovered water, called frac flow-back water, contains both dissolved and suspended solids that are introduced into the original fracture treatment fluid or are picked up in the shale formation. The types and concentrations of minerals in the frac flow-back water vary from basin to basin.

Technologies to process frac flow-back water for reuse involve removing the suspended solids from the wastewater and creating clean brine. This processed water can then be added to other make-up water for future hydraulic fracturing operations, reducing the total amount of new water required. There are many companies providing different technology solutions for processing flow-back water for reuse. The most common are filtration or chemical flocculation systems. The differentiation between service providers generally revolves around portability, capacity, and wastewater chemistry capability. Reusing frac flow-back water is a key water management strategy in many operating regions.

A move up from reuse is recycling. In water recycling, the wastewater stream is cleaned to a higher standard, potentially to freshwater standards. The typical technology used to recycle frac flow-back water is mechanical vapor recompression (MVR), a version of evaporation and distillation. One company, Fountain Quail Water Management, has been operating semi-potable MVR units in United States shale plays for more than 8 years. These units are skid mounted and can be set up in new drilling areas and moved as gas development areas progress. The MVR technology produces distilled water with a very low level of total dissolved solids. With necessary regulatory approvals, the processed water can be used for other applications, such as agriculture, or released back into the environment. The typical use of recycled water is as make up water for additional fracture treatments. Water recycling to the higher freshwater standard is used in limited areas, because of the cost and a lack of need for better water quality.

Choices in water management strategy vary for many reasons in each oil and gas basin. Some of the issues that must be considered include water availability, cost, treatment and disposal options, and transport. In addition, indirect cost issues such as public perception, environmental liability, and risk may also be considered. Generally the industry has not internalized a full lifecycle cost of water management. Better tools for evaluating the range of options and costs are likely to support better water management and support new technology commercialization.

**Footprint**

The “footprint” of a drilling location refers to the land area impacted by the drilling site and related infrastructure. The size of the footprint or disturbed area varies depending on the size of the rig and other local factors. The vast majority of on-shore wells drilled in the United States were drilled with one well on each drill pad. The advent of drilling in Arctic Alaska resulted in technology advances of drilling multiple wells on a single pad. The wells
Advanced Research Center (HARC). The HARC EFD combines scientific research with advanced technologies to create systems that address environmental issues associated with petroleum drilling and production operations. The objective is to identify, develop and transfer critical, cost effective, new technologies that can provide policy makers and industry with the ability to develop reserves in a safe and environmentally friendly manner. The program continues to add participants from environmental organizations, academia, government agencies, government laboratories, and industry. Currently over 100 organizations support this effort. The HARC EFD is recognized as a leading resource for objective data concerning oil and gas operations by industry, environmental organizations and regulators. It also sponsors public perception studies which raised public awareness and understanding among all stakeholders.

Role of Government Regulation

The role of regulators is to ensure the protection of health, safety, and the environment. In oil and gas development, regulators also have a key role to ensure the conservation of the resource. In the United States, state governments began regulating the oil and gas industry long before the federal government. One of the earliest laws regulating oil and gas development was Indiana’s 1893 statute, which was affirmed by the US Supreme Court in 1898. The great advantage of the State regulatory model for on-shore oil and gas development is that States can tailor regulatory programs to fit regional geology, topographic, other scientific factors, as well as social and community differences. One-size-fits-all approach of federal regulation does not provide for these key differences between areas of the country.

Role for Multi-Stakeholder Engagement

There is a growing role and need for multi-stakeholder approaches to address concerns related to oil and natural gas development. A multi-stakeholder effort brings industry, academics, non-governmental organizations, government, and other interested parties together to proactively and productively seek solutions to issues around the environmental or community trade-offs in oil and natural gas development. His approach has proven to be effective in addressing a number of concerns.

An example of this approach in practice is the EFD managed by the Houston Advanced Research Center (HARC). The HARC EFD combines scientific research with advanced technologies to create systems that address environmental issues associated with petroleum drilling and production operations. The objective is to identify, develop and transfer critical, cost effective, new technologies that can provide policy makers and industry with the ability to develop reserves in a safe and environmentally friendly manner. The program continues to add participants from environmental organizations, academia, government agencies, government laboratories, and industry. Currently over 100 organizations support this effort. The HARC EFD is recognized as a leading resource for objective data concerning oil and gas operations by industry, environmental organizations and regulators. It also sponsors public perception studies which raised public awareness and understanding among all stakeholders.

