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Hydraulic fracturing and the need for risk assessment

Robert O. Schneider, PhD

ABSTRACT

This analysis examines the perceived lag in the policy process with respect to risk assessment and risk management in relationship to the development of new technologies that have the potential to create new threats to public health and safety. Hydraulic fracturing and the ongoing revolution in natural gas exploration make an excellent case study of the difficulties that inevitably arise, are difficult to resolve, and that expand threats to public health and safety when policy makers do not prioritize risk assessment and risk management until the negative impacts or potential harms of previous decisions are felt. The analysis begins with a description of the hydraulic fracturing revolution and a discussion of the potential risks associated with it. This will include some of the preliminary scientific work on the subject. The analysis will highlight concerns that timely assessment and management of these risks is often frustrated by the policy process itself. In essence, the conclusion reached is that significant improvements in the timely assessing and managing the risks associated with technological advances require policy makers to emulate the emergency management profession in elevating risk assessment and risk management to the level of a first priority in the policy process.

Key words: hydraulic fracturing, risk assessment, risk management

INTRODUCTION

Hydraulic fracturing or hydrofracking (ie, the fracturing of rocks far beneath the earth's surface for the recovery of natural gas) has generated both staunch support and significant criticism. Supporters have applauded the new technologies that have opened up new potential for the exploration for natural gas. They have praised natural gas as the cheap, clean, and abundant fuel for the future. Some critics have suggested that the new technologies for the drilling of natural gas will have large and undesirable environmental effects and pose significant risks to public health.[1] New natural gas discoveries suggest that the United States is awash with reserves that can be used to substitute for coal in power plants, serve as a bridge to a low carbon future, and provide a transition fuel in the ongoing battle against climate change. However, concerns about the possible risks associated with hydraulic fracturing (fracking) have escalated as this method of natural gas extraction has become more commonplace and its effects have been debated.

The purpose of this analysis is to examine the phenomenon of risk assessment in relation to hydraulic fracturing as a case study that demonstrates some of the inefficiencies built into the policy process with respect to risk assessment and risk management in relation to new technologies. It is often the case with the development of new technologies that the assessment and management of risks associated with them tends to lag behind the innovations that may create new threats to public health and safety. This is a function of the policy process itself. As an unfortunate by-product, the possibility for risk management is frequently delayed. This is, it shall be suggested, a problem that should be a special concern with respect to the development and implementation of new technologies that, in addition to providing benefits, may impose new risks and harms associated with public health and safety. It is likewise contended that, as the public policy discussion surrounding new technologies and their impacts inevitably expands over time, the need for both the assessment and the management of risk does inevitably ascend to a higher level priority on the policy agenda. The question is whether this pivoting toward

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risk assessment comes in a timely (ie, most efficient) manner to protect public health and safety. This is a question that should be of considerable importance to emergency management professionals.

Although emergency management practitioners tend to be focused on the technical and immediate aspects of their work and are somewhat reluctant to get caught up in broader policy discussions, they nonetheless will have to prepare for, adapt to, and cope with the effects of decisions by policy makers that may increase some risks they will ultimately be expected to help manage or respond to in their communities. In relation to hydraulic fracturing and the assessment of any risks associated with it (as with any other potential for industrial disasters in the communities it serves), the emergency management profession must be more than an interested observer of the policy discussion. It should see itself as a stakeholder with a significant vested interest. Likewise, and perhaps more importantly, as governmental entities at all levels (national, state, and local) study and debate the merits of hydraulic fracturing and the potential risks associated with it, informed input from an emergency management perspective would be of practical value to decision makers. Policy makers have often needed a nudge to engage the concerns that are critical to emergency management.

The early literature in the field of emergency management demonstrated that disaster preparation in general and hazard mitigation in particular were of low salience to policy makers and the public alike.[2,3] In fact, the literature often noted indifference or outright opposition to disaster preparedness.[4] Public policy makers and officials were often described as uninvolved or disinterested.[5] Until a disaster was on them and required immediate response, policy makers (and the public) were just not that interested. They were certainly not prepared to focus on the issues of disaster preparation or mitigation. As the 1990s progressed, this situation improved considerably as the rising costs of natural disasters and federal leadership over that decade combined to produce a more proactive approach to disaster planning and mitigation. It became obvious over time that there was a necessary connection of disaster planning and mitigation to development strategies and community resilience in the face of various natural and human-caused threats.[6,7] However, it remains an important question whether this progress has carried over to include a timely assessment and management of the risks or disaster potentials associated with new technologies.

