Journal of Environmental Management 163 (2015) 174–183

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Permitting program with best management practices for shale gas wells to safeguard public health

Terence J. Centner [a, *], Ludivine Petetin [b]

[a] 313 Conner Hall, University of Georgia, Athens, GA 30602, USA
[b] Wilberforce Building, University of Hull, Hull HU6 7RX, UK

ARTICLE INFO

Article history:
Received 12 July 2015
Received in revised form
13 August 2015
Accepted 14 August 2015
Available online 28 August 2015

Keywords:
Shale gas
Pollutants
Toxic chemicals
Air emissions
Permitting program

ABSTRACT

The development of shale gas resources in the United States has been controversial as governments have been tardy in devising sufficient safeguards to protect both people and the environment. Alleged health and environmental damages suggest that other countries around the world that decide to develop their shale gas resources can learn from these problems and take further actions to prevent situations resulting in the release of harmful pollutants. Looking at U.S. federal regulations governing large animal operations under the permitting provisions of the Clean Water Act, the idea of a permitting program is proposed to respond to the risks of pollution by shale gas development activities. Governments can require permits before allowing the drilling of a new gas well. Each permit would include fluids and air emissions reduction plans containing best management practices to minimize risks and releases of pollutants. The public availability of permits and permit applications, as occurs for water pollution under various U.S. permitting programs, would assist governments in protecting public health. The permitting proposals provide governments a means for providing further assurances that shale gas development projects will not adversely affect people and the environment.

1. Introduction

Due to concerns about sufficient, affordable energy supplies, the United States has embraced the development of its unconventional hydrocarbon resources including shale gas. The development of these resources using hydraulic fracturing and horizontal drilling has been controversial. Some people feel that the production activities are accompanied by too many health and environmental (collectively referred to as "health") damages (Osborn et al., 2011). To encourage production, the U.S. Congress exempted hydrocarbon development from a number of federal environmental and public safety laws (Centner, 2013; Roberson, 2012). With the absence of these federal safeguards, U.S. state governments have needed to determine what health, safety, and environmental provisions are needed to respond to the risks posed by shale gas extraction (Grinberg, 2014). In general, states allowed production of shale gas to commence before developing comprehensive regulatory safeguards and oversight to respond to all of the expressed concerns (Jackson, 2014; Weinstein, 2013).

With the advent of hydraulic fracturing, various U.S. state governments did not always provide proficient oversight (Rawlins, 2013). Pollution events involving damages to properties and people and the impairment of water and air resources from shale gas wells suggest that the U.S. regulatory framework was too lax (Ely vs. Cabot Oil & Gas Corporation, 2014; Justiss Oil Company vs. T3 Energy Services, Inc., 2011). State legislatures did not always allocate sufficient funds to enable regulatory agencies to hire sufficient personnel (Wiseman, 2014c). This meant the regulatory agencies were delayed in developing essential regulations to safeguard health and performing inspections of wells located over vast distances (Wiseman, 2014a). Budgetary constraints meant that most state governments lacked the personnel necessary to meaningfully enforce their regulations, meaning that firms failing to obey regulatory proscriptions did not suffer any consequences (Fershee, 2014; Wiseman, 2014b). Governments also lacked satisfactory regulations dealing with the structural integrity of older producing wells and abandoned wells (Jackson, 2014).

An example disclosing this conundrum has been reported by Robertson (2013). The state of Ohio had twenty-one oil and gas inspectors in its Division of Mineral Resource Management for investigating citizens' complaints, enforcing and overseeing gas

* Corresponding author.
E-mail address: tcentner@uga.edu (T.J. Centner).

http://dx.doi.org/10.1016/j.jenvman.2015.08.019
0301-4797/

well construction and waste disposal activities, and providing oversight for plugging of wells and site restoration. Assuming the inspectors divided the work equally, each inspector would have been responsible for reviewing and processing 33 drilling permits, 17 wells being plugged, 22 new oil and gas wells, and 2354 production reports in one year. Given that wells are scattered over considerable areas and the timeliness of an inspection depends on when the well is being drilled or plugged, an inspector might need 39 work days just to inspect each well once.

An examination of governmental responses to negative externalities disclose six factors suggesting that U.S. state governments have underinvested in the protection of people: (1) interference with safety requirements due to economic objectives, (2) time lapses and externalities associated with new technology, (3) lack of scientifically-based maximum contaminant levels and exposure information, (4) obsolescence of management approaches, (5) difficulties in proving damages, and (6) lax oversight and preemption (Centner and Eberhart, 2015). Given this underinvestment, governments should consider developing additional procedures to reduce health damages. Shale gas should only be perceived as a sound environmental option if accompanied by tight regulation (Meng, 2014; Stamford and Azapagic, 2014).

