POLITICS OF TRANSPARENCY: CONTESTED SPACES OF CORPORATE RESPONSIBILITY, SCIENCE AND REGULATION IN SHALE GAS PROJECTS OF THE UK AND THE US

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To Emre,

in his companionship I found the strength to complete this thesis.

ABSTRACT

This thesis presents a political geography of transparency, regulation and resource making in shale gas projects in the United Kingdom (UK) and the United States (US). The emergence of shale gas as a politically and economically desirable resource occupied national political aspirations, most notably in the US and to some extent in the UK, for reasons of energy security and economic development. Although shale gas has become a globally desirable resource, this thesis shows that the resource is not same everywhere. Following knowledge making practices in distinct regulatory regimes of the UK and the US, I trace how making of shale gas resource is subjected to contestation in a range of technical fields, such as law, economics, geosciences and environmental impact assessment. The study is based on in-depth analysis of technical and policy documents, and interviews with a wide range of actors (i.e. regulators, gas companies, investors, scientists, landowners), and field visits in the US (New York, Pennsylvania and Texas) and the UK (Lancashire, Litchfield and London). Drawing on theoretical insights from the Science and Technology Studies (STS), legal and resource geographies, I empirically showed that both regulatory practices and resource materialities matter in encapsulating making of shale gas projects in different national contexts. Documenting how information production and its contestation is entangled with assemblages of materials and technologies, as well as regulatory, geoscientific and market interventions in the context of the UK and the US, this thesis offers an alternative account of the geography of transparency and regulation regarding the development of shale gas policies. The political viability of shale projects depends on how these informational spaces are generated, contested and transformed in nationally specific scientific practices and regulatory regimes.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Over the last decade, we have witnessed the emergence of shale gas as an economically and politically desirable resource, transforming the global energy landscape (Yergin 2012). During that time, the material qualities of shale gas formations have played an important part in the making of this "unconventional" resource and its circulation in the global markets (Bridge 2009; Bradshaw et al. 2014). Historically, the making of shale gas as an economically viable resource depended on two kinds of technologies: first, the advancement in technologies of extraction, enabled by the availability of funding and research from federal agencies (Trembath et al. 2012), and second, the ability to raise investment capital on Wall Street, to finance the high operational costs of fast-paced, large-scale development (Mitchell 2013; Rogers 2013).

In the US, a number of regulatory and business initiatives have contributed to the expanding frontier of shale gas development. These initiatives transformed the sector from a characteristically small-business industry into one of large-scale enterprises, whereupon the major oil and gas companies entered, transforming the business landscape again (Selley 2012; Zuckerman 2013). Thus, the US was the first country to procure a well-developed shale gas industry, a success that captured political aspirations for scaling up shale investments in different localities (Tsing 2005). In Europe, meanwhile, the UK, Poland and Germany had already taken new economic and political measures to generate their own home-grown shale gas industries.

In the US, the rapid and large-scale development of shale gas resources had emergent impacts on the environment and public health (Zoback et al. 2010). Local communities living in close proximity to gas sites and environmentalists raised concerns about industry practices and the capacity of government agencies to monitor them (McGraw 2012; Wilber 2012a). Public concerns over the safety of hydraulic fracturing (HF) technology, the toxicity of fracturing chemicals, methane contamination, seismicity and other drilling related problems triggered an intense debate about the non-transparent industry practices and their implications for environmental protection (Wisemann 2011; 2013).

In response to these concerns, both federal and state agencies took action in restructuring regulatory frameworks and quantifying the environmental impacts (Jasanoff 2011). At the same time, the operating gas companies began to publicly disclose information about their operations, in order to generate an image of responsible resource development (Barry 2013). Observing the developments in the US, the UK government began to state that they were learning from the American experience in their attempt to achieve the large-scale resource development. In reality, doing this depended on national interventions in science, economics and law in different spatialities and temporalities (Bridge 2014; Kama 2013; Mitchell 2013). Accordingly, the UK adopted a different notion of objectivity in regulatory science, with the claim that a UK-style unified regulatory framework would ensure scientifically sound, transparent and safe industry practices (Jasanoff 2005).

In this thesis, I explore issues of transparency, scale-making and the science-policy relationship in the governance of the shale gas projects in the US and UK. The shale case controversy is an ongoing debate, shaped by technical, regulatory, economic and legal discussions on the future of the industry and its practices. By

comparing the experiences of shale gas projects in these two countries, I aim to answer two key research questions:

1) How is transparency enacted and contested in practice?

2) How do the industry projects shape and how are they shaped by national regulatory frameworks?

In particular, I focus on the constitution and contestation of different practices of transparency, engaging with the literatures of resource geographies, science and technology studies (STS) and legal geographies. This research thus fills a literature gap by bringing together the geography of regulation and the geography of transparency.

By embedding the analysis of shale gas development in disparate geographies of knowledge making, regulatory environments and regimes of corporate disclosure (Barry 2013; Clark and Wojcik 2007; Jasanoff 2005), I argue that transparency is a multi-faceted, dynamic and fluid notion that embodies multiple spaces of information production. In the next sections, I will discuss how regulatory contexts and resource materials matter in understanding the making of the shale gas resource and transparency in the US and the UK.

1.2 Contested Spaces of Transparency, Expertise and Resource Making

The bodies of literature on STS and economic, legal and resource geographies challenge the notion of transparency as a static and universal democratic ideal over and above practice (Barry 2013; Bridge 2009; Bloomley 1994; Jasanoff 2005). Here, transparency is not expected to render an "objective" way of seeing, as often construed through authoritative knowledge claims articulated by modern nation states

and companies (Ferguson 2005; Jasanoff 1998; Scott 1998). Instead, it is treated as a dynamic "spatial" concept which is context-dependent and embedded in national knowledge-making practices (Jasanoff 2002; Clark 1992). Accordingly, an analysis of transparency requires a careful examination of how different spaces of information production – environmental, scientific, legal and economic – might sometimes overlap and become contested and entangled with particular objects, materials, technologies and issues (Barry 2013; Latour 2004). A spatial conception of transparency is rendered through a network of technical expertise embedded in entities such as corporate headquarters, consultants, NGOs, international organisations and state agencies (Barry 2013).

The institutionalisation of disclosure practices generated a "new market for metrics" that had transformative effects on the organisational structure of companies in their capacity to convey more information about their operations to investors and the public (Clark and Wojcik 2007; Grossman et al. 2006). However, this new quest for disclosure generated a vicious cycle of auditing, and required a new kind of knowledge and expertise in order to assess and deliver transparency – the expert knowledge involved in auditing process also widening the gap between professional and lay knowledge practices (Power 1997).

On this subject, economic geography provides a good framework for locating the economic, moral and organisational aspects of corporate transparency across time and space. It elaborates on the forms of corporate disclosure practices and the range of influential stakeholders who influence the institutionalisation of these practices (Clark and Knight 2008; Clark and Wojcik 2007; Power 2007). The economic geography perspective also allows for a critical conceptualisation of transparency as a spatially

construed notion, embedded in varied practices of disclosure across different physical and political territories.

The notion of transparency is increasingly associated with governance of fossil fuels, the creation of new informational spaces on a wide range of technical competences and the development of new measurement and assessment techniques (Barry 2013; Mitchell 2013; Watts 2005). The generation and public disclosure of information became integral to the new model of responsible corporate governance in resource making. Informed by STS analysis, the resource geographies literature presents an important theoretical framework with which to analyse the role of materials and techniques of resource assessment in the making of resources and their contestation across different geographies, (Bakker and Bridge 2010; Barry 2005; Kama 2013). This "materially-informed" analysis of resource making also suggests that the material world is continuously connected with multiple calculations in the social, economic and political worlds and negotiated in national and international technical networks of expertise and resource assessment (Bridge 2009; Kama 2013).

Benefiting in particular from object-oriented accounts in resource geography, I seek to understand the relationship between resource calculations and financial valuation in shale gas projects, and the formation and contestation of reserve estimates in their scientific and economic networks (Barry 2008). I empirically ground the works of Mazzen Labban (2010), Bruno Latour (1993) and Timothy Mitchell (2013) to frame the impacts of reserve estimates on speculation about shale gas projects in the financial markets in two ways. First, I investigate how a network of geologists and the publication of early reserve estimates contributed to the shale gas boom; second, I unravel ways in which the transparency dispute over reserve estimates generated a

broader debate about corporate misreporting and economic valuation in the US shale gas projects.

The notion of transparency is entangled with multiple technical disputes in legal and scientific contexts of the US and the UK. Legal geography and STS literatures are particularly useful in framing of law in distinct social, scientific and economic spaces (Clark 1991; Delaney 2006; Holder and Harrison 2003; Jasanoff 2005; Whatmore 2003a). In particular, the connections between law, science and space become quite clear in various knowledge controversies about the governance of environmental impacts and national regulatory responses to "matters of concern" (Barry 2013; Latour 2004).

Inasmuch as such disputes about the governance of technologies and environmental impacts are associated with different understandings of nation making, civic engagement and cultural forms of rationality in distinct legal contexts (Jasanoff 2005), legal disputes are also framed in terms of forms of association, of networks of events, people and things, such legal documents and materials (Latour 2009). As Whatmore (2003a) stated, legal knowledge practices in socio-technological disputes can mobilise the boundaries between things and humans, between nature and society, through spatial assemblages of private property relations. Similarly, I show that the governance of environmental impacts requires a careful analysis of different legal socio-technical assemblages of humans and non-humans that confront the bifurcation of science and politics and of law and society. In this thesis, I will present an object-oriented analysis of multiple assemblages of things (e.g. HF technology, chemicals, methane, seismicity, legal, scientific and consultancy reports) and people and institutions (experts, regulators, companies, publics, etc.) that became mobilised in several legal disputes.

Through these analyses of socio-technological controversies, I aim to show that the making of transparency embodies geographically distinct knowledge-making practices and associations of experts and public in different national contexts (Jasanoff 2005). As I will illustrate in multiple public performances of transparency in the US and the UK, transparency necessitates some form of public staging of science, whereby expert-lay person interaction occurs and matters of concern are expressed and disputed (Callon et al. 2001; Whatmore 2009). The formation of a public space for articulation and contestation of various knowledge claims is an integral part of knowledge controversies. In this respect, a range of issues relating to ethics, law, economics and politics can help articulate such contested objects (Latour 2004).

It is crucial to emphasise here that the presence of multiple representations does not mean an end to controversy. Some representations are rendered more powerful than others, and these authoritative forms may become labelled as "objective" by the public staging of science (Ezrahi 1990; Jasanoff 1998). The sequestration of science for commercial purposes can also limit publically available information in knowledge controversies (McGoey 2009a; Michaels 2006). Indeed, the contest for objectivity recognition becomes paramount. The question of whose representation gains the greater weight is critical in knowledge controversies (Jasanoff 2003).

In this thesis, therefore, I argue that the notion of transparency should be analysed in culturally specific, institutionally varied and materially informed practices of disclosure and knowledge making in disparate geographies. Transparency demands in shale gas projects in the UK and the US have rendered new spaces of information production which contribute to the risky entanglement of materials, technologies and humans (Barry 2013; Latour 2004) and yield different regulatory outcomes in distinct institutional, legal and economic spaces (Clark and Wojcik 2007; Jasanoff 2005).

1.3 Research Objectives and Significance

I provide a materially informed analysis of the making of scale and transparency in shale gas projects in two distinct geographies: the Marcellus Shale in the US and the Bowland Shale in the UK. I selected these sites as they have been extremely critical in shaping the political future of shale gas in the US and Europe. In these geographies, public debate has focused on the governance of environmental impacts and related technical issues in respect to the calculation of reserves, methane contamination, integrity, seismicity and fracturing chemicals. Methodologically, my empirical research includes in-depth interviews, case studies and documental analysis.

The international and national network of experts located in state agencies, universities and consultancies played a key role in framing the terms of debate on various environmental matters. Interviews with gas companies and policy-makers were also crucial in mapping out the relationship between science and policy with respect to these controversial issues. These methods helped me contextualise the multiple ways in which making of scale is subject to national interventions in economics, politics, geosciences, environmental science and law. Through analysis of the various assemblages of humans and non-humans in the shale gas controversies considered, this thesis contributes to scholarly work on material accounts of resource geographies and the related STS literature.

This thesis makes various other contributions. To begin with, it presents an interrogation of the notion of transparency as it is manifested in a variety of shale gas debates. Then, it engages in existing theoretical debates in STS and economic geography literatures on the role of sight and witnessing, the perils of disclosure practices and constitutive visions and spaces of information production and law. The investigation of transparency as a spatial concept affords a critical insight into how

practices of transparency are constituted and contested in their distinct geographies of knowledge making and disclosure. The analysis presented here reveals how these distinct spatial arrangements are subject to different modes of governing and public reasoning in the different geographical contexts (the UK and the US). In so doing, new insights are presented on the relationship between the institutional accounts of science and policy making and the transparency demands of administrative processes and monitoring of corporate practices.

Generally, this thesis presents an empirical study of shale gas development benefiting from the literatures of economic geography, STS and legal geographies by analysing 1) the relationship between resource making and corporate misreporting on shale reserve estimates; 2) different national routes of public reasoning in controversies over the regulation of disclosure of fracturing chemicals; 3) practices of litigation and corporate sequestration of scientific information in the governance of environmental impacts; 4) public performances of transparency and the role of witnessing in generating authoritative forms of "objectivity" and their contestation; 5) networks of information production and technical expertise across different geographies; and 6) distinct national economic, political and scientific arrangements in monitoring and regulation of drilling impacts. Specially, I address the following research questions in four empirical chapters:

1) What role have geoscientific practices, economic and political interventions played in the over-promotion of the American shale boom?
    a. How did shale gas become an economically viable and politically desirable resource in the US?

b. What were the technical and geoscientific interventions that circulated in financial markets, and how were these interventions contested in the public space?
c. In what ways did the public controversies over the safety of shale gas technologies contribute to the different routes of regulatory arrangements across the Marcellus Shale?

2) How has corporate nondisclosure generated different forms of science and policy relationships in the governance of fracturing chemicals in the US and the UK?
   a. What has been the role of actors, such as institutional investors, environmental NGOs, academics, gas companies and regulators, in defining the scope and limits of corporate transparency?
   b. In what ways did different institutional traditions impact on science and policy relationship in regulatory decisions over fracturing chemicals disclosure?
   c. What are the new forms/platforms of voluntary corporate disclosure and their influence on new spaces of information production on fracturing chemicals?
3) What has been the role of expert judgements in the governance of environmental impacts of shale gas drilling and technologies?
   a. In what ways did experts frame the drilling impacts in Dimock, Pennsylvania, and influence the politics of shale gas development at the local and national levels?

b. How did measuring these impacts generate new spaces of information production and contestation and become entangled with ethical issues of responsible development and compensation?
c. What was the relationship between litigation and scientific review in defining the limits of corporate responsibility?

4) What role have national economic, scientific and political interventions played in making the scale and transparency in the UK-style shale gas development?
   a. How has the UK's vision of large-scale development been claimed and contested in the socio-technical and political project of British government? What forms of translation and scientific practices were required to fit the shale gas resource into domestic energy system in the UK?
   b. In what ways have the physical and political processes become entangled in technical disputes over governing seismic impacts? How did measuring impacts generate new spaces of information production and contestation of corporate transparency?
   c. How has administrative transparency been constituted through public staging of science? What was involved in public disclosure acts and its contestation?

1.4 Overview of the Chapters

Following this introduction, the thesis proceeds with seven further chapters which include a literature review, methodology and four empirical chapters, whereby the contested spaces of transparency, corporate responsibility, science and regulation in

the shale gas projects of the US and the UK are traced. A short review of each chapter is given below.

Building on critical academic scholarship on transparency and resource making, Chapter 2 presents the main theoretical approaches and concepts utilised in the thesis and a survey of relevant literature from resource geographies, STS and economic and legal geographies (Barry 2013; Bridge 2009; Blomley 1994; Holder and Harrison 2003; Jasanoff 2005). Here, I show that a critical analysis of transparency pays attention to the spatial constitution and contestation of information production, as well as to different forms of public disclosure in distinct geographies (Barry 2013; Clark and Wojcik 2007; Jasanoff 2002). It is important to note that transparency is a dynamic concept entangled with particular objects, materials and technical networks of expertise in various domains, including geosciences, law and economics (Callon 1998; Latour 2004).

Tracing different lines of inquiry in developing a spatial conception of transparency and resource making, this thesis bases upon and contributes to the following theoretical fields: 1) a conceptual interrogation of transparency in theory and practice vis-à-vis the theoretical debates in economic geographies of corporate disclosure and standardisation (Best 2005; Clark and Wojcik 2007; Fischer 2010; Power 1997; Strathern 2000); 2) relational theories of resource materiality and transparency in fossil fuel economies (Barry 2008; 2013; Bridge 2009; Bridge and Le Billion 2013; Mitchell 2013; Watts 2005); 3) emergent literatures on object oriented accounts of space, law and knowledge making in legal geographies (Holder and Harrison 2003; Latour 2009; Whatmore 2003a); 4) constructivist and object-oriented STS accounts of transparency, constitutive visions and public staging of science (Callon et al. 2001; Ezrahi 1990; Jasanoff 2005; Shapin and Schaffer 1985).

Chapter 3 discusses the methodological underpinnings of the research, detailing the techniques of data collection, analysis of research findings and ethical considerations during the fieldwork and writing process. The research process involved tracing historical, scientific, political and economic practices in the making of the resource and of transparency in disparate geographies (Barry 2013; Bridge 2009; Kama 2013). In-depth examination of industry accounts, technical reports and interviews with a range of actors involved in socio-technical controversies revealed that multiple realities could both co-exist and conflict and also open up new opportunities for understanding of the thing itself and its contestation in different regulatory contexts (Latour 2005b; Mol 1999).

Following object-oriented accounts of knowledge controversies, I focused on the objects of contestation, such as fracturing chemicals, well integrity and methane, and their impacts on the politics of shale gas development (Latour 2005b). As I travelled between different sites in the US (Texas, New York and Pennsylvania) and UK (Lancashire, Lichfield and London) and participated in events and interviewed a range of people with diverse agendas (including in Poland), new opportunities emerged for "two-way encounters" between the researched and researcher (Massey 2003; Kirsch 2006; Whatmore 2003b). Finally, the chapter discusses personal reflections on the identity of the researcher in these ethically challenging encounters, the fieldwork strategies, the researcher's engagement with highly technical, messy and contested research material and the ramifications of my account of events analysed in this thesis (Thrift 2003; Latour 1987; Whatmore 2003b).

Chapter 4 offers a historical review of the development of HF technology, financing of American boom and the development of the Marcellus Shale, and how the American success captures the resource imaginary of British government. While

the technology has been in use for more than sixty years and advanced with the primary aim of improving efficiency in the oil and gas fields, its application in the shale gas formations generated multiple controversies that led to different articulations of the technology beyond the industry's limited commercial definition. Situating the development and application of the shale gas technologies locally and historically in the US and the UK, this chapter examines relations between the science, politics and economics in the making of shale gas projects in four parts.

The first part reviews how the HF technology has evolved both as an "art and science," being developed in the US both in the field and in laboratory conditions and supported through a governance regime of public-private partnerships. The second part reviews the speculative nature of the American shale boom, analysing the relationship between the hype around the discovery of new gas fields across America and the ability to extract funds from the investors in the Wall Street. The third part returns to the commercial development of the Marcellus Shale, presenting an analysis of the relationship between shale reserve estimates, financial appraisal and land grab competition, as well as examining the very different trajectories of shale development in the neighbouring states of Pennsylvania and New York. Final part discusses how national aspirations of scale making captured an alternative energy vision for British policy-makers. The chapter aims to situate the shale gas debate geographically in the context of technology and finance, discussing the connectedness therein between science and technology and politics and economy in the development of the American shale gas sector, and its influence on the shale projects in the British context. In doing so, it lays the empirical ground for the following chapters.

Chapter 5 focuses on the regulation of fracturing chemicals, as this constitutes the starting point for transparency discussions in the shale gas controversy. Operating

companies' initial aversion to public disclosure of fracturing chemicals and federal regulatory exemptions in the US intensified the debate on corporate transparency and failure to regulate the industry at the federal level. In the UK, although it was just at the early stage of shale gas development, a similar parliamentary investigation on how to regulate the industry unfolded.

In response to this particular crisis of corporate transparency, this chapter examines the treatment of scientific evidence in the regulation of the fracturing technology vis-à-vis the chemicals. The first part examines national regulatory debates in both countries, including an analysis of political ramifications of the EPA's scientific studies on fracturing technology in the US and informal expert consultations in oral evidence sessions in the UK parliament. The second part of the chapter compares the evolution of voluntary chemicals disclosure initiatives in response to reputational and regulatory concerns in the two countries. Finally, the chapter discusses the ramifications of corporate secrecy over fracturing chemicals for the politics of technology, as well as its repercussions for the industry, for science and for public access to information.

Focusing on the water contamination case in Dimock, PA, Chapter 6 examines the role of science in debating the safety of the fracturing technology and the strategies of the operating company, Cabot Oil and Gas, in response aimed at shaping the water contamination controversy. The first part of the chapter reviews how the Dimock case attained political significance, together with the state and federal investigations into the operations of Cabot and the ways in which the complexity of issues and actors involved in the controversy broadened the debate about fracturing technology to other drilling-related problems. The second part presents a discussion about the investigations of Cabot, the Pennsylvania Department of Environmental

Protection (PA DEP) and the Environmental Protection Agency (EPA) in establishing the cause(s) of the water contamination incidents. While the company used scientific uncertainty strategically in their defence at the federal lawsuit and Consent Order settlements with PA DEP, it suffered a lot in terms of reputation and license to operate for not accepting responsibility for water contamination in Dimock. Overall, the chapter argues that bad corporate practices, such as distorting scientific evidence, attacking counter scientific studies and confrontational community relations, reflect wider defects in corporate accountability and lack of transparency in the early stages of shale gas development in the US.

Chapter 7 presents the making of shale gas projects and transparency in the UK, focusing on two specific instances, one relating to a seismicity dispute and the other to the public staging of science in governing the environmental impacts. In the case of seismic impacts, the installation of a traffic-light system was intended to minimise seismic risks related to fracturing, but it quickly became entangled within a larger debate about the UK government's capacity for regulatory oversight and failures of corporate transparency. The informational space generated by the installation of monitoring devices and measurement of impacts had anti-political effects; while the discussion about safety of fracturing technology was limited to monitoring efforts, it also delineated other legitimate technical questions about shale gas drilling (Barry 2013). Finally, this chapter discusses how transparency demands had transformative effects on state agencies and the operating company to perform public acts of disclosure and the staging of science in public forums (Callon et al. 2001; Ezrahi 1990; Scott 1998; Power 1997).

Chapter 8 discusses the main findings and arguments of this thesis. In the concluding chapter, I argue that transparency debates in shale gas projects of the UK

and the US should be analysed by paying attention to the different geographies of regulation and resource-making practices. This comparative analysis empirically grounds the literature in legal and resource geographies identified, showing that both regulatory practices and resource materialities matter in encapsulating making of shale gas projects in different national contexts. Although shale gas has become a globally desirable resource, I argue that the resource is not the same everywhere. Rather, the viability of the shale gas development is contingent on distinct geographies of knowledge making and regulation, and on the generation of multiple material realities in various and contested technical networks. It is thus, having documented how information production and its contestation is entangled with assemblages of materials, technologies, technical reports and monitoring devices, as well as regulatory, geoscientific and market interventions in the context of the UK and the US, that this thesis offers an empiricist account of transparency and regulation surrounding the development of a shale gas policy. The political future of shale projects will depend on how these informational spaces are generated, contested and transformed in nationally specific scientific practices and regulatory regimes.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This research project explores multiple contested spaces of transparency associated with the development of shale gas projects in the UK and the US. Framed as an indispensable component of a democratic modern state, transparency is also a practice; the enactment of transparency generates the production of public information, and is accompanied with performances of disclosure, witnessing and contestation (Ezrahi 1990; Shapin and Schaffer 1985; Scott 1998). Although mainstream political theories frame transparency as a welcome outcome of deliberative processes (Fung et al. 2007), there has been little questioning of what it actually entails in practice. In effect, the problem of transparency is often seen as an informational dilemma that could be fixed with a simple technical solution; the disclosure of more information in the public space and the progressive standardisation of disclosure practices (Power 1997). However, there is more involved in making things transparent than simply making information public. As the disciplines of STS, economic geography and critical legal scholarship have shown, we need to pay attention what more information means in practice and how production of information depends on the distribution and contestation of technical competences in various areas, such as ethics, law, and economics (Barry 2013; Fischer 2010; Jasanoff 2005; Latour 2004). Accordingly, the boundaries of transparency are fluid and varied, as they are made and remade in knowledge making practices and entangled with multiple assemblages of humans and materials (Barry 2013).

Drawing on the existing critical scholarship on transparency, this project opens up how the making of shale gas projects was bound up with multiple contested spaces of information production and addresses the implications of new knowledge making practices and their contestation on the making of the resource. Here I argue that a series of scientific, economic and political interventions that aimed to facilitate large-scale development enabled regulators and gas companies to generate a "constitutive vision" of transparency. Yet, at the same time, regulators and companies' practices of transparency were heavily scrutinised and criticised by the media and wider publics (Scott 1998; Ferguson 2005). In these circumstances, the study of transparency must address not just the principle and its legal enactment, but also a geographically disparate and historically contingent set of knowledge making practices, and culturally specific forms of civic engagement and policy making. In Jasanoff's terms, a reflexive approach to transparency demands that we are more attentive to both the varying relations of power in information production and to the nationally specific cultures of science, politics and policy (Jasanoff 2005; 2006b). In her analysis of governance of biotechnologies in the US and Europe, Jasanoff shows that how national political structure has an impact on regulators' desire for objectivity and transparency.

The chapter starts with the observation that the making of fossil fuels is necessarily tied to information production in multiple technical expertise areas: just as geological estimations and complex engineering relationships are critical to constitution of a resource (Richardson and Weszkalnys 2014), further technical expertise in law, economics and environmental assessment become important for the making of fossil fuels (Barry 2013; Bridge 2009; Bridge and Le Billion 2013; Callon 2009). In fact, the existing scholarship on shale gas resources provides a cursory

overview of both the multidimensionality of issue areas and the complexity of technical expertise that come to be implicated in the debates that develop around the transparency of the industry. Nonetheless, although some academic studies of shale gas development include a critical economic analysis of acclaimed local development benefits (Christopherson and Rightor 2011; Kay 2011), regulatory discussions (Rahm 2011; Sakmar 2010) and climate impacts (Howarth et al. 2010), there has been little research to date on how different domains of expertise are related in making of the resource. Practically, the majority of published material on shale gas comes in the form of policy or consultancy reports on economic, technical, communication and legal aspects of shale gas development. In turn the information provided by multiple techno-scientific aspect(s) of the shale gas development becomes a source of live contestation by actors involved in the controversy. What can be regarded as a war of technical reports constitutes a rich empirical resource for this project. This vast body of documentation enables us both to understand the social life of expertise beyond the confines of a particular discipline, and to trace how knowledge claims about shale gas are constituted and contested in the public space.

Theoretically, this research project is influenced by two schools of thought in the Science and Technologies Studies (STS), namely the co-productionist approach (Jasanoff 2005) and the Actor Network Theory (ANT) approach (Barry 2013) in analysing contested spaces of transparency. Influenced by these two accounts of transparency, this thesis argues that the making of a resource and the development of a shale gas policy can be better understood by looking at the institutional and political processes in disparate geographies, as well as by the generation and creation of contested materialities and technologies in relation to the shale gas projects.

In her analysis of the development of biotechnology policies in Europe, Jasanoff's (2005) co-productionist framework pays attention to how the political and epistemic orders support and reinforce each other in a process of co-evolution. In other words, the development of European biotechnology policy is not inseparable from the contested politics of EU as a unified political space, which is not only generated by institutional developments but also by the generation of common European discourses, publics and values. Jasanoff's co-productionist framework gives an elaborate account of different national styles of administrative transparency, knowledge making practices and political processes during the development of government policies on controversial technologies. This thesis is influenced by Jasanoff's co-productionist account of different national styles of regulation surrounding controversial technologies, adopting her comparative perspective on the varying methods of administrative decision making, legal systems, public engagement and the scientific review processes in different geographies of knowledge making.

Despite co-productionist framework can be useful in analysing the institutional and political processes behind the development of shale gas policy in the UK and the US, it fails to account for the role of materials and the complexity of multiple spaces of information production for the politics of shale gas. Here, Barry's (2013) object-oriented account of transparency better captures the role of materials and technologies in contestation of shale gas projects and corporate responsibility. In his book *Materialist Politics*, Barry (2013) gives an alternative account of corporate transparency and the politics of oil, underlining the central role of materials in defining the spatial limits of corporate responsibility. Barry proposes a new political geography of oil that pays attention to the formation of an informational corridor and its contestation along the BTC oil pipeline. This thesis benefits from Barry's account

in opening up the multiple ways in which the informational spaces around the shale gas projects are generated and contested within two countries' political and institutional processes, and the role of materials in shaping the politics of shale gas policy in two countries.

In this chapter, I provide an overview of literature on transparency, and advance a critical notion of transparency that developed throughout the thesis. Overall, the notion of transparency, both as a concept and practice, is interrogated in the following four sections. First, I explore theoretical critiques of the principle of transparency as a democratic ideal, opening up the question of the spatiality and temporality of transparency (Clark and Wojick 2007; Jasanoff 2006b). Instead of treating the notion of transparency as a universal concept and norm, integral to the practice of democratic states, I argue that the boundaries of transparency are much more fluid and varied. In short, transparency has a legal and political geography. I then introduce the specific debates on transparency in the resource geographies and STS literatures (Baker and Bridge 2006; Barry 2013). The subsequent section deepens the discussion of legal geography, by introducing emerging literature on object-oriented accounts of space and knowledge making in different legal contexts. Relatedly, the final section discusses what is involved in the performance of transparency and contestation. This further echoes object oriented accounts of knowledge controversies in understanding what transparency means for the governing of science and fossil fuels (Barry 2012; Callon et al. 2001; Latour 2004). This project brings together the multi-faceted, contested and spatial analyses of transparency, showing that the making of transparency is complex and varied across different geographies.