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Regulation is intended to set a common denominator and common require-
ments for companies. Effective regulations should establish the minimum level of acceptable and required performance. By being performance oriented, rather than prescriptive, regulations allow for innovation and the development of best practices that may go beyond the minimum requirements.

Clearly articulating the minimum performance standards and expectations is essential for effective regulations. Without clear standards, the regulated companies do not know how to set their own standards, so they can meet the regulations. Providing a clear standard and allowing companies to find the best ways to meet that standard is essential for innovation and development of new technologies that improve processes. It is these evolving technologies that offer the opportunity to further reduce environmental impact and improve operating efficiency.

Role of Industry Best Practices

The oil and gas industry is most known for technology development that leads to greater oil and gas production, such as three dimensional seismic, horizontal drilling, and hydraulic fracturing. While these technologies have enabled new production, including shale oil and gas, the industry has also led the development of technologies that have reduced the environmental and social impact of oil and gas development. In fact, technology that lessens the environmental impact can also reduce long-term costs of production.

The continuous improvement of processes often leads to higher standards of environmental protection. In many cases the technology is developed to solve a problem in high cost, remote, and possibly sensitive environments. Once technology is developed and implemented successfully, the cost generally decreases and can then be cost effectively applied more broadly. As previously stated, the multi-well pads that are typical in shale gas development through the United States to minimize surface impact were developed in the Alaska Arctic during the 1980s.

A best practice system is a mechanism to catalogue effective practices and technology solutions, so that others can apply them for similar circumstances. From an environmental stewardship standpoint, industry best practices are an effective way to develop new and better processes for protecting the environment. The best practices are not a substitute for a comprehensive regulatory system, but a way to catalogue advances and raise the expectations for future performance. Once new best practices demonstrate capability to exceed current standards, regulations may be revised to higher standards. In this way best practices and regulations can be used together to reduce trade-offs and create a continuous improvement cycle.

An example of the opportunities of combining best practices and regulations is the success of the North Dakota Industrial Commission in reducing well construction failures. Over several years of shale oil well drilling in the Bakken formation, the Commission compiled information on a small number of well construction failures (less than 0.2 percent). While the construction failures did not result in contamination of ground water, they did result in significant financial loss to the well owner and presented a potential environmental problem, if left uncorrected. The state regulatory agency created a working group in collaboration with the industry to determine the root cause of the well construction failures. The group was able to recommend changes to the drilling process, which eliminated casing damage during the drilling process. The regulatory agency required these changes as part of the permit conditions. Over an eighteen month period following the implementation of these drilling process requirements, North Dakota has not identified any new well construction failures. Effective regulations should establish the minimum level of acceptable and required performance. By being performance oriented, rather than prescriptive, regulations allow for innovation and the development of best practices that may go beyond the minimum requirements.
construction failures. This is a successful example of how the industry can develop best practices and regulators can use those best practices to advance regulations.

Implications for Non-Market Dynamics of US Shale Oil and Gas Development

Shale oil and natural gas development in the United States provide important economic and energy security benefits for the country. Industry, government, and other organizations are making progress by reducing the adverse environmental and social trade-offs of oil and gas development. Industry and state regulatory agencies have moved quickly to address concerns regarding hydraulic fracturing. Regulations and practices regarding ground and surface water protection and land use have been implemented. Understanding and protecting air quality is improving. Research to understand induced seismicity is underway. While more remains to be done, organizations that involve multi-stakeholder participation are addressing these issues in a way that builds public confidence.

The regulatory structure for overseeing oil and gas regulation is largely in place. Many states have increased staff and resources to ensure effective implementation, although an effective performance measurement system would prove useful. Several regional best management practices groups are under development. These best management practice systems will provide a process for cataloging effective new technologies to address environmental and social issues, setting the stage for raising standards and reducing trade-offs in the future.