Historically, it is accurate to say that both corporate leaders and public policy makers are too quick to take the position of minimizing the risks attached to promising new technologies and practices.[8] They tend to overlook or underestimate long-term risks in the pursuit of immediate economic and political benefits and values. Although the research on the risks associated with hydraulic fracturing is in its infancy, relatively speaking, it is beginning to raise some very important concerns that natural gas producers and politicians have been slow to engage. The concerns raised are pretty basic and straight forward to emergency management professionals, public health officials, and scientific researchers. This case study will highlight these concerns and assess the need for responsible analysis and timely policy with respect to them. After discussing the technological revolution in natural gas exploration, we shall examine the potential risks to be assessed and managed, including some of the preliminary scientific work on the subject. We shall see how this work has begun to influence the policy process and is pivoting it, inevitably if belatedly, toward the necessity of risk assessment and risk management. We will conclude this analytical case study with some recommendations concerning the perceived need for improvement in the timely assessment and management of the risks associated with technological advances.

AN ENERGY REVOLUTION AND A POLICY CHALLENGE

Risk assessment identifies, quantifies, and measures risks and vulnerabilities. Conversely, risk management consists of the evaluation and application of risk mitigation options.[9] Risk assessment and risk management techniques have become refined and have been routinely applied to the planning for natural, industrial, and national security crises or disasters. As we examine the recent boom in hydraulic fracturing and the politics surrounding it, we will see, however, that the politics of the policy process often works against

both timely risk analysis and the public interest in health and safety.

At present, natural gas provides about 22 percent of the energy in the United States and about 26 percent worldwide.[1] In addition to conventional sources of natural gas, unconventional sources (ie, ocean deposits of methane hydrates, coal-bed methane, and shale gas deposits) may be able to provide larger amounts of fuels than previously thought. These unconventional sources, targets made ever more exploitable by new technology, are understandably inviting to energy producers. In July 2009, the US Department of Energy announced that estimated US gas reserves were 35 percent larger than previously estimated.[1] Much of this abundance can be attributed to the new possibilities for tapping into unconventional sources. Together these unconventional sources may provide as much as 60 percent of all natural gas in the United States by 2035. This suggests that they will be prime targets for the accelerated application of new technology. Presently, the most inviting target would appear to be shale gas deposits.

Shale is one of the most common kinds of rock in the United States (found in 23 states) and, with recent technological developments, holds particularly great potential for natural gas exploration. Presently, shale gas deposits provide about 25 percent of the natural gas in the United States but, with both the abundant supply and new hydraulic fracturing technology, are expected to provide 45 percent by 2035.[10] This trend will be accentuated by the popularity of natural gas as a supposedly clean and affordable energy alternative. All of this has spurred a rapid development of the large deposits of shale gasses in the United States. It is accurate to say that what has resulted might be called a revolution in natural gas exploration.[11]

In the first decade of the twenty-first century, shale gas production has exploded. There has been a rapid, and relatively unregulated, expansion of shale gas production in the United States. It began in Texas (the Barnett Shale Field) in 2000 and has led to a race to leverage immense shale deposits around the country. The two best known deposits may be the Hainesville Shale in Louisiana and the Marcellus Shale that stretches from West Virginia through Pennsylvania and New York. US shale gas production jumped from almost zero to about two trillion cubic feet between 2000 and 2008.[11] As the boom in shale gas exploration took off, the conversation about the new horizontal fracturing (ie, fracking) technology and any potential risks it may pose to public health and safety has lagged behind as natural gas producers, public policy makers, and media were all relatively silent on the topic over much of the decade.

Hydraulic fracturing or fracking is a drilling technique that involves pumping large volumes of water, sand, and chemicals into deep shale deposits. This is done to fracture the rocks and release the oil or gas. Although some drillers have been fracking since the 1950s, the last decade has seen advancements in technology that have taken this drilling technique to new levels.[10] The major technological advancement has been related to new horizontal drilling techniques that have enabled producers to extract gas from deposits that used to be inaccessible. Fracking had been used in vertical wells for some time, but it did not retrieve enough shale gas at economic levels. As drilling advanced to where drillers were able to frack horizontally, it broadened greatly the potential for extraction from a single well and improved its profitability in no small measure.[10] Both popular and profitable, this new technique of natural gas exploration is not without some potential risks to the human and animal populations.