2.2 Transparency in "Theory" and "Action"

The idea of transparency has much been applauded as a desired outcome of good governance. Advocates of transparency argue that all varieties of transparency policies share common roots, characteristics, and challenges, and hence an effective single policy innovation can solve the problem of access to information (Fung et al. 2007). As Oliver (2004:10) puts it, transparency is understood to be "the flashpoint at the intersection of *the public's right to know* and the individual's organisation's *right to privacy*." A step further towards a general theory of transparency, Florini (2007) points out that the struggle over the right to know versus to withhold reflects different patterns of economic and political positioning in a society. This belief in the power of information puts an emphasis on the value of public knowledge that is expected to facilitate informed and rational action.

These functional theories of transparency, however, lack a critical understanding of "transparency of what?", "transparency for whom?" (Fisher 2010) or "why there is almost always a quest for more information in demands for transparency?" (Barry 2010). A reflexive appropriation of the idea of transparency pays attention to the contested boundary between what is rendered visible/open and what is kept invisible/secret. And it also addresses whom this information is conveyed to and in what form, and what the publication of information does or achieves in practice. What does transparency entail then? Fisher (2010: 275) identifies four underlying components of transparency: "*a) a departure from status quo where a valuable information is concealed or not made visible; b) making the exercise of power accessible or visible, particularly power exercised by institutions; c) what is being made visible is a source of power that those within an institution are drawing*

on for their power; d) access and visibility may take different forms." What is interesting in this set of questions is the recognition that transparency is inconsistent in practice. As Jasanoff (2002) rightly observes, transparency is "far from consistent but selective", as it conceals even as it discloses through various legal and non-legal practices. This paradoxical nature of transparency in operation encapsulates the irregularity of transparency.

Although transparency demands are historically associated with the activities of governments, they have also been directed towards business, especially after infamous corporate scandals involving financial misreporting in the 1990s. As the quality and quantity of information provided to market agents gained prominence, a wide array of regulatory and voluntary frameworks emerged in order to facilitate the standardisation of corporate disclosure in "each and every market against various public and private templates" (Clark and Wojcik 2007). Following this critical moment in corporate governance, disclosure has constituted the linchpin of debates about the role and responsibilities of corporations (Conrad 2006).

Central to the debates on corporate scandals, it is important to examine the rationale(s) behind corporate secrecy. Theories of corporate secrecy identify economic efficiency (Hebb 2004; Pratt 2005), moral value (Clark 1990), and organisational aspects (Nadel 1975) as key drivers for corporate secrecy. The principle-agent problem, as theorised by institutional economics, identifies information asymmetries between principal and agent as the main issue (Hermalin and Weisbach 2011), because *secrecy* as a default option for the agent is justified on economic grounds (Pratt 2006). From a normative perspective, Clark (1990) argues that corporate secret-keeping attacks social norms, which can be damaging to economic relationships and the effectiveness of regulatory agencies. Furthermore,

Nadel (1975) shows that organisational culture of corporations affects their decisions to put information in the public domain which can take the form of selective disclosure or complete non-disclosure. All of these arguments frame corporate secrecy as an intentional act of concealment that distort regulatory practices, send wrong signals to market and investors, and foster public mistrust (Clark 1990).

From a historical and comparative perspective, other scholars make a convincing case for the transformative effects of the institutionalisation of transparency for the governance of financial organisations and corporations (Best 2005; Clark and Wojcik 2007). For Best (2005), transparency is often assumed to be a solution to the uncertainty in financial systems; however, in practice, the publication of more information does not necessarily lead to good finance governance. On the contrary, the success of a financial regime depends on adaptation of ambiguity into the organisational system instead of denying or eliminating it (Best 2005). In their analysis of the development of Anglo-American financial markets, Clark and Wojcik (2007) also give an elaborate account of how the closed corporate governance model has been transformed into an open one, in which the new "market for metrics" is purported to help calculating risks of investments and eliminating information asymmetries between investors and borrowers. Corporate transparency, therefore, is better understood by looking at its transformative effects on organisational structures rather than focusing solely on the sheer amount of information disclosed (Grossman et al. 2006).

The standardisation of corporate disclosure has been seen as a part of solution to secrecy over corporate practices. Under this new regime of corporate disclosure, the development of new standards, metrics, guidelines and codes were mainly driven by international organisations, civil society organisations, and the business

community (White 2006). Moreover, ideas about corporate regulation have slowly evolved from regulating through hard laws which assumed a controlling government, to soft laws where a plurality of organisations are involved in the regulation process (Power 2007). These regulatory and organisational changes were mainly about laying out an institutional environment, where narrative reporting disclosures and metrics became a norm (Power 2007). At the same time, the new auditing systems have been translated into the regulatory frameworks of the UK and US. For example, after a decade of revisions, the adoption of the UK Companies Act (2006) was a major step in re-defining the responsibilities and role of corporations in financial and non-financial matters. As Clark and Knight (2008) argue, new standards for auditing and reporting of non-financial parameters is mainly driven by institutional investors rather than stakeholders, and it has more do with the market pricing of corporate value than corporate social responsibility (CSR). Likewise, the adoption of Sarbanes-Oxley Act (2002) in the US heightened standards for corporate disclosure, and aimed to tackle with corporations' selective disclosure of their performance (Crusto 2005).

The institutionalisation of new accounting standards, however, has been criticised on various fronts. Power (2007) brilliantly argues that standardisation of accounting principles in fact rendered a new kind of knowledge that requires more expertise. This standardisation process also widened the gap between lay and expert knowledge which brought about a vicious audit cycle: whenever auditing systems proved to be ineffectual in delivering desired level of transparency, the answer become more auditing (Power 2007).

2.3 Transparency, Materiality and Resource Making

Secrecy has long been central to knowledge production in the history of the oil and gas sector (Bowker 1994; Mitchell 2013; Yergin 1990). From early on, the sector developed their knowledge practices, both in the field and research laboratories, in a "black-boxed" fashion (Bowker 1994). In African countries, some oil companies still build "extractive enclaves" around their operating sites, protected by private armies and detached from any "vision" of the society (Ferguson 2005). However, in recent years, efforts to establish new accountability measures in tackling corruption, human right abuses and to foster environmental and social responsibility contributed to the heightened attention to transparency in the sector (Barry 2013; Watts 2008). For Watts (2008), the idea of transparency and accountability almost becomes forced onto the international agenda not only as a consequence of alliance between oil companies and oil producing states, but also due to resource curse theorists who restated the belief that the solution to the root of economic problems of oil producing states lies in the publication of particular information about oil revenues and the creation of a civil society who can assess this specific information. As Watts rightly points out, the commodity determinism reproduced by resource curse theorists diverts our attention from the underlying dynamics governing the political struggle over oil in specific regions, such as the Niger Delta.

In his analysis of "multiple spaces of transparency" along the route of Baku-Tbilisi-Ceyhan pipeline, Barry (2013) describes how public disclosure became integral to new model of corporate governance in the oil sector. Nevertheless, the publication of information has to be understood in relation to its intended effect of transparency within a "new, responsible and ethical" model of corporate governance

(Barry 2013). According to Barry, however, the availability of more information does not necessarily mean the end of controversy. Far from its intended effect of transparency, the production of more knowledge multiplies the surfaces upon which new controversies emerge. Moreover, the proliferation of new spaces of knowledge production, whether it is environmental, social or technical, does not automatically lead to a reduction in the level of secrecy (Barry 2013). In this case, the publication of vast amount of information about the pipeline seems to make a particular sort of information visible to the audience while concealing other sorts of information, including the production of information about the process of information production itself.

Following Mitchell (2013), we could argue that the development of new forms of energy requires a number of different forms of technical, legal and political interventions over time and space. Considering that each country has historically and culturally different trajectories of resource governance, it is equally critical to analyse how a globally desirable shale resource slips into dissimilar categories in different geographical contexts (Bridge 2009). In the case of shale gas, making the resource depended on a complex processes of political, economic and technical negotiations. Just as technical competencies in geoscience mattered in assessing the potential of the shale resource, other technical apparatuses in the domain of legal, economic and environmental impact assessment are critical for the constitution and contestation of the resource in different geographies (Bridge 2009; Callon 1998).

Furthermore, the demand for transparency in fossil economies needs to be understood in relation to other technical disputes about the technologies and geophysical processes that affect the becoming of resource as an economically and politically viable project in different localities and temporalities. Recent work by

resource geographers and anthropologists offers a rich analysis of materiality in hydrocarbon economies, drawing insights from political economy, STS and geopolitics (Bakker and Bridge 2006; Barry 2013; Bridge 2009; 2011; 2013; Kama 2013; Watts 2013; Richardson and Weszkalnys 2014). Although geographers have already adopted the concepts of non-humans/things and material agency in their study of resources (Baker and Bridge 2006; Bridge 2009), the need for defining what constitutes "the material" in the term "resource materialities" is a challenging undertaking for the critical scholarship on resources (Richardson and Weszkalyns 2014). The new attention to the 'rematerialisation' of human geography follows the 'cultural return', responding to the lack of attention to the non-humans worlds of nature and objects (Baker and Bridge 2006). A parallel movement in the STS and actor-network theory called for a pluralist ontology that resists the dualisms of nature/culture and material/immaterial (Braun and Castree 1998; Braun 2005; Whatmore 2002). Drawing insights from this object-oriented analysis, resource geographers adopted new resource ontology in shifting analysis from social relations to relational materiality, arguing that materiality and sociality are 'co-produced' (Bakker and Bridge 2006; Latour 1999; Kama 2013).

As put by Bakker and Bridge (2006), a relational analysis of resource making should account for the role of 'non-humans' in the ways in which social and economic relations are unfolded. To understand classification of a material as a resource, one needs to pay attention to the technological developments, political and social environments, within which 'resource matters' are constituted and contested (Barry 2013; Mitchell 2013; Kama 2013). According to this approach, the material world is continually connected with various calculations in the social, political and economic realms, and contingent purification of these categories are often negotiated in the

national technical networks (Bakker and Bridge 2006; Kama 2013; Latour 2004). Instead of treating the resource as a social construct and/or letting the social triumph over the material, this new approach to the study of resource making as a material process brings forward the relationship between the social and the material (Richardson and Weszkalyns 2014). In this relational framework, resource materialities refer to more than the physical and chemical properties of the resource. This framework also pays attention to the ways in which resource ontologies are negotiated in making of local, regional, and global scales, and the varying technical processes for resource assessment, as well as to the ways in which these resources are transformed by people who work with them (Richardson and Weszkalyns 2014).

In this new field of study, Richardson and Weszkalnys (2014) identified the need for comparative empirical work on resource materialities, studying the specific characteristics of resources and the processes through which they become resources in different localities. The becoming of a resource often depend on the technical interventions and physical production, yet the potentiality of a resource needs to be rethought in relation to the history of political, economic and cultural factors that transform the ways in which we think about the resources over time (Richardson and Weszkalnys 2014). In her comparative analysis of making of oil shales in Estonia, Jordan and the US, Kama (2013) makes a compelling argument about the varying and conflicting forms of resource materialities that come into being through geographically different knowledge practices in geoscience and the technological development. By tracing the making of shale gas as a resource in the US and the UK, this thesis empirically adds upon the comparative studies on resource materialities that examine the relationship between the geoscientific practices, technological development and above-the-ground regulatory arrangements in different localities and

temporalities. As Chapter 4 illustrates, American shale boom quickly captured the resource imaginary of the British government in securing alternative energy future, yet the resource had to be conceptualised and negotiated within the technical, political, economic and cultural context of the UK.

One example of such a relationship examined in this research project involves transparency discussions over the calculations of reserve estimates and economic valuation of the shale gas investments. Here, we see that the mobilisation of a resource through financial markets can be based on early reserve estimates and financial speculation in the short term (Bridge and LeBillion 2013; Labban 2010; Mitchell 2013). As Mitchell (2013) argues the making of shale gas projects depended on the development of technologies of production and extraction but also on the ability of firms to raise financial capital on the Wall Street. Moreover, Labban (2010) goes further, arguing that the financialisation of investments in oil has transformed the relations between price, investment and production, through which oil become a "virtual" commodity that could be exchanged in the financial markets relative autonomously from its physical production. Although Labban's argument assumes a separation of material production from financial valuation of a resource, it captures something of the speculative nature of trading of oil in the financial markets.

In the case of shale gas projects, the making of the scale depended not only on the technical calculations about the potential of the shale plays, but also on the mobilisation of these calculations among the investment community. Although the global gas markets operates differently than the oil market, the trading of shale gas assets was based on financial speculation than the material production of the resource in the US context (Rogers 2013). At the early stages of financing shale gas projects, we have seen a shale bubble as a result of the above-the-ground financial

arrangements that facilitated quick profit returns for the investment community in Wall Street (See Chapter 4 for details).

The STS scholarship on metrology can add more theoretical insights for understanding the relationship between the techniques of resource assessment and economic valuation (Barry 2008; Bowker 1994). Following Barry (2008), we can argue that disputes about estimates of reserves in shale gas projects have to be rethought in relation to scientific and technical networks within which these unstable objects were formed and contested. Here, we might further argue that the immediate impact of circulation of reserve estimates on economic valuation of the resource in the financial markets has to be thought as a dynamic process (Callon 1998; Latour 2004). In Latourian terms (1993), we can suggest that a network of geological assessments and economic valuations of reserves were entangled in making of shale gas projects in both countries. As elaborated in Chapter 4, various "inscriptions", such as written records of a geologist's communications with the industry and investors, and maps and back-of-the envelope calculations, became mediators of converting the matter into an economically viable resource (Latour 1987). According to Latour (1999), the material world goes through a series of transformations and translations, along which a chain of "circulating references" are established and realised in the form of publication. In this chain of references: knowledge is not a result of passive encounter between the subject and object but a consequence of succession of representations and re-representations (Latour 1999). For Latour (1999), these successive transformations at each stage of information production can lead to greater standardisation, calculation and universality, but elimination of intermediate steps made us to believe such a distinction between the material and social world exists.

However, the study of technical disputes regarding the reserve estimates potentially opens up what is not recorded in these chains of transformations. Accompanied with stories of corporate misreporting in the US, the speculative appraisal of shale gas reserves had direct impacts on the economic and political discussions about shale gas investments. In a way, transparency dispute disrupted what was regarded as undisputable about the geophysical properties of shale gas reserves. Relatedly, these disputes made connections between the material and social world more visible, leading to a questioning of what these calculations represented and their implications for fast-paced large-scale shale gas production.

2.4 Law, Science and Geography

Central to this project on making and contestation of shale gas projects, a comparative analysis of the association of law and science in different spatialities and temporalities can be pursued as a geographical inquiry. The legal geography is relatively a new field that links spatial dimensions of social life with numerous legal questions. As an interdisciplinary field, its intellectual roots lies in socio-legal studies, urban studies, critical human geography, and other social sciences with a spatial focus. Furthermore, the STS discipline explores the undertheorised area of science and law by looking into the ways in which legal practice(s) treats both scientific knowledge and non-human objects (Jasanoff 1995; 2004; 2005; Latour 2009; 2004; Whatmore 2003a). The literature review presented here follows parallel movements in legal geography and STS that both addresses the problem of how to map out how the spatial, scientific and legal practices come together in different legal contexts.

The first attempt to theorise the relation between law and geography combined legal positivism with physical geography. The regionalist approach, put forward by

Jean Bodin and Charles Montesquieu in the 19th century, was built upon a reductionist theory of mono-directional causation between physical geography and legal systems (Blomley 1994). Nonetheless, in the 20th century, comparative law scholars (Wigmore 1928; Stein 1977; Grossfeld 1990) revived what Blomley (1994) calls as a "spatial fetishism" by comparing legal systems on the basis of series of geographical characteristics. This approach, however, failed to grasp the complex social, economic and cultural contexts underlying different legal cultures. As Kahn-Freund (1974) put it, analysing different systems of law in strictly legalistic terms without looking at the social context implied an utter misuse of comparative law as an academic field.

One important criticism of the legal positivist approach to the geography of law came from socio-legal studies. Legal pluralists responded to legal positivism's flat account of space (Friedman 1975; de Sausa-Santos 1995; Nelken 2004). In response to legal positivism, a group of legal sociologists and social anthropologists moved away from a static understanding of law in distinct spaces to a superimposition of legal spaces in our actions and thinking (Butler 2003). Moreover, a prominent legal pluralist, Friedman (1975) first introduced the concept of legal culture into legal sociology. In a broad sense, this refers to "relatively stable based on plurality of legal systems operating at various levels of abstraction" (Nelken 2004). Yet, as with any notion of "culture", the employment of the term legal culture is also open to the criticism for failing to account for actual sources of social action underlying legal systems (Nelken 2004). Nelken (1984) provides a convincing argument against using the idea of "legal culture" as an adequate starting point to analyse differences and similarities between legal systems, and warns scholars about comparative law's tired conceptions of "families of law" as the basis of comparison.

Here, it is essential to note that the STS literature made parallel observations about the association of science, politics and law in different legal geographies (Jasanoff 1995; 2004; 2005). In her study of science within the US courtrooms (1995), Jasanoff convincingly shows that the cultures of science and law are distinctive, but nevertheless compliment one another in shaping contested knowledge making practices in environmental tort cases. For Jasanoff (1995; 2004), the epistemic spaces of law and science had to be rethought in co-productionist terms; both scientific and legal knowledge are coproduced through the physical reality of the world and the social organisation of scientists, lawyers and judges who put the reality into orderly systems of knowledge. Accordingly, rationality in judicial decisions is not just based on pre-existing principles in certain political contexts; instead they derive from active performances and enactments of other forms of rationality embodied in varied cultural domains (Jasanoff 1995). Expanding on her co-productionist view to consider the making of biotechnology policy in Europe and the US, Jasanoff (2005) advanced the argument that the ethical, legal and social challenges on new technologies are treated differently in distinct political cultures. According to Jasanoff (2005), technical disputes about the governance of biotechnology are entangled with understandings of nation making, constitutional understanding of citizenship, and forms of civic engagement in different geographies.

In his analysis of the French Conseil d' Etat (State Council), Latour (2009) also points out different regimes of truth pertaining to scientific and legal practices, according to which science operates through a chain of references in producing new knowledge, whereas in legal practice, knowledge is often linked to existing set of rules and articles written in the law. However, Latour (2009) does not propose a reading of law as abstract technical set of rules independent from the society or a

social science reading of law as a system of power relations, political interests or nation making. Instead, he views law as a form of "association", a network of people and things, and a way in which the world is assembled; events, people, artefacts— such as legal documents and other objects— are an important part of these assemblages and play an important role in the decision making process in legal practices. It is important to note here that in legal practices, less attention is paid to the "things" than "persons" (Whatmore 2003a).

Whereas Latour is centrally concerned with the distinctiveness of law as a 'regime of enunciation', Whatmore addresses the way in which legal knowledge practices incarnate boundaries between people and things/nature and society. Offering a novel hybrid analysis of a legal dispute over GMOs, Whatmore adds upon the literature in geography and law by looking at mobilisation of "things" and "persons" in spatial assemblages of private property relations. For her, just as geography is coming to terms with the conceptual and empirical challenges brought by new forms of socio-technical assemblages, so too law should confront the classification of world into distinct categories of nature and society.

The heightened attention to "geography in law" and "materiality" has also been tackled in the legal geography literature. Influenced by critical socio-legal scholarship, legal geographers have offered a profound explanation of how the social, legal and physical spaces are interrelated (Delaney 2006). Accordingly, law offers an arena in which the politics of space is construed and contested (Delaney 2006). However, in this understanding of law in space, "the legal" is inscribed into the material world. In other words, much of legal geographies literature is based on a false assumption of the bifurcation of law and society, and law and space (Delaney 2010). By contrast, for Blomley (1989), law is more than an abstract technical set of

rules separated from the empirical world of "space". In fact, these sets of abstract rules are grounded in social practice. In Clark's terms, "real regulation" only becomes visible in distinct geographical and economic spaces (Clark 1991). Moreover, the spatial turn in legal geography has important implications for connecting the material world with the social world (Phillippopoulous-Mihalopoulus 2010). Using Lefebvre's notion of "concrete abstraction", Phillippopoulous-Mihalopoulus argues that law is characterised by its materiality and immateriality; the introduction of space forces law to question its internal conflict between its claims to universality and its situatedness in specific material and cultural environments. As a result, law does not only have multiple physical presences; it also shapes and legitimises its material placement spatially (Holder and Harrison 2003).

2.5 Transparency, Constitutive Visions and Governing Spaces of Knowledge Making

As discussed in the previous section, STS oriented approaches to the study of law and science contribute to our understanding of how knowledge-making practices in two fields are both distinct and yet interconnected. Expanding on the spatial debate in legal geographies, constructivist theories of STS and object-oriented accounts of knowledge controversies, I now turn to discuss how contested spaces of transparency and constitutive vision(s) of scientific authority became critical to governing of spaces of knowledge making in the US and the UK. Central to this research project, two theoretical observations will be made about the entanglements of science and politics: first, disparate forms of knowledge making practices should be analysed within their distinct cultural domains of rationality and history of the institutional (both scientific and legal) practices (Jasanoff 2005); second, knowledge controversies could multiply

the spaces upon which new forms of socio-technological assemblages of materials, technologies, scientists, companies, regulators and public are constituted and contested, resisting the demarcation of nature and society/science and politics (Callon et al. 2001; Latour 2004; Whatmore 2009).

In describing the controversies within which transparency became a centre of political contention in both countries, I paid attention to how political authorities and companies assured the public about the objectivity of their decisions and the role of science in these assurances (Jasanoff 2005). Here, this project interrogated the emergence of transparency as a problematic concept that was viewed as a symbol of objectivity[1] in politics, examining the display of public reason in different cultural domains and the role of institutions and scientists staging objectivity in the public sphere (Dalston and Gallison 1992; Hillgartner 2000; Jasanoff 2010). Almost always, making things transparent is associated with the act(s) of witnessing; the power of science and democratic politics is based upon the assumption of being seen, but the space of sight is often culturally varied, institutionally regulated and subjected to change in different spatialities and temporalities (Ezrahi 1990; Jasanoff 1998; Shapin and Schaffer 1985).

If transparency demands are associated with some form of public staging of science, then what is the role of witnessing in the constitution of both the authority of science and politics? It is essential to note here that the constructivist approach in STS theorises these acts of witnessing as an important part of the construction and display of objectivity (Callon et al 2001; Ezrahi 1990; Latour 1986, 1993; Jasanoff 1998).

[1] According to Daston and Gallison (1992), the notion of objectivity gained its ideal status in mid 19th century, especially when scientists began to think about themselves in the research process. Daston and Gallison challenge the modern notion of scientific objectivity as a monolithic category, by showing that it embodies multiple, culturally and historically disparate conceptialisations.

Different ways of seeing produce multiple representations, some which are presented as "objective", but in reality only particular representations are rendered more authoritative than others (Jasanoff 1998). For Ezrahi (1990), a scientific mode of witnessing played a critical role in the formation of modern liberal democracies. In his historical analysis of the development of visual culture in Western science, Ezrahi (Ezrahi 1990) accounts for the transformation of Western societies from a celebratory visual frame to what he terms "attestive culture", in which matters of fact and political acts are constituted in spaces open to public scrutiny. Much as Ezrahi describes the role of witnessing, Shapin and Schaffer (1985) argue that reports of Boyle's experiments conducted at the Royal Society also allowed a public space for performing scientific objectivity, as a part of which matters of facts were certificated through witnessing acts of the members of society. In Shapin and Schaffer's analysis, the image of experiments in the mind of the reader of these reports aimed to depict the scientist as a disinterested observer, who by way of presenting procedures and empirical results in a direct manner distracted the reader from his theoretical conjuncture.

As a crucial component of making things transparent, the culture of seeing needs to be addressed in relation to constitutive vision(s) of modern nation states and corporations, and the role of citizens in such visions (Ferguson 2005; Foucault 1978; Scott 1998). Providing a convincing theory of disciplinary forms of seeing, Foucault's (1979) interpretation of the Panopticon captures the role of sight in a constitutive conception of power. In Foucauldian terms, Panopticism refers to the status of disciplinary society, in which surveillance deepens the modern state's increasing control of individual citizens' lives. In *Seeing like a State* (1998), Scott makes a similar argument about the constitutive vision of the modern state which refers to the

authoritative ways of rendering certain things more visible with the aim of managing them. For Scott, seeing is never neutral; when a particular framing is made visible, other things become invisible. In his paper 'Seeing Like an Oil Company', however, Ferguson (2005) questions Scott's notion of constitutive vision with the example of African "extractive enclaves", a highly protected private space within which achieving the economic goals of a global oil company does not require any vision of the society beyond the borders of the enclave. Ferguson's discussion of this spatialised order proposes a different way of seeing fitting to practices of global oil companies which does not necessarily depend upon standardisation and homogenisation as modern states do in Scott's analysis.

It follows that while the notion of transparency is expected to render the "objective" way of seeing, in practice the notion is selective, constituted and contested in particular spaces and entangled with specific objects, technologies, and problems (Barry 2013; Latour 2004; Strathern 2000). To put it differently, the relationship between sight and power has to be rethought through multiple spaces of information production as a part of which certain materials, objects and issues are made visible while others are rendered invisible. In Barry's (2013) analysis of the BTC pipeline project, he shows that geographically varied performances, enactments and practices of "making things public" and criticisms of what is made public are key to governance of oil. According to Barry (2013), the BTC pipeline project articulated a novel practice of transparency which came to forge "multiple spaces of information production along the route of the pipeline – environmental, geological, technical, legal and social – spaces that are not necessarily isomorphic with one another and that sometimes overlapped" (p.18). Furthermore, the informational enrichment of the pipeline within these spaces is rendered and contested through a network of company

offices, NGOs, consultants, international organisations based in different geographies (Barry 2013). In effect, the assemblages of technical expertise, objects and materials are bound up with a vast amount of information production which marked the (contested) boundaries of the oil company's social and environmental responsibility (Barry 2013).

Yet if the constitution and contestation of transparency is networked through these multiple spaces of information production, then there is something political about making of knowledge claims and the things that occupy a central place in these claims (Barry 2013; Bridge 2009; Mitchell 2013). ANT analyses have already scrutinised the association of science and politics in the making of claims to matters of fact, raising important questions about assemblages of experts, non-humans, and the political power in socio-technical controversies (Callon et al. 2001; Latour 2004; Marres and Rogers 2008; Whatmore 2009). Moreover, the production and circulation of knowledge claims plays a critical role in the constitution of what Michael Watts, following Foucault, terms 'governable spaces' (Mitchell 2013). For Barry (2012), the notion of "political situation" offers a new geographical framework to understand the place of materials on these spaces of knowledge networks. In this framework, materials are not given, but have to be constituted and contested in a series of related events and become more visible through informational enrichment.

If making materials visible requires information production in multiple technical fields, then how is information about things both publicised and contested? Scholars of public knowledge controversies already point to the importance of public forums for the articulation and testing of authoritative knowledge making practices (Callon 1998; Latour 2004; Marres 2007; Whatmore 2009). Callon et al. (2001) also draw our attention to deliberative processes performed during knowledge

controversies, which allows a public space for articulation of multiple points of views, demands and expectations through "hybrid forums". In Whatmore's (2009) lexicon, knowledge controversies can be viewed as "generative events", which can, in principle, serve as collaborative occasions for information production that draw non-scientists into the process of knowledge making. In these object-oriented accounts of knowledge controversies, STS theorists point to democratic processes in which "unknown entanglements of humans and non-humans" are introduced, and a range of concerns about ethics, politics, law and economics contribute to the articulation of "risky objects" (Latour 2004). Marres (2007), in particular, argues that these performances of public involvement are mainly concerned with articulation of contested objects (i.e. dams, roads, pipelines); therefore, it is critical to understand how publics can make a difference in politics by rendering such risky entanglements of humans and contested objects, as well as by analysing the attempts at the publicisation of issues (Barry 2012; Stengers 2000).

Nonetheless, the knowledge controversies literature tends to fail to account for the power positioning of ordinary publics and elite groups (i.e. scientists, regulators, companies), and whose voice has more legitimacy in these deliberative processes (Jasanoff 2003). Considering production and contestation of information as a critical part of governing transparency discussions, it is important to note here that different forms of civic engagement in public disputes about socio-technical matters could render different forms of association between science and politics, nature and society, humans and non-humans (Jasanoff 2005). From a comparative perspective, Jasanoff (2005) makes a convincing case for how disparate forms of public participation and institutional reasoning yield different national responses to governing of biotechnology in Europe and the US. In her account, distinct cultural, legal and

political traditions were crucial in cross-national divergences in administrative responses, public engagement and the methods of expertise advice in policy making.

In this research project, a range of public performances of transparency acts are analysed in relation to how humans and non-humans are entangled, yet the project also pays attention to how historically different forms of public engagement and expertise knowledge making affected public discussions on shale gas development in the UK and US. Overall, the project synthesises the theoretical tenets of object-oriented and institutional accounts from STS to analyse different forms of information production and contestation in British and American contexts. Throughout the thesis, I argue that the notion of transparency should not be taken as granted, but it is constituted and contested through materially informed and institutionally varied practices of knowledge making in disparate geographies. Furthermore, I discuss how transparency demands generated new public spaces of contestation, mobilising risky entanglements of materials, technologies and humans (Latour 2004), and yielded different regulatory outcomes in distinct cultural, political and legal spatialities (Jasanoff 2005).