Shale oil and natural gas provide an exciting opportunity for energy supply and economic growth in the United States and around the world. Technology development to solve environmental and social trade-offs offers further opportunity.
Chapter 5.
Regulatory Standards and Industry Practices:
Managing Externalities in Development of
Unconventional Oil and Gas in the United States

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Development of unconventional oil and gas in the United States is well underway and moving along at a blinding pace. With potential economic gains mounting, total investment in shale plays exceeded US$133 billion during 2008-2012. According to most estimates, production and development looks to increase at an even faster rate as the share of natural gas and oil production coming from shale and tight formations is expected to rise into the future (See Figures 1.3 and 5.1). There are, however, several unknowns that may pose significant challenges to unconventional oil and gas development in the United States.

The factor we have focused on in this report is regulatory control. As concerns about the environmental and social impacts of fracking continue to grow, there is an increasing potential for the kind of regulatory intervention that may pose severe restrictions on unconventional oil and gas development. Discussions in the preceding chapters reveal several important lessons that may prove useful in estimating the likelihood for this kind of shift.

We know, for instance, that there are extensive regulatory controls on licensing, planning, leasing, development, and reclamation on federal lands, but we also know that these existing regulations may not be adequate given that drilling operations vary according to subsurface geology and technology. Secondly, we also know that public concerns about well-bore integrity, transparency, and water management have pushed various federal agencies, such as the BLM, to adapt new rules which themselves are subject to change depending on negotiations with various social interests. In short, what this suggests is that there is some room for uncertainty about the direction of regulatory controls as we speculate on the future of unconventional oil and gas development on federal parcels.

With respect to state-level regulation, we found significant variations in enforcement as well as pre-conditions on various drilling sites across different states. The single greatest challenge appears to be the lack of comprehensive regulatory framework as far as fracking is concerned; however, development of
a one-size-fits-all policy with respect to unconventional gas and oil development is problematic given that geological specificity and variations in climate as well as topography largely determine the method and technology used to extract resources from tight formations. Given also that certain regulatory environments are more favorable for certain types of extraction methods and technology, the impact that more or less stringent regulation can have on overall productivity is likely to be cushioned by the variation in regulation, holding all else (i.e. recoverable supply) constant. However, spots of poor regulation can potentially be areas of risk whereby a single environmental or public health fallout can prove to be the basis for harsh regulatory backlash against the industry as was the case in the recent BP Deepwater Horizon drilling rig disaster and the restrictions on drilling that followed shortly thereafter.

While the discussion suggests that state-level regulation, in conjunction with federal, regional, and local regulations, perform relatively well in addressing many concerns, it also appears to be the case that existing regulations are dated in relation to the change in technology and methods. Some potential problems point to a lack of adequate information about the state of regulations across different states as well as personnel resources to enforce existing regulations. Clearly, it seems to be the case that there is room for improvement on this front meaning this is an area in flux and much like federal regulation can change for better or worse.

The question about the kinds of regulation that we may see developing across different states may depend, in part, on how well the industry or the market may manage public concerns as well as the risks associated with drilling. The evidence from the above discussion suggests that there are improvements in at least two fronts in addition to changes in government regulation. One is on the technological front. Innovative approaches to managing water use along with the utilization of multi-well pads and green completion technology have assuaged some environmental concerns. Second area is in inclusive cooperative engagement. Multi-stakeholder approach, which brings together players from the industry, academia, government, as well as other interest areas, have allowed for better problem identification, greater transparency and more effective solutions to potential problems in unconventional oil and gas development. Finally, we also see the emergence of best industry practice which incorporates all of these elements along with effective regulation in order to minimize well construction failures and other potential fallouts. Whether these market-based developments will be able to adequately address public concerns and thereby preclude the need for a comprehensive regulatory control remains to be seen.