It may take up to 8 million gallons of water mixed with sand and fracturing fluids (ie, chemicals) to frack a well. A well may be fracked up to 18 times.[10] As we have already noted, this is done to fracture the rocks and release the oil or gas. With each fracking treatment, about half of the fracking liquid returns to the surface with the gas (via collection pipes) and about half remains in the ground. The retrieved gas is piped to compressor stations, purified, and compressed for transport. The returning fracking fluids, now called wastewater, are handled in a variety of ways. They may be transported to water treatment plants (most of which are not really designed to handle or treat fracking fluids), may be stored in large tarp-lined pits and be allowed to evaporate, or may be reinjected into old wells.[10] As one might expect, the fracking fluids are a

primary source of concern. This is because of their chemical composition, concerns about their usage and disposal, the potential risk of polluting water tables needed for drinking water and agricultural use, and other potential public health related impacts.

Many fracking fluids can be toxic to humans and wildlife. This includes chemicals known to cause cancer. Chemicals used in fracking include, potentially at least, benzene, toluene, boric acid, xylene, diesel fuel, methanol, formaldehyde, and ammonium bisulfate.[10,12] It should be noted that, in deference to any proprietary interests, drillers are not required to report or make public the chemicals they use. The potential for the contamination of groundwater from these chemicals exists primarily due the possibility of leaks through cement well casings. Most of the fluid remaining in the ground is lower (ie, 5,000-8,000 ft beneath the surface) than groundwater aquifers that are generally not more than 1,000 ft below the surface. However, the potential for cracks in cement well casings and the escape of chemicals or methane gas during the process of insertion and extraction is real. This could pose a threat to groundwater aquifers. In addition to the fracking chemicals or fluids, the impact of potential methane gas leaks (potential for explosion and asphyxiation) is a very important concern with respect to ground wells in rural areas. Finally, the potential for errors in waste disposal and improper treatment of the retrieved wastewater are among the other major concerns associated with the relatively unregulated acceleration of horizontal fracking.[13,14]

Energy producers are quick to deny that any of the risks associated with fracking represent significant concerns. They reassure us, as a matter of routine but often without the rigorous science to back up their reassurance, that all risks are minimal and manageable. This is to be expected. The energy industry has a long history of developing new technologies that expand risks as it identifies the potential for greater profits. Companies often embrace risk believing they can either manage it or safely roll the dice as they seek to expand their market presence and reap the gains to be had by being aggressive. Their success at avoiding regulation in risk-taking adventures is often aided in circumstances where the negative impacts may take 30-40 years to be felt. Being aggressive, in particular, is not necessarily a bad thing. However, being reckless with respect to risk assessment and risk management is always a bad thing.

Energy producers are understandably quick to embrace new technologies for production. They are also often unacceptably slow to assess and manage the risks associated with them.[15] Ideally, risk assessment leads to risk management (ie, mitigation) and perhaps even necessary governmental regulation for public health and safety. However, safety is costly and, together with regulations, may reduce profits. Energy producers are more inclined to cut costs, including safety related costs, to maximize profits than they are to assess and manage risks. For example, this has been a common practice in the oil industry.[15-17] This has led to more than a few disasters that could have been avoided. Energy is an industry where failures in risk management stand out and catastrophes abound. For example, the BP Gulf disaster of 2010 took place in the midst of contentious and unresolved debates over the safety and environmental impact of deep water drilling. It also highlighted BP's history of routinely failing to invest in safety as a means of cost cutting and the lack of significant governmental oversight of deep water drilling.[15]

Like most organized interests and all corporations, energy producers work hard to influence the policy process. They spend great amounts of money to avoid governmental regulation and to, in effect, bury risks associated with their work. For example, corporations and fossil fuel interests have used a handful of dissident scientists to cast doubt on the likelihood of adverse impacts arising from global climate change. These scientists who oppose the scientific consensus about global climate change have been funded primarily by the fossil-fuel industry to create the illusion of uncertainty.[18] This support of "experts" who promote research outcomes desired and paid for by the industry is intelligently combined with sophisticated political and public relations campaigns designed to reduce the visibility of risks and, thus, the likelihood of governmental regulation. Corporate financing and use of front groups (ie, corporate-generated grass roots responses) provide a cover of community concern for

corporate interests. These front groups also give elected officials the appearance of responding to voters rather than voting for (or being the tool of) corporate interests.[18,19] These practices have been common and ever more effective over the past two decades. Whether restoring the image of an industry, promoting its interests in avoiding governmental regulation, or weakening public awareness of environmental threats posed by their activity, corporations spend immense resources to shape public opinion and influence public policy makers.[18,20]