CHAPTER 3: METHODOLOGY

3.1 Introduction

This thesis aims to expand the understanding of shale gas technologies and techno-scientific controversies regarding the governance of shale gas sites in the US and UK from a comparative perspective. It examines the ways in which the properties and potential impacts of different components of such technologies are regulated and disputed. At the same time, the research focuses on the spatial limits to corporate responsibility in shale gas sites, the accountability of public institutions and the role of experts in investigations of environmental impacts of shale gas drilling. The production of a massive amount of information on shale technologies had two significant political impacts. First, while the fabrication of information about the economic benefits of shale gas development generated financial hype about future investments (Rogers 2013; Mitchell 2013) it also narrowed down the governing of environmental impacts into a series of fixable technical problems which ultimately limited the social responsibilities of gas companies in the local context. Second, it invigorated a broader debate on what is revealed and concealed in the act(s) of public disclosure, raising questions about the role of gas companies and regulatory agencies in generating information about the material qualities of shale gas technologies and impacts of drilling (Barry 2013; Clark 1990; Strathern 2000).

The research process was composed of two stages. The first part involved tracing the evolution of shale gas technologies and the expansion of the American shale gas frontier from the Barnett Shale in Texas to the Marcellus Shale in upstate New York and Pennsylvania. Since, at the start of my project, the shale gas boom had already became a much-celebrated phenomenon in the US, I aimed to contextualise

how the technological preconditions of this boom had been established through countless experiments in the field and laboratory (Bowker 1994). At the same time, I considered how such technologies found wider acceptance in the economics of shale gas through speculative investments on Wall Street. While the shale gas boom began in the US, new shale gas reserves were being discovered in the UK, triggering a nationwide debate about whether the UK should follow the American model in governing this allegedly lucrative and strategically significant resource. Drawing on other technical disputes about scientific, legal and environmental issues related with large scale development, the second part of research process was an inquiry of different national responses to shale gas policy including, in particular, debates about transparency in both the US and the UK (Barry 2013; Jasanoff 2005). In-depth examinations of industry accounts, scientific reports, and interviews with both the veterans of the sector, industry consultants, academics and activists helped me understand the becoming of shale gas as an economically viable and politically desirable resource (Richardson and Weszkalnys 2014).

Overall, the research process involved mapping out critical issues and key actors engaged in public environmental controversies nearby shale gas sites in the northeast region of the US and northwest region of the UK. In the following sections of this chapter, I will discuss the methodological underpinnings of my research, detailing methods for data collection, analysis as well as ethical considerations and reflections during the writing process.

3.2 Research Design

Considering the complexity and wide range of issues raised in the shale gas debate in both the US and the UK, this thesis focused on case studies of specific controversial

environmental issues (see Figure 3-1). These were selected on the basis of the following criteria; first, the case had to be coherently linked to the broader discussions about the responsibilities of gas companies and regulatory agencies in the US and the UK; second, the case had to involve participation by a multitude of actors disputing a particular scientific-technical aspect of shale gas drilling technologies and/or activities; third, the case should provide a comparable and highly rich empirical content that had important political impacts beyond the boundaries of a local and/or national context. This thesis benefited from the case study approach in generating empirically rich evidence to analyse theoretical questions raised in the literatures of resource geographies, economic geography and object-oriented STS approaches (Castree 2005; Flyvbjerg 2006; Levy and Newell 2000).

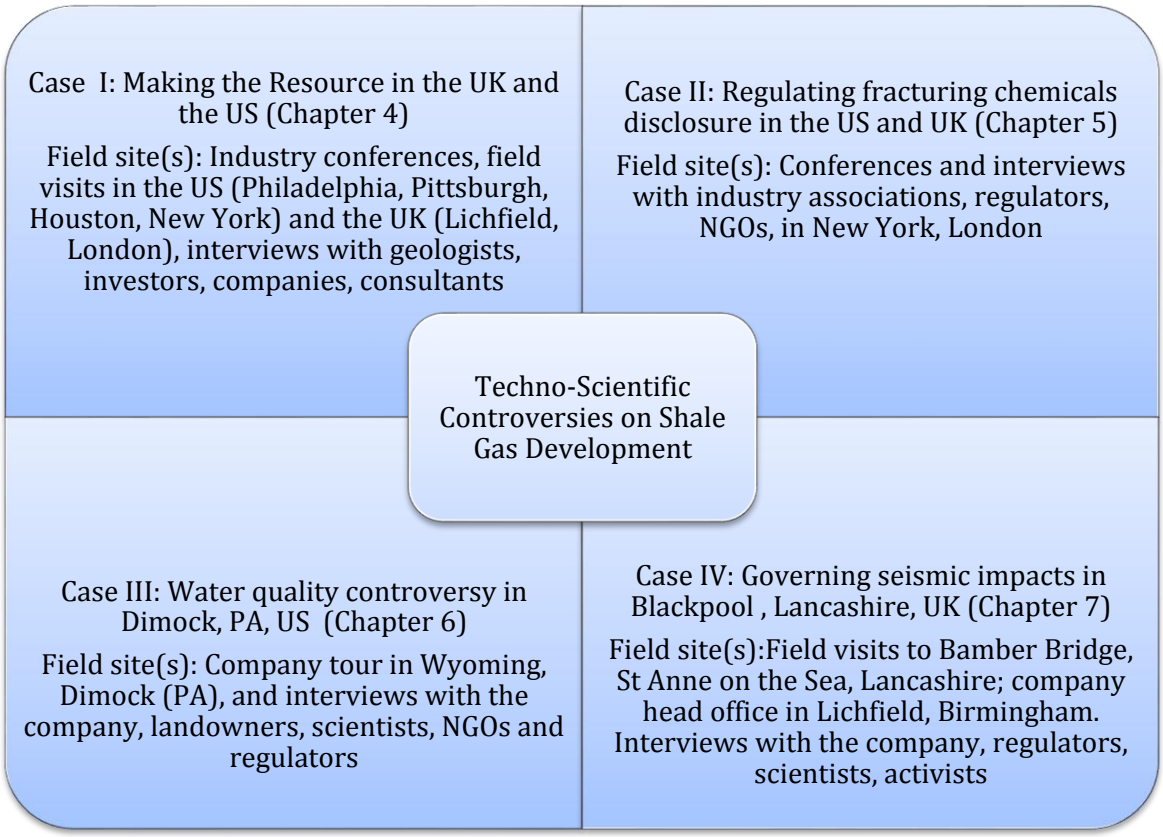


Figure 3-1: Distribution of issues and sites selected for the empirical chapters

The comparative nature of the research made the fieldwork process challenging, but such an approach was necessary to understand the spatial constitution of corporate responsibilities and regulatory regimes regarding controversial technologies in different cultural contexts (Jasanoff 2005). However, the project did not consist of a fieldwork study in the traditional sense, in which the researcher's engagement with the field includes prolonged acts of immersion in a specific territory. Instead, I undertook multi-sited and condensed field visits and attended public and industry events as a participant observer, all of which could be described as insightful ethnographic moments (Kama 2013; Massey 2003; Powell 2002).

Following how the objects of techno-scientific controversies were referenced and controversial corporate practices were discussed in between conferences sessions and public forums, and collecting artefacts and technical documents helped me develop a reflective understanding of the objects of contestation and their entanglement in social-technical networks (Latour 1999). To illustrate, between conference sessions, I approached industry consultants who provided me with important information on the industry's practices of managing drilling impacts, as well as collected various pamphlets, consultancy reports, samples of drilling pad liners and fracking sand. During these conferences, I benefited from attending expert workshops, i.e. water management workshops in Warsaw, Poland and Philadelphia, PA, US, where the industry consultants addressed the most pressing concerns relating to drilling impacts and the companies relayed information about their management practices. Treating "everything as data" (Latour 1999), these events and research materials became critical in fostering my understanding of the pressing issues for the industry before arranging further interviews and conducting field visits.

Visiting the local offices of the gas companies in the US and UK helped me gain valuable insights about the organisational structure and positioning of the companies I studied with respect to the techno-scientific controversies over the impacts of drilling. Although these visits were critical in framing the spatial limits of corporate responsibility, I noticed that it was equally important to explore what was omitted in the official reviews of drilling impacts, and compare these with the official accounts. In the same vein, my participation in public events, where the public actively deliberated the terms of controversy (Callon et al. 2009), played a crucial role for mapping out different articulations of environmental issues in nearby shale gas sites. For example, I participated in a public forum in NYC and a public event in Lancashire. Both events helped me develop a deeper understanding of how issues travelled across borders, and which issues were given more weight and which were completely omitted from the discussion, considering the local sensitivities around the issues at hand. To illustrate, seismic activities were not considered to the degradation of freshwater supplies in NYC, whereas small cracks on the walls of houses, putatively generated by seismic activity, constituted a key evidence for failure of corporate responsibility in Lancashire. To put it simply, even when activist networks were involved in information sharing between North America and the UK, certain site-specific characteristics enacted different sites of contestation which were not generalizable across borders (Barry 2010).

Experts were central to the shale gas development in both countries, and played a critical role in the production of knowledge. This had a direct influence on the financing of shale gas economies, while also establishing the empirical ground on which environmental impacts could be governed. During the data collection process, I paid particular attention to how experts framed and defined the terms of contestation,

how they contributed to the public debate about techno-scientific dimensions of a controversy, and how they were positioned in relation to the industry, local authorities and national government. To give an example, the first empirical chapter on financing of shale gas economics traced how speculative reserve calculations by industry and academic geoscientists were critical in creation of a financial hype about shale gas investments in the US. Echoing Latour's notion of circulating reference (1999), I traced notebooks and the personal written accounts of a geoscientist who was influential in the making of Marcellus Shale as a viable resource. I had a unique chance to observe how academic scholars conducted research, and interacted with the investment community, public and other scientists during my visits to their university offices. These visits also enabled me to observe the social life of expert knowledge making and its ramifications for the governance of shale gas sites.

In sum, the case studies presented in this thesis are carefully selected to give a nuanced analysis of the role of techno-scientific practices in the making of shale gas economies, the spatial limits of corporate responsibility, and the competing claims of experts regarding the presence and severity of environmental impacts in shale gas sites. In the following sections, I will describe how these case studies contribute to broader theoretical discussions on resource geographies, the politics of expertise and economic geographies of corporate responsibility.

3.2.1 Selection of field sites

Undertaking research in multiple sites was reinvigorating and necessary to understand dynamics of spatial constitution of shale gas economies in dissimilar geographies. Nevertheless, it was equally challenging to analyse how different governments govern newly emerging shale economies, considering that the majority of regulatory framework had to be updated or rewritten entirely in response to the fast changing

environmental and economic impacts. Since the hype for shale investments peaked in the US between 2008 and 2012, the search for new reserves expanded to other countries, such as the UK, Germany, Romania, Poland, Mexico, Argentina, Australia, and China. Given the wide range of countries where shale gas was in the process of becoming a major subject of political debate, it was necessary to narrow down the selection of field sites to make the study more manageable. Accordingly, I selected two critical shale gas sites in the Northeast US and Northwest UK – both controversial sites for the political future of shale gas development in North America and Europe, respectively. The idea of selecting prominent controversies to understand broader ramifications of the making of shale gas economies comes from the renowned methodological approach of the object-oriented STS and resource geographies literatures (Barry 2013; Bridge and Baker 2009). As scholars of knowledge controversy studies literature point out, controversies can slow down public reasoning, making it possible to allow diverse actors into the debates over material components of a particular techno-scientific controversy (Whatmore 2009). Since the American model of shale gas development – the first economically viable shale reserve was developed in Barnett Shale, TX– was associated with multiple public debates over governing of adverse environmental impacts (see Chapters 5,6,7), the UK government made visible attempts to distinguish itself from the US model discursively (see Chapters 5,7). Although the public debate on shale gas development in the UK was relatively small at the time of data collection for this project, terms of the debate were affected by the regulatory developments and controversies in the US (Chapters 5,7).

It is important to note that temporal and spatial constitutions of American and European models of shale gas development were different. Independent contractors,

who wanted to have access to low land-leasing prices and less competition from other contractors, carried out operations rapidly and secretly in the initial stages of shale gas development in the US. However, the transformation of shale gas industry from a small play field of wildcatters to an extremely competitive sector with the inclusion of major oil and gas companies took over three decades. Unlike Barnett Shale in TX, the discovery of the Marcellus Shale occurred concomitantly with the expansion of shale gas sector, after a rapid transformation of business landscape between 2008 and 2014. The physical proximity of Marcellus Shale to the Northeastern consumer gas markets and the financial centre in New York City made the economic investments in the region lucrative to the industry and investors. Whereas the shale gas development in the UK was comparatively slow and small in scale, a limited number of companies applied for exploration rights to the Crown Lands and were overseen by the Department of Energy and Climate Change, which owned the rights. In an effort to accelerate shale gas development and subdue local opposition, the UK government announced "all out for shale" strategy, which would allow local councils to keep the entirety of business revenue from fracturing sites while at the same time approving direct cash transfers to local households from shale revenues (*The Guardian* January 13, 2014). Despite government tax support for the industry and revenue transfers to local authorities, the rate of shale gas development in the UK will not match the American "shale revolution" that transformed the US from a net gas exporter to importer within a decade (McGlade et al. 2014).

Moreover, throughout the course of this project, I also witnessed how shale gas politics transformed quickly in response to economic, environmental and political issues that were raised during prominent knowledge controversies. At the start of this project, transparency debate over fracturing chemicals constituted a major political

debacle for the industry, state authorities, public and investors in the US. The failure to disclose propriety information about the composition of chemicals in fracturing fluid did not only have material effects on shale investments, but also became a public concern due to potential contamination of drinking water resources. The regulatory exemptions over fracturing chemicals disclosure at the federal level in the US led to a heated discussion over responsibilities of gas companies and regulatory oversight. Despite the rise of transparency issues at a parliamentary hearing in the UK, managing environmental risks stemming from disclosure failure did not translate into equivalent legislative response from the UK parliament. Considering that a number of policy papers framed transparency failure as an adversary to good resource governance (Liroff 2011; Konschnick et al. 2013; Wiseman 2011), this project problematised the idea of transparency as a universal ideal by tracing legislative discussions in two countries. Following different modes of governing and public reasoning as they were made in live knowledge controversies, the analysis sought to give a nuanced understanding of transparency in disparate geographies of resource making. Through field visits and interviews I aimed at drawing out the relationship between science and policy in public debates over transparency, resource governance and corporate responsibility nearby shale gas sites.

Although there are important similarities between the UK and the US in their support of large scale shale gas development, the lack of regulatory capacity, and high influence of oil and gas industry in regulatory processes, two countries differ immensely in their legal systems and the conduct of politics. Table 3.1 summarises these similarities and differences. As Jasanoff (2005) points out, the UK and the US has significant differences in the formality and extensiveness of legal processes, the styles of administrative decision making, the expert consultations and public

engagement. Echoing Jasanoff's work, this thesis empirically grounded these differences in the case of shale gas governance. In the area of environmental regulation, this thesis emphasised the differences in legal frameworks which governs the environmental risks of shale gas projects. In the case of the UK, goal-based risk assessment regime is prescriptive in terms of objectives, however regulators and companies work together in setting these goals. In the US, however, descriptive regulatory regime itemises what the companies ought to do in line with the riskiness of the industry, and the regulators expects companies to adhere to the stated goals. Other structural difference that affects the scale and pace of shale gas development is the mineral rights regime. In the UK, mineral rights belong to the Crown Lands that requires lengthy process of acquiring exploration rights from the state, whereas in the US, with the exception of federal lands, mineral rights belong to the landowners.

Table 3.1 Comparative politics of shale gas regulation and transparency

	United Kingdom	**United States**
Legal environmental framework	Prescriptive environmental regulatory framework	Descriptive environmental regulatory framework
Mineral rights	Crown Lands	Private ownership; federal lands
Administrative style; expert consultations	Informal; expert consultations	Formal; technical and lengthy scientific review process
Regimes of corporate disclosure	Voluntary public disclosure; full disclosure to state agencies	Voluntary public disclosure; selective disclosure to state agencies
Reputational concerns	Important	Important
Public engagement	By invitation at formal settings; selective representation of recognised stakeholders	Self generated by affected groups; open to all stakeholders

There are, as well, critical similarities in the political discussions over disclosure requirements and public accountability in both countries. Faced with transparency demands, operating companies and regulatory agencies in both countries have to disclose some form of information about the environmental impacts of the industry in the public domain. In the US, although the disclosure requirements grant selective disclosure to state agencies, a new regime of voluntary disclosure emerged to remedy reputational concerns over the lack of corporate transparency. Here, we also see the critical role of litigation and the legal aid from the environmental community, i.e. NRDC, in generation of scientific information to support the affected communities. In the UK, although the litigation is not integral to knowledge making practices, regulators and the operating company agreed on the need for public disclosure as a best practice to tackle with the reputational concerns. Yet, as we will see in the following empirical chapters, the forms and processes of public disclosure, expert consultations and public engagement on the 'matters of concerns' mark the UK and the US styles of shale gas governance and transparency.

3.3 Research Methods

This research is based on a combination of qualitative methods and document analysis. The qualitative methods utilised included field visits to shale gas sites and company offices, participating in industry and academic conferences, community meetings and senate hearings, and semi-structured interviews, while the document analysis method investigated technical and policy reports, industry papers, legal documents, and the local and national news media resources. During my stay in the US, I also visited Cornell and Penn State Universities, which were key institutions with a significant number of scholars working on the Marcellus Shale. As part of my

field study between July 2012 and August 2013, I spent a total of 11 months in the US, and 2 months in the UK, in addition to a short-term industry conference trip to Warsaw, Poland. In doing so, I was able to fully immerse myself into the debates as they were happening, and had enough time to arrange field trips, conference participations, and in-depth interviews that informed the empirical part of this dissertation.

3.3.1 Field Visits

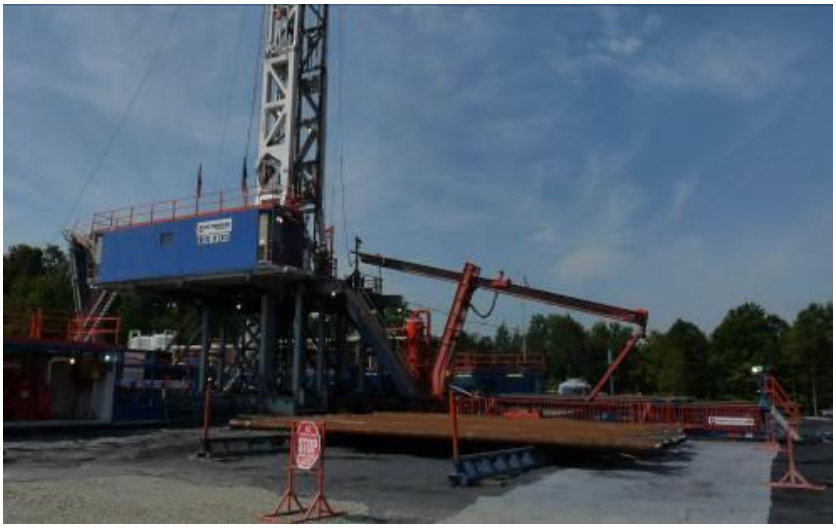
Access to shale gas sites and corporate offices was particularly difficult to negotiate at the beginning of the project, as they were severely restricted to outsiders. The heightened media attention on adverse environmental impacts of shale gas developments made companies especially careful about giving interviews and allowing researchers to participate in their field tours. Snowballing methodology became particularly useful to gain my initial access to these sites. I followed up on the referrals of consultants and policy experts I met during the conferences I attended. These referrals opened important doors for me, in that I secured permission for supervised visits to shale gas sites in the Blair and Wyoming counties in Pennsylvania, US. These visits comprised of brief visits to the sites that lasted only a couple of days, however, they were packed with information about corporate practices in the local contexts.

I began my field visits in the US, in the summer of 2012, where I spent a total of 6 months attending industry conferences, arranging company tours, visiting universities, interviewing political, business and academic experts in New York and Pennsylvania. After familiarising myself with the political and economic landscape of American shale gas development, I travelled back to the UK in January 2013 for 3 months, researching shale gas development in Lancashire and political discussions

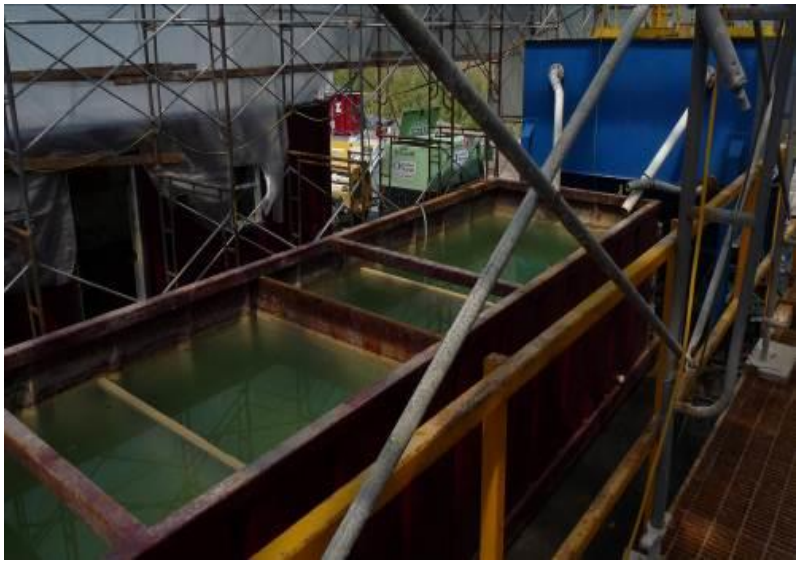
about the future of shale gas development in London. Although I started with the aim of mapping scientific, technical, political and economic issues raised in knowledge controversies in disparate geographies, my knowledge about the industry grew deeper as I gained improved access to companies and the investor community during these field visits. Later visits were undertaken in Houston, TX in the US in June 2013. Visiting different sites of shale gas extraction was particularly helpful for understanding disparate corporate and political cultures, as well as mapping multiple versions of reality in knowledge controversies.

As rightly put by Whatmore (2003b), the relationship with the field is a "risky, open-ended and experimental process" that will help the process of "generating materials" rather than collecting data. As I explored heated public knowledge controversies that had wide media coverage in selected field sites, I was able to identify gatekeepers when I sent out requests for field tours and interviews with the company. In some cases, however, my access to the field was negotiated through such gatekeepers, who tried to influence what I could actually investigate during these field visits (Born 2010). As seen in Figure 3-2, I participated in the company tour of Cabot Oil and Gas, which organises tours for landowners who wanted to visit Cabot's site before leasing their lands as part of their public relations. The aim of outreach program was to convince prospective leasers about the limited impacts of drilling. In fact, the tour was an act of making incommensurable truth about shale gas drilling: the company enacted a reality that aimed to address the lack of technological and economic information that would foster development of a shale gas economy. Therefore, the witnessing act performed by the landowners was a public experiment of transparency, in which stakeholders witnessed different stages of responsible resource development openly (Barry 2013; Shapin and Schaffer 1985). As the

company was in the middle of a liability lawsuit for negligence and environmental degradation in Dimock, Pennsylvania, this tour also stood in stark contrast to competing versions of reality that portrayed the company as irresponsible.



(a)



(b)

(c)

(d)

(e)

Figure 3-2: Company field tour in Wyoming county, PA, August 2012. (a) A week-old drilling site with a close-loop system, (b) (c) & (d) A water recycling unit and testing laboratory as an alternative method for waste water treatment, (e) A completed well site
(Photos taken by the author during the company field tour)

My identity as a graduate researcher from University of Oxford was particularly important for the company. From the start of the field visit, Cabot's employee responsible for community relations closely monitored my field notes, my interviews with the company's employees after the tour and intervened in places if an

employee was making a precarious statement that might put the image of company in jeopardy. As landowners and I were about to be distributed to company cars to go to drilling site, this community relations person made sure that he was accompanying me during the car trip to the site. To them, I was not just a passive participant to this witnessing event. As a part of their public relations program, they cared more about what I would write about the company in my thesis that would be stored in Oxford libraries. In other words, I was regarded as an "expert" that could potentially help them in disseminating a fabricated reality about the company's operations in the region. Throughout the field tour and interviews with the company, I had to negotiate my presence as a researcher and played the card of "objectivity" to keep a healthy distance from their public relations campaign (Bosco and Moreno 2009; Powell 2002; Rose 1993).

This site visit was also critical in understanding the industrial cycle of upstream shale gas business. Although the majority of American shale debate was focused on the fracturing process, this perspective only brought forward the entrepreneurial story behind the shale gas revolution (see Chapter 4). However, the focus on the HF technology did not reflect the entire industry cycle in the upstream business. As it can be seen in Figure 3-3, upstream shale gas activities consist of three industry processes, namely pre-drilling, drilling and production phases. During drilling process, in particular, issues of well integrity (Chapter 6,7), waste water management and surface spills are equally critical for managing environmental impacts, but less known than the hydraulic fracturing process in the public perception of the upstream industry cycle.

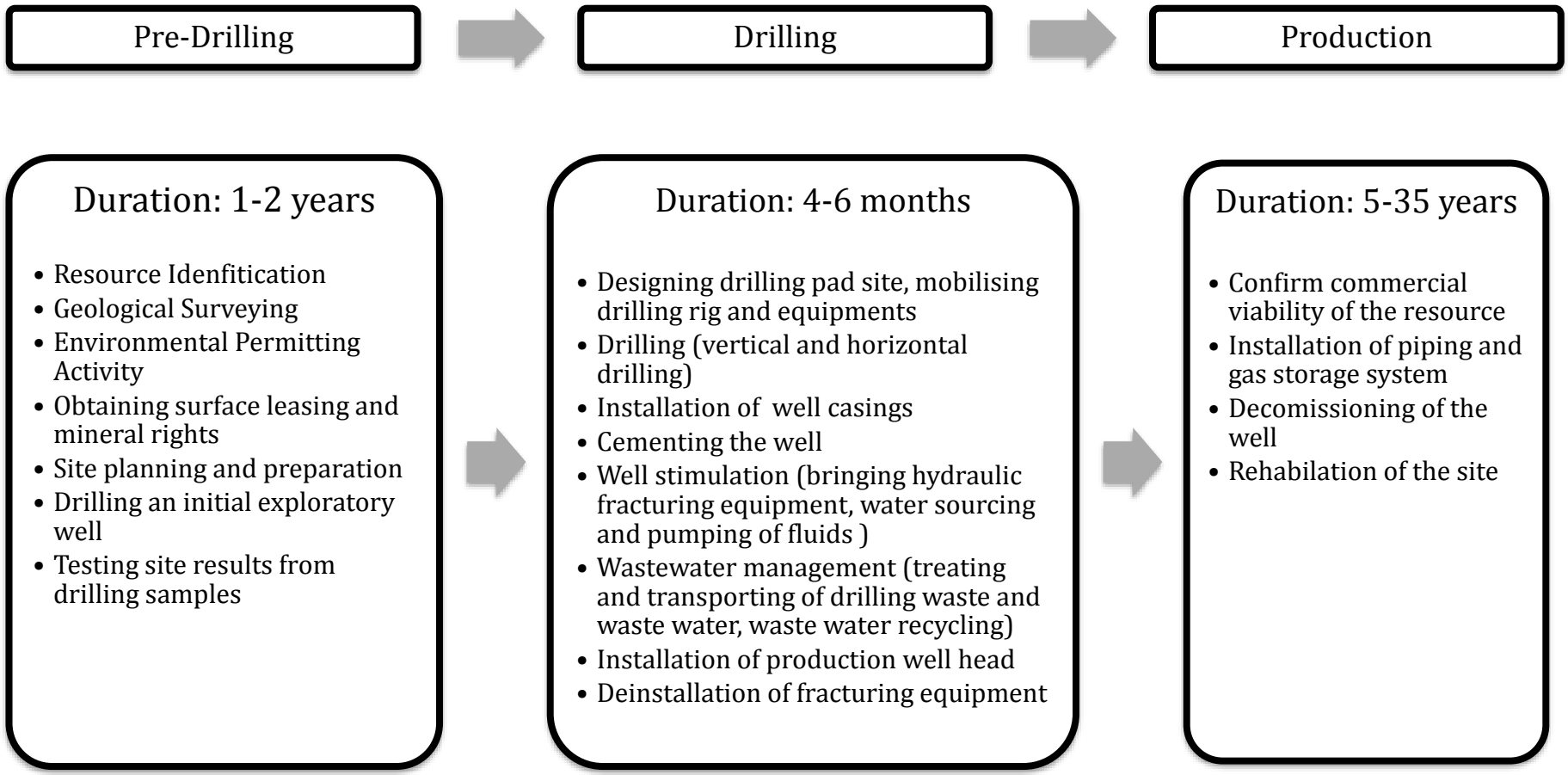


Figure 3-3: Industrial cycle of the upstream shale gas industry

(Source: Field tour, Cabot Oil and Gas, PA, US, August 2012)

Equally, this field tour was critical in understanding the business model of upstream shale gas companies (see Chapter 4), which relies on the complex contractor-subcontractor relationships embedded in the industrial cycle of upstream activities. After operating companies, like Cabot Oil and Gas, identified the shale resource for appraisal, obtaining surface and subsurface rights are mediated through a petroleum landman who is chiefly responsible for negotiating the acquisition of mineral rights with landowners. As the site plan is carried out by the company, drilling site will be prepared for incoming infrastructure of well pads, storage facilities and pipelines. During the drilling phase, a range of service companies provide field services, such as well completion, hydraulic fracturing and waste water management, to the operating companies, therefore these service companies become critical to bringing down the development costs of a shale gas well. In the Marcellus Shale, for instance, the emergence of waste-water recycling companies (see Figure 3-2 above) did not only bring down the cost of acquiring water for fracturing process and managing waste water, but also was instrumental in reducing the environmental impacts of shale drilling activities. Despite bringing down the costs of developing the well, the confidential nature of contracts between the contractors and subcontractors could also become a source of contention. As Chapter 5 elaborates, the fracturing chemicals controversy has to be negotiated in the background of contractual obligations of the operating companies towards the field service companies in protecting propriety information— a complex contractual relationship less visible to the public prior to this controversy.