Aside from the above non-market factors, there are other critical dimensions that cannot be overlooked. First and foremost is the supply of oil and gas in shale and other tight formations. According to the EIA, estimates of technically recoverable resource (TRR) are a function of land area, well spacing, percentage of area untested, percentage of area with potential, and estimated ultimate recovery (EUR) per well. Unproved TRR refers to estimates of resources that can be recovered using current technology without concern for additional economic or operating conditions. As wells are drilled and resources are extracted, unproved TRR become proved TRR and then ultimately catalogued as production. The problem is that the projection figure has a high degree of variance (See Figures 5.2 and 5.3). The EIA reasons that since the economics and timing of development can affect production, TRR does not necessarily reflect projected production. One of the criticisms against the development of shale and tight formations, however, is that the projected supply is grossly overestimated. Whatever may be the case, volatility in projected estimates of supply should be weighed in towards decisions about future invest-
Infrastructure conditions are also critical in processing and delivering natural gas for domestic as well as foreign consumption. LNG terminals and storage facilities as well as pipelines will be required to prevent bottlenecks and stranded supplies from areas that previously were not considered as a resource base for natural gas. Some estimates suggest that the cost of new natural gas transmission infrastructure and processing facilities will require about US$160 billion of infrastructure investment by 2035. Of course, infrastructure development itself poses a whole new set of questions with respect to regulation and environmental as well as public health concerns.

**Implications for South Korea**

Short-term trends in US shale gas and tight oil should not be underestimated. Some recent estimates suggest that the exploitation of shale oil, for instance, will boost GDP of large net oil importers, such as Japan, by around 4 percent to 7 percent by 2035. The impact on South Korea, which stands as the world’s second largest importer of LNG and the seventh largest importer of oil, is significant. As shown in Figure 5.4, the price of crude oil and natural gas imports in South Korea has consistently increased over time. Similar to the Japanese counterparts, both the Korea National Oil Corporation (KNOC) and the Korea Gas Corporation (KOGAS) have responded by increasing their investment in US...
These conditions, however, do not necessarily imply unabashed optimism as far as energy prospects for South Korea are concerned. As discussed in the previous section, there are many risks and unknowns with respect to long-term outlook on unconventional oil and gas in the United States. Perhaps a more forward-looking approach that problematizes risk management could prove useful. A step in this direction is strategic emphasis on optimal energy mix. As of today, nuclear power stands as one of the most important sources of electricity generation in South Korea and this is not likely to change into the future (See Figure 5.5).

Figure 5.5: Sources of Electricity Generation in South Korea, 2001-2010

Dependence on coal, which currently stands to account for little over a third of electricity generation, will decrease into the future. In its place, LNG has emerged as an important alternative. As of 2001, only 8 percent of all electricity generated in South Korea came from LNG. This figure is more than...
doubled by 2010. Given that much of this energy source cannot be homegrown and the geopolitical risks associated with overdependence on Middle East sources have gone up, South Korea is likely to shift its attention to the development of unconventional oil and gas in North America. The exact measure of how much South Korea will rely on this energy source, however, should be tempered with the outlined risks as it forges ahead.

Executive Summary

1. See US Energy Information Administration (EIA), “Foreign Investors Play Large Role in US Shale Industry,” Today in Energy, April 8, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10711. There are other estimates. For instance, the Advanced Resources International (ARI) presents another estimate of about 488 billion barrels of recoverable shale oil and 1,161 trillion cubic feet of recoverable shale gas (EIA, 2013). CSIS (2010) presents other estimates that suggest a supply ranging from 274 trillion cubic feet to 616 trillion cubic feet. Just to provide some perspective, the total US residential use of natural gas during 2012 was about 4.2 trillion cubic feet while the total usage for electric power generation was 9.1 trillion cubic feet. As far as the consumption for oil is concerned, the United States consumed about 7 billion barrels of refined petroleum products and biofuels annually in 2010–2011.


4. Ibid., 2012.


Chapter 1.
Lessons and Implications from Non-Market Considerations in the Development of Unconventional Oil and Gas in the United States

1. See US Energy Information Administration (EIA), “Foreign Investors Play Large Role in US Shale Industry,” Today in Energy, April 8, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10711. There are other estimates. For instance, the Advanced Resources International (ARI) presents another estimate of about 48bb of recoverable shale oil and 1,161tcf of recoverable shale gas (EIA, 2013). CSIS (2010) presents other estimates that suggest a supply ranging from 274tcf to 616tcf. Just to provide some perspective, the total US residential use of natural gas during 2012 was about 4.2tcf while the total usage for electric power generation was 9.1tcf. As far as the consumption for oil is concerned, the United States consumed about 7 billion barrels of refined petroleum products and biofuels annually in 2010-2011.