Millions of dollars are being spent by energy groups (including the American Petroleum Institute) to promote hydraulic fracturing. The goal is to influence the political process with respect to policies that impact the industry and to minimize governmental regulations.[21] Building on the accepted and popular notions that natural gas is the cleanest of the fossil fuels, abundant enough to provide for America's energy needs for the next 60 years, safe to process, and thus a logical fuel source to pursue American energy independence, the ad campaigns and lobbying efforts of energy interests emphasize the potential of natural gas in promoting the goal of American energy independence (ie, a real-world solution to our energy needs). They also stress the theme that policies favorable to them will strengthen the economy and protect our national security.[21] For example, most of the television advertising of the American Petroleum Institute is not about promoting consumerism but is about creating an impression (ie, it is political). All of this is everyday politics and business as usual.

Trying to change or influence the way the public and politicians think, a legitimate practice to be sure, may include as a matter of unfortunate routine corporate efforts to weaken public awareness of environmental threats or public health risks. Indeed, corporate responses to scientific research that point out these threats or risks often include millions of dollars spent for cover-ups, deceptions, data manipulation, fraudulent claims, and fake studies.[18] One might suggest this is why it is of critical importance that governments play a proactive role in monitoring and regulating public health and safety. However, governments under the influence of corporate lobbying and public relations campaigns are often reluctant or tardy with respect to meeting this responsibility.

The 2005 Energy Policy Act passed by Congress (crafted by Vice President Cheney who once ran Halliburton, one of the companies that pioneered fracking) exempted hydraulic fracturing (fracking) from meeting the requirements of the Clean Air Act, the Safe Drinking Water Act, and the Clean Water Act.[10] This was preceded by a 2004 determination (that was neither comprehensive nor scientifically rigorous) by the Environmental Protection Agency (EPA) which concluded that the extraction of natural gas via horizontal fracking posed little to no threat to drinking water or public health. This study was denounced by at least one EPA whistleblower for its poor science and as having been the product of an industry-influenced review panel.[22] In 2010, the EPA reversed this earlier stance and announced it would launch a $1.9 million research program to assess public health risks associated with fracking.

Currently, there are one million fracking wells operating in the United States. The natural gas industry claims that this drilling has not caused a single case of groundwater contamination. This is not true according to the Pennsylvania Department of Environmental Protection, which has documented the contamination of an aquifer that fills household wells in a rural area where more than 60 wells were drilled in a 9-mile^2 area.[10] There are other such reports from Pennsylvania to Colorado of possible groundwater contamination.[22] Recent studies from New York assert that improperly treated fracking wastewater (containing radioactive materials and harmful chemicals) is finding its way into the state's bodies of water.[23]

As the EPA conducts its long overdue study (after abandoning its incomplete 2004 assessment) and public policy makers slowly begin to react to growing concerns, one might well wonder if drilling in areas where water supplies might be impacted is a good idea. Given some recent research findings, and a growing public concern, policy makers will at least be compelled to seriously engage in the assessment and management of risks. As both scientific inquiry and public awareness expand, new policy challenges are emerging on the public agenda. It would appear that an important

and an inevitable corner has been turned in the policy process and that risk assessment and risk management are about to be elevated on the policy agenda.

POTENTIAL RISKS AND NEW STUDIES

In December 2010, the nonprofit Civil Society Institute issued a report on a national fracking survey it had commissioned. This was presented as the first national poll conducted to gauge the attitude of American citizens on the subject of fracking. Sixty-nine percent were concerned about the possible threat to safe drinking water posed by horizontal fracking. Seventy-eight percent said they would support requirements for drillers to publicly disclose the chemicals used in the fracking process (something they are not presently required to do) and agreed that more study into the health and environmental impacts of fracking was needed. More than half (56 percent) said they think the federal government is not doing enough to require disclosure of the chemicals used, and nearly three out of five polled said they would vote to protect public health and the environment over energy production where the two may be in conflict.[24] Poll results such as these will no doubt influence policymakers to pivot toward a greater concern for risk assessment and risk management. Just as important, if not more, the results of some new scientific studies that call into question the assurances and assumptions of the natural gas industry and its supporters may also begin to expand the policy discussion.