As I travelled in Dimock, I came across conflicting accounts of what had happened in the aftermath of shale gas operations. Before going to the field, I had

already familiarised myself with journalistic accounts of adverse community relations with local landowners in Dimock (Wilber 2012a; McGraw 2012). Although I was aware that these stories presented a particular narrative through the lens of aggravated landowners, I realised that these multiple versions of reality did not need to intersect, but could provide different descriptions of events and objects in the making (Mol 1999). Latour (2005a) explains how multiple realities occur simultaneously over a political issue: when the reality of one interest group is in conflict with the reality of another, this moment of conflict could open a broader understanding of the thing itself. For Latour (2005a), things are far from inert objects waiting to be discovered; instead new sites of contestation could act like a forum for "making things public", which could generate new matters of concern, political sites and publics. Following the steps of Latour (2005a), I traced how things (i.e. bottled samples of contaminated water, fracturing chemicals, methane) became integral to the discussions over spatial limits of corporate responsibility, transparency and relations of power in Dimock.

Following these texts and encountering multiple versions of reality articulated by different actors throughout the field trip was challenging. Since the Dimock water contamination incident was presented as the 'poster-child' of the adverse effects of fracking in the media, this small town had seen flocking of an unprecedented number of visitors, including journalists, scientists, environmentalists and state officials. After finishing the company tour and interviews with employees, I made my own visit to Dimock to interview landowners. As seen in Figure 3-4 below, there were visible banners and signs that draw attention to "matters of concern" (Latour 2004) relating to the company's operations and the fracturing technology. As water contamination constituted a key matter of concern that became central to a federal inquiry and lawsuit against the company, popularisation of this town among environmentalists

expanded knowledge practices through which technologies of shale gas development was contested beyond the local context. As explored in Chapter 5 and Chapter 6, Dimock became a central political site for competing knowledge making practices over new matters of concern.

Figure 3-4: Signs in Dimock, making a case for unpalatable tap water and asking for compensation
(Photos taken by the author in Dimock PA, 24 August 2012)

By the time I was doing my field study in the US, shale gas drilling operations were stalled due to seismic events caused by hydraulic fracturing of Preese Hall-1 well in Lancashire. Following the temporary moratorium passed in November 2011, Cuadrilla Resources closed down three exploratory shale gas wells (Harvey et al. 2012). Although the government lifted the restrictions on fracking in December 2012, the company was moving drilling equipment and preparing for new applications for exploratory wells when I submitted a formal request for a company field tour. Since there was no active drilling site at the time of my field study in the UK, I visited the Cuadrilla Resources' head office in Lichfield, where I had an extensive interview with an employee who was responsible for overseeing the entirety of operations related to environmental impact assessment. Even though my plans for visiting a drilling site were halted, I made a short field trip to Lancashire to observe a local event and

interview officials at local offices of the Environment Agency in Bamber Bridge. At the time of my visit, there was a community event in St Anne's on the Sea in Lancashire. As I spent time with locals before the event, my knowledge about matters of concern significantly expanded. At the event, I had the chance to observe how locals debated the future of shale gas development following a presentation by an anti-fracking activist from Canada. As I became familiar with issues raised during this event, these observations added to my understanding of how different articulations of a shale gas future was constituted vis-à-vis new knowledge practices in Lancashire.

When I was completing my field study in England, I was offered a new opportunity for a second field trip in the US. This second field visit was made to a major company's headquarter in Houston, TX and their site in Williamsburg, PA. As opposed to the first tour, I was accompanying an investor[2] who was invited by the company for an extended overview of the company's operations, and observation of the research done at the company's headquarters in Houston. My conversation with this investor during an Oxford dinner was a lucky encounter for the research, because I gained access to one of the major oil and gas companies through his connections. Along with his financial and scientific advisors, we travelled together during two days of a company introduction tour in Houston, TX and Pennsylvania. This visit also proved substantial for understanding how the company presented itself to investors, the nature of scientific research done at their laboratories and their drilling operations

[2] I was introduced to the investor during a dinner in Oxford, organised by Weidenfeld and Hoffmann Scholarship and Leadership Programme, which generously provided me with funding for studying for MSc studies at Oxford. As I was seated next to the investor, he began asking questions about my doctoral project and then invited me to his planned trip to Houston. The investor only covered my travel expenses, and I submitted a briefing on my observations during the tour to his advisors in the following week. As a general rule for the field trips, I refused any form of payment from the operating gas companies due to possible conflict of interest.

on the ground. I had plenty of time to talk with the company employees during and in the aftermath of their formal presentations, regarding the economics, technologies and politics of shale gas operations. As my familiarity with the industry grew, I also became acquainted with different corporate cultures, including corporate organisational structures, key areas of scientific research done in research and development departments, and community relations on the ground.

3.3.2 Participant Observation

In line with the broader aims of the project, participant-observation took place in the form of participating in certain industry, policy, academic and community events (Atkinson and Hammersely 1994). As a student from the University of Oxford, I managed to negotiate my way into significant regional industry and policy conferences and workshops, either through volunteering as a room observer at the conference sessions, obtaining a registration fee waiver or paying a reduced fee. In total, I went to three regional industrial conferences and meetings, two of which took place in Philadelphia, PA and the other in Warsaw, Poland; two policy-oriented meetings, one in State College, PA and another in London, UK; one senate hearing in the New York City Hall; two grassroots/community meetings, one in New York and other in St Anne's on the Sea, Lancashire; and two shale gas related film screenings followed by Q&A sessions with activists in NYC. My notes taken during these conferences/meetings were not confidential, therefore did not affect the ethics review of research.

Even though these events were condensed and took over a relatively brief period, I was able to observe key issues being discussed in the sessions and meetings as they were debated locally and nationally at the time. As noted by Kama (2013), conference ethnography is one of the new sites of knowledge production in STS

ethnography, which traditionally focused on lengthy immersion of the researcher in a laboratory setting. For Kama, by following "science-in-progress" through speeches, texts and artefacts during conferences, the researcher could be engaged in witnessing the multiplicity of "the thing" in knowledge practices. During industry conferences that I attended, I also followed multiple representations of key controversial issues, such as water contamination, community relations, transparency and public policy, had extensive talks with the event participants in between sessions, as well as gathered documental resources and material samples from service companies presenting their work at the expo. As I witnessed multiple knowledge practices inside the industry, I was also able to understand the ways in which their realities were organised under a united agenda: the promise of fast and cheap shale gas production in the US. Although environmental concerns and "governance problems" nearby shale sites were addressed in multiple sessions, the majority of participants viewed these issues as an impediment to the future of unconventional energy production in the US.

Nevertheless, conducting conference ethnography presented ethical challenges, especially when the industry in question was engaged in adverse relations with the public. While the conference organisers accepted me as a suitable observer, the tension between the industry and public was quite visible in the conference venue. One of the peak moments of this tension happened at the Shale Insight Conference in Philadelphia, Pennsylvania in September 2012. On first day of the conference, a large group of activists were protesting the companies in front of the conference venue, which was guarded by private security forces. When I stepped out of the session room, I saw conference participants watching and listening to speeches at an anti-fracking rally from windows of the venue. As the day progressed, however, observing immediate reactions of people inside and outside of the venue became revelatory for

me as a researcher. While I did not belong to either side of the fracking debate, this encounter made me feel uneasy about my presence as a researcher. I had the mobility to travel between different groups, participate in events and interview a wide range of people with diverse political agendas. As most of researchers of shale gas found themselves in either side of the debate depending on their field of inquiry, I began to question maintaining my position throughout the research process. Was I truly allowing a "two-way encounter" (Kirsch 2006; Massey 2003) between the researched and myself? Did my research contribute to legitimisation of the industry by unravelling knowledge-making practices that were not visible to the outsider? Although I resisted any hierarchical relation between companies and myself, I was also aware that I was admitted to these conferences because my research was viewed as a good public relations practice for their industry.

My encounters with the field took a different turn as I began participating in public forums organised by anti-fracking groups in both countries. Contrary to meticulously exclusive corporate events with high participation fees, these forums were open to the public and were free of charge. My attendance to several public forums became critical for understanding how "matters of concern" (Latour 2004) were constituted vis-à-vis different representations, speech acts, and expert testimonies. For instance, NY senate public hearing at New York City Hall resembled a "hybrid forum" (Callon et al. 2009), where experts, politicians, activists and residents came together to discuss a long list of issues surrounding shale gas sites and the city. During the meeting, experts and activist groups addressed scientific and technical uncertainties that led to the reformulation of problems facing local communities, as well as residents of New York City. Addressing a wide range of issues from presence of radon in natural gas from shale gas to be used in NYC homes

to prenatal risks stemming from exposure to contamination during pregnancy, the forum did not prioritise "hot" themes (i.e. regulation of fracturing chemicals) over lesser-known issues. The emergence of new questions, and inclusion of new actors who redefined terms of the shale gas debate was not just a technical exercise. In line with observations of Callon et al. (2009) about the features of hybrid forums, plurality of demands and expectations articulated by heterogeneous actors characterised democratic processes during knowledge controversies over shale gas development.

3.3.3 Semi-structured interviews

Since object-oriented STS approach pays attention to articulations of issues, political agendas and techno-scientific problems performed by heterogeneous actors in knowledge controversies, the research utilised semi-structured interviews with key actors involved in the shale gas debate in both countries. These interviews were conducted either following a field tour, in-between conference sessions or through scheduled appointments with interviewees in their work environment or at a public place. To capture plurality of views articulated by diverse groups, I conducted extensive textual analysis and eventually became informed by interviews, which helped in understanding how a network of experts, politicians, companies and public were interacting with each other. Instead of treating knowledge shared during these interviews as "matters of fact", I also paid attention to the ways in which interviewees recounted a particular reality and their engagement with the material artefacts in a knowledge controversy (Latour 2005b). Therefore, this method was based on an empiricist approach (Barry and Slater 2005); semi-structured interviews generated the empirical ground for mapping various configurations of people, things, scientific and technological practices that animate a particular controversy surrounding shale gas projects.

As Goldstein (2002) rightly notes about the nature of elite interviews, getting access to research subjects proved to be important in rigorousness of the research. Since the majority of my interviews were elite interviews, the issue of access constituted a major challenge in getting a response to my formal interview requests submitted to gas companies. Although I started sending my formal interview requests before going to the field (Healey and Rowlinson 1993), several companies either declined to respond or directed me to the company website at most. After attending the European Shale Gas Conference in Warsaw (March 2012) and the Shale Insight Conference in Philadelphia (September 2012), I managed to get contact details of some companies through referrals of industry consultants or talking to company representatives in between sessions. Therefore, I was able to arrange some company interviews by snowballing (Burgess 1990).

Interviews were conducted in a semi-structured way so as to encourage interviewees to raise issues that they perceived to be the most crucial (Valentine 2003). While I raised a set of themes to discuss with the informants, I also took note of new and interesting points raised by the interviewee during the course of more fluid conservations (Hughes 1999). Since most of the informants who were involved in the debate did not want to be named or recorded due to the controversial nature of the current shale gas debate, all interviews were made with extensive note-taking and transcribed immediately after the interviews took place. In the beginning of each interview, all interviewees were asked to sign the consent form, which formally recognised their wish to be kept anonymous. Except for some informants who could easily be identified and asked to waive anonymity, the majority of informants' names are kept hidden throughout the thesis. After a formal review of my consent form, companies mostly agreed to have their names indicated

in the research. Only exception was applied to a major oil company that I visited in Houston, TX. Since I was accompanying an investor and presented with confidential information that might impact their business practice, the company imposed a conditional permission to be named if their legal team were to be allowed to review the draft chapters I wrote. However, a hierarchical relationship with the company and their direct control over what I could write about them would impact integrity of this research project. After talking to my supervisor, I agreed not to include name of this company to preserve independence of the research.

Overall, 29 formal semi-structured interviews[3] were conducted during my fieldwork in the US and the UK, and these were supported by informal extended talks during the field site visits, conferences and community meetings. Interviews could be divided into the following groups:

- Operating oil and gas companies in PA state, US and Lancashire, UK
- Industry employees (i.e. fracturing, well operation, environmental impact management, community relations)
- Regional Industry Associations, i.e. Marcellus Shale Coalition.
- Investors
- Energy research analysts based in NYC, NY and Houston, TX
- Industry consultants specialised in environmental management
- Senior experts from international energy agencies
- Government officials based in environmental, oil and gas regulation and the health and safety regulation agencies.

[3] See Appendix for detailed list of interviewees and timeline for interviews

- Academics involved in the shale gas debate (i.e. geologists, petroleum engineers, water scientists)
- Environmental NGOs based in PA and NY
- Landowners in Dimock, PA
- Grassroot activists from NYC, Pennsylvania (US), and Lancashire (UK).
- Local journalists

The selection of interviewees was based on their relation to a particular knowledge controversy. Initial interviews were conducted with the industry to capture knowledge making practices in the shale gas sector. As I became more familiarised with the workings of the industry, I began sending out interview requests to key actors involved in highly disputed controversies in both countries. While I was building the content of interviews on textual materials, such as corporate and organisation reports, scientific papers and media reviews, I tailored the interview questions according to the individual's background, institution and political agenda. For instance, I did not ask same set of questions to landowners, independent scientists and industry consultants. In some cases, however, the companies that I sent a formal interview request asked for a review of interview questions prior to the interview. Although I sent out a broader set of questions regarding the operations of the company and industry in general, I did not necessarily follow them rigidly if an interesting angle came up during the interview. In effect, interview questions were not structured strictly to discourage interviewees from raising issues that they see important. Starting from the specifics of the case study in question, I tried to be comprehensive as possible to have a broader understanding of how each actor framed the issue, their positioning with the institutions and other actors involved in a debate.

3.3.4 Documental resources

Considering a vast number of company, consultancy, policy and government agency reports were published on the shale gas issue, documental analysis became a key methodology in tracing legal, techno-scientific and corporate disclosure practices. Through document analysis, I paid attention to how these documents often raised contradictory, competing and technically complex issues associated with shale gas development. During the course of the project, I examined an expanding archive of documents that included multiple reports on technologies, environmental risks and financing of shale gas development. To give examples from both countries, Investor Environmental Health Network's report on Disclosing Risks from Hydraulic Fracturing Operations (2011), The Royal Society and The Royal Academy of Engineering Report on Review of Hydraulic Fracturing (2012), the US Environmental Protection Agency multiple reports on Potential Impacts to Underground Drinking Waters (2004; 2011a; 2012), and the UK Department of Energy and Climate Change Report on Earthquake Risks (2014) were critical documents written by experts who were seen as qualified people to examine the particulars of a techno-scientific debate. All these reports were a display of the complex, multi-layered and highly contested techno-scientific issues that underlined the debate over environmental and economic impacts of shale gas projects in the US and UK.

Just as Barry (2013) illustrates how information about the qualities of materials played a central role in the political life of the BTC pipeline project, this project showed that estimation of shale gas reserves, behaviour of methane, contents of fracturing chemicals and seismic risks were bound up with information production. Although the shale gas development is relatively a new project in both countries, a good number of reports and scientific papers were published on these themes. For

instance, the knowledge controversy in Dimock (Chapter 6) was tied to consultant reports and scientific papers that conveyed competing information about the causes of water contamination, spanning geological features of the region in the past and after the shale gas operations. In juxtaposition to each other, these reports and papers defined the spatial limits of corporate responsibility and liability. Following Barry (2013), therefore, I acknowledged that these documents were part of dynamic interaction of practices and processes in certain places, and had "emergent effects" on the politics of shale gas development and corporate responsibility.

Furthermore, I reviewed legal documents, including relevant regulations, parliamentary hearings, and commentaries on these documents as a way of understanding how legal practices played out in different localities. Majority of these documents were open-access online in relevant government, media, and consultancy and company websites. In particular, documental analysis of legal frameworks from a comparative perspective was informed by debates in legal geography (Blomley and Clark 1990) and STS disciplines (Jasanoff 2005). Following Clark's (1992) observation about regulation as a social practice, I paid attention to how regulatory discussions were made in distinct geographical and economic context(s). Moreover, the project embraced Jasanoff's (2005) approach on comparative law; by accounting for cultural specificities in law making practice, the project examined science-policy relationship through a community's own terms of reference and history of institutions as they were manifested in legal documents. This project, therefore, utilised from documental analysis to map out how different aspects of legal cultures of the US and the UK resonate and fit together in varying shale gas controversies, providing "thick descriptions" of law and what they imply for corporate governance and public science in individual events selected for case studies (Jasanoff 2005; Nelken 2004).

3.4 Research Ethics and Writing Reflexively

As noted in previous sections, this project was attentive to various ethical issues involved in formulating research questions and use of theory, research process and generating materials, and writing reflexively about it. From its inception to completion and writing of results, I was aware of my interventions as a researcher, which brought along ethical responsibilities carried over each and every stage of the project. As I participated in research events, my encounters with the field also required a questioning of my own position in the process of knowledge production (White and Bailey 2004). Although this project adopted an agnostic approach towards shale gas industry at the beginning, there were multiple occasions where I had found myself transformed by such ethical encounters throughout the research process (Massey 2003; Stengers 2005). Following Thrift (2003), I worked towards "exercising of better judgement in the conduct of research as a whole". Throughout the research process, adopting this understanding of ethics as practice often required creative imagination and trying to sustain good encounters with the researched (Thrift 2003).

Researching controversial issues was not devoid of challenges. In field visits, there were critical ethical encounters when I reflected upon my subjectivity. While I was questioned about my motives on numerous occasions, being a researcher from Oxford was intriguing for several companies, consultants and experts working in the industry. As my first impressions were accumulated about the industry, I understood that my alleged "objectivity" was met with suspicion. Since gas companies were already struggling with bad reputation, they were carefully reviewing whom to talk to and what to say to outsiders to the industry. In industry conferences, my presence was

confusing for other participants who came together to network, present their product and talk about new business opportunities away from the eye of public. When we talked in between sessions or at lunch breaks, conference participants were mostly surprised about how I gained access to the conference and intrigued about my research. In as much I was trying to get to know the industry, they also inquired about my background, and why I was conducting a research on them. I often found myself explaining this study as a broader inquiry about the industry, not an inspection of their operations. When I established myself as a credible source, I became valuable to companies, who thought my research could disseminate knowledge practices and portray them as an industry working towards being more responsible and transparent.

There was more involved in negotiating the terms of my engagement with the industry. From the beginning of research, I was attentive to the forms of power relations arising from the epistemic positioning of the researcher in terms of gender, race, age and class (Harraway 1988; Longhurst 2009). In the energy sector dominated by men, I was noticeable as a young woman, who was neither native to the country nor a professional from the industry. In a conference room full of men, my presence generated enthusiasm among participants, who were eager to talk for extended hours and get to know me in between sessions. On one occasion, a senior industry veteran, whom I interviewed previously, introduced me to another colleague: "There is a Turkish lady who wants to speak to you about corporate practices in the sector". In another instance, I was told that I should better understand that fuzzy tap water was not a bad thing as a citizen of Turkey. Although I often exercised sympathy with the researched, I realised these remarks were generally coming from conservative and older members of the industry. Considering ethics as "a two-way encounter" with the researched (Massey 2003), these encounters were critical for myself to come to terms

with my identity, but also informed my understanding of how notions of gender and race were construed in the sector.

During the process of collection of data, there were some ethical considerations regarding the conduct of semi-structured interviews. Before going to the field, this research was reviewed by ethics board in Oxford, which provided institutional ethical guidelines generally give a set of formal rules about consent, anonymity, privacy, confidentiality, and identified various risk areas to the researcher and the subject (Dowling 2009). In general, the project did not necessarily conflict with any of these rules, but it went beyond the positivist tradition of ethical review (Thrift 2003). Throughout the research process, I discovered that conducting interviews was in fact a form of art: encountering different personalities, and creating a space for interviewee to raise issues important to them while maintaining a direction was a difficult task. In some elite interviews, the interviewee went along with the open structure, raising new issues enlightening for the research. A minority of interviewees tried to control the structure of the interview, and instructed me about whom I should speak and should not to speak after the interview. These interviews turned out to be difficult; in some cases, I struggled to get a response beyond few sentences, and in others, the interviewee saw himself/herself as a lecturer directing the course of the interview. These encounters made me to become aware of power relations between the researched and researcher in elite interviews, and how a hierarchal positioning could jeopardise a dialogical relationship in a semi-structured interview (Longhurst 2009).

Some of ethical questions derived from epistemological and ontological assumptions related to adopting a pluralist ontology, which recognise the influence of non-humans in politics (Barry 2010; Latour 2004; Whatmore 2003b). As I became

embedded in knowledge making networks of the shale gas industry, I noticed the connections between things and narratives told in knowledge controversies. The material artefacts, i.e. samples from operating companies, examples of shale rock, information pamphlets and reports about the technologies of shale gas were part of the research experience and had emergent effects on the politics of shale gas development (Barry 2013; Latour 1999). As a researcher, I took account of how these artefacts travelled across different localities, and their connections to networks of expertise. Throughout the research process, I engaged with these artefacts, and experienced how material qualities of things became important in knowledge controversies. Overall, these artefacts were inseparable from the research process and my account of the shale gas development in both countries.

These ethical questions continued as I began writing my research results. Informed by object oriented STS literature, this project acknowledged that ethics of writing process necessitated a situated and reflexive relationship with the research material. In Latour's (2005b) words, writing is in fact an act of transformation, a practice, a process of assembly of words, and inactive accounts. Writing process is, therefore, far from transparent and objective; instead it requires reflexivity about the whole research process with its research methods/design, research materials, theory and the writing itself (Bingham 2003). Although there were several ethical, epistemological and ontological questions that rose throughout the whole research process, the project worked towards engaging with these encounters in a creative and productive way during the writing process. The process from research design to writing allowed for possibilities of co-production; by admitting the researched into co-fabrication of research material, I had a "risks relationship with the data", not knowing what issues, concerns, and actors would exactly come up during the research

process (Thrift 2003; Whatmore 2003b). Analysing interviews, field notes and reports, I noticed that I was recounting the knowledge practices that were not necessarily visible to the outsider. In a way, this project runs the risk of being viewed as a promotion of industry practices. I was aware of limits of my engagement with research material: since I was deeply immersed in the process of knowledge making practices as they were made and contested, my writing also reflected highly technical, messy and complex reality of shale gas politics. For these reasons, this project is a partial account of the everyday realities of shale gas industry.

CHAPTER 4: MAKING THE RESOURCE IN THE US AND THE UK

4.1 Introduction

On April 11, 2011, the cover of Time Magazine displayed a black shale rock, accompanied with the title "This Rock Could Power the World: Why Shale Can Solve the Energy Crisis" (Walsh 2011). The lengthy section on the American shale gas boom in this issue underlined what the industry, politicians and investment community were already speculating about: the promise of a shale gas boom across the US, bringing cheaper energy and millions of jobs at a time of recession, albeit with the risk of environmental problems if its rapid development was not properly handled. As observed in the afterword section of Timothy Mitchell's *Carbon Democracy* (2013), however, while the shale bonanza would massively expand American energy resources and was interpreted by political leaders and the news media alike in terms of energy self-sufficiency, it also meant a long-term dependence on fossil fuels, which were becoming more costly to develop. In other words, there were major issues around the environmental costs and economic costing of the shale revolution.

The economic and energy security implications of the US shale revolution also had transformative effects on other countries, which had already begun appraising their resource base and expected to develop it (Bradshaw et al. 2014). The UK government, as well as the governments of a number of countries in the Eastern Europe (including Poland, Romania, and Ukraine) were enthusiastic supporters of the shale gas industry. By contrast, the French and German governments adopted a precautionary approach to the industry from the start (Reed 2013). Despite the initial enthusiasm of the Polish government, Poland's shale gas development came to be

viewed as a failed experiment, as the government imposed a stringent tax regime and enforced conditions on foreign investments (Anderson 2014). In 2013, France banned fracking and cancelled the exploration rights of oil and gas companies citing concerns about environmental protection (*The Guardian* October 11, 2013). Against this background, making the shale gas resource became an important undertaking for the UK.

At this point, one may ask exactly how the resource imaginary of the American shale boom captured the political imaginations of resource making elsewhere. At first sight, the enthusiasm of the UK government might seem surprising. Kama (2013) rightly pointed out that the globalisation of a resource often operates through geographically divergent and contradictory practices that transform both national and transnational knowledge-making practices. As this chapter shows, the UK scaled its shale gas projects differently from the US. Shale gas as a commercially viable resource was realised in the US at a large scale because of the country's unique social, technical and economic arrangements which eased development and production. However, a process of translation was required to fit the shale resource into the UK's domestic energy system (Callon 1998; Kama 2013).

Although the energy security and economic implications of shale gas development have been critically appraised by academic scholarship (see Christopherson and Rightor 2012; Kay 2011), there is little social science research investigating the technological and geoscientific practices on which the shale boom are based or the implications of these knowledge practices with the increase of shale gas production. It is in this context that the present chapter examines the development of the technologies of shale gas extraction, taking a historical perspective, as well as the impact of this technological breakthrough and the geoscientific practices it

involves, focusing on the financial and land-leasing markets during the recent, fast-paced and large-scale shale gas development in the US, and its implications for the UK's vision of resource development. This chapter, therefore, does not look at environmental issues *per se*, but rather at the history and economics of the American and British cases.

As noted in the scholarly work informed by Science and Technology Studies (STS), the technologisation of the oil and gas sector led to the transformation of its business landscape from independent wildcatters to a globally integrated industry depending on large capital investments (Barry 2005; Bowker 1994; Mitchell 2013; Wylie 2011). Historical accounts of the early development of the sector point to the prevalence of vertically integrated companies, which took control over the entirety of oil supply and distribution networks (Olien and Olien 2000; Yergin 1990). In his rich analysis, Bowker (1994) noted that already in the 1920s, just a small number of companies had access to the large oil fields; a small independent oil-field service company, like Schlumberger, was only able to consolidate in specific locales for a short period of time. Nowadays, the globally integrated industry depends on a complex ownership structure, in which the operating companies owns the mineral rights through land leases or contracts with nation states, which are then subcontracted to specialised service companies (Mitchell 2013; Wylie 2011).

Similarly, technological advancements and financial and land-leasing speculation have been critical in the formation of today's shale gas industry as a lucrative business. In *Carbon Democracy*, Mitchell (2013: 258) argues that "the shale oil and gas producers depended on a further technology to develop the industry: not the technology of extracting energy but the means it developed for extracting funds from investors." While Mitchell draws attention to the financial speculation behind

American shale boom, however, he says little about the technologies that rendered the shale gas formations economically viable fields and their impact on the consolidation of shale markets.

Against this background, the first part of this chapter documents the factors that triggered the recent interest in shale gas projects through a relational analysis of resource making and the material qualities of shale formations in different geographies. Four important factors emerge from this analysis: 1) the technological advancements in hydraulic fracturing (HF) and horizontal directional drilling (HDD) techniques, 2) calculations of reserves, 3) the availability of financial markets to support development costs in different territories across America, and 4) the recent economic interventions for scaling up British shale gas projects. To this end, the chapter aims to provide a "materially-informed" (Bakker and Bridge 2006) analysis of the emergence of shale gas as an economically viable resource in disparate geographies. The chapter first examines the role of field experiments and technological developments that made the Barnett Shale, in Texas, an economically viable resource. It then presents a discussion of the technical processes and methods of translation required for making of the Marcellus Shale, in the Appalachians, located near to the Northeast energy markets. Last part will discuss the UK government's interventions and geoscientific knowledge making practices for developing the Bowland Shale, located in the north-west UK.

4.2 A Relational Theory of Unconventional Resources

Although the field of unconventionals is largely unexplored in geographical terms (see Kama 2013), there is a growing interest in the study of materiality in the resource geographies literature (Bakker and Bridge 2006; Bridge 2009, 2011, 2013).

Establishing an important research agenda by introducing issues around materiality into the field, Bakker and Bridge (2006) proposed a hybrid ontology for a relational analysis of resource making. This acknowledged the importance of "things," – i.e. commodities and biophysical processes – in making a "difference in the way social relations unfold," arguing that these relations were also variable and subject to "the historical products of material, representational and symbolic practices," which, indeed, they themselves became (Bakker and Bridge 2006: 18). As expressed by Bridge (2009), the classification of a material as a resource depended on its relation to technological change and the political and social environments, through all which the non-human world acquired new commodity value to be distributed socially and geographically.

Other scholars have also provided a rich analysis of the materiality of resources, informed by the political environment and physical properties within which resource matters are constituted (Barry 2013; Kama 2013; Mitchell 2013). Kama (2013), for instance, made a compelling argument for the emergence of oil shale as a resource in materially varied forms due to disparate geographies of resource assessment and technological development. For her, a relational conceptualisation of resource materiality requires the situating of unconventional energy resources in the context of their varying and conflicting forms, which result from geographically different knowledge practices in geoscience and technological development. Her object-oriented analysis of the making of Estonian oil shale as a global resource focuses on how the resource is objectified and universalised, and subsequently becomes a potential future resource at specific localities outside of Estonia. In this process, the materiality of oil shale is inseparable from 'above-ground' institutional and socio-technical systems through which shale resources are rendered economically and

socially viable in different localities. Here, Kama (2013) argues that the discussion about economic viability of unconventional energy resources should not be restrained to existing regulatory constraints and market arrangements; instead we need to pay attention to how the 'below-ground' realities, which are a product of abstractions of knowledge practise and technical interventions, have emergent effects on 'above-ground' realities, such as energy security and emissions pricing.

Certainly, the material properties of natural gas[4] were crucial in the production and distribution of this resource and the organisation of a socio-technical life around a new carbon future (Mitchell 2013). The economic valuation of reserves based on the geological properties of shale formations has constituted an important line of inquiry in understanding the development of shale gas as an economically viable energy resource. As noted by Mitchell (2013: 259), gas companies, land speculators and investment banks have played a critical role in marketing the technologies of shale gas "as an engineering process similar to manufacturing, with a greater probability of production than the drilling of conventional wells," which "depend more on the physical characteristics of the oil and the geological properties of the source rock." As this chapter show, the excitement created over the shale gas technologies was also supported by geoscientists, who were instrumental in translating production data into potential reserve estimates for the industry and the investor communities. In the light of recent controversies regarding reserve estimates of particular shale formations, this chapter argues that the questions of economic valuation need to be addressed in relation to variations in reserve calculations and their contestation by rival agencies and federal inquiries.

