Energy Policy 118 (2018) 109–120

Contents lists available at ScienceDirect

Energy Policy

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

Monitoring of unconventional oil and gas extraction and its policy implications: A case study from South Africa

Surina Esterhuyse[a,*], Marinda Avenant[a], Nola Redelinghuys[b], Andrzej Kijko[c], Jan Glazewski[d], Lisa Plit[d], Marthie Kemp[a], Ansie Smit[c], A. Tascha Vos[a]

[a] Centre for Environmental Management, University of the Free State, P.O. Box 339, Bloemfontein, South Africa
[b] Department of Sociology, University of the Free State, P.O. Box 339, Bloemfontein, South Africa
[c] Department of Geology, University of Pretoria Natural Hazard Centre, University of Pretoria, Private Bag X20, Hatfield, Pretoria, 0028, South Africa
[d] Institute of Marine and Environmental Law, University of Cape Town, Pvt Bag X3, Cape Town, South Africa

ARTICLE INFO

Keywords:
Unconventional oil and gas
Biophysical
Socio-economic
Monitoring
Framework
Policy development
South Africa

ABSTRACT

Biophysical and socio-economic monitoring during unconventional oil and gas (UOG) extraction is important to assess change and to have reference conditions against which to identify UOG extraction activity impacts. The large-scale cumulative impacts of UOG extraction makes standardised monitoring across geographic and socio-political regions important. This article emphasises the importance of a robust monitoring framework that must serve as a guideline for planning monitoring activities during UOG extraction. A case study from South Africa is presented to illustrate important aspects to address during the development of a UOG extraction monitoring framework. The South African case is critically assessed and resultant policy implications are discussed. Important policy considerations include performing baseline monitoring during UOG extraction, performing UOG extraction monitoring in an integrated, systematic, and standardised manner, ensuring that proper resources are available to perform the monitoring and implementing an adaptive management plan that is linked to UOG extraction monitoring.

1. Introduction

In recent years, unconventional oil and gas (UOG) has become an increasingly important additional resource for many countries to augment their energy resources (EIA, 2017; Castro-Alvarez et al., 2017; Agerton et al., 2017). UOG is defined as oil and gas trapped in geological formations with low permeability, requiring stimulation to free the gas (Broomfield, 2012). Typically, stimulation entails hydraulic fracturing. This method requires the pumping of hydraulic fracturing fluid into the target formations via a deep well, resulting in microfractures in the rock through which oil and or gas is released. The microfractures are kept open by solid particles (typically sand) which is included in the hydraulic fracturing fluid. This enables trapped oil or gas to flow out to the surface. Until quite recently these resources were not accessible for extraction, but as a result of technological advances such as hydraulic fracturing, they are increasingly within reach.

UOG extraction is associated with a range of interlinking impacts of concern at a regional scale. Possible negative environmental impacts include impacts on the quality and quantity of both surface water and groundwater resources (Jackson et al., 2014; Rahm et al., 2013; Herridge et al., 2012; Rahm and Riha, 2012; Williams et al., 2012; Broderick, 2011) and possible increased seismicity associated with deep well wastewater injection as well as fracking operations (Kijko et al., 2016; Rubinstein and Mahani, 2015; NRC, 2012a). Air quality impacts can ensue from fugitive releases and flaring (Farina, 2011; Elvidge et al., 2011), while UOG extraction can also cause landscape fragmentation and biodiversity impacts (Slonecker et al., 2012). The negative socio-economic impacts resulting from UOG extraction can include: (1) the disruption of social cohesion, (2) competition over water between oil and gas companies and existing lawful water users, (3) the potential health risks associated with lack of access to water and adequate sanitation, and (4) higher population density in ecologically sensitive and water scarce areas (Redelinghuys, 2016; Schafft et al., 2013; Warren, 2013; Broderick et al., 2011; Dolesh, 2011).

The impacts that may emanate from UOG extraction makes environmental and socio-economic monitoring of various aspects before, during and after unconventional oil and gas (UOG) exploration and extraction vital. Through effective monitoring of areas of concern decision-makers are able to assess changes in these aspects and act to

* Correspondence to: Centre for Environmental Management (67), University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa.
E-mail address: esterhuyses@ufs.ac.za (S. Esterhuyse).

https://doi.org/10.1016/j.enpol.2018.03.001
Received 20 April 2017; Received in revised form 28 February 2018; Accepted 2 March 2018

either prevent or mitigate potential impacts. The complex nature of UOG extraction and its related impacts calls for a robust monitoring plan to limit potentially harmful environmental and socio-economic impacts and to gather relevant data that can be used by governments to manage UOG extraction. A monitoring framework that includes information on the biophysical and socio-economic aspects to be monitored; the frequency of monitoring and; parties responsible for the monitoring would be a useful tool for governments in this regard. A UOG extraction monitoring framework can be used as a guideline for planning monitoring activities during the various phases of UOG extraction. The usefulness of monitoring frameworks to gather environmental data of complex development activities have been illustrated by various researchers (Li et al., 2016; Harris et al., 2016; Kinchy et al., 2016; Vos et al., 2000; Phinn, 1998).

This article describes the development of the South African UOG extraction monitoring framework and its policy implications. Two monitoring aspects of this framework, namely surface water and socio-economics, are presented in the form of a case study to illustrate the importance of monitoring both biophysical and socio-economic aspects during UOG extraction.