An important study concerning the methane contamination of drinking water in conjunction with hydraulic fracturing was published in the spring of 2011.[25] The researchers identified the specific fracking concerns related to drinking water (ie, toxicity of produced water from fracturing fluids that may be discharged into the environment, fluid and gas flow and discharge into shallow aquifers, the impact on private wells that rely on shallow groundwater for drinking and agricultural use, and the potential for explosion) and proceeded to conduct tests in Pennsylvania of drinking water wells in the proximity of fracking activity. Sixty wells were tested and methane concentrations were found in 51 (85 percent) of them. The average methane concentration in shallow groundwater in active drilling areas was 17 times higher and exceeded the level identified for urgent hazard mitigation by the US Office of the Interior. In this study, there was no evidence of contamination of drinking water by fracking chemicals or fluids. However, the correlation of drilling and high methane levels was considered a cause for heightened concern.[25]

The authors of the Pennsylvania methane contamination study recommended the long-term monitoring of the industry and private homeowners. They urged drilling firms to comply with a recent request by the EPA to voluntarily report the constituents of fracking fluids. Most importantly, they called for systematic and independent data collection on groundwater quality before drilling begins in any region and stressed the need for greater stewardship, more knowledge, and regulation to ensure the sustainable future of shale gas extraction.[25]

In an interesting aside to the methane contamination study, residents in Pennsylvania reported that their water wells had exploded or could be lit on fire. The drilling industry and its supporters described these cases as anecdotal. They also said the findings of the study were unconnected to drilling activity. Clearly, and despite this industry response, it would at a minimum be wise to continue investigating such widespread cases of methane contamination.

Another new study released in the spring of 2011 called into question the notion of natural gas as the cleaner energy alternative. It also cast significant doubts on its benefits in combating global climate change.[26] The authors of this study concluded that the greenhouse gas footprint of natural gas is actually greater than that of conventional gas and oil or coal. They demonstrated that when you look at the footprint of shale over a longer time span and include in that time span the assessment of waste, leaks, production technology, and consumption, etc, a natural gas well will, over the course of its lifetime, contribute more greenhouse gas emissions than previously thought. In fact, the overall carbon footprint of shale gas will be 20 percent greater than that of coal according to their analysis.[26] Other recent studies have also suggested that methane has greater global warming potential than previously assumed thus challenging the notion

of natural gas as the cleaner energy alternative or a bridge fuel to a cleaner energy future in the battle against climate change.[27-29] The natural gas industry has questioned the accuracy of all of these studies. In fact, on the release of any new research on the risks or negative environmental impacts associated with fracking, the industry is quick to question the legitimacy of the conclusions or the methods of analysis and to reaffirm the safety of their drilling technology. However, the questions raised are serious enough to demand further study and rigorous scientific research.

As the much needed research into the risks associated with hydraulic fracturing continues, it is wise to remember that neither the industry nor its critics have enough knowledge to provide the answers we need. It would certainly be premature to abandon natural gas as a viable energy option or horizontal fracturing as a means of natural gas extraction. However, it would also be premature and utterly irresponsible to proceed as though the industry's belief that its practices and technology are perfectly safe is an uncontestable truth. The research is incomplete to be sure, but enough has been done to recommend caution. The need for risk assessment and the identification of risk management techniques are clearly required as an urgent necessity.

The concerns related to public health and safety with respect to fracking risks cannot be left in the hands of the energy producers and their supporters alone. Their first priority is clearly and understandably their own economic self-interest. That is business (and politics) as usual. Safety and public health are concerns that require an active governmental role and the application of the best scientific research. What is required is the performance of risk assessment as a public function and the promotion of risk management as a policy priority. As we turn our attention to a discussion that need and assess the inevitable pivoting of the hydraulic fracturing policy conversation in that direction, we must also ask whether policy makers might need to be more efficient with respect to the general meeting of their presumed responsibility for public health and safety. With respect to hydraulic fracturing and natural gas extraction, as well as with most technical advances that may expand risks to public health and safety, the more efficient and effective application of risk assessment and risk management techniques must become a prerequisite for policymaking and a foundation for identifying and establishing any needed regulatory requirements.