[4] As Bradshaw et al. (2014) elaborate, the material properties of natural gas as "a high volume, low value commodity" make it costly to transport.

The relationship between the calculation of reserves and economics is well explored in the peak-oil literature informed by the STS scholarship (Barry 2008; Bridge 2010; Kama 2013; Mitchell 2013). For Barry (2008), reserves are volatile objects of the scientific and technical networks in which they are construed and contested, and they may circulate in various forms when they enter the economic calculation. Indeed, scholars working at the intersection of economic sociology of markets and STS (Callon 1998; Callon and Caliskan 2010) point to the dynamic nature of the commodification of things as they enter the economic calculation and actual exchange. In Barry and Slater (2002), Callon emphasised the role of technologies in the organisation of economic markets, linking the study of materials and technology to the economic sociology of markets. For Callon, questions pertaining to the materiality of markets and technical devices are inseparable from the study of the organisation of economic markets. This chapter further explores this area, with regard to the impacts of technological developments and reserve estimates on the consolidation of shale gas markets, particularly the financial and land markets.

In the following sections, four related arguments are advanced in analysing the technologies and economics of the shale gas projects in the US and the UK. First, the high hope for technologies of shale gas development has to be understood in relation to its historical, economic and political environments, in which previously unviable unconventional resources suddenly became economically and politically desirable. Second, the acceleration from development to boom was founded on complex technical arrangements and geoscientific practices that circulated in varying forms upon entering into the economic calculations. In particular, financial and land speculation behind the American shale boom has been shaped and contested vis-à-vis the estimates of shale reserves and their revision by rival calculations. Third, the

politicisation of shale gas technologies led to different regulatory arrangements across the Marcellus Shale formation. As the comparative case study of the different trajectories of Pennsylvania (PA) and New York (NY) states reveals, the technical disputes became central to the economic and political processes that stalled the expanding frontier of shale gas development at the PA and NY border. Last, British government's future vision of large scale resource development depended on the construction of shale gas as an economically viable resource with energy security benefits, as well as on geological and regulatory interventions.

4.3 Technologies of Shale Gas Development

Common industry descriptions of hydraulic fracturing technology begin with a basic explanation of how the injection of large amounts of water with small amounts of chemicals and sand into deep underground rock enables the economic development of low permeable gas formations. George P. Mitchell – owner of the independent energy company Mitchell Energy – is often cited by the industry as the genius behind the successful application of the HF technology to shale gas formations. Although the initial applications of the technology date back to late 1940s, it is Mitchell's development and application that is viewed as the necessary enabler in shale formations (King 2010). A closer look at the history of the technology, however, reveals that its development is actually the result of a countless number of experiments in the field and laboratory (King 2012; Montgomery and Smith 2010), supported by decades of federally funded research and public-private partnerships (Trembath et al. 2012).

Various historical accounts and interviews with industry scientists and engineers point to the intense technologisation of the process and increase of knowledge about

fracture behaviour and how fluids work under the surface over the last sixty years. Although the field-based experiments of gas companies like Mitchell Energy enabled the successful application of the technology to the shale gas formations, scientific developments in hydrogeology and fluid chemistry and new underground imaging techniques also proved to be crucial in development of the technology and its practical application on the unconventional shale formations.

The early history of the technology indicates that it was neither a technically complex nor a large-scale industry practice. Montgomery and Smith (2010) trace the origin of first experimental treatment to "hydrafrac," a well drilled into the Hugoton gas fields of Grant County, Kansas, by Standolind Oil (and later again by Amoco and then BP) in 1947, using mainly naphthenic-acid and palm-oil thickened gasoline and sand to enhance well performance. Then, in 1948, the hydrafrac treatment was introduced to the industry via a paper written by J.B. Clark from Standolind Oil; and in 1949, the Halliburton Oil and Well Cementing Company (HOWCO) received an exclusive patent for the hydrafrac process, whereupon it proceeded to apply the hydrafrac treatment to numerous wells over the next 20 years. The original practical use of the hydrafrac process was based on a simple and unsophisticated engineering, which was mainly small scale and aimed at bypassing pore space near wellbore clogged by drilling mud during drilling operations (Suchy and Newell 2012).

Similarly to what Bowker (1994) describes as the process behind Schlumberger's development of a market niche in the oil and gas fields in the 1920s, the HF technology has also evolved between oil field and laboratory in a "black-boxed" fashion. In the period between 1949 and 1953, Halliburton – as the exclusive owner of hydrafrac patents – experimented with fracturing in its oil fields, paying royalties to Standolind for each frac job (Cahoy et al. 2012). In response to high

market demand from oil and gas industry, however, Halliburton had to switch to a non-exclusive license in 1953. This opened up the practical use of hydrafrac to other oil service companies, which conducted numerous experiments and engaged in a fierce patenting competition over new fracturing techniques in the following years.

In this regard, field experiments played a pivotal role in developing diverse fracturing techniques and the industry's knowledge about the technology's interaction with different geological formations. Both the wildcatters and field service companies relied upon extensive field experiments, which became integral to a company's experience with the "art of fracturing" and developing propriety information embedded in this field experience – as an industry veteran explained, fracturing techniques "evolved as an art, as much as science, since everybody has a different recipe."[5] Thus, developing a fracturing recipe required experimentation with fracturing techniques in the field while keeping company-specific information secret through patents.

The field experiments were critical for a proliferation of different fracturing fluid formulae over the last six decades. The initial hydrafrac treatments mostly used gelled or crude petroleum products and sand in small volumes (Montgomery and Smith 2010). In the period between 1949 and 1954, however, new fracturing techniques emerged. For instance, the original gel fracs were replaced with sand fracs and acid fracs, which were patented by companies like Dow Chemicals (Cahoy et al. 2012). By the mid-1950s, high-volume water frac and river frac was introduced by Dowell (a subsidiary of Dow Chemicals, later Schlumberger), which completed the

[5] In-person interview with the best-practices expert from Marcellus Shale Coalition, Philadelphia, 21 September, 2012. During the course of fieldwork, the concept of "art of fracturing" repeatedly emerged in interviews with industry experts and in keynote speeches at industry conferences. An industry consultant described it as companies' heavy reliance on field experiments as a crucial way of producing new propriety knowledge about fracturing techniques and fluid formulas (Interview with industry consultant, NYC, July 2012).

first high-volume water frac job with 250,000 gallons of fresh water and 200,000 pounds of sand (Cahoy et al. 2012). Additional gelling agents were required to enhance the viscosity of the water (Montgomery and Smith 2010), which eventually led to an enhanced viscosity water-based fracturing process at higher temperatures. These developments were accompanied by an increasing number of patent applications, as each company wanted to maintain product secrecy against competitors (Cahoy et al. 2012).

In the 1970s, the Department of Energy's (DOE) Eastern Gas Shales Project conducted its own research on the Appalachian basin and later funded public-private shale drilling projects, which in turn led to "the biggest accumulation of data and knowledge to date" (Breakthrough Institute 2011). Federal involvement in the development of shale gas extraction technologies, in particular the advancement of drill bits and three-dimensional microseismic imagining, facilitated more effective drilling through shale and enabled drillers to monitor fractures under the surface (Breakthrough Institute 2011).

Three-dimensional microseismic imaging was originally developed by federal researchers and engineers working at the Sandia National Laboratories for imaging coal mines. The idea behind microseismic monitoring goes back to the prediction of mine failures in England. Applied to the monitoring of shale gas drilling, this technology enabled companies to better visualise the direction of fractures and their geographic location (Trembath 2012).[6] In the absence of advanced monitoring techniques, laboratory testing had been integral to identifying the parameters that would determine whether the outcome of a hydraulic fracturing was successful or not

[6] Microseismic frack mapping requires the placement of seismic tools into a listening well near the fracking well and helps with listening to the noise of the frac when the rock begins to break (Interview with Dan Steward, Breakthrough Institute 2011). By listening to the noise, it is possible to produce more accurate data about the frac growth and geometry.

(Jennings 2001, in Cahoy et al. 2012). As a former industry engineer put it, these models shed a light on the "ground truth" with colourful pictures of propagation geometry and underground conductivity (Montgomery and Smith 2010).

Although this technology was initially developed for low-permeable formations, it also found a market niche in conventional oil and gas fields, such as in Alaska and offshore in the Gulf of Mexico (Montgomery and Smith 2010). The wider, successful application of the fracturing technology in shale gas formations, however, only came after two decades of field experiments in the Barnett Shale, Texas, by Mitchell Energy, as mentioned above.

Starting in 1981, Mitchell ordered his engineers to investigate possible ways of producing gas from the commercially non-viable tight rock formation at Barnett (Hinton 2012). The Barnett was known to be rich in natural gas, yet it was not possible to develop it economically due to its low porosity and permeability (Kutchin 2001). Charged with execution of the exploratory task, Dan Steward utilised the best-available science and field experiments employing fracturing technology for the economic development of the Barnett (Breakthrough Institute 2011). The company benefited immensely from the knowledge accumulated from the DOE's Eastern Gas Shales project in the Appalachia basin, and later they received direct research and funding support for the Barnett from the DOE and Gas Research Institute (GRI), eager to support the development alternative fossil fuel resources. During this period, the company approach was to assess the potential of the Barnett without any competition from other developers (Breakthrough Institute 2011).

Initially, Mitchell Energy used the fracturing method with the aim of connecting natural fractures, but when they realised that the Barnett did not have open fractures, they began to experiment with inducing them to release the gas from tight formations

(Breakthrough Institute 2011). By mid-1997, the company discovered that "slick-water fracking" worked better with shale formations than any foam gel, reducing the cost of development significantly (Trembath et al. 2012). This discovery was partially adopted from the water frac used by small operators in the Texas Cotton Valley (Cahoy et al. 2012). Mitchell Energy engineers decided to mix water with chemicals[7] for the purpose of killing bacteria, reducing friction and increasing the viscosity of the water, and they added a little sand to keep the fractures open (Cahoy et al. 2012).

According to an insider account of Mitchell Energy's business history, adopting light sand fracturing and replacing expensive gels with large amounts of water to carry the sand to the fractures significantly reduced the well operation costs while also increasing the amount of recoverable reserves from low porous and permeable Barnett Shale (Kutchin 2001). This new formula also worked better than the expensive foams and gels, which tended to clog under pressure and still sometimes did not work (McGraw 2012). In the meanwhile, Mitchell Energy secretly acquired a huge number of leases on the Barnett Shale, and in 2001 the company was sold for 3.5 million USD, to a larger independent called Devon Energy (Hinton 2012). As a large independent company specialised in HDD, Devon had noticed the significant amount of gas coming from the Barnett Shale under the Mitchel Energy operations and began acquisition talks with Mitchell (Cahoy et al. 2012). After the acquisition, it combined Mitchell's expertise in "slickwater" fracking, as it became known, with its own specialisation in horizontal directional drilling, which led to a take-off in the Barnett Shale field.

Looking back sixty years, we can see that both the field and laboratory experiments became central to the knowledge production process behind the

[7] As opposed to the big oil and gas service companies, Mitchell and Devon Energy did not bother with getting patents for their discoveries (Cahoy et al. 2012).

development of fracturing techniques and their application in unconventional shale plays (King 2012). As summarised by a fracturing engineer, shale reserves are now defined by stimulation technologies, geological features and fluid types.[8] While the early practical use of fracturing technology was based on a simple engineering idea applied on a small scale with little equipment and only a modest volume of fracturing fluid, today's technology requires a large scale, complex and sophisticated application based on advanced theoretical engineering relationships.

Meanwhile, the research laboratories of field service companies, such as Halliburton, Schlumberger and Baker Hughes, have spent significant resources on researching and developing fracturing fluids (Cahoy et al. 2012). Increased knowledge of both the geological features of the reserve and fracturing fluid recipe has become essential to capturing the gas from tight gas shale reserves. It has always been necessary to test laboratory developments in the field, since the geological features of the shale determine the outcome of the technology.[9] Together with these technological advancements and a better understanding of geology and fluid dynamics, it is now possible to visualise the field data and create models about fracture networks and characteristics of the rock at depth (Smrecak 2011).

Fracturing technology has many practical applications in conventional and low permeable oil and gas fields, and it has become indispensable for the natural gas industry. HF is a major facilitator of shale gas development in North America, which

[8] Field notes, Marcellus Summit, State College, PA, October 2012.

[9] Since there are no identical two shale plays, a process of translation is essential in determining technology outcome (King 2012). Just as Mitchell Energy needed to adopt water fracking from an operator in Cotton Valley, so, in 2004, did Range Resources have to adjust slickwater technology from the Mitchell Energy to fracture the Marcellus Shale (McGraw 2012). It is crucial for a technology to be tested in a particular geological formation to see how the fracturing products interact with their immediate environment (Cahoy et al. 2012).

makes up 16% of the total natural gas production in the country.[10] While gas companies hold on to their findings for competitive reasons, the majority of fracturing operations in the natural gas sector still follow the industry dictum "*The more you frac, the more you know*."[11] Despite the huge improvements in fracturing techniques and imaging technologies, there is still a lot to learn about the depth, direction and number of fractures (Montgomery and Smith 2010). As a senior fracturing engineer explains, the industry better understands now the old saying "*Good judgement comes from experience, and a lot of that comes from bad judgment*" (Montgomery and Smith 2010). This encapsulates the necessary adjustments between the field and laboratory conditions as a dynamic learning process over time underlying the "art and science" of fracturing technology.

4.4 Financing the American Shale Boom

The economic implications of the expanding unconventional gas frontier became important in convincing the investment community to funnel funds into exploration and other resource development. As Mitchell (2013) observes, further to the HF and HDD technologies, the post-2009 unconventional gas boom depended on the means to extract funds from investors. In the aftermath of the home mortgage ("subprime") crisis in 2008-09, the shale gas boom provided a new field of speculation for Wall Street financiers, who were interested in the possibility of earning profits from buying and selling land and investing in gas companies that projected profits from reserves they held. According to Rogers (2013), shale became one of the largest profit centres for some Wall Street investment banks, which promoted shale gas drilling, even at

[10] DOE website http://energy.gov/fe/science-innovation/oil-gas/shale-gas-rd
[11] Interview with an environmental consultant working for the industry, NYC, 20 July, 2012.

lower natural gas prices, based on profits to be earned from mergers and acquisitions (M&As) and transaction fees.[12]

The American shale boom clearly changed the business landscape and funding structure in the natural gas sector. As Yergin (2012) records, natural gas extraction from shale formation had been possible since the first gas well in Fredonia, NY, drilled in 1821, but the problem with large-scale gas extraction from shale was "the economics"; simply, it was always very expensive and difficult to extract gas from deep shale formations. However, just as independent prospectors had played a critical role in the development of natural gas sector in the US, so did a new opportunity arise for small enterprises in shale. With the focus of major energy companies fixed on profitable oil fields outside the US, independent wildcatters like George Mitchell were able to develop marginally profitable projects that were being overlooked by the vertically integrated, larger companies (Hinton 2012; Zuckerman 2013). Benefitting from the majors' focus on oil, the independents were easily able to identify land to lease for gas drilling, and, moreover, they received federal funding and research support to develop the fields.

The pioneering ventures certainly expended risk capital. As often narrated in the industry and by journalists, George Mitchell's stubbornness in cracking the code for shale gas at Barnett (and Fort Worth, also in Texas) met with scepticism from his employees, who saw two decades of research and exploration as a waste of financial resources (Zuckerman 2013). Section 29 of the Crude Oil Windfall Profits Tax Act in 1980 provided some federal credit for unconventional drilling (Yergin 2012). Without this federal funding – and the majors' lack of interest in the unconventionals –

[12] In 2011 alone, the shale M&As amounted to $ 46.5 billion in deals (Rogers 2013).

Mitchell would not have been able to afford the expenses of shale gas exploration and HF and HDD experimentation.

When Devon Energy acquired Mitchell and gained access to Mitchell's reserves in Texas, it became the second largest independent natural gas producer in the US (Sidel and Cummins 2001). As Devon further developed HDD in the Barnett Shale, the results were promising, leading to a rush to buy or lease mineral rights from landowners (Zuckerman 2013). Following Devon's successful application of hydraulic fracturing and HDD in Barnett, another independent producer, Chesapeake Energy, from Oklahoma, began acquiring the remaining land in the Barnett Shale and also other promising shale formation, such as Haynesville Shale. Within a year, Chesapeake had become the second largest natural gas company (after Exxon Mobil) in the US. The Wall Street investors financing Chesapeake's land acquisitions were convinced by the vision of Audrey McClendon (then company co-owner) for the future of shale gas production in the country. Chesapeake was to become the company most cited as behind the American shale gas boom; certainly, the idea of "full-speed-ahead natural gas extraction" contributed to the hype around the future of shale gas among the investor community (Gustin 2012).

When new shale fields were discovered in North Dakota, Pennsylvania and Ohio in 2004, land grab became a lucrative investment opportunity in the industry, leading to competition among a number of independent gas companies (Monks et al. 2013). In fact, some independent operators made their fortune by securing these land rights by leasing or buying up lands in promising fields at very low prices. As a landman[13] at the beginning of his career, McClendon's land-grab strategy was executed in secrecy so as to ward off other gas companies; in his talks with the

[13] One who negotiates and manages mineral rights for oil/gas exploration companies. See http://www.landman.org/

investment community on Wall Street, he only promised to develop the world's largest gas field in the Southern US, without, that is, disclosing its exact location to bankers (Krauss and Lipton 2012).

In the period between 2009 and 2012, the shale boom (See Figure 4-1) became a nationwide phenomenon, resulting in the entry of major oil companies into the land grab race, funded by the investment banks (Monks et al. 2013). In order to gain access to land in promising gas fields and experience in unconventional gas fields, major oil companies began acquisition talks with independents. In 2010, Shell acquired East Resources, which held significant lands in Marcellus Shale, following other major acquisitions in the same period, such as the Exxon Mobil acquisition of XTO Energy and BP's of Devon Energy (Pals 2010).

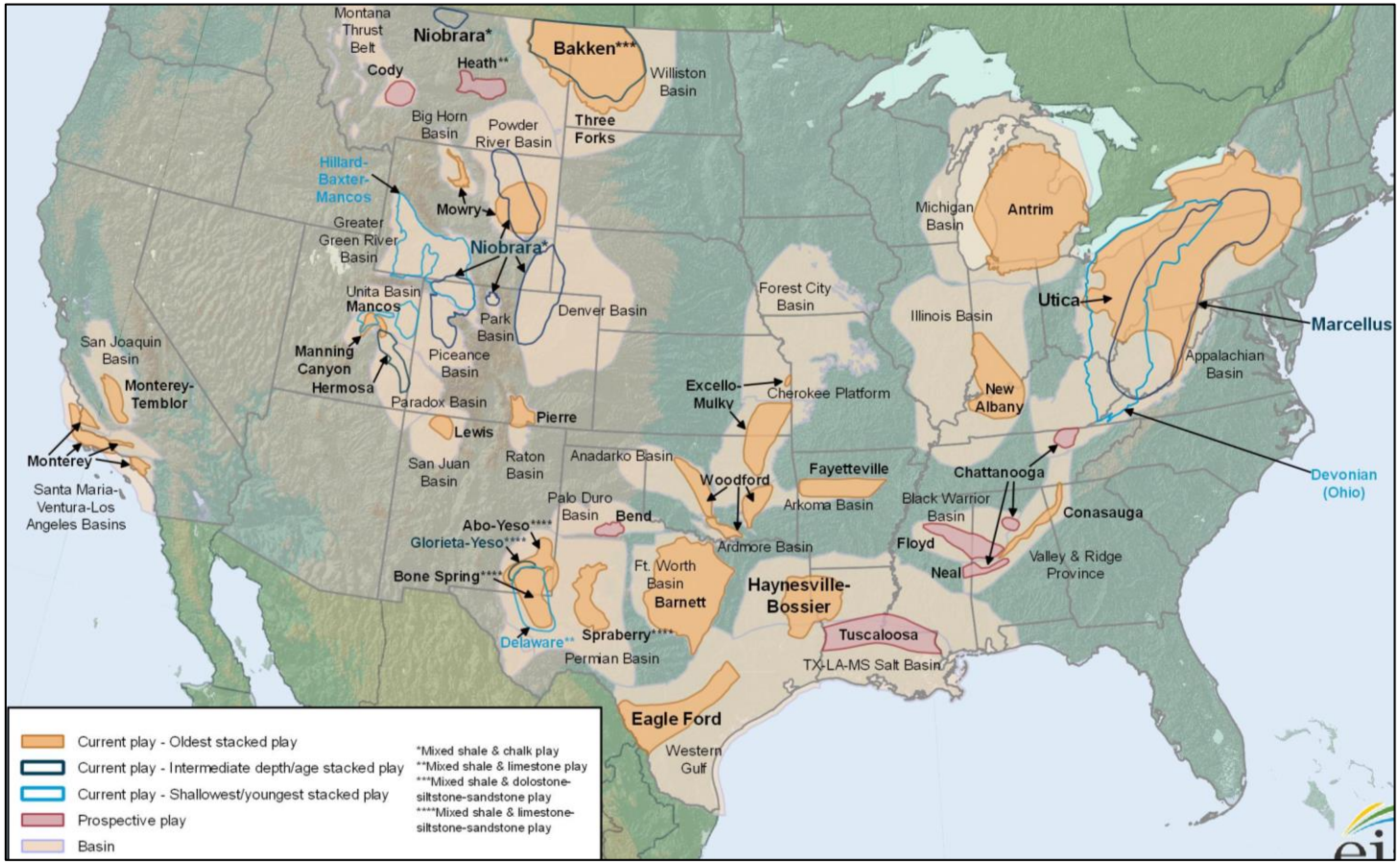


Figure 4-1: US shale plays, last updated by the US Energy Information Administration in April 2015
Source: https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm

To understand how American shale gas industry has transformed from a relatively small business model to a complex one, we need to pay attention to how the industry evolved in the past 25 years (Clancy 2014). As seen in the Figure 4-2 below, independent gas companies, such as the Mitchell Energy, Cabot Oil and Gas, dominated the shale gas industry in the period between 1980 and 2000 (Wilber 2012). Starting with early 2000s, Chesapeake Energy's – an integrated gas company whose operations spans from upstream to downstream, role in expansion of shale gas frontier from Texas to other states was critical (Zuckerman 2013). From 2008 onwards, oil and gas majors' acquisition of independent companies changed the business landscape, indicating a major shift in the role of shale gas reserves in global energy mix. As substantial amount of shale gas flooded the energy markets, the need for capturing, storing and transporting natural gas became equally important. Since 2009, therefore, we have seen the proliferation of midstream companies, which specialises in pipelines, processing facilities, and compressor facilities (Clancy 2014). By 2010, abundant shale gas became a strategic choice for downstream users, such as the LNG sector and the petrochemicals industry that uses the by-products as an industrial feedstock (Clancy 2014).

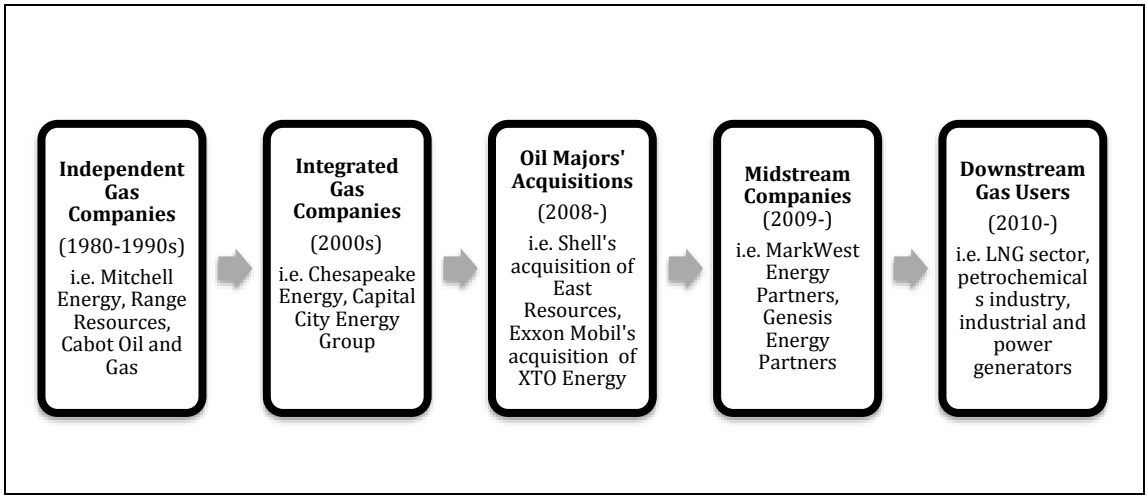


Figure 4-2: Timeline of the American Shale Gas Industry (1980-2015)
Sources: Clancy 2014, ANGA 2015

Between 2009 and 2012, the shale gas hype created in collaboration with the leading gas companies and the Wall Street investors contributed to the generation of a financial bubble, where real monetary gains were made from M&A deals and transaction fees associated with company development costs (Rogers 2013). A recent study by the Oxford Energy Institute (Sandrea 2014) has shown that it was the availability of investment (venture) capital that made the American shale development possible: 200 billion USD were made from M&A deals and joint ventures (JVs) as a result of industry repositioning, and the annual capex from shale plays increased from 5 billion USD in 2006 to approximately 80 billion in 2013.

Following Rogers' (2013) study of financial speculation in the shale gas sector, it is important to note that perceptions of financial gain from emerging gas fields were manipulated in an effort to keep drilling going. The shale gas sector continued to grow even through the economic recession and falling gas prices. Although analysts attributed the price fall in 2009 to the economic recession, they had to revise their projections downward as the sector began booming and prices continued to decline (Levi 2013). The booming shale sector was driving prices down, it appeared.

In the unconventional gas markets, the question of how low gas prices are going to get is a reflection of the geological properties of the shale play and the technology.[14] Since there are geological risks associated with locating unconventional reserves and determining on extraction, it is relatively difficult to make a rough estimate of how many cubic meters of gas can be extracted from a shale play.[15] When the supply of natural gas from shale plays rocketed and prices tumbled, gas companies

[14] Interview with an energy analyst from an international investment bank, NYC, 30 August, 2012.

[15] Interview with an energy analyst from an international investment bank, NYC, 30 August, 2012..

continued drilling, either because they had acreage or were waiting for a pipeline development, which would get the gas to the energy markets.[16]

In 2013, however, all the major companies began massive shale gas asset write-downs. Quoting disappointing well results and profit margins, Shell, for instance, sold 700,000 acres of US shale assets, in addition to reducing permanent staff and contractors by 30% (Schaps and Zhdannikov 2014). Rogers (2013) notes that at the end of 2012, the hype around shale gas in the investment community was slowing down, resulting in a 52% decline in M&A activity. For Rogers, geological constrains and financial exuberance created unsustainable conditions for the sector. In fact, the questions surrounding shale economics had become a subject of debate among the industry even at the peak of the boom.

Leaked industry documents and e-mail exchanges published in the *New York Times'* "Drilling Down" series indicated that the industry had been unconvinced by the shale gas economics from the beginning. On August 28, 2009, the following e-mail sent by a drilling data research team at an energy consultant firm pointed out the questionable economics of shale gas investments:

> The word that l hear from every company that is not in the Haynesville and Marcellus is that they are not economic (…) The word in the world of independents is that the shale plays are just giant Ponzi schemes and the economics just do not work. I just thought you should see it.
>
> (*The New York Times* 2011a)

As the leaked documents and e-mails make clear, shale gas drilling was considered uneconomic even in 2009, at the peak of the shale gas boom. Although the doubts about the economic prospects of shale gas drilling were mentioned, they did not make it to the headlines at the time. In fact, the leaked documents demonstrated

[16] Interview with an energy analyst from an international investment bank, NYC, 30 August, 2012. Meanwhile, other small gas companies began moving to wet gas or shale oil fields, where they could profit from the higher prices from oil and other petroleum products found there.

that various company employees and industry consultants had over-interpreted gas-well results in an effort to funnel funding to their projects. The industry employee quoted below, for example, strongly implied such considerations:

> After reading your reply and your frustration as to how anyone can interpret the results to data and come up with the story these companies put out (…) I do not know of a single individual in the oil business that is investing their money drilling in the Haynesville Shale play. Every single one that I know, that has the ability to analyse the play, has chosen to sit it out (…) So why is it that all of us that are investing our own money are choosing not to invest …… are we all wrong? The education that I get at Enron with these type of people (…) has given me more confidence to go with what I believe once I have the data needed to make the proper decision. I have the proper data needed to evaluate the Haynesville Shale and I will be sitting it out for the foreseeable future.
>
> (*The New York Times* 2011a)

Despite the rising prominence of shale gas investments among policy and investment circles, insider talk among corporate geologists, analysts and energy consultants portrayed a real concern about the speculative nature of well productivity and reserve estimates reported by gas companies. Company employees certainly seemed to see a striking dissonance in the way that Enron marketed itself as compared to the gas company misreporting of the estimates about gas-well productivity in the Haynesville Shale Play, and, hence, misled the investment community.

In April 2012, Audrey McClendon of Chesapeake Energy found himself at the centre of a Securities and Exchange Commission (SEC) investigation targeting his billion-dollar personal loan related to a compensation scheme from his stake in the Chesapeake gas and oil fields (Gustin 2012). As revealed by a Reuters reported investigation, loans were taken from Wall Street investments firms but the information not disclosed to company shareholders. According to a personal account relating to this matter written by Gregory Zuckerman (2013), McClendon failed to

explain his expenditures and loans from the investors to the shareholders. In fact, McClendon's risky strategy of land grab was based on "junk bonds and complex partnerships and future production deals, creating a highly leveraged, deeply indebted company that has more resemblance to Enron than Exxon Mobil" (Goodell 2012).

Even when natural gas prices went down significantly, Chesapeake continued to drill in new gas fields and took loans to fund the land grab expenditures, leaving the company seriously indebted (Zuckerman 2013). As Reuters also discovered, McClendon owned 200 million USD to a hedge fund, which traded the same commodities that Chesapeake produced and could thus be used for price manipulation in the natural gas sector (Schneyer et al. 2012). Since McClendon became an object of accusations and investigation, the company dismissed him from the chairmanship and started its own inquiries about undisclosed financial information regarding his expenditures and loans (Schneyer et al. 2012).