4. Ibid., 2012.


Chapter 3. US Regulation of Unconventional Oil and Gas Development: Progress and Challenges


3. See, e.g.: Pennsylvania Department of Environmental Protection, “Hydraulic Fracturing Overview,” http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/MarcellusShale/DEP%20Fracing%20overview.pdf (explaining that “[c]urrent drilling practices in the Marcellus Shale in Pennsylvania utilize both horizontal and the more traditional ‘vertical’ wells,” and that both vertical and horizontal wells in the shale typically require hydraulic fracturing).


6. See: Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 2 (Tex. 2008) (describing the first commercial use of fracturing as occurring in 1949).

7. See J.A. Harper, “The Marcellus Shale – An Old ‘New’ Gas Reservoir,” Pennsylvania Geology 38, no. 1 (2008), http://www.dcnr.state.pa.us/topogeo/pub/pageolmap/pdfs/v38n1.pdf, 12 (estimating that “[b]ased on information from the Barnett Shale play, a horizontal well completion might use more than 3 million gallons”); New York State Department of Environmental Conservation, “Revised Draft: Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program,” September 7, 2011 (“It is estimated that 2.4 million to 7.8 million gallons of water may be used for a multi-stage hydraulic fracturing procedure in a typical 4,000-foot lateral wellbore”); Railroad Commission of Texas, supra note 5 (“Slick water fracturing of a vertical well completion can use over 1.2 million gallons (28,000 barrels) of water, while the fracturing of a horizontal well completion can use over 3.5 million gallons (over 83,000 barrels) of water. In addition, the wells may be re-fractured multiple times after producing for several years.”).


15. New Mexico’s Oil and Gas Agency, for example, has a long list of incidents in which surface oil and gas pits contaminated underground water resources. New Mexico Oil Conservation Division, “Cases Where Pit Substances Have Contaminated New Mexico’s Ground Water,” as of September
17. Ibid.
19. Ibid., 25.
23. See, ibid., 67-68 (describing diesel spills noted by state inspectors).
24. See, e.g., ibid., 36-38 (describing flowback spills noted by state inspectors).
25. Ibid., 71.
26. Ibid., 74.
39. See ibid. (discussing certain wastes that contained toxic substances when the EPA conducted a study of the wastes to determine whether they should be exempted).
42. See Delaware River Basin Commission, Draft Regulations, infra note 95.
43. See Susquehanna River Basin Commission, State of the Susquehanna 2010, the Susquehanna River Basin Commission’s Role in Natural Gas Development.
See, e.g., Anschutz Exploration Corp. v. Dryden (N.Y. Sup. 2012); Cooperstown Holstein Corp. v. Town of Middlefield (N.Y. Sup. 2012) (allowing towns to exclude oil and gas development and fracturing through zoning regulation).


46. See infra Figure 2.


45. See also “All fresh water sands shall be fully protected by the setting and cementing of surface casing to prevent the fresh water sands from becoming contaminated with oil, gas, or salt water.” AOGC, Rule B-15 (2010).

2 Colo. Code Regs. 404-1:317(f), (g) (Westlaw 2012).


76. See AOGC, Rule B-19(e) (2012).

77. See AOGC, Order No. 146-2005-09, Cove Creek Field (2005); AOGC, Griffin Mountain Field, Amendment (2005); AOGC, Order No. 97-2005-06, Gravel Hill Field; AOGC, Order No. 96-2005-06; Scotland Field (2006).


N.M. Code R. § 19.15.17.10 (Westlaw 2012). The regulations require the setback to be from a produced water.

Ky. Admin. Regs. 5.090 Section 1(13) (Westlaw 2012) defines “holding pit” as a pit that holds administrative regulation 401 KAR 30:030,” which now appears to be codified as 401 KAR 30:031. 401 Ky. Admin. Regs. 5.090 Section 9(5)(a) (Westlaw 2012) provides, “[h]olding pits shall be constructed in accordance with KRS Chapter 151 and Division of Waste Management administrative regulation 401 KAR 300:30,” which now appears to be codified as 401 KAR 300:31. 401 Ky. Admin. Regs. 5.090 Section 11(1) (Westlaw 2012) defines “holding pit” as a pit that holds produced water.

N.M. Code R. § 19.15.17.10 (Westlaw 2012). The regulations require the setback to be from a “continuously flowing watercourse.” The setback is 200 feet for other “significant” watercourses.


