FORUM

Nuclear Waste Disposal: A Cautionary Tale for Shale Gas Development

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Nuclear energy and shale gas development each began with the promise of cheap, abundant energy and prospects for national energy independence. Nuclear energy was touted as "too cheap to meter," and shale gas promised jobs and other economic benefits during a recession.

In each case, industry and government moved quickly to realize the economic and political benefits. It is perhaps ironic that nuclear energy, a mature technology with low greenhouse gas emissions, is now being replaced by lower-cost shale gas, for which the environmental impacts are hotly debated.

After more than half a century, the nuclear industry still has no place for final disposition of its most dangerous wastes. Likewise, the shale gas industry may find itself facing decades of vociferous public opposition. There are lessons to be learned from similarities in the factors driving these controversies. Given the uncertainties and economic importance of shale gas development, a comprehensive scientific effort is needed to evaluate the environmental impacts and inform the regulatory framework.

The Fear Factor

Images of the victims of Nagasaki and Hiroshima reinforced by mushroom clouds and children taking "shelter" under desks have been called one of the most powerful complexes of images ever created outside of religion [*Weart,* 2012]. Intertwined is the fear of radiation and cancer. Thus, many perceive the risks of nuclear power and its wastes as uncontrollable, catastrophic, and dreaded [*Slovic et al.,* 1991].

For shale gas development, flames from kitchen faucets (e.g., as displayed in the documentary *Gasland*) supplemented by explosions of well houses likewise present a powerful image in framing negative public perspectives. In place of radiation is the fear of unknown chemicals used in hydraulic fracturing, or "fracking," and unpredictable events. Once embedded in people's minds, these images and fears are difficult to dispel. A contributing factor in both cases is a perceived imbalance of power between ordinary people on one side and "big money" or "big oil" on the other.

Technical Overconfidence

In contrast to public fears is a steady confidence by industry and dismissal of public concerns as irrational. For decades, industry and government considered nuclear waste disposal to be a trivial technical problem, in part because the volume of nuclear waste generated per energy consumed is small. Scientists and policymakers were slow to recognize the importance of public perceptions in shaping the nuclear waste debate [*Slovic et al.,* 1991].

The overconfidence carried over to the sites investigated. Early in the Yucca Mountain studies, the Board on Radioactive Waste Management forewarned that unrealistic expectations for prior knowledge risked undermining public trust, as surprises inevitably would occur [*National Research Council,* 1990]. The warning was largely ignored, but it turned out to be a premonition of events to come.

Among these, bomb pulse levels of chlorine-36 found in the exploratory tunnel at Yucca Mountain suggested that water percolated along unexpectedly fast pathways. Though never confirmed, the Energy Department responded with an abrupt about-face from touting the natural system to an emphasis on the engineered barriers. This dealt a substantial blow to the project's credibility [*Alley and Alley,* 2013].

Technical overconfidence, exacerbated by insufficient geoscience input, also led to reliance on model predictions in the nuclear waste program that far exceeded what most geoscientists believe science can provide [*Cherry et al.,* 2014].

Similarly, technical overconfidence undermines public attitudes toward shale gas development. Most notable is the statement made by many in the industry that there are no documented cases of hydraulic fracturing contaminating groundwater.

This nuanced statement referring to the process of hydraulic fracturing ignores the known cases of contamination by oil and gas operations [*Jackson et al.,* 2013]. The public does not distinguish between the fracking process and the totality of unconventional oil and gas operations; thus, any reports of contamination seem completely at odds with industry assurances.

In addition, there are inevitable surprises, including seismic activity resulting from underground waste injection [e.g., *Ellsworth,* 2013] and methane leaking from shale gas operations in greater amounts than previously recognized [e.g., *Brandt et al.,* 2014].

Lack of Trust in Government and Institutions

A lack of confidence in government and institutions appears to be endemic in today's society. Secrecy and exemptions from environmental regulations exacerbate this problem. The nuclear energy industry inherited a culture of isolation and secrecy from the nuclear weapons program. Key decisions on nuclear waste were made with almost no public involvement, and nuclear weapons sites were exempt from pollution control laws for many years.

Shale gas development has its own secrets in the lack of disclosure of fracturing chemicals, leasing activities, and settlement claims. Likewise, the industry has exemptions from various environmental laws and regulations.

Contributing to the lack of trust, self-appointed experts and the media can direct great attention to minor problems, while bigger issues are neglected. For example, a focus on fracking chemicals coming up through geologic layers has diverted attention from more important issues, such as proper well sealing and management of the chemicals and flowback/produced water at land surface.

Lessons Learned

Strong public opposition can be seen as a breakdown of trust in the governmental and industrial managers of these technologies. Moreover, trust is quickly lost and slowly regained. The problems are deeply rooted and not resolvable by public relations campaigns [*Slovic et al.,* 1991].

In dealing with complex issues such as nuclear waste and shale gas development, it is critical to communicate to the public which issues have a large scientific consensus, where the technical uncertainties and disagreements lie, and how important these are to resolve. A focus on efforts to address critical questions—in some cases, as they arise by surprise—is much preferred to blanket assurances.

Many public concerns are legitimate. Shale gas development can bring an intensive industrial operation with associated traffic, noise, and construction to a populated or pristine area over the short term and unknown effects to water quality over the longer haul. This is a major contributor to public opposition, reinforcing the importance of early engagement of citizens to address their concerns.

To build credibility with the public, some degree of consensus within the scientific community is necessary. This requires an ongoing open process of inquiry and reexamination. Good science moves slowly. It takes time to develop defensible, evidence-based science for complex issues such as shale gas and nuclear waste. The public should be engaged during this learning process.

Despite more than 150 years of oil and gas production, little is known about the extent of groundwater contamination caused by upstream practices. Until recently, there has not been much incentive for such monitoring and research.

As a result, rapid development of shale gas has outpaced the science and regulatory framework. Shale gas development has proceeded on the untested hypothesis that its

impacts are no different than those known for conventional oil and gas development.

Long-term, field-based hydrogeologic research and monitoring are essential to help resolve the issues [e.g., *Jackson et al.,* 2013; *Council of Canadian Academies,* 2014]. However, studies of groundwater impacts have been based largely on sampling water from domestic wells. While providing some information on drinking-water quality, such wells are poor instruments to study contaminant migration pathways, attenuation processes, and impacts to freshwater resources.

Not surprisingly, these studies have resulted in contradictory findings and fostered a lack of consensus within the scientific community. They also lead to a false sense that the issues are being addressed in a meaningful way for an industry that contributes an estimated $238 billion to the U.S. economy [*IHS,* 2012]. In the absence of more rigorous study, lack of evidence should not be used as evidence for lack of impacts, nor should every high-methane occurrence be attributed to shale gas development.

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