In Rogers's (2013) account, the public relations campaign launched by gas companies exaggerated the actual scale of development in comparison to the actual well performance data. For Rogers, two kinds of "economics" – the field economics (the actual operational costs in the field) and the Wall Street economics (maintaining industry attractiveness to the energy analysts) – constituted the basis of a new business model for the shale gas industry. But the stark difference between these two economic models also made the industry vulnerable, resulting in the massive write-downs referred to above, not only as the price of natural gas went down, but also with increasing operational and land leasing costs, as early as 2011.

Nevertheless, since there was little transparency regarding well production data and operational expenditures in the company reports, investments in the shale gas sector continued. Even non-profitable gas sites were supported by Wall Street

investors who saw an opportunity to earn transaction fees from the still expanding sector, notwithstanding the write-downs. The production of information about the finance and geology of shale gas development, therefore, constituted a field of speculation for investors and gas companies profiting from these transactions.

4.5 Developing the Marcellus Shale Play

In December 2007, Penn State University geology professor Terry Engelder made calculations for the Marcellus Shale, providing a rough estimate of gas reserves tapped in the tight shale formation lying between the states of Pennsylvania and New York and parts of Ohio and West Virginia (Lavette 2010). As a geologist studying the characteristics and formation of rocks, Engelder's "back-of-the-envelope" calculations (see Figure 4-3) for 54,000 square miles (14 million hectares) of rock made the Marcellus Play known to the investment community and resulted in a rush of gas companies into the region.[17]

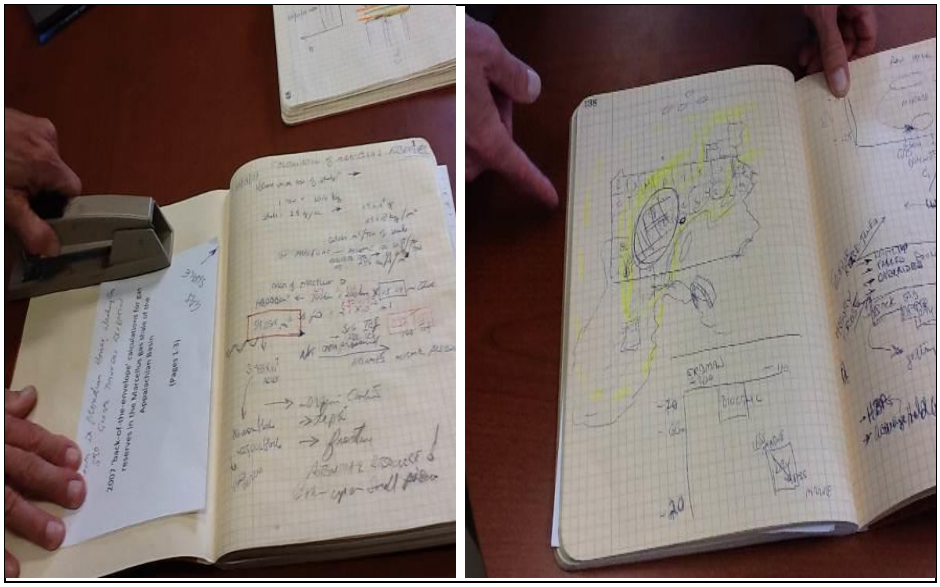


Figure 4-3: Prof Terry Engelder's collection of notebooks detailing the discovery of the Marcellus Shale
(Photos taken by the author at State College, PA, 12 October 2012)

[17] Interview with Terry Engelder, State College, PA, October 12, 2012.

From an investment perspective, the discovery of the largest shale reserve near the Northeastern energy markets was a lucrative investment opportunity and a new market for speculation opportunity after the crisis. As the excitement around natural gas production was making news in respect to the Barnett and Haynesville Shales, Engelder's calculations based on the early production results from gas companies operating in the region constituted a real turning point for the gas rush for the Marcellus Shale (Engelder and Lash 2008).

In fact, Engelder had used the production data provided by a former student working for Range Resources, a natural gas exploration and production company operating in the area.[18] Using the limited available corporate data on well production rates and projecting these onto the whole Marcellus region, Engelder took what he regarded as a "reasonable risk" in making these estimates – yet the rough estimate was also one that was desirable for the industry and its investors. Even though the DOE's Eastern Gas Shales Project had indicated a potential in black shale in the Appalachian basin in the 1970s (Engelder and Lash 2008), there was little enthusiasm left in the industry for the Appalachian basin by 2000 (McGraw 2012). Thus, when speculators began bidding up the land leasing prices, Engelder's estimates also added value to the Range Resources mineral rights (Wilber 2012a).

As one of the first gas companies drilling for shale gas in Pennsylvania in the early 2000s, Range Resources experimented with the old-school drilling methods to extract gas from shale formations in Pittsburgh. Even though the first tests yielded some positive results, these wells dried up quickly, generating serious doubts about the exploration and drilling expenditures made by the company for three years. In 2004, the company began applying the HF technology used by Mitchell's engineers in

[18] See http://www.rangeresources.com/

the Barnett Shale. As narrated by a senior executive from the company, a process of translation and countless number of frac experiments were necessary to "crack the working code for the Marcellus Shale."[19]

By 2007, several independent gas companies began sending their landmen to secure mineral rights in the Marcellus Shale, particularly concentrating on the sweet spots lying on either side of Pennsylvania-New York border (Wilber 2012a).[20] Although leasing for gas reserves was not new to the area, it was mostly small in scale and constituted a small side income for landowners who were used to sporadic appearances from small gas companies interested in accessing mineral rights. When Engelder's calculations made the Marcellus Shale a lucrative investment opportunity, land-leasing prices also increased – from 25 to 2,500 USD per acre (McGraw 2012).

According to a gas company that acquired significant land leases in 2007, before the calculations were reported and the real, supposed potential of Marcellus was known, the market for gas leasing was around 3 USD per acre, so landowners were happy to receive the 25 USD for gas drilling.[21] Later, these low land leasing prices became a subject of controversy when small landowners, particularly those with very small holdings (up to seven acres), became disgruntled about not having received proper monetary compensation.[22] Some landowners that signed early became angry about being tricked into signing the land lease without being informed about true economic potential of shale gas production on the land they sold. The rush to acquire remaining lands by gas companies certainly created a precarious situation for the landowners, concerned to realise full value rights to their lands (Green 2010).

[19] Shale Insight Conference, Philadelphia, PA, September 20, 2012.
[20] Independent gas companies from Texas and Oklahoma, namely Cabot Oil and Gas, Chief Oil and Gas, Range Resources and Chesapeake Energy, were the first comers to the region and acquired significant land leases and purchases at relatively cheap prices (Wilber 2012).
[21] Interview with external relations person from the Cabot Oil and Gas, State College, October 11, 2012.
[22] Interview with a landowner from Dimock, August 24, 2012.

In the period between 2008 and 2012, gas drilling expanded dramatically across the Pennsylvania state, adding up to 6,391 active gas wells in producing counties (Amico et al. 2012). As shown in Figure 4-4, the distribution of gas wells across the Marcellus Shale Play are mostly concentrated in the north-west and south-east regions of the state, where the counties of Bradford, Washington, Tiago, Susquehanna and Lycoming became top producers in the region. As the Pennsylvania gas production more than quadrupled from 2009 to 2011 due to the expansion of the Marcellus Shale development, the state became one of the top ten producers of natural gas nationally. As of March 31st 2015, a total of 9,031 wells had been drilled in the state.

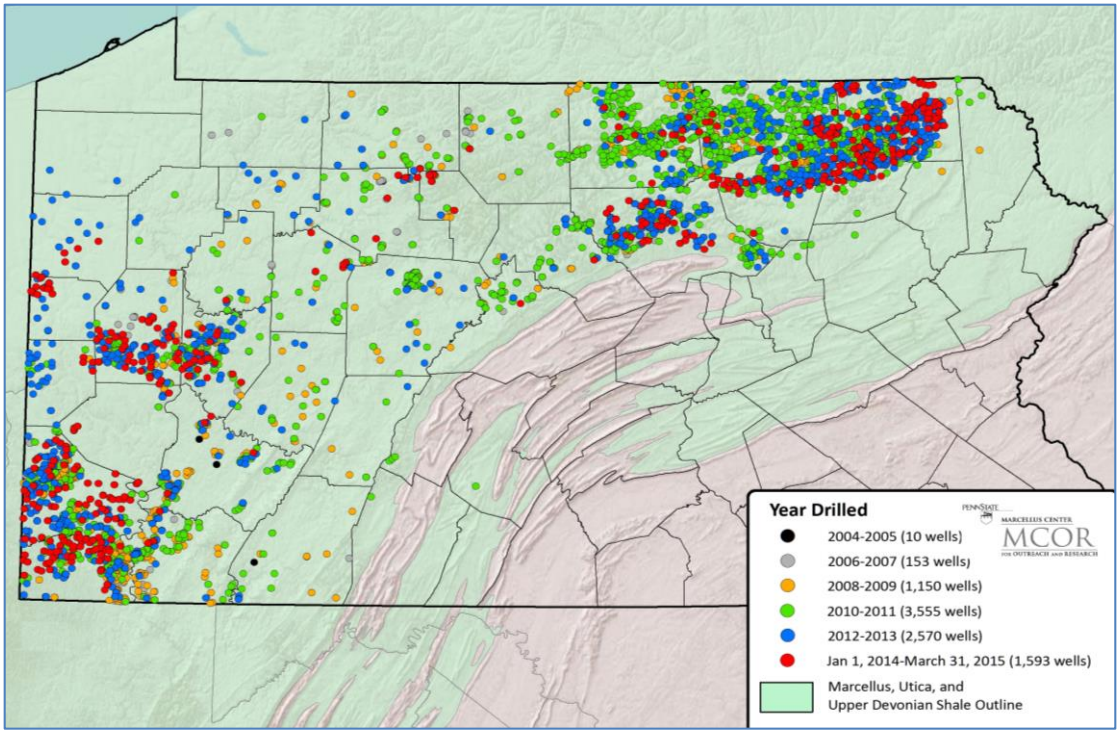


Figure 4-4: Distribution of natural gas wells from Marcellus Shale Formation across Pennsylvania
(Source: Penn State Marcellus Center for Outreach and Research [PSMCOR])[23]

North-western Pennsylvania had been the site of the first American oil boom, in the 1860s .[24] Now again, the rapid expansion of shale gas development in the

[23] At http://www.marcellus.psu.edu/resources/maps.php

Marcellus Shale entered the boom-bust cycle of the extractive industry in the US, generating concerns about the long-term economic, environmental and community impacts of this explosion of activity (Black 2000; Christopherson and Rightor 2012; Kay 2011). Even though the shale boom in the Marcellus was in many ways merely reflective of the wider national expansion of shale gas development, additional factors, such as reduced transportation costs due to market proximity and lack of severance tax and regulatory requirements in the state at the time led to a particular concentration of speculative investment and competition for access to capital among gas companies, exponentially accelerating the pace and scale of development in the region (Christopherson 2011).

Following the expansion of production, more industry data came from the gas sites, generating a heated debate about the real potential of the Marcellus Shale among geologists, state institutions, gas companies and investors. In the debate over the geology of Marcellus Shale, however, the estimates of proven reserves[25] have been changed several times. In the Annual Energy Outlook 2010, the Energy Information Agency (EIA) increased its estimates for unproven reserves for the Marcellus Shale and gave an estimate of 410 trillion cubic feet (tcf) of gas for the recoverable proven reserves (AEO 2010). Although this estimate generated great enthusiasm among investors regarding the potential of Marcellus Shale, it became a subject of controversy when the US Geological Survey (USGS) released its proven estimates for the Marcellus as 84 tcf (USGS 2011), which was significantly lower than both the

[24] The oil boom in the Alleghenies of north-western Pennsylvania, also known as the Oil Creek Valley, came to define the business landscape of the American oil industry, with its reliance on technology, land leasing and financial speculation (Black 2000).

[25] "[E]stimates of hydrocarbons that geologic and engineering data demonstrate with reasonable certainty can be recoverable from identified fields under existing economic and operating conditions. The location, quantity, and grade of the energy source are usually considered to be well established in such reserves." (EIA). At http://www.eia.gov/tools/glossary/?id=P

EIA's and Engelder's estimates. In line with the USGS report, the EIA lowered its estimate by 75%, but the agency had to face an inquiry from the Congress regarding the methodology it had used to calculate its numbers and its dependency on the industry data (Urbina 2011).

Indeed, a senior employee from the EIA stated in testimony given at the Congressional hearing that the agency had calculated the estimates of proved reserves for the Marcellus Shale from private as well as public operators (EIA 2012). Although the agency mainly relies on the USGS data, the non-availability of new information from it combined with the advancements in drilling technologies and the doubling of production between 2010 and 2011 that contributed to the overstatement of the potential of the Marcellus. When the USGS published its own estimates, the EIA took their estimates as the most reliable data, followed by a disclaimer that there was still a room for uncertainty regarding the well productivity data produced by the operating companies in the region (Efstathiou Jr. and Klimasinska 2011).[26]

At the Marcellus Summit in October 2012, a policy expert from the agency explained how opaqueness in the type of production information, which is often provided in the form of cumulative production by gas companies and state agencies, made it difficult to provide a resolution to estimate future reserves in the Marcellus Shale.[27] USGS also made an estimate based on an extremely detailed analysis of geology across all reserves in the US; however their estimate was also affected by the quality of production data. Therefore, the confidentiality of industry data still stood in the way of making better estimates, rendering it difficult to calculate the real potential of Marcellus Shale.

[26] In an interview given by the EIA, the agency stated that the USGS had the expertise in regards to the geology of Marcellus Shale, so it took their data as the most reliable information (Efstathiou Jr. and Klimasinska 2011)

[27] Marcellus Summit, State College, PA, October 11, 2012.

With the estimated potential of the Marcellus Shale constituting a promising opportunity for the industry, a significant number of gas companies joined the land grab race. From 2008 to 2012, the business landscape of the Marcellus expanded dramatically with the inclusion of a range of industry players from small independents to major oil and gas companies, resulting in a total of 59 gas companies operating in the region.[28] With a handful of independent companies, such as Chesapeake Energy, Cabot Oil & Gas and Range Resources, having made their initial land acquisitions secretly at profitable rates (as indicated, above), it became more difficult for latecomers to lease or buy lands at lower prices (Wilber 2012a). Therefore, access to capital, financial speculation and bargaining with landowners became integral to the land acquisition competition (Green 2010).

Starting in 2008, Chesapeake, Fortuna and the Hess Corporation began negotiations for leasing rights on the southern border of New York State, which became the centre of attention after Cabot Oil extended its leasing activities from Susquehanna County, in the north of the state, to Broome County, in the south (Wilber 2012a). In response to this land leasing competition, large landowner coalitions were formed in the area, in order to bargain with collectively the gas companies. Having faced serious informational disadvantages in one-to-one negotiations with gas companies historically – the drilling activities in Pennsylvania were coupled with some notorious cases of intensive land use associated with fast-paced development (see Chapter 7) – these landowners aimed at gaining leverage over the companies before signing away their rights. Through this process, they also became critical of the education of local people on land use and other environmental

[28] For the names, location and production well numbers of operating companies see the National Public Radio (NPR) Media Project. At http://stateimpact.npr.org/pennsylvania/drilling/operators/

impacts (Jacquet and Stedman 2009).[29] Land leases were signed with several gas companies at higher prices – rising up to 5,000 USDs per acre with 20% royalties – although even this, as we have seen from the subsequent land market proved to be a rock bottom price. Thus, XTO acquired the leases to lands in Pennsylvania along the Millennium Pipeline, Fortuna in the south-west and Cabot, Chesapeake to the south and Norse Energy to the north (Wilber 2012).

Development of the shale sector in New York State took a very different course than its neighbouring state. In a series of negotiations with gas companies interested in leasing in southern NY, landowners' coalitions worked towards securing better leasing prices with detailed surface use agreements. These, it was hoped, would protect the rights of landowners to control the nature, magnitude and the scope of land use by operating companies (Wilber 2012a). During the process of these leasing negotiations, however, the New York State Department of Environmental Protection (NY DEP) began to inquire into the environmental impacts on watersheds in the Catskills, which provide the drinking water for New York City, while environmental groups from Ithaca to the New York City began organising against shale drilling across the state. At anti-shale gas meetings held in NYC, watersheds emerged as a key issue.[30]

In the summer of 2008, then Governor David Patterson signed the legislation for a moratorium allowing the NY DEP to study the environmental impacts of shale gas drilling technologies, aiming to provide a balanced review of both environmental and economic issues (Navoro 2010). Although the moratorium was intended to give the space for a short study, it was extended with a series of additional inquires and opposition from both sides. Initially, with gas companies negotiating with the

[29] Interview with a local journalist from upstate NY, New Haven, CT, November 15, 2012.
[30] Field notes, anti-shale public meetings in New York, July-October 2012.

landowners' coalitions, exploratory drilling activities were permitted to continue during the moratorium. In 2009, however, at the request of environmental advocacy groups, such as the Sierra Club and Natural Resources Defence Council, the state passed legislation to suspend all drilling permits until the NY DEP study was completed (Ayala 2011).

Under pressure from what had become an environmental campaign, the NY DEP had to expand its initial study to include other critical issues, namely, health, waste-water disposal and socio-economic impacts, which had not been mentioned in the first drafts of the Supplemental Generic Environmental Impact (SGEIS). Meanwhile, Governor Cuomo repeatedly delayed a final decision on shale gas regulation by extending the scope of the study in the light of criticisms raised against the draft SGEIS.[31] Shale-drilling in the state had become politicised, hardening into a clash of aims and ideologies, with the industry, landowner coalitions and activists pit against one another.

Activists blamed the NY DEC for working too closely with the industry and ignoring public comments and alternative academic research on public health risks and climate change.[32] For gas companies, the extended moratorium meant lost income and high political risk, obviously, and in their view, unnecessarily. And the landowner coalitions, meanwhile, were both upset with company sharp practice and angered by campaigners' zealousness, which together stopped them from getting the drilling benefits they envisioned and thought they were entitled to (Wilber 2012a). Thus, the political process led to the involvement of state representatives and institutions together with the industry, landowners and activists in a series of inconclusive negotiation, that, even today, remain unconcluded. A fast-paced shale gas

[31] Interview with a senior expert from the Natural Resources Defence Council, November 14, 2012.
[32] New York State Senate Hydrofracking Public Forum, NYC City Hall, July 17, 2012.

development in the NY state was stalled in sharp contrast to that of its neighbour, Pennsylvania.

4.6 "All-out-for Shale": Making the Resource in the UK

In January 2014, the UK Prime Minister David Cameron announced that his government was "going all out for shale" (Watt 2014). This new shale gas policy was intended to inaugurate the development of shale gas in the UK on a large scale, in imitation of the American shale boom. In the period leading up to Cameron's announcement, Britain had imposed a temporary moratorium following seismic events at Cuadrilla Resources' first on-shore shale gas well in Lancashire in 2011. Although the moratorium was lifted in 2012, there had been no attempts to commercialise shale gas resources (*The Economist* June 20, 2015). The potential ramifications of the announcement were thus two-fold: first, it was expected to create new economic incentives for the industry and local economy, and second, it would subdue the growing public controversy on the safety and environmental impacts of the hydraulic fracturing process. Nevertheless, building a home-grown shale gas industry would prove difficult until the 2020s due to technical barriers to large-scale development in the UK (Stevens 2013). New socio-technical arrangements, therefore, had to be discussed against the background of public disputes over regulatory agencies' ability to monitor fast-paced resource development.

Though still at an early stage of exploration in 2011, the scale and pace of shale gas project development occupied a prominent place in political discussions over the future of natural gas in the UK. Scale making and negotiation depended on the social construction of shale gas as an economically viable resource with geopolitical importance (Marston 2000). Decreasing rates of recovery in the North Sea since 2004

had led to increasing dependence on gas imports, rendering the natural gas security of the UK vulnerable to events in global markets (Bradshaw et al. 2014). In principle, the discovery of shale reserves in the North England could provide a solution to the growing problem of gas security in Britain (Richards 2012). Indeed, the UK government was particularly enthusiastic about the potential of shale gas, projecting large-scale shale gas production in the country by the 2020s (DECC 2013d). Admittedly, the pace of development would not match the American shale revolution, as there were significant differences in geology, research and development, regulatory frameworks and the nature of gas markets (Stevens 2013), yet there was an expectation, in government at least, that large-scale gas production would be achieved within a decade.

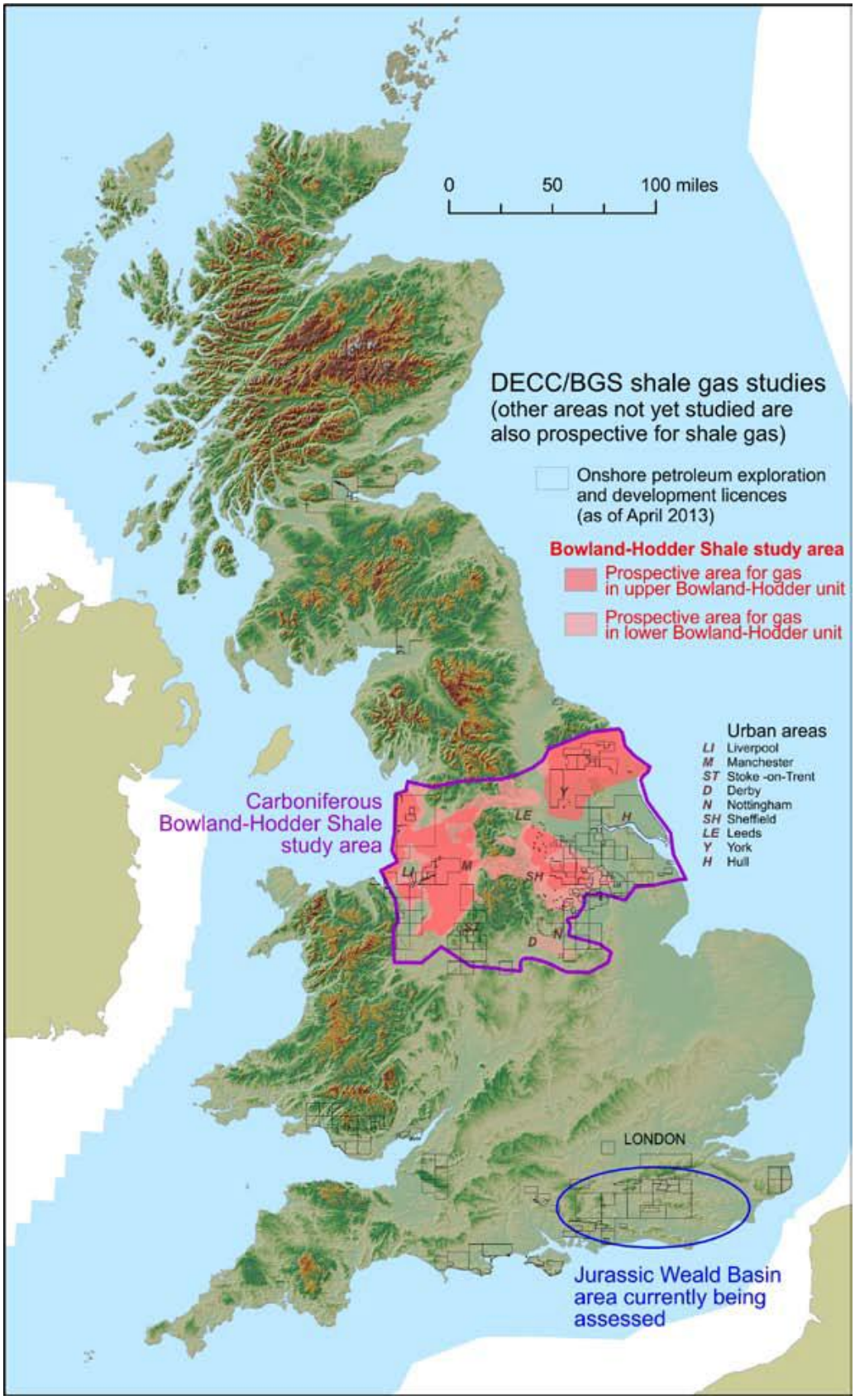


Figure 4-5: Map of shale gas formations in the UK, including DECC/BGS study area, licensed acreage and urban areas. Source: Andrew 2013, p. 2.

Nonetheless, despite the UK government's enthusiasm the scale of shale gas production was not free from contention even at the beginning of exploration activities. Early estimates of the resource base were one area of speculation and dispute and the question of the scale of UK reserves quickly became critical in shaping the grand narrative of the UK's natural gas security and integration into global gas markets. Indeed, as early as 2011, the UK parliament commissioned the Energy and Climate Change Select Committee to produce a report on shale gas. Yet, the Committee concluded that shale gas resources would provide some security for the UK's energy supply but would not be a "game changer" to the extent that it had been for the US (HC Report May 10, 2011). The report based its conclusions on British Geological Survey's (BGS) calculations of shale potential and used the Barnett Shale in the US, which had a similarly low clay content, as a reference for UK reserves estimates. In a 2010 estimate for the UK Department of Energy and Climate Change (DECC), the BGS had put the UK's shale gas reserve potential at around 150 billion cubic feet, a fraction of the estimate provided by the exploration company Cuadrilla Resources of 200 trillion cubic feet (*The Economist* November 2, 2011). In fact, BGS came to a radically different conclusion to Cuadrilla, arguing that it would be difficult to extract the full reserve and recovery rates of 10 to 20 per cent were a reasonable expectation in practice (*The Economist* November 2, 2011).

This lack of consensus over reserve estimates can be understood in relation to the politics of scale making. The geophysical constraints on making of the shale resource are often reflected both in geoscientific and discursive practices. Yet the availability of a resource often requires further contextualisation to understand how uncertain geoscientific calculations of "below the ground" relate to the realities of politics and economics "above the ground" (Bridge and Wood 2010). For instance,

the American success with large-scale shale gas production led to a new economics of the global natural gas trade. Estimates of the global potential of unconventional resources generated new investments in infrastructure, such as pipelines and LNG export terminals. These new investments in turn created a complex and interconnected geography of global gas markets (Bridge 2015). As the rules of the game changed and the UK became progressively more exposed to risk in global gas markets, the British government also began to assess its domestic unconventional resource base. This was necessary not just to ensure the physical security of natural gas, but also to ensure price security (Bradshaw et al. 2014). Crucially, reserve estimates were not confined to the realm of geoscientific practices of resource appraisal, but had to take into account their impacts on the politics of resource making (Barry 2005; Kama 2013; Latour 2005).

Against this background, disputes about the geological reality of the shale gas resource base proved critical for the UK's political aspirations to achieve domestic energy security. As Barry (2006) noted, reserve estimates often change dramatically during the early stages of exploration when there is a lot of uncertainty regarding the scale of the resource base. The UK also saw significant changes in reserve estimates following new calculations based on geological surveys of the Bowland Shale. In June 2013, the expectation that shale gas would not be a game changer was revisited in light of these new estimates, which were published in a new BGS report. In this report, the BGS estimated that the gas resources were about 1,329 trillion cubic feet, yet cautioned that total recoverable reserves were far less than the resource base (DECC/BGS 2013). In fact, the different estimates published by Cuadrilla and BGS stemmed from the use of different metrological definitions of how to calculate the resource, as well as different levels of access to data (Bassi 2014). According to the

BGS, Cuadrilla's estimations were for 'technically recoverable resources' that were generally higher than actual feasibility of extraction (Bassi 2013). Indeed these discrepancies reveal the complexities involved in the geological assessment of the shale gas reserves (Barry 2006).

There is a crucial difference between resources, reserves and technically recoverable resources (TRR). In a note published by DECC (2013a:2), resources were defined as the "estimate of the amounts of oil and gas that are believed to be physically contained in the source rock"; reserves as "an estimate of the amount of oil or gas that can technically and economically be expected to be produced from a geological formation"; and technically recoverable resources (TRR) as "an estimate of the amount of gas that might be technically recovered if production were not constrained by economics". Bowland Shale was similar to some North American shales (i.e. Barnett and Marcellus) in terms of its maturity (DECC/BGS 2013) and there was an expectation that it would generate similar productivity once drilling activities were accelerated.

Moreover, the geophysical properties of Bowland Shale had to be reconsidered in light of other technical, economic and political factors affecting the feasibility of extracting the resource (Bridge 2009). While geologists who were expected to measure, discuss and understand potential recoverable resources in Britain, energy policy analysts also began to speculate about the various specialised technical practices critical to the realisation of the resource (Barry 2006). As analysts observed (Rogers 2010; Stephenson 2012; Stevens 2010, 2012, 2013), the geological understanding of the resource was entwined with environmental constraints, the specificity of the national regulatory framework, as well as technological challenges: all played a constitutive role in the calculation of recoverable resources in the UK

(See Figure 4-6). As Stevens (2013) argued, an understanding of the geographical specificity of socio-technical arrangements is critical if we are to account for the significant differences between resource making in the UK and the US.