PIVOTING TOWARD RISK MANAGEMENT

As we have seen, risk assessment and risk management are not always a first priority for corporations and policy makers. They are just as often not priorities for the public they serve either. The interest of the public and public policymakers in risk reduction is in fact much lower than one might wish to think. This is especially true when the risk being discussed is a statistical probability not yet known through experience. When a disaster is unfolding, or when it has been experienced for the first time, attention to risk reduction and mitigation generally increases.[30] However, even in those situations where the public and policy interest has peaked, usually in the aftermath of a catastrophe that may be expected to occur again, planning and timely action for risk reduction must be accomplished before public and political interest inevitably begins to wane. This can be especially troubling with respect to technological disasters associated with scientific and industrial advances. The risks they impose are new, often take decades to reveal themselves through adverse impacts on humanity and society, and are easy to ignore until a worst case scenario is on us.[31]

Risk is best thought of as something that can be measured in terms of the potential loss or decrease of valued assets (life, health, property, income, etc). Often we forget that the very things we do that may constitute a benefit (eg, the eradication of insects and pests) carry inevitable risks or potential losses (eg, the poisoning of crops or people) with them.[31] The conventional wisdom is with risk assessment and with subsequent measures to manage risk (ie, mitigation), the probability for hazards that will place humanity at great peril should decline. However, the political and social reality is that managing risk is subject to social, economic, and political relations that often obscure our focus and embed the process of risk assessment in ideological clashes and conflicts of interest.[32] This

frustrates risk management in significant ways and works against risk reduction as a public policy priority. Even with respect to commonly occurring natural disasters, the United States has not always excelled at risk assessment and risk management. One need to think only of Hurricane Katrina to perceive the cost of such failure.[33] The challenge is even more daunting with respect to technological and industrial risks.

The impact of delays or lags in risk assessment and risk management is only enhanced by early policy initiatives that are initiated without rigorous scientific analysis. The 2004 EPA pronouncement and the 2005 Energy Policy Act, both of which we might say prematurely and rather unscientifically downplayed any risks posed by hydraulic fracturing, led to the exempting of fracking from federal environmental regulation. This not only weakened the federal role in promoting safety and risk reduction with respect to unconventional natural gas exploration, it also delayed (for nearly a decade) any sustained efforts at risk assessment and risk management. Supporters of these measures would say that it was left up to the states to perform this function. The natural gas industry thinks that states are doing more than an adequate job of protecting the public.[34]

The 2005 Energy Policy Act in essence created a policy void removing the EPA as a monitor on the boom in gas fracking. This void was not, as the natural gas industry suggests, adequately filled by the states. State efforts vary greatly and, in most cases, are heavily influenced by the industry. Some states, Colorado for example, are said to provide reasonable protection for their residents from groundwater contamination. The state of New York, after discovering untreated fracking wastewater in its bodies of water, suspended fracking in the Marcellus Shale as it set about to create new protection rules.[35] However, most states, especially those new to the fracking revolution, have few if any safeguards. It is interesting to note that as the fracking revolution has spread and the risks associated with the technology have become a matter for wider public concern and discussion, some states and the federal government are just beginning to do what should have been done long ago. They are getting serious about risk assessment and risk management. The policy void may soon be filled.

The EPA's decision in 2010 to reconsider its 2004 assessment and launch an intensive study to learn whether the technology associated with the fracking boom in natural gas production is a threat to drinking water and to public health is an important first step on the path to responsibility. However, both the EPA and the Congress should have taken this step at the very beginning of the boom. Having taken this step now does signal the beginning, however belatedly, of a necessary process for risk assessment. As the EPA completes its study over the next several years, it should also determine if the urgency of the concerns that have led to this decision to study might require some regulation of hydraulic fracturing even before the assessment is completed. Several options are obvious.

The EPA could delay any regulatory recommendations or decisions about hydraulic fracturing until its study is completed. This would leave the question of regulation up to the states, as is currently the case, and allow the status quo to prevail. As a second option, the EPA could place a moratorium on all fracking operations until its study is completed and new federal regulations are developed. A third option would be to begin, based on evidence already available in existing studies and the concerns expressed or being addressed at the state level, to regulate hydraulic fracturing immediately in a manner that balances the need to protect public health and safety with the benefits gained from hydraulic fracturing. This third option has gained considerable support in the US Congress.