While several issues accompany the development of shale gas reserves, the two major health concerns involve the pollution of water and air resources. In the absence of a federal permitting system, wells have been developed without complete consideration of the associated health risks. For example, the Texas permitting application for new wells fails to request documentation of any environmental quality except applicants must set and cement sufficient surface casing to protect usable-quality water strata (Texas Railroad Commission, 2008).

The lack of fully developed transparent permitting programs for gas wells may be contrasted with the permitting system required for addressing water pollution from concentrated animal feeding operations. Under the Clean Water Act, each farm with the requisite number of animals must secure a permit that meets federal requirements. These permits employ flexible best management practices to reduce releases of pollutants into surface waters to reasonable amounts. In a similar manner, a permitting system could be used to address health damages associated with toxic fluids and air emissions that accompany shale gas extraction. To assist governments around the world in devising appropriate regulations to protect people's health, this paper proposes oversight of shale gas development through a permitting program incorporating best management practices.

2. Dangers and risks associated with shale gas production

Although numerous issues have been raised about potential damages from shale gas development, two have been prominent: (1) the pollution of water and land resources by toxic fluids and (2) emissions of air pollutants. The identification of potential contamination problems provides a foundation for developing management practices to address health concerns.

2.1. Toxic fluids

Most hydraulic fracturing is slickwater fracturing that involves the use of large amounts of water and sand with smaller amounts of other substances and chemicals. Several tons of chemicals are normally used to fracture a well and flowback fluids containing other elements from the rock strata pose pollution issues (Werner et al., 2015). The concern is that toxic chemicals and flowback released during well development and operation will contaminate land, enter the groundwater, or be released into surface waters. The pollution of water resources also includes pollutants in the air that may be deposited on land and surface waters during a precipitation event. A mishap in Texas in April 2015 forcing the evacuation of residents demonstrates the concerns that people may be harmed (Schrock, 2015).

To fracture shale underneath the ground and maximize production, drilling firms employ a number of different chemicals to aid in the recovery of natural gas (Vidic et al., 2013). These may include an acid, biocide, breaker, brine, corrosion inhibitor, crosslinker, demulsifier, friction reducer, gel, iron control, oxygen scavenger, ph adjusting agent, scale inhibitor, and surfactant (Pennsylvania Consolidated Statutes, 2012). Approximately 200,000 L of chemicals may be used per well (Howarth and Ingraffea, 2011). While some of the chemicals used are not dangerous, others are toxic so that releases of fluids from a well may lead to contamination. Table 1 sets out some of the known toxic substances that may be accidentally released from well sites.

Researchers from several universities collaborated to identify scenarios that could lead to water contamination by fluids accompanying hydraulic fracturing (Vengosh et al., 2014). The first and major concern is that toxic materials may contaminate shallow aquifers in areas adjacent to shale gas development. This generally involves the leakage of methane gas. Multiple reports by persons with groundwater wells near shale gas operations have claimed that methane gas was present in their tap water (Adair et al., 2012). While it is common for aquifers in regions of methane-bearing shales to contain some methane (McKay et al., 2011), concentrations in areas with gas wells may be greater due to leaking well casings (Osborn et al., 2011). A study in Pennsylvania found that methane concentrations in drinking water wells of homes near natural gas wells were six times higher on average than concentrations for water wells of homes farther away (Jackson et al., 2013). Baseline testing is recommended to discern the presence of methane and other gases in groundwater. Water sources are tested before wells are drilled so that the data can serve as a reference point for determining whether gas wells drilled at a later date are contaminating water sources.

A second concern is that spills, leaks, and the disposal of fracturing fluids and inadequately treated wastewaters will cause contamination. While only 0.5% of wells may experience a spill (Gross et al., 2013), with more than one million oil and gas wells in the United States (USEPA, 2014c), there may be 5000 spills per year. Moreover, other sources estimate considerably higher spill-rate estimates, and mixtures of chemicals may cause individual chemicals to become more mobile (USEPA, 2015). Safety procedures are needed to respond to these problems. While state governments have adopted provisions to augment health and safety, evaluations of the provisions have routinely concluded that they are insufficient (Wiseman, 2014a). Furthermore, given that firms fracturing wells are not disclosing all of the chemicals used due to trade-secret exemptions, regulators lack information as to what chemicals might be a source of contamination (Konschnik and Boling, 2014). Given past experiences with MTBE, PCBs, and hazardous wastes, it cannot be determined whether any of the toxic chemicals used in fracturing are causing problems (Rawlins, 2014).

Third, improper wastewater disposal and spills may be causing the accumulation of metals and radioactive elements in stream, river, and lake sediments (Warner et al., 2013; Vengosh et al., 2014). Given the costs of disposing well wastewaters in deep injection wells, a number of alternative disposal methods were tried including treating wastewater at municipal wastewater (sewage) treatment plants and using oil and gas brines for deicing roads. A number of the practices have been stopped due to their association with elevated naturally occurring radionuclide levels in nearby soils and streams (Vengosh et al., 2014). However, these activities