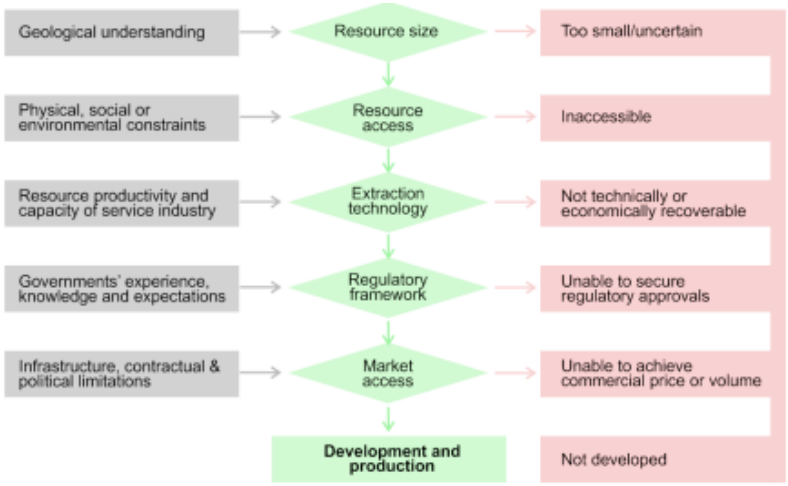


Figure 4-6: Factors affecting the economic viability of shale gas development (Source: DECC/BGS 2013)

As we have seen, the realisation of shale gas resources in the US was justified by favourable economic and legal conditions that were critical to the operation of shale gas industry. In comparison, the socio-technical practices pertaining to the UK's natural gas sector were governed by different regulatory standards, mineral ownership structure and economic incentives (Stevens 2013). For instance, while the US had a private mineral ownership regime, in the UK onshore gas resources were governed by the Crown, which required a lengthy application and approval process for exploration rights (UKORG 2015). A consultant report commissioned by the industry noted that shale gas development in the UK required technical expertise in onshore drilling, specialist equipment and an experienced services sector (Ernst &Young 2014). To build a home-grown shale gas industry within a decade, the report concluded, there had to be equivalent investment in technical expertise in *inter alia* geosciences, drilling, planning, health, safety and the environment (Ernst &Young 2014).

In December 2013, a new regulatory roadmap for shale gas exploration was published by DECC. This was "intended as a general guide only and will be revised as legislation develops, new regulations are introduced; or when best practice evolves" (DECC 2013d). Although the roadmap did not intend to replace legislative discussions in parliament, it was perceived as critical for lifting some regulatory burden off the industry's shoulders. One of its highlights was the simplification of the regulatory requirements under a single point of contact. A year earlier, the Office of Unconventional Gas and Oil (OUGO) had been established within DECC's Energy Development Unit, and was responsible for encouraging "the safe, responsible and environmentally sound recovery of the UK's unconventional reserves of gas and oil."[33] The coordination of the roadmap was given to this new office in order to streamline the regulatory regime and enable the swift entry of newcomers.[34] Given the limitations of the regulatory regime at the time, this new roadmap would provide effective coordination between regulatory agencies – such as the Environment Agency and the Health and Security Executive – and local planning departments. Accordingly, these new technical arrangements would reduce the level of regulatory uncertainty that would impede large-scale shale development.

Just as importantly, the making of scale depended also on generating new economic incentives and meeting the market expectations of the UK government. The Conservative-led coalition government rendered a new "resource imaginary" which emphasised the geopolitical and economic benefits of developing the resource with a view to creating a large-scale shale economy (Bridge 2009). Moreover, as outlined in the Economic Affairs Committee report of the House of Lords, developing the

[33] For more details on the structure and responsibilities of the OUGO, see https://www.gov.uk/government/groups/office-of-unconventional-gas-and-oil-ougo
[34] Telephone interview with a senior employee from Health and Safety Executive (HSE), New York, NY, March 13, 2013.

resource was expected to "reduce imports and enable security of supply, and generate direct employment in North England" (HLEAC 2014). To this end, Prime Minister David Cameron's announcement of "going all out for shale" strategy was intended to create a favourable investment environment for the shale gas industry. The strategy argued that shale investments would generate thousands of jobs and lower gas prices[35] in Britain (Watt 2014). According to a report prepared by the Institute of Directors and funded by Cuadrilla Resources, the annual economic contribution of the industry would be approximately GBP 3.7 billion (IoD report 2013). It envisioned the creation of 75,000 jobs in the local services sector and seasonal employment during drilling phase. Most of these jobs would thus be transitional, during a 2–3 year time frame.

In July 2013, the Treasury announced generous tax breaks for operators to facilitate shale gas investments, and introduced economic incentives for local councils[36] so as to distribute the benefits from drilling activities. The proposed tax regime reduced taxation on the company's production income from 62% to 30%. The Treasury also envisioned that communities would share in £100,000 of benefits per 'fracked' well site during the exploration phase (HM Treasury 2013). Furthermore, the Treasury proposed setting up a sovereign wealth fund[37] to support a low carbon future and enable long-term economic investments for the North of England (Nichols 2014).

[35] Although the government argued that shale gas would lower gas prices, the economist Lord Stern made a counter argument that natural gas was a commodity that could be traded on the global gas markets, therefore a shale boom in the UK would not lower the price of natural gas either nationally or internationally (Bawden 2013).

[36] Local opponents of shale gas drilling viewed these economic incentives as "bribes" (In person interview with local resident, Fylde, St Annes on the Sea, Lancashire, March 07, 2013). These incentives were intended to generate some form of compensation to subdue the objections of local residents.

[37] However, there remains a dispute about who benefits from this wealth fund, although Chancellor George Osborne implied that it would benefit the North of England (Nichols 2014). The idea of the sovereign wealth fund was inspired by the Norwegian Government Pension Fund which reserves government revenue from oil and gas resources in the North Sea and Norwegian Sea and invests in other financial assets for the future generations (Froley 2015).

DECC contended that the development of shale gas in the UK would yield three positive outcomes: energy security, decarbonisation and economic growth (DECC 2014b). Yet DECC's verdict on the future of gas was cautious at best, because the Department depended on the Treasury's tax incentives, and on other planning and environmental regulations (Cairney et al. 2015; Stevens 2012). Economist Lord Stern argued that the divisions between DECC and the Treasury stemmed from uncertainty over the government's position on decarbonisation strategy which was affected by the Treasury's commitment to shale gas which would deter future investments in clean energy technologies (Bawden 2013). Tyndall Centre researchers argued that the shale gas development was incompatible with the UK's climate change targets, making the shale gas investments a stranded asset for the UK even if the boom were short-lived (Broderick et al. 2011). Despite the tentative nature of DECC's conclusions on the economic viability of the shale gas resources, the UK government began introducing regulatory measures to accelerate the home-grown shale gas industry.

Notwithstanding the geological estimations, regulatory restructuring, generous tax breaks, the scale and pace of the development of the resource fell short of the British government's expectations. As pointed out by Dutton et al. (2014), the promise of shale gas as articulated by the British government was, in fact, highly speculative. The expectation that shale gas energy would decrease energy prices and improve energy security in the short term was unfounded, given that exploration was still in its infancy. Since the British government announced these new arrangements in 2013, there have been only 11 exploration wells for shale gas – a figure which hardly indicates rapid US-style shale development (Vaughnan 2015). As analysts observed, the UK shale gas industry would not achieve a significant scale until the 2020s and

until then, it would be unrealistic to expect shale gas to make a critical impact on energy security (Dutton et al. 2014).

Put simply, the technical arrangements for shale gas affect the making of scale in disparate geographies (Kama 2013). The UK case is no different. As evident in the development of new economic and technological arrangements, the British government "conjure[d] up" a vision of large-scale shale gas development that resonated with national aspirations for both energy security and economic growth (Tsing 2005). In Callon's terms (1998), the making of the shale gas economy depended not just on the successful application of hydraulic fracturing technology to shale gas formations, but also on a broad range of technical expertise in geoscience, law and economics. Just as the UK's technical experience with shale gas drilling was limited and ended up being more expensive than the US, social and environmental negotiations impeded the British government's vision (See Chapter 7).

4.7 Conclusion

Until the early 2000s, the development of unconventional gas resources was considered to be economically unviable by major companies in the sector, even though there was a significant amount of federal, academic and industry research on the potential of shale formations. Due to the consequent lack of interest in unconventional gas fields on the part of major oil companies, along with the availability of federal funding to support the development of alternative fossil fuel resources, the independent wildcatter George Mitchell was able to acquire land leases at cheaper prices and experiment with the tight formations for more than two decades (Kutchin 2001; Zuckerman 2013). Before Mitchell's engineers and geologists cracked the code for the Barnett Shale, a series of adjustments were necessary to test the

potential of shale gas formations. The HF process thus evolved as both an "art and science", requiring adjustments between the research laboratories and different gas fields, where fracturing service companies carried out in-situ testing to see if a particular formula would work with that formation. Therefore, a process of translation (Callon 1986) is needed in order to find out if the fracturing process can yield successful results in other shale formations.

As the section on shale gas technologies has elaborated, there was nothing unconventional about the technologies, namely the HF, HDD and microseismic imaging technologies, which had been in use in the industry for a long time. Company engineers at Mitchell Energy, however – unencumbered by competition from major oil companies –were able to translate the results of different fracturing experimentations from other gas fields for the Barnett Shale. Later, these technologies were popularised and, together with the new interest in shale gas aroused, led to an increase in patenting activity among the oilfield service companies.[38]

The process leading to the shale gas boom also needs to be understood in relation to the estimation of potential reserves and availability of financial resources to develop these resources. Before the true extent of the nascent gas reserves in the Barnett and Haynesville Shales were known, independent gas companies, such as Chesapeake, were able to convince investors in Wall Street to fund their development costs, which included drilling and land leasing costs. Marketing the technologies of shale gas as something similar to the manufacturing process (Mitchell 2013), these independent gas companies contributed to the creation of hype about the potential of shale gas formations and earned large profits from land speculation as demand for the gas fields dramatically increased.

[38] These patents also served as "information containment tools" (Cahoy et al, 2012), when the contents of the fracturing fluid formula became a subject of nationwide controversy and federal investigation. See Chapter 6.

As Rogers (2013) pointed out, the discrepancy between the actual operational costs and speculative reporting of production data contributed to the creation of a financial bubble. Although the industry created huge excitement around the potential of shale gas reserves for the long term, there were major write-downs due to the reduced prospective returns, not only as a result of the rising costs of gas field development (with the increased land prices) and the fall in gas prices (again, partly because of the shale boom), but also as an effect of the rashly over-estimated potential of the fields.

In fact, leaked industry e-mails indicated that the financial valuations of the shale formations and reserve estimates were based on exaggerated industry production data from the very beginning. The speculative nature of raising capital for the rapidly expanding shale gas frontier was criticised for its reliance on a distortion of the production data coming from the gas wells. As the SEC investigation of Chesapeake Energy's former CEO showed, financial non-disclosure to investors regarding company expenditure became a subject of controversy. Thus, against several indicators, Wall Street investors continue to fund gas companies. The shale rush generated massive profits from M&As and other transactional fees related with operational costs. The production of information about the geo-physical characteristics of shale formations, therefore, constituted a new field of speculation for Wall Street investors profiting from these transactions.

In the case of the Marcellus Shale development, several factors affected the development of the shale formation as an economically and politically desirable resource. First, the location of Marcellus formation made it lucrative for investment community, as it was close to the Northeastern energy markets. Second, the initial reserve estimations generated a land grab across the Pennsylvania and New York

states. As more production data became available, these calculations were adjusted several times and contested by rival calculations. Last, technical disputes over the environmental impacts of hydraulic fracturing technology became central to the regulatory discussions concerning drilling activities in New York State. In contrast to the more relaxed, *laissez-faire* regulatory environment in Pennsylvania, the controversy that erupted over shale gas technologies in New York State created an alternative political space, within which a variety of actors participated and negotiated about the terms of drilling. This slowed down the expanding frontier of shale gas development in the NY state, to the point, now, where it has been frozen.

The UK government hoped to replicate the American success with shale gas development and passed a series of economic incentives to make the resource. Nonetheless, the formation of a home-grown industry would depend on the further development of national expertise in fields such as geology, law, and economics. Although Bowland Shale resembled to Barnett Shale in terms of geological maturity and characteristics, developing the resource required costly technical interventions due to the lack of well-developed field services sector and shale drilling experience in the UK. As British government conjured scaling up the shale projects, new regulatory arrangements, i.e. tax breaks and compensation schemes, had to be negotiated within the political context of the UK. Therefore, this chapter has shown that the UK scaled the shale gas projects differently than the US.

Overall, this chapter has argued that the technologies and economics of the shale gas boom has to be understood in relational terms, paying attention to the impacts of technological advancements on resource-making processes and their contestation in distinct historical, economic and political contexts. In fact, the American shale gas boom depended on a complex combination of technical

arrangements and geoscientific practices that entered into the economic calculations, which also influenced resource imaginaries in different geographies, as in the case of the UK. As the next chapters will elaborate, moreover, a range of technical controversies over the shale gas technologies also led to disparate regulatory arrangements in different national contexts of the US and the UK, respectively.

CHAPTER 5: GOVERNING FRACTURING CHEMICALS IN THE UK AND THE US

5.1 Introduction

Conventional theories of transparency share a common ground: disclosure of more information in the public domain leads to good governance (Fung et al. 2007; Florini 2007). Despite conflicting political and social positions on what transparency actually entails in practice, it is often taken as self-evident that some degree of openness is a remedy for the crisis of secrecy and for governance issues, whether for governmental affairs, business relations or the behaviour of organisations (Hood 2006). In his historical account of transparency in the Western world, however, Hood (2006) observes that transparency has attained a "quasi-religious" status in the late twentieth century, and is unquestioningly perceived as a "cure-all for better governance". According to Hood, the concept of "transparency" embodies different literatures and policy domains with conflicting doctrines of governance that have a bearing on legislative acts regarding information disclosure. He argues that the institutionalisation of these contradictory doctrines leads to balanced legislative outcomes in most modern democracies, where, for instance, it is not uncommon to see privacy enacted laws alongside the freedom of information laws.

Hood does not, however, dwell on what is actually revealed through the production of information and concealed in the process of making information public, and the transformative effects information production has on individuals and organisations (Barry 2013; Strathern 2000). Other scholarly works raise important questions regarding the economic, political, legal and scientific aspects of

transparency which are left out of Hood's analysis: for instance, how is transparency affected by different institutional traditions, legal and political reasoning? (Jasanoff 2006b); what kind of disciplinary techniques and institutional transformations are involved in making information public? (Power 1997; Strathern 2000); and in what ways are multiple spaces of information production networked and disputed in "political situations"? (Barry 2012). In short, a richer analysis of transparency pays attention to the complexities of financial, institutional, legal, scientific and social spaces of information production and the transformative effects of making information public through these spaces (Barry 2013).

In a canonical essay, Strathern (2000) draws our attention to the tyrannical nature of making things transparent, and the selective process of choosing what is made visible and what is concealed during the institutionalisation of new auditing practices in British higher education. In Strathern's terms, this is a "tyranny of transparency" partly because there is an act of concealment in the production of information that is made visible, and partly because individuals begin to conform to the new auditing system through authoritarian techniques of assessing, auditing and evaluating. Barry (2010) also observes how transparency requires a discretionary process about "what is only partially known about, but cannot be made transparent". His analysis advances Strathern's argument about the selective nature of transparency, observing how the availability of more information does not necessarily mean more transparency. For Barry, more information is a product of transparency, yet this process requires selective disclosure of what we should see and what should be left out of the picture, and hides the ways in which individuals and organisations work and adapt to the very process that make things visible to the outside. Neyland's (2007) analysis of transparency reviews also points out the power relations between the

inside and the outside of organisations, showing how techniques of auditing only re-format a particular version of the internal dynamics of organisations visible to the outside. As auditing practices show (Power 1997), the institutionalisation of transparency standards often generates new kinds of knowledge that require expertise, judgement and new techniques of assessment. Power shows that the practice of auditing widens the gap between lay and expert knowledge: when auditing systems proved to be ineffective in delivering the desired level of transparency, the answer is always more auditing (Power 1997). Techniques, instruments and expertise are critical disciplinary devices of transparency in generate some form of visibility, calculability and accountability (Grossman et al. 2006).

During the controversy over fracturing fluid chemicals, demands for transparency surfaced as a point of contention between gas companies, critics, and regulatory agencies. In the US, gas companies' initial aversion to disclose fracturing chemicals and federal regulatory exemptions intensified the debate on corporate transparency and the failure to regulate the industry. In the context of a growing backlash against the booming shale gas industry, information about fracturing fluid chemicals became a matter of political significance, which transformed the way regulators, the industry and public perceived the entirety of business operations. These chemicals are seen as intrinsic to the "art" of fracturing in the industry, and are therefore protected as intellectual property by field service companies. Information about these chemicals became a political subject with important regulatory, economic and societal implications. Although shale gas development is at an early stage in the UK, a parliamentary investigation on how to regulate the industry also unfolded in Westminster. Here, institutional procedures were significantly different from the US, as British counterparts framed this issue in a more opaque way, offering an expert-

based solution to a political impasse (Jasanoff 2005). Instead of going through a lengthy scientific review process as in the US, the UK government consulted experts on the environmental impacts of hydraulic fracturing technology and chemicals in a Parliamentary Committee hearing. Various national legislative arrangements and voluntary industry initiatives were made to remedy public and investor concerns in response to this crisis of corporate transparency. As the debate expanded in both countries, however, these new legal and technical arrangements themselves became a new source of controversy, expanding discussions on corporate responsibility, transparency and regulatory oversight.

Coinciding with the period when shale gas development has gained more visibility in the media, a series of academic and policy papers (see Cahoy et al. 2013; Konschnik et al. 2013; Wiseman 2013) addressed the controversy over regulation of fracturing chemicals. Although they give a detailed analysis of the legal (Wisemann 2013; Konschnik et al. 2013) and economic (Cahoy et al. 2013) aspects of chemicals disclosure for the regulation of shale gas development, these works do not question the notion of transparency in principle, or interrogate its contestation in practice. Instead they seem to share the belief that transparency is better for good governance of hydraulic fracturing technology and its possible environmental impacts. This chapter gives a critical analysis of what the enactment of transparency has entailed, what is made visible and invisible in disclosing some information about chemicals, and whose voices get heard or silenced. I also address the transformative effects of transparency discussions on corporate governance structure and regulatory outcomes in the UK and the US.

This chapter advances the following arguments. First, a wide range of actors, including institutional investors, environmental NGOs and academics, has taken

transparency as indispensable for good governance of hydraulic fracturing technology, however each actor has tried to shift the debate on regulation of fracturing chemicals disclosure in a different direction. Giving the differing articulations of transparency for each actor in each institutional context, the chapter gives a more nuanced understanding of how transparency is made and remade in practice, and whose voice become more important in regulatory outcomes. Second, despite the fact that they hold different worldviews on the future of shale gas development, some of these actors have been adamant about the need for proper scientific investigation of fracturing technology. This demand became more visible in the US than the UK, where informal expert consultations seemed to inform UK policy on fracturing chemicals disclosure.

Comparing how this particular controversy has generated different relationships between science and policy in the two countries, the chapter aims to show how different institutional traditions have a bearing on regulatory decisions on disclosure and the need for further scientific investigation. Although transparency is a significant component of the Anglo-American regulatory context, there are significant procedural differences regarding the treatment of scientific evidence on fracturing chemicals. Last, reputational concerns, investor pressure and regulatory threats have led gas companies to organise around a voluntary chemicals disclosure registry in the US, whereas in the UK voluntary disclosure is determined by the gas company in operation and remains informal. Discussing the controversies surrounding the public-partnership initiative and individual corporate disclosure policies in both countries, the chapter explores how new forms of corporate transparency aim to shape the informational space regarding chemicals disclosure and its implications for the politics of shale gas regulation.

5.2 Regulating corporate scientific disclosure

The disclosure of scientific information withheld for commercial interests is a contentious issue. In Clark's (1990) words, corporate secret keeping often distorts regulatory practices, sends the wrong signals to market and investors, and creates public mistrust. The literature on corporate transparency in scientific controversies suggests that non-disclosure is often justified on the grounds of confidentiality of business information and can take many forms (Haack 2006; McGoey 2007; Michaels 2008; White 2006). However, unlike other forms of corporate disclosure, the regulation of corporate sequestration of science has not been extensively investigated. Company laws and environmental laws encourage corporate disclosure of scientific information pertinent to the market and public, yet intellectual property law in the Anglo-American world protects sequestration of science for commercial purposes.

The politics of scientific non-disclosure is often tied with public expectations about corporate science and the responsibilities of corporations in disclosing this information. Jasanoff (2006) argues that not all concealment of scientific information is intentional; "sequestration of science" better captures contextual features that affect the transmission of scientific knowledge to the public, irrespective of whether this publicly useful information is concealed intentionally or not. Nevertheless, there are certain trade-offs in the sequestration of science for commercial interests; in particular, this concealment limits public knowledge about possible health and environmental risks (Michaels 2008), leading to demands for greater disclosure. In her analysis of Colorado "shale gas patch communities", for example, Wylie (2011) draws our attention to how information sequestration around chemical content mobilised a small advocacy organisation to develop an alternative chemicals database

that details the contents of chemicals protected as proprietary information. For Wylie (2011), this platform has been critical in addressing a vacuum surrounding fracturing chemicals, as well as fostering nation-wide debate about "the ecological and bodily impacts" of fracturing.

The regulation of corporate disclosure of scientific information often reveals a tension between, on the one hand, the health of the public, and on the other hand, the financial health of companies (Haack 2006). Examining transparency problems in different sectors, the literature on the regulation of corporate scientific disclosure raises important questions: how is public access to health and safety data affected by economic considerations in the chemicals industry? (Conrad 2006); in what ways can transparency and public health interests be balanced in regulating the timely communication of the risks of drugs to the public? (Lassman 2006); how do government-led disclosure registries affect corporate non-disclosure about clinical trials? (Lurie and Zieve 2006). Though the value of scientific information depends on the specificity of each case, there is a common recognition that there may be a contradiction between the public value and the market value of scientific information.

Observing corporate misdeeds in the sequestration of science, Michaels (2006) goes even further, and advocates for a Sarbanes-Oxley initiative for science to protect the integrity and transparency of scientific data. The question of standardisation of scientific disclosure, nonetheless, requires careful attention considering the nature of scientific activities and problems, as well as the political consequences of new forms of assessment and expert judgment. As Power (1997) rightly points out, the institutionalisation of standards often relies on new kinds of expert knowledge and disciplinary techniques of assessment. Moreover, the standardisation process itself can become a subject of political controversy. This becomes a salient issue when

standardising the disclosure of science information, which may involve various technical, financial and regulatory negotiations during its development and implementation. In effect, these instruments of transparency might create a kind of openness and visibility, but they may also transform individuals and organisations in the process, hiding a great deal about how these techniques are developed, and their unintended effects in practice (Strathern 2000; Grossmann et al. 2006).

Equally, the history of institutions and traditions of legal and political reasoning are critical in influencing knowledge making process and demands for transparency in science (Jasanoff 2005). Institutional differences become especially significant in regulatory decisions over controversial technologies and the treatment of scientific evidence during this process. In her comparative study of regulatory debates over the safety of bio-technology in the US and Europe, Jasanoff (2005) argues that national characteristics define how scientific evidence is treated in different policy environments, leading to variations in timing, priorities, and the forms and urgency of interventions to the industry. Under constant scrutiny to be transparent, as she puts, American regulators are not as free as their British counterparts to delegate scientific authority to a group of experts (Jasanoff 2005). Instead American regulators feel the need to build their objectivity based upon a "view from nowhere", supported by quantifiable and demonstrable facts, whereas British regulators often justify their objectivity on a "view from everywhere", relying on expert consultations in semi-public institutional environments (Jasanoff 2011). In her words, institutional traditions have a bearing on different kinds of objectivity informing policy making and the treatment of transparency in regulatory science (Jasanoff 2011).

Regulation of corporate scientific disclosure could also be shaped by litigation, especially when commercially protected information is a subject of scientific inquiry by regulatory agencies. Jasanoff (2006) sees litigation as an indispensable aid to knowledge production that might benefit public science. Here, the question is not about ensuring disclosure of useful information but about transforming the whole judicial system for public benefit and establishing some form of external review to improve the quality and reliability of the science that the lawsuits help generate (Jasanoff 2006). This becomes particularly important in US legal culture, which is more litigious than the UK (Armour et al. 2007). Juni (2000) also notes that transparency is more distinctively characteristic of American legal culture, which relies on civil litigation as a tool for ensuring compliance with standards, whereas the British approach is more opaque in its reliance on bargaining between regulators and companies to achieve compliance.

Nonetheless, there are limitations to litigation for public access to science generated by companies. Law can be an impediment to penalising wrongdoing; both US and UK regulatory laws privilege confidentiality of company-held data, and even in cases where this information is in the public interest, they prefer selective disclosure to those affected rather than providing universal access to scientific data (McGoey 2009b). A common problem in court is the practice of sealing records of dispute produced during litigation process; another relates to the cost and time commitment in pursuing litigation (Jasanoff 2002). Moreover, companies can successfully employ ignorance as a strategic defence of non-liability for failing to disclose publicly useful scientific data (McGoey 2007).

Beyond questions of litigation and liability, companies also employ a multitude of strategies to shape public debates on corporate disclosure of scientific

information. As Haack (2006) observes, legal sequestration or financial disclosure policies are not the sole corporate practices keeping scientific findings secret. Funding scientific research in universities, organising conferences to disseminate a particular form of knowledge, issuing rebuttals for media, assembling industry or academic scientists to respond to the EPA reports, building coalitions within industry to mobilise third parties to attack other forms of scientific knowledge, and digital communications are all major corporate strategies in discrediting counter scientific information (Haack 2006; McGarity 2009a). These strategies become important in affecting regulatory process, avoiding liability, and restoring financial and public trust. In the controversy over the regulation of corporate disclosure of fracturing chemicals, the aforementioned strategies have been utilised. As we will see later in this chapter, when secrecy over fracturing chemicals came under close scrutiny, gas companies employed a variety of communication strategies in an effort to shape public debate and regulatory processes. Along with the inclusion of activist groups, institutional investors, academics and media into the debate, these strategies have also been questioned and deepened as regulatory discussions and scientific investigation occurred in both countries.

5.3 United States: A contested scientific review process

Politically, the starting point of contention in the shale gas debate was the statutory exemptions granted to the industry under the Energy Policy Act of 2005. Also known as the Halliburton Loophole,[39] this bill was important for the political future of fracturing activities for two interrelated reasons: first, the EPA's authority to regulate

[39] Under the Bush Administration, oil and gas companies were quite influential in Vice President Dick Cheney's Energy Task Force, which drafted the Energy Policy Act of 2005 (Rahm 2011). In reference to Cheney's position as the former chief of Halliburton, the bill was named the Halliburton Loophole for introducing and expanding federal exemptions for fracturing in the bill (Phillips,2011).

the industry under the Safe Drinking Water Act (SDWA) and Clean Water Act (CWA) was significantly diminished;[40] second, environmental regulation was left to the discretion of state authorities[41] who could decide on fracturing fluids disclosure requirements and level of enforcement. The Act echoed the industry's position on the regulation of fracturing activity,[42] which supported state-level regulation on the grounds that state agencies have appropriate expertise and know the local environment better than federal agencies.[43] As the scale of shale gas development expanded in the US, federal exemptions became a subject of heated controversy in regards to environmental and health impacts of chemicals used in fracturing activity. Limited public access to the contents of fracturing fluids generated scrutiny of scientific studies granting these exemptions and constituted a major challenge, not just for federal agencies, but also for the reputation of the industry.

Scientific justifications for the federal regulatory exemptions were based on the EPA Coalbed Methane Study published in 2004. This study was a direct response to the decision of the Eleventh Circuit Court in Law Environmental Assistance

[40] Prior to the Energy Policy Act (2005), SDWA required any underground injection activity to be regulated so as to protect groundwater resources, and the EPA was responsible for regulating these activities under the Underground Injection Control (UIC) programme. From the early 1990s, however, the EPA was already considering the fracturing activity to be subject ot the UIC programme (Burger 2013).

[41] Given the public concerns over secret fracturing chemicals, leaving the government oversight of the industry to the states mean a fragmented and uneven regulatory environment (see McFeeley 2014). States often require disclosure of fracturing chemicals to the state environmental agency or health officials through Material Safety Data Sheets (MSDS). However, there are several issues with the MSDS reporting system: first, the MSDS are specifically designed for the health and safety of workers, but does not include other hazardous chemicals that might lead to human exposure through different environmental pathways, such as surface spills into the water resources; secondly, since the composition and concentrations of fracturing fluids are considered to be proprietary information, they are often reported under the trade names, providing a general description of chemicals (i.e. friction reducer) or a fraction of the total composition without giving away the individual chemical names; lastly, states may choose to withhold proprietary information from the public, therefore there is limited publicly available information about the characteristics and properties of the chemicals (Cahoy et al. 2013; Wiseman 2011).

[42] See Spence (2012) and Burger (2013) for counter-arguments on benefits/drawbacks of federalism in regulation of fracturing activity in the US.

[43] Presented by a senior external relations officer from a major oil and gas company, Houston, TX, June 15 2013.

Foundation (LEAF) v the EPA, which ordered the EPA to regulate fracturing in Alabama CBM wells according to SDWA (Cupas 2008). Although the EPA had not regulated the underground injection of fluids for hydraulic fracturing of oil and gas production wells before, the agency began studying the risks of fracturing activity for CBM production to drinking water supplies following the court decision (Tiemann and Vann 2013). Completing an extensive literature review and data analysis of state agency reports on the possible effects of hydraulic fracturing on groundwater resources in CBM wells, the EPA decided not to carry out further empirical research and concluded that "the injection of hydraulic fracturing fluids into the CBM wells poses minimal threat to underground drinking waters" (EPA 2004). This conclusion provided the rationale for the federal regulatory exemptions granted under the Energy Policy Act of 2005.

The EPA report, however, recognized the possible environmental impacts of diesel fuel used in fracturing fluids despite the industry's insistence that diesel does no harm to water (EPA 2004). In the Memorandum of Agreement (MOA) signed between the EPA and BJ Services, Halliburton and Schlumberger, companies[44] agreed to eliminate and if necessary find a replacement for diesel fuel to protect underground water supplies (MOA 2003). As clearly stated in the MOA, this document was not legally binding for the companies, and did not give the EPA authority to regulate fracturing under SDWA or the EPA's Underground Injection Regulations (EIR) (MOA 2003). Evidently, the EPA trusted the companies to come up in good faith with a cost-effective and technologically feasible solution to replace diesel fuel in fracturing. With the exception of diesel fuel, the EPA left the regulation of fracturing to the states. In 2011, regulation of the diesel fuel by the EPA became a subject of

[44] According to the EPA, these three service companies represent %95 of the fracturing jobs done in the country (EPA 2004).

debate when three members of Congress alleged that the EPA never fully regulated the use of dangerous fuel in fracturing sites. When the EPA updated information on permit requirements in its website, the Independent Petroleum Association of America (IPAA) filed a case against the EPA, saying that the agency did not specify the regulations on diesel permits set out in the Energy Policy Act of 2005 and could not use it retroactively with a website clarification (Lustgarten 2011).