An effort to legislate and address the concerns associated with hydraulic fracturing was finally initiated in Congress in 2009, almost a full decade into the fracking boom. Those efforts failed but were renewed in 2011 with the reintroduction of the "Fracturing Responsibility and Awareness of Chemicals Act" (FRAC Act).[36] The Senate version of this bill would close the oversight gap that the natural gas industry has benefited from since the passage of the 2005 Energy Policy Act. It would repeal the provision of the 2005 Act that exempted the industry from complying with the Safe Drinking Water Act. The bill would also require the public disclosure of chemicals used by the natural gas industry in its fracking operations although they would not be required to reveal specific

formulas where there is a proprietary interest. However, there is an emergency provision that would require that proprietary chemical formulas be released to attending physicians, the state, and the EPA where the information is needed for treatment in emergency situations.[36]

The FRAC Act died in committee in 2009. Its reintroduction in 2011 may not lead to passage either. The natural gas industry is lobbying aggressively against this legislation as a part of its overall agenda to limit federal oversight of gas drilling. Congress itself remains far from united in perceiving the need to act. It is clear that the process of risk assessment and risk management will most likely continue to be pursued in the American policy process in an overtly partisan manner and, as such, it is far from efficient in serving the public interest in safety and health. A responsible approach to risk assessment and risk management is perhaps compromised to the degree it is dependent on the vagaries of partisan politics and economic self-interest. However, the potential for responsible action exists nonetheless as both the public interest and the new documentation of risks are beginning to place new demands before policymakers.

Just as the policymaking process (and the politics that influences it) may promote a lag between new technologies and the analysis of risks they may impose, the inevitable impact of those risks soon becomes an impetus to bring the policy process back to dealing with them. This inevitable pivoting of the policy agenda, a response to the growing perception of or experience with the risks posed by a new technology, opens up new possibilities that the policy process will in turn investigate. Not only policymakers but also some natural gas producers have expressed a willingness to cooperate in determining the effects of hydraulic fracturing and establishing appropriate safe guards.[37] In a policy environment where risk assessment and risk management were first and nonpartisan priorities, this willingness could be tested and so much more efficiently capitalized on to promote industry cooperation in the thorough and credible analysis of the impacts that a surge in natural gas production may have on air, water, and landscapes. It could lead to expanded industry efforts to reduce methane releases during the production and distribution of natural gas, the establishment and regulatory enforcement of best practices, and the public disclosure of toxic chemicals used in natural gas production.

As the policy discussion pivots to focus more on risk assessment and risk management, the challenge will be to create policies and regulations that are grounded in scientific understanding and to achieve effective communication of fact-based assessments of environmental impacts. More science must be injected into the fracking conversation so policymakers will have the foundation they need for responsible action. As this redirecting or pivoting of the hydraulic fracturing discussion begins, it may also be useful to use the occasion of this reorientation to broaden the discussion to include ways of addressing the need for general improvement in the public functions of risk assessment and risk management with respect to new technologies.

CONCLUSIONS: A PATH TO RESPONSIBILITY

As this analysis is concluded, it can be said that there is much room for improvement in the use of the techniques of risk assessment and risk management in the public policy process as it relates to hydraulic fracturing or any other new technology that may bring with it new risks to public health and safety. The techniques for risk assessment and risk management are well known and used in the field of emergency management generally, but there is a dearth of consideration of such techniques in the public policy making process until such time as negative impacts or crisis events force risk assessment and risk management onto the public agenda. At that juncture, the policy discussion inevitably shifts to risk analysis. Such a shift seems now to be in motion with respect to the impact of hydraulic fracturing. As such, it may be a good case to use to invigorate the national discussion of risk assessment and risk management as a public function and to elevate it as a priority in the policy process.

As we have previously noted, the benefits derived from new technologies are frequently (ie, almost always) accompanied by new risks. The policy process, influenced by the ideological clashes and conflicts of interest that shape it, rarely elevates risk to the level of

first priority. Such attention that risk does receive tends to be reactive as opposed to proactive. This can result in tragic and perhaps even deadly delays in the meeting of any responsibility for public health and safety.

As our case study suggests, private decision makers are generally and understandably more inclined to the pursuit and promotion of self-interests as opposed to the public well-being. This means that the ultimate responsibility for public health and public safety resides with public policy makers and public sector agents. Yet in a policy-making process driven by the influence of economic interests and political variables that often move policy makers to act before they study risks, that is, before they have the capacity to make knowledge-based judgments, one is tempted to suggest that the responsibility for public health and safety is doomed to be unmet until a disaster strikes.