100. See Colorado Department of Natural Resources, Oil and Gas Conservation Commission, http://cogcc.state.co.us/ (follow “Rules” hyperlink in blue menu to the left of the page, then follow “2008 Rulemaking” hyperlink, then follow “COGCC Amended Rules Redline”).


105. Ibid., (modifying 58 Pa. C.S.A. § 3218 (c)(2)).

106. See N.Y. Department of Environmental Conservation, supra note 7.


110. See infra Figure 1.


113. See Freeman, supra note 68.


116. Data for the Colorado Oil and Gas Conservation Commission.

117. Data for the Michigan Department of Environmental Quality. Unless otherwise indicated, all Michigan data in the table (active wells, staff, etc.) from: E-mail from Mr. Joe Pettit, Enforcement Section, Resource Mgmt. Division, Michigan Dep’t of Env’t Quality, to Jeremy Schepers (June 22, 2011).
118. Data for the New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation
Division. Unless otherwise indicated, all New Mexico data in the table (active wells, staff, etc.)
from Jeremy Schepers, Information Sheet prepared for Hannah Wiseman (Sept. 22, 2011) (on
file with author).
119. Unless otherwise indicated, all Ohio data in the table (active wells, staff, etc.) from:
E-mail from Tom Tugend, Deputy Chief, Ohio Department of Natural Resources, Oil & Gas Program,
To Matthew Peña, Sept. 26, 2011.
120. Data for the Pennsylvania Department of Environmental Quality, Bureau of Oil and Gas Manage-
ment.
121. Telephone conversation between Hannah Wiseman and Margaret Ash, Field Inspections Manager,
Colorado Oil & Gas Conservation Commission, September 27, 2012, 2:45 PM Eastern.
122. Colorado Oil & Gas Conservation Commission, Colorado Weekly & Monthly Oil & Gas Statistics,
123. Telephone conversation between Hannah Wiseman and Joseph Pettit, Michigan Department
of Environmental Quality, Permitting & Technical Services Section, Sept. 27, 2012, 3:20 PM.
124. In 2008, Michigan had 25,706 active wells. Oil and Gas Wells in Michigan, April 2008,
125. Telephone conversation between Hannah Wiseman and Daniel Sanchez, Enforcement and
Compliance Manager, New Mexico Oil Conservation Division, Sept. 27, 2012, 3:00 PM.
126. Telephone conversation between Hannah Wiseman and Stephen Riley, Permitting Geologist,
Ohio Department of Natural Resources, Sept. 27, 2012, 2:55 PM and 3:40 PM. Note that the 55,
083 number indicates total active oil and gas wells listed as producing. Only 49,787 wells have
actual production data in 2012.
127. Shankman, note 11.
128. Pennsylvania Department of Environmental Protection, “Pa. DEP Oil & Gas Reporting Website –
Statewide Data Downloads by Reporting Period,” https://www.portal.state.pa.us/publicreports/Modules/DataExports/DataExports.aspx
(follow 2010, Jan-Dec 2010 (Annual O&G, without Marcellus) Production CSV hyperlink, then follow 2010,
Jul-Dec 2010 (Marcellus Only, 6 months). This number adds the number of active Marcellus wells from July through
December 2011 to the total number of active non-Marcellus wells for January through December 2011.
129. E-mail from Leslie Savage, Chief Geologist, Railroad Commission of Texas, to Hannah Wiseman,
Oct. 1, 2012, 12:30 PM.
130. Pennsylvania Department of Environmental Protection, “Oil and Gas Compliance Report,”

enrd.state.nm.us/ocd/ocdpermitting/Data/Incidents/Spills.aspx.

Chapter 4.
Challenges for Shale Oil and Natural Gas: Environmental Stewardship and Opportunities through
Innovation

1. America’s New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy,
2. Social License to Operate refers to the acceptance and support of industry operations from the
public and communities. Social license is not defined by law, but by community standards.

Chapter 5.
Regulatory Standards and Industry Practices: Managing Externalities in Development of Uncon-
ventional Oil and Gas in the United States

1. Sarah O. Ladislaw, David Pumphrey, Frank A. Verrastro, Lisa A. Hyland, and Molly A. Walton,
Realizing the Potential of U.S. Unconventional Natural Gas (Washington, DC: Center for Strategic