The shale gas boom has changed the landscape of discussions on the science of fracturing activities, exposing the flaws in the EPA study. The release of an early draft of the study revealed that there was a discussion of possible evidence of water contamination from hydraulic fracturing fluids which was dropped in the final report after industry and political pressure on the agency (Urbina 2011). A letter sent to Congress by an EPA employee clearly stated that some of the participating EPA scientists were worried about the environmental and health impacts through a possible leakage of dangerous fracturing chemicals to the underground water wells near CBM sites (Lustgarten 2008). The final report dismissed such a possibility, referring to these incidents as "naturally occurring" phenomena (Cupas 2009). In the employee's words, however, the EPA study's conclusions were scientifically flawed and affected by industry influence:

> Recent events at EPA have caused me and several of my peers at EPA great concern. In June this year, EPA produced a final report pursuant to the Safe Drinking Water Act that I believe is scientifically unsound and contrary to the purposes of law. In this report, EPA was to have studied the environmental effects that might result from the injection of toxic fluids used to hydraulically fracture coal beds to produce natural gas. (…) While EPA's report concludes this practice poses little or no threat to underground sources of drinking water, based on the available science and literature, EPA's conclusions are unsupportable. EPA has conducted limited research reaching the unsupported conclusion that this industry practice needs no further study at this time. EPA decisions were not supported by a Peer Review Panel; however five of the seven members of this panel appear to have conflicts-of-interest and may

> benefit from EPA's decision not to conduct further investigation or impose regulatory conditions.
>
> (EPA Employee Letter to Congress 2004)

The EPA employee's account of the scientific review process for the study is representative of what McGarity and Wagner (2008) call "bending science": a contamination of each step of the scientific review process by incentives and pressures from policy circles. According to the employee, special interests infiltrated the EPA's review process not just in data collection, but also through direct influence in the peer review panel, which comprised experts with direct ties to industry. The employee claimed that the EPA did not have full access to the fracturing chemicals protected as trade secrets. In his words, making an conclusion based on limited data and following the panel's decision to drop further investigation indicated a scientifically flawed process which was unsuitable for regulatory outcomes affecting the fracturing activities.

As the shale gas controversy unfolded, environmental groups and an increasing number of media reports[45] started questioning the tenets of the study and lack of federal oversight. Recognising the salience of regulation of the fracturing fluids, environmental groups[46] saw an interest in the disclosure of chemicals as a leading issue to start negotiating with the industry and regulators.[47] Among the issues that stand out in these negotiations, a seemingly simple yet the most significant one is thought to be the secrecy over fracturing chemicals. In response to these groups'

[45] In particular, Abraham Lustgarten's series on shale gas drilling in ProPublica and Ian Urbina's Drilling Down Series in *The New York Times* brought a nationwide recognition for the perils of the industry and politics of shale gas debate.

[46] A number of environmental groups, most notably NRDC, Earthjustice, Environmental Working Group, were quite active on fracturing fluid chemicals debate (Burger 2013). These environmental advocacy groups have petitioned EPA to collect and share health and environmental effect information for hydraulic fracturing chemicals under the Toxic Substances Control Act and to require the oil and gas extraction industry to report the toxic chemicals it releases under EPCRA Section 313, which established EPA's Toxics Release Inventory (Tiemann and Vann 2013).

[47] Interview with a senior policy expert from Natural Resource Defense Council (NRDC), November 14, 2012, New York, New York.

demands for corporate transparency and federal regulations, the industry reacted aggressively, not willing to accept any compromise on the exemptions granted under the Energy Policy Act. In particular, the industry's hesitance to disclose fracturing fluids and accept federal regulations became a significant issue of contention. The idea that keeping fracturing chemicals secret might later become a serious reputational issue for the entire shale gas operations was, to the industry, a very distant possibility at the time.[48]

Already under public and political pressure, in 2010 Congress urged the EPA to conduct a comprehensive study on the environmental impacts of hydraulic fracturing. In preparation for the study, the EPA sent letters to nine[49] oil field-services companies, requesting they provide detailed information about the chemicals used in fracturing by December 2010 (Zeller 2010). Clearly, the EPA prioritised a response to public anxieties over the industry's determination to maintain secrecy on the content of fracturing chemicals. Although eight companies replied to the agency's urgent request for voluntary disclosure, Halliburton refused to disclose information within the EPA's time frame (Power and Hughes 2010). In response, the agency subpoenaed the company to provide all the information, including the fracturing fluid contents used in the company's operations in the last five years and company data and studies relating to environmental and health impacts of fracturing (EPA 2010). Halliburton made an official statement welcoming a federal court investigation of their good faith efforts with the agency, and stated that it found the prompt informational request unreasonable (Rudolf 2013).

[48] Keynote speech given by a senior gas company executive, Shale Insight Conference, Philadelphia, PA, 20 September 2012.
[49] Nine companies included BJ Services, Complete Production Services, Key Energy Services, Patterson-UTI, RPC, Inc., Schlumberger, Superior Well Services and Weatherford, and Halliburton. (Bradbury 2010).

Over the course of the controversy, demands for stringent federal oversight and transparency become a recurring theme in congressional discussions[50] and reports. In February 2010, the minority staff at the House Committee on Energy and Commerce launched a comprehensive study[51] on environmental impacts of hydraulic fracturing, with a particular interest in attaining information on chemicals used in fracturing fluids. During the investigation, the House Committee found that oil and gas field service companies continued to use diesel fuel as a hydraulic fracturing fluid (with the exception of CBM wells) and sent two letters[52] to the EPA's administrator, sharing information about the lack of environmental review or permit application pertaining to the use of diesel by these companies. Since this finding meant that companies explicitly ignored their legal requirements, the EPA had to review its permitting process relating to diesel use under the UIC programme (Soraghan 2011). The House Committee Report (April 2011) identified an "informational void" due to the lack of minimum national standards for disclosure of fracturing fluids and exemptions from SDWA. In their informational request from the companies, the House Committee encountered issues in accessing proprietary information on chemicals which were not available to the operating companies due to supplier

[50] Several bills were proposed in Congress to overturn the Energy Policy Act. In June 2009, The Fracturing Responsibility and Awareness of the Chemicals (the FRAC Act) was introduced to the US Congress with the purpose of making hydraulic fracturing a federally regulated activity under the Safe Drinking Water Act. Specifically, the FRAC Act aimed at bringing uniform federal disclosure requirements for states regarding fracturing fluids and availability of this information to the public (Nicholson 2012; Wiseman 2011). This bill, however, met great opposition in Congress and failed to pass in the 11th and 12th congressional meetings. Despite being re-introduced along with other bills in Congress, the FRAC Act has not been passed so far.

[51] The Committee requested 14 leading oil and gas companies and oil field service companies in the US to disclose information about contents and volume of chemicals being used in fracturing activities between 2005 and 2009 (Waxman 2011). Accordingly, these companies used over 2,500 hydraulic fracturing products all together, and 29 out of 650 chemicals used in these products are known to be human carcinogens, which are subjected to SDWA regulations or listed as hazardous air pollutants under Clean Air Act.

[52] The first letter was sent in the early days of the investigation (January 31, 2011), while the second letter (October 35, 2011) updated information about use of diesel fuel in the fracturing process. Both letters can be accessed from http://democrats.energycommerce.house.gov/index.php?q=news/waxman-markey-and-degette-investigation-finds-continued-use-of-diesel-in-hydraulic-fracturing-f http://democrats.energycommerce.house.gov/sites/default/files/documents/Jackson-Hydraulic-Fracturing-2011-10-25.pdf

information issues (The House Committee 2011). The implications of this informational void, the report argued, were limited regulatory and public access, which would impede the assessment of the impacts of fracturing fluids on the environment and public health (The House Committee 2011).

At the request of Congress, the EPA began a second study[53] on the potential impacts of the hydraulic fracturing on water resources in November 2011 to be completed in 2014 (EPA 2011a). According to the EPA's plan, the study would be conducted in a "transparent, peer-reviewed process that will ensure the validity and accuracy of the results" (EPA 2011a: vii). The scope of the study included the hydraulic fracturing water use lifecycle, from water acquisition to wastewater treatment and disposal (EPA 2011a: ix.). The scope of the study was criticised both by opponents and the industry for different reasons. From the point of opponents of fracturing, the EPA study failed to include critical issues such as the treatment of radioactive materials that came to the surface after fracturing process (*The New York Times*, March 02, 2011). Whereas the industry detested the scope of the study, urging the EPA to narrow the objective and scope of it (ANGA 2011).

One of the EPA study's methods was the analysis of collected samples from controversial prospective cases, such as Dimock, Pennsylvania and Pavilion, Wyoming, with the aim of establishing whether there were any linkages between hydraulic fracturing and groundwater contamination. As the EPA's research process was under close scrutiny due to the high profile of the shale gas debate, the study's selected sites became a subject of controversy during the course of investigation. The

[53] The study plan was officially published in November 2011 with the title of "Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources". The document could be accessed at http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hf_study_plan_110211_final_508.pdf

investigation of water contamination in Pavilion, Wyoming, in particular, constituted a major challenge for the agency. The purpose was to investigate the causes of groundwater contamination and its possible links with drilling activity near the town of Pavilion. Responding to residents' complaints about water problems, the agency collected samples from 42 shallow monitoring wells near gas drilling sites between September 2010 and April 2011. Released in December 8, 2011, the draft report concluded that part of pollution stemmed from nearby waste pits, whereas a number of chemicals found in deep monitoring wells indicated a "direct mixing of hydraulic fracturing fluids with groundwater in the Pavilion gas field" (EPA 2011b:27). Contrary to the industry's claim about the technology's safety, the report presented scientific evidence on possible links between hydraulic fracturing activity and water contamination.

Nevertheless, the draft report's findings were met with serious scrutiny from the industry and state regulators/agencies who questioned the methodological approach and interpretation of data collected from water wells (*Huffington Post* July 3, 2013). The industry claimed that evidence had been contaminated during sample collection (Lomax 2012). However, the point to note in this controversy was not whether proper scientific evidence was collected, but the materiality of this information for regulation of the industry at the federal level. Understandably, the agency came under close scrutiny from industry and politicians alike (Lustgarten 2013). While the agency defended the accuracy of data, it did not produce a final report based on these findings (Drajem 2013). Leaving the investigation to the state of Wyoming, the agency chose to abandon the case and omit it from its fracturing study.

The federal regulatory policy on fracturing chemicals remains unresolved. While the EPA received negative press from environmental groups, the industry and

politicians were also quite influential in attacking the investigation on fracturing chemicals, including the scope of the second EPA study on hydrofracturing. At each step, the agency had to justify its findings, especially when a possible causation between fracturing activity and water contamination in Pavilion brought much more pressure to bear. This review process showed that what counts as acceptable evidence in the US context is affected by a multitude of actors and politics that have a bearing on the scientific review process (Jasanoff 2005).

5.4 United Kingdom: Expert consultations

If the fracturing controversy started with the questions of scientific evidence and public disclosure of chemicals in the US, then the expertise on hydraulic fracturing technology came under comparable pressure in the UK. As Chapter 7[54] will elaborate, it was not the fracturing chemicals that posed a major threat to the regulatory authorities and the operating company, Cuadrilla Resources. Indeed only a small part of the parliamentary debates focused on the chemicals used, compared to lengthy discussions on seismic risks which led to a yearlong moratorium in the wake of minor earthquakes in Lancashire. Following the controversy over fracturing chemicals in the US, however, the question of transparency came out early in the UK parliamentary investigations. While relying on the "wealth of experience"[55] developed in the US, regulatory bodies in the UK believed that they had sufficient regulations to govern environmental risks associated with shale gas development.

[54] Chapter 7 will focus on the controversy over earthquakes caused by fracturing activity by Cuadrilla Resources in Lancashire. Two minor earthquakes that happened in April 2011 led to a yearlong moratorium on any shale gas activity in the UK, resulted in a higher public and regulatory scrutiny on the shale gas development.

[55] This phrase became common in the debates over shale gas in the UK. Since the UK government primarily looked to the US for technical and regulatory collaboration, the US experience with the unconventional sector have affected a majority of UK regulatory decisions.

Central to the public debate in the UK was designing a proper regulatory oversight.[56] As reflected in the Energy Minister's opinion piece in *The Guardian*, the UK government was satisfied that the existing regulations were "the most sufficient and robust regulatory frameworks in the world" (Hendry 2011). Unlike the fragmented state-based regulatory approach in the US, environmental and health and safety regulations are applicable to shale gas activities throughout the UK. However, this does not mean that a one-size-fits-all approach governs the regulation of unconventional activities. Despite being prescriptive in terms of their objectives, in line with the European Directives, in practice the UK regulations are based on a relatively flexible goal-based risk assessment regime (UK POST 2011). Depending on the hazardousness of the industry, UK regulators work with the operating companies in setting goals and expect them to implement these in line with best practices.[57] In contrast to the prescriptive regulatory regime of the US, where regulations details what companies ought to do item by item, this regime identifies end goals proportionate to the riskiness of the industry and expects companies to adhere to the stated goals.

Nevertheless, in several instances, environmental groups and research institutions called the appropriateness of existing regulations into question. In January 2011, the Tyndall Centre for Climate Research in Manchester published a report on the environmental impacts of shale gas activities in the UK (Broderick et al. 2011). Based on a review of scientific studies[58] from the US, one of its important conclusions was the existence of significant risks to underground and surface water resources. In

[56] Shale gas development is jointly regulated by Environment Agency (EA), Scottish Environment Protection Agency (SEPA), Health and Safety Executive (HSE), Department of Energy and Climate Change (DECC) and the Local Planning Authority.
[57] Telephone interview with a senior regulator from the Health and Safety Executive, New York, 13 March 2013.
[58] The Tyndall report identifies issues related with collecting reliable data from the US resources by putting a disclaimer on the quality and accuracy of scientific evidence to the beginning of the report.

particular, the report drew attention to "the risk of aquifer water supply contamination due to hazardous chemicals", which was predicted to be a likely reason for local opposition in the UK (Broderick et al. 2011: 7). Considering the ongoing review of scientific evidence on environmental impacts in the US, and the EU requirement for application of the precautionary principle, the Tyndall report called for a moratorium in the UK until there was clear evidence from the second EPA study and the safety of the technology was established. It is crucial to note that the ongoing controversy in the US was critical in the report's call for further scientific evidence and a moratorium which would give time and space to evaluate environmental risks.

In response to public concerns, the Select Committee on Energy and Climate Change carried out an official investigation on shale gas and fracturing technology. Started in November 2010, the Select Committee inquiry included trips to the Barnett Shale and Washington, DC to observe shale gas development in the US, and accepted written and oral evidence from the experts involved in the debate. Between February and March 2011, the Select Committee debated the environmental impacts of shale gas activities in "a quasi-public forum" (Barry 2005) by calling experts to testify on the issue at the House of Commons. In May 2011, the Select Committee published a final report (HC Report May 10, 2011) which identified possible risks of water contamination due to well integrity issues, but did not recommend a moratorium on shale gas activities. Lack of scientific evidence linking the technology and water contamination was a compelling reason for the Select Committee to give a clean environmental bill of health for shale gas activities.

When evaluating evidence on the safety of hydraulic fracturing technology, the Select Committee prioritised socially contentious issues such as fracturing chemicals and water contamination. However, published records of the oral evidence

sessions show that the Select Committee was dismissive towards claims of scientific uncertainty. This was clear when the Select Committee heard testimony from a Tyndall Centre scientist on the possibility of chemicals entering surface and groundwater resources. When the scientist suggested that anecdotal evidence and the EPA's inquiry in the US justifies a precautionary approach, a Select Committee member questioned what constitutes scientific evidence and its implications for social acceptance of shale gas activities and public trust in institutions. The following exchange between the Tyndall Centre scientist and the Select Committee member reflects the tension about the supremacy of "scientific evidence" over "anecdotal evidence" in evaluating environmental risks:

> Committee member: When you say anecdotal, what do you mean?
> Tyndall scientist: Well, in the absence of any investigation at the moment, until we get the EPA study, I would suggest that is probably the first time we will have a real handle on it. Once you get the EPA study then we will know. This is how science works. You observe something, you do a hypothesis and then you go and investigate it.
> (…)
> Committee member: The point is in the process, a lot of damage was done to people's perception of science, people's perception of truth, and whether to trust governments or organisations and that is why I am just a bit anxious about basing it upon anecdotal evidence.
> Tyndall scientist: (…) That is perfectly reasonable, but what is important there is that you undertake a scientific investigation. So anecdote and science are bedfellows.
>
> (HC Report May 10, 2011)

This conversation makes it clear that the Select Committee member considered the fragility of public trust in institutions if anecdotal evidence becomes the main source of information. Following Jasanoff (2005), it is possible to say that procedures of public reasoning functions differently in the UK. What counts as acceptable evidence in the US does not necessarily translate into proper evidence in the UK (Jasanoff 1990). Although the Select Committee member and Tyndall scientist seemed to agree upon the need for scientific certainty, they differed on

whether anecdotal evidence can be relied on as a justification for further review of science. In the Tyndall scientist's testimony, the EPA's scientific investigation was presented as an authoritative intervention into the political debate on fracturing technology in the US. Nevertheless, the Committee member pointed out that in the light of the 2004 report the new EPA study did not guarantee that it would be independent of economic or political influence. Even though the second EPA study became a subject of public debate for its limited focus on water issues, it is critical to note that the politics of science was brought up as a legitimate concern for the loss of public trust in institutions carrying out scientific investigation in the Select Committee hearing. In this regard, the Select Committee member's point about anecdotal evidence hints at possible corruption of scientific review under external influences and the fragility of public confidence in these institutions during the investigation process.

Later in the oral evidence sessions, the issue of public trust emerged in the testimony of the Environment Agency. Responding to public concerns regarding the regulation and monitoring of the industry, the Select Committee investigated regulatory requirements followed by the agency in monitoring Cuadrilla's activities in Lancashire. In particular, groundwater risks and disclosure of fracturing chemicals were key areas of inquiry. During the testimony, a regulator from the Environment Agency explained that operating companies had to disclose all fracturing fluid chemicals prior to an assessment of whether a permit is needed under the Environmental Permitting Regulations, and to inform the agency about their plans under the Water Resources Act (HC Report May 10, 2011). In the case of Cuadrilla Resources, the agency decided that the chemicals used by the operator did not pose

significant risk to groundwater, which was already saline and bad quality, and therefore did not require an environmental permit.[59]

Since the fracturing chemicals controversy had endangered public confidence in shale gas activities in the US, however, the agency decided to monitor the fracturing fluids used by Cuadrilla anyway. Trust between the agency and the company, as well as the level of risk, determined the degree of scrutiny over chemicals. The following conversation between the Select Committee member and the agency illustrates the workings of this trust-based system in disclosure and risk assessment:

> Committee member: You are depending on them to tell you what is in the fracking fluid.
> Environmental Agency: Yes, we need to know.
> Committee member: If you are depending on them to tell you, how do you know what to check for?
> Environmental Agency: It would a requirement that they disclose to us the chemicals.
> Committee member: But if they are using something that you are not checking for you wouldn't know.
> Environmental Agency: If we felt there was a concern, we would take check samples.
> Committee member: How would you know that there was a risk when you were not being told what was in it?
> Environmental Agency: There would be an inherent risk in terms of the type of activity and environmental setting. Clearly, if there was a low risk in terms of the setting, we wouldn't have to go into too much detail with respect to the chemicals being used. If there is a high risk then would obviously expect a higher degree of scrutiny of the chemicals. We would expect full disclosure in that case.
> Committee member: You wouldn't know whether you were getting full disclosure.
> Environmental Agency: I think on the whole we will know, because on the whole we will be dealing with bonafide, respectable companies. I agree there is the possibility that a company would seek to hide something from us, and we do random checks to ensure that that is not widespread occurrence.
>
> (HC Report May 10, 2011)

[59] Interview with a senior regulator from the Environment Agency, Oxford, February 19, 2013.

Thus chemicals disclosure depends on accurate self-reporting from operating companies. Responding to difficult questions raised by the Select Committee member, the agency details the operating principles of risk assessment system and trust relationships in meeting disclosure requirements. The questions of what is considered "full disclosure" or a "risky activity", and whether it possesses this knowledge, are challenging for the agency, considering the implications for the level of monitoring required for a low-risk activity. If the politics of disclosure revolve around the degree of knowledge possessed by the agency and ensuring that companies do not cheat, then the Select Committee member's concerns and his understanding of the relationship between disclosed information and risk assessment are reflective of the perceived failures of a trust-based system. Even though the Select Committee member questioned technical details of disclosure and monitoring requirements, he viewed these as an indicator of the agency's capability for oversight. The agency was confident in its access to information regarding chemical content, as well as its ability to monitor operations of gas companies on the ground. While the agency acknowledged possible failures in self-reporting, it did not see this as a significant challenge for ensuring environmental safety and a level of scrutiny over operating companies.

Critical to environmental regulation in the UK is the case-by-case risk assessment and implementation of industry best practice. As presented by the Environmental Agency,[60] case-by-case assessment includes reviewing each applicant's technical competence, the local conditions, and risks to the immediate

[60] Environment Agency presentation titled as "What is the Regulatory Framework for Shale Gas Exploration in Great Britain" at the Geological Society Shale Gas Event, June 18, 2011. This presentation can also be reached from https://www.geolsoc.org.uk/shalegas

environment, e.g. groundwater quality,[61] in each environmental permit application. Every fracturing chemical reported by the company has to be assessed prior to operations and peer reviewed through a joint agency group, such as SEPA and the Northern Environment Agency.[62] Accordingly, chemicals deemed hazardous are not approved under the Underground Water Directive. In principle, the agency could detect whether the company failed in reporting by randomly checking the flowback water in a random check after operations. Due to the short time frame of fracturing operations, the local environmental agency has to perform announced visits related to fracturing activities.[63]

In addition to the Select Committee hearing, the UK government's chief scientific advisor, Sir John Beddington FRS, commissioned the Royal Society and the Royal Academy of Engineering to conduct a further independent scientific review on the health, safety and environmental risks associated with hydraulic fracturing and its use in shale gas development. As disclosed in the final report published in June 2012, the purpose of this independent review was to analyse "the scientific and engineering evidence relating to the technical aspects of the risks associated with hydraulic fracturing to inform government policymaking about shale gas extraction in the UK" (The Royal Society 2012: 8). Financed by the Government Office for Science, the Working Group held evidence sessions with a range of experts and stakeholders on risks associated with hydraulic fracturing (The Royal Society 2012: 72-73). Like the UK Select Committee hearing in February-March 2011, the Working Group gathered

[61] To given an example, groundwater conditions in Lancashire and Sussex, where unconventional activities are planned, makes a difference in requesting environmental permit from the operating companies. For instance, EA considers the groundwater in Lancashire salty, deep and bad quality therefore did not require a permit here. Whereas in Sussex, groundwater risk was a greater concern as it constitutes an important water supply (Interview with a senior regulator from the Environment Agency, Oxford, February 19, 2013).
[62] Interview with a senior regulator from the Environment Agency, Oxford, February 19, 2013.
[63] Interview with a senior regulator from the Environment Agency North West Region, Bamber Bridge, March 7, 2013.

evidence from all perspectives, and relied on expert judgments from different backgrounds (Barry 2005).

After expert consultations and peer review, the report outlined important recommendations for the regulation of shale gas development in the UK. Regarding environmental risks, the report concluded, "risks associated with hydraulic fracturing (…) can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation" (The Royal Society 2012: 4). While this conclusion was an extension of the Select Committee report in terms of environmental and health risks involved in shale gas development, it departed from earlier official statements by calling for stronger regulations, which amounted to better enforcement and monitoring of the implementation of operational best practices. Regarding fracturing fluid chemicals, however, the report was less concerned about corporate transparency than ensuring the use of non-hazardous chemicals. The report stated:

> Disclosure of the constituents of fracturing fluid is already mandatory in the UK. Ensuring, where possible, that chemical additives are non-hazardous would help to mitigate the impact of any leak or spill.
>
> (The Royal Society 2012)

Notably, the report identified the potential risks of leakage to water resources due to well integrity problems or surface spills, and recommended the use of non-hazardous chemicals to lessen the impacts of a potential leakage or spill. This was a direct response to the controversies surrounding the possible causal connection between fracturing chemicals and water contamination in the US. The report disclosed in its Appendix II (The Royal Society 2012), that the Working Group consulted experts from the EPA and the American shale gas industry in reaching this conclusion. In the light of these consultations, the report attributed water

contamination to well integrity problems and surface spills, not to the hydraulic technology itself. In this regard, the report authoritatively reaffirmed technical conclusions from the US, where these issues were still subject to heated controversy and the focus of the EPA's second study. Secondly, the report gave a detailed analysis of the transparency crisis and its ramifications for regulation of the industry in the US, yet went on to say that chemicals disclosure was not a major regulatory concern due to the UK's mandatory disclosure laws. Strikingly, less attention was given to public access to the informational content of fracturing fluids in the UK. In a way, the Working Group agreed with the UK government that existing disclosure laws would not lead to public controversy on corporate transparency.

On one issue, however, the report did not agree with the UK government's position on shale gas development. Given the uncertainties around the scale of shale gas development in the UK, the question of an appropriate regulatory response and preparedness rose to political significance. In Recommendation 8 of the report, this point was further emphasised with a call for additional resources to be devoted to addressing the gaps in existing skills and training for better enforcement of regulations (The Royal Society 2012).

The official government response to the report rejected the argument that existing regulations were insufficient to ensure the safety of hydraulic fracturing and its potential impact on water resources. In the likely event of increased shale gas activity in the country, the UK government foresaw possible regulatory adjustments along the way.[64] While there have been recent developments towards a more integrated regulatory framework,[65] the UK government's confidence in the regulatory

[64] Interview with a senior regulator from the Environment Agency, Oxford, February 19, 2013.
[65] Interview with a senior regulator from the Environment Agency, Oxford, February 19, 2013..

agencies' capacity to meet the demands of a larger scale shale gas development persist.

5.5 Corporate self-disclosure

As the previous sections have shown, the informational void regarding chemical content led to intense regulatory debates in both the UK and the US. This became a reputational issue for operating gas companies, who contracted fracturing to field operations companies and were bound by confidentiality agreements, yet had to face scrutiny from local communities, activist organisations, media and institutional investors. Embedding the corporate voluntary disclosure initiatives into larger regulatory context(s), the following sections give an in-depth analysis of corporate strategies in facing serious reputational and regulatory threats. They advance two important field observations. First, I show how this new information about chemicals has important implications for corporate governance models in both countries, pushing the gas companies to become more transparent about their operations along the supply chain. Second, the limitations of these transparency initiatives have become more prominent as other actors entered the debate. Although the industry presumed corporate self-disclosure would put an end to this particular controversy, these other actors deepened the debate on regulation in both countries. As we will see, the availability of more information in the public domain does not necessarily lead to a resolution of transparency issues in the sector (Barry 2013). Instead, disclosure platforms have to be analysed in relation to their regulatory effects and how they transform participating individuals and organisations (Strathern 2000).

5.5.1 Development of a fracturing chemicals registry in the US

After heightened attention to the scientific review of hydraulic fracturing technology and fracturing chemicals, corporate disclosure emerged as an important regulatory, reputational and financial issue for the industry in the US. As one of the institutional investors put it, corporate disclosure risks constituted a key investment concern at the end of 2009, when gas companies had done little in terms of disclosure beyond publishing general statements saying that "we have 60 years of safe experience of extraction".[66] When investors raised questions about the operations of companies in shale gas fields where the questions of water contamination became a vital concern, bilateral talks between investors and companies began on how to improve corporate disclosure in the public domain.[67] There were several negotiations on the establishment of a chemicals disclosure registry which would not meet only public demand, but also respond to possible regulatory threats and not jeopardise confidentially agreements with field service companies (Liroff 2011).

In April 2011, the industry took the important step of launching the FracFocus website. An online chemicals disclosure database set up by the Groundwater Protection Council (GWPC) and Interstate Oil and Gas Compact Commission (IOGCC), and funded by two industry trade organisations (the American Petroleum Institute and America's Natural Gas Alliance), the idea behind FracFocus was to introduce voluntary self-regulation on public disclosure. As stated on the website, the registry aims to "provide objective information on hydraulic fracturing, the chemicals used, the purposes they serve and the means by which groundwater is protected".[68] The initiative promised a "win-win" situation for the industry for the following

[66] Telephone interview with an institutional investor from Boston, August 02, 2012.
[67]Telephone interview with an institutional investor from Boston, August 02, 2012.
[68] For more information about the mission of this registry, see About US section reached from http://fracfocus.org/welcome

reasons. First, it argued that voluntary disclosure could eliminate the need to unify the fragmented state regulatory approach through a new federal regulatory framework (Haas et al. 2012). Secondly, at the state level, the industry could respond to limitations of Material Safety Data Sheet (MSTS) that do not focus on environmental and public health.[69] Finally, operating companies could deal with reputational issues without compromising their confidentiality agreements with service companies.[70]

This private initiative to resolve public informational access initially aimed at protecting the industry from "threats of federal intervention" (Wiseman 2013). US congressional debates, as indicated above, did not lead to a unified regulatory regime for the producing states. Already under increased public scrutiny, several states saw the FracFocus as an effective regulatory tool for public disclosure of chemicals. In February 2012, for instance, Pennsylvania Department of Environmental Protection (PADEP) passed a new law mandating all operators[71] to use the FracFocus disclosure registry form to disclose their use of chemicals on the website in addition to the reports submitted to the department (Cahoy et al. 2013). With an increasing number of producing states[72] mandating disclosure on the website, FracFocus become an acceptable self-regulatory tool in the industry.[73]

[69] Telephone interview with a senior researcher from an institutional investor network