In an ideal world, public decision makers and private actors alike would routinely examine each new technology and the benefits it promises in the context of the inevitable new threats and risks they may impose. Remembering that every benefit involves a potential cost or risk, and that with respect to hydraulic fracturing or any number of other technological advances, we are often talking about costs that impinge on public health, it would be desirable to see risk assessment and risk management integrated much earlier and more routinely into the process of public and private decision making. This would entail both an upfront and ongoing threat assessment determining the credibility and nonrandomness of threats, vulnerability assessments, measures of expected impacts and losses, and the integration of this information into a cost-benefit matrix of sorts that would inform the development of policies to reduce risks to tolerable levels and eliminate some of the perils that invite hazards which may escalate losses.

At a minimum, in an effort to propel risk assessment and risk management to a place of first priority in the policy process as it relates to new technologies that carry potential risks with them, three general principles should be elevated above all other competing and valid concerns or interests. First, the policy discussion must be infused from the very beginning with the appropriate and necessary scientific analysis. The development of the necessary foundation for knowledge-based decision making must be of greater priority and should never be short changed in the more immediate service of any other political, ideological, or economic interest. Second, as the science is infused, it must be directed to a comprehensive risk assessment as a prerequisite for any long-term policy development. Third, the implementation of new technological methods proven to be associated with new risks to public health and safety should be subject to reasonable and scientifically based requirements for mitigation planning or risk management. These, where appropriate, should inform any eventual regulatory structure.

The application of these three principles to the hydraulic fracturing policy discussion (ie, at the very beginning of the process) would have looked very much like, frankly, what appears to be happening now some 10 years into the boom. The EPA research program to assess environmental and public health risks associated with fracking would have been pursued as a necessary first step in the policy process and completed years earlier. The exemption of natural gas producers from federal regulation (ie, the Safe Drinking Water Act, the Clean Air Act, and the Clean Water Act) would not have been enacted before the scientific study required to inform policy. The void created by removing the EPA as a monitor on the boom in gas fracking, a boom that has cut across state lines into almost every region of the country with the potential to impact public health and safety across the nation, would not have been allowed to exist. The concerns related to drinking water, the toxicity of fracking chemicals, the impact on shallow aquifers, the correlation of drilling and high methane levels in groundwater used for drinking, etc all would have been much more thoroughly explored and much earlier. Responsible interim legislation, perhaps something like the presently proposed FRAC Act, would have been enacted years earlier. By now, some 10 years into the fracking boom, the foundation for knowledge-based decision making would have led to the establishment of sensible federal and state regulations protecting public health and safety and ensuring, no doubt, the sustainable future of shale gas extraction.

There is no doubt that economic and technological advancement requires risks to be taken. There is also no question that the industries taking those risks and the public policy makers who monitor and potentially regulate them are interested in a variety of valid and competing economic and political objectives. However, given that major and complex technological advances carry the potential for inflicting greater and unacceptable risks with them, it follows that risk assessment and risk management should be a higher priority for public policy makers. This is neither to disregard partisan divisions and ideological conflict over the concept of governmental regulation nor to forget that corporate resistance to regulation may successfully drive much of the political process. This is not to say that the function of governmental regulation, whatever its basis, is without its imperfections. It is simply to say that the discussion of risk assessment and the public policy promotion of risk management must be a first priority as opposed to an inevitable agenda item some years after the negative impacts or threats of a more or less unregulated new technology are already and often tragically on us.

It may be more than a bit idealistic to suggest that the public policy process can be anything more than reactive with respect to the assessment and management of risks associated with new technologies. However, given the potential for severe and negative public health and safety impacts, not to mention the great costs these may impose when they are fully on us, it is reasonable to promote a more proactive approach. It may be reasonable to place the same expectations on our policy makers that are placed on emergency management professionals with respect to making risk assessment and risk management an expected first step. As the belated analysis of risk with respect to hydraulic fracturing gains momentum, it might serve as an impetus to explore new mechanisms for elevating risk assessment and management as a priority in the policy process and to eliminate the delay or lag that postpones the inevitable at the expense of public health and safety. That is the needed first step on the path to responsibility.

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