2. Monitoring UOG extraction impacts on water resources and socio-economics: The global and South African context

2.1. The Global context

Policy-relevant aquatic resources monitoring for UOG extraction is lacking in most countries (Brantley et al., 2014; Small et al., 2014; Vidic et al., 2013). Water resources monitoring is mostly focused on groundwater protection and to ensure well integrity (Kang et al., 2014; Ingraffea et al., 2014; Jackson et al., 2013). In most cases, the availability of monitoring data to assess surface water contamination events are limited (Brantley et al., 2014; Kurek et al., 2013; Entrekin et al., 2011). For the purpose of developing sound environmental policy, Entrekin et al. (2011) and Kurek et al. (2013) stress the need for a well-executed monitoring programme to assess changes in aquatic ecosystem structure and function caused by UOG extraction.

In the US, baseline information for surface and groundwater quality is usually sparse or non-existent (Bowen et al., 2015). Here, water resources monitoring is typically coordinated at the state level and requirements vary by state, while data collected by private oil and gas companies are proprietary and not available to the public (Bowen et al., 2015). This limits the availability of consistent monitoring data across regions. Bowen et al. (2015) conclude that, because water quality for UOG extraction is monitored at state level and not for set analytes at an appropriate spatial distribution at regional level, this data cannot assess water quality at national level. This was also a concern in Norway (Gray et al., 1999) and Canada (Seitz et al., 2011). Jefferies (2012) and Tan et al. (2015) reiterates the importance of regional monitoring of water resources to assess the cumulative risk of UOG extraction.

Important recommendations for existing water resources monitoring programmes include, amongst others:

- High quality baseline surveys of water resources should be performed before UOG extraction (Krupnick et al., 2014; Sheelanere et al., 2013; Cook et al., 2013).
- Best monitoring practice should be followed (Cook et al., 2013).
- Aquatic monitoring programmes should establish an ongoing system of independent scientific input to the program (Ayles et al., 2004).
- Monitoring programmes should use adaptive feedback loops and change the monitoring programme based on findings (Ayles et al., 2004).
- Monitoring should include an information management system (Sheelanere et al., 2013; Ayles et al., 2004).
- Monitoring data should be made available to all stakeholders (Sheelanere et al., 2013).
- The correct variables for water resources need to be monitored during UOG extraction (Dubé et al., 2006).
- Consistency between monitoring efforts in different regions and on different administrative levels needs to be improved (Sheelanere et al., 2013; Dubé et al., 2006).

With regard to socio-economic variables, in spite of the potential value of socio-economic monitoring of the impacts of UOG extraction, it is rarely done at local, state or federal level in the US (Haggerty and McBride, 2014). Some states mandate pre-development impact assessments, but no socio-economic monitoring occurs during and after UOG extraction (Haggerty and McBride, 2014). Any monitoring for socio-economic impacts of UOG development typically occur on an ad hoc basis and at a localised level. Perry (2013), for example used ethnography to monitor chronic stress in individuals and communities associated with UOG development, while Esswein et al. (2014) offers an example of the monitoring of the health of UOG industry workers. Werner et al. (2015) also note that most of the studies on the environmental health impacts of UOG extraction lacks methodological rigour.

Socio-economic impacts from UOG extraction may include diminished long-term economic performance due to boom-bust cycles, poverty, unemployment, property devaluation and social disruption when rapid industrialization and population growth intersect with limited local capacity (Haggerty and McBride, 2014; Jacquet and Kay, 2014). Mining companies will typically attempt to secure a “social license to operate” (SLO) through various community initiatives, including charity, infrastructure improvement, health programmes, support to local businesses through procurement policies and sustainable livelihood projects (Curran, 2017; Kotilainen et al., 2015). These company interactions with local community groups may create dependency relations (Kotilainen et al., 2015), or relationships of patronage and clientelism in the local community (Rajak, 2012), which may reduce the willingness of local leaders to monitor UOG company activities.

Rapid UOG development can also increase the nature and level of risks faced by local authorities (Atkinson et al., 2016) as development often proceeds at a pace that exceeds the ability of governments to keep up with necessary service delivery and infrastructure needs. Local authorities often have to bear the brunt of new service delivery demands immediately following mining developments, but the expected revenue does not arrive until much later, either from local taxation or government grants (Atkinson et al., 2016; Chapman et al., 2014). To alleviate the strain on government, the European Commission's *Oil and Gas Sector Guide on Implementing the UN Guiding Principles on Business and Human Rights* advises that UOG companies should monitor the impact of their activities on the human rights of employees and communities (EC, n.d.).

2.2. The South African context

In 2011, various UOG extraction companies applied for exploration licenses with the Petroleum Agency of South Africa (ASSAF, 2016). At that time, the researchers realised that this new extractive technique could impact negatively on the biophysical and socio-economic environments in South Africa. After studying the possible biophysical and socio-economic impacts of UOG extraction (Esterhuyse et al., 2013; Esterhuyse et al., 2014) the researchers realised the importance of preparing for the possibility of UOG extraction by performing baseline monitoring before exploration starts. In view of this, the research team developed a monitoring framework for UOG extraction in South Africa from funding provided by the South African Water Research Commission.

After the development of this framework, the South African government, through Cabinet and various other decision-making institutions, has made high-level public commitments to shale gas exploration (Scholes et al., 2016). This monitoring framework (Esterhuyse et al., 2014) was subsequently taken up in the Strategic Environmental Assessment (SEA) for shale gas development, which was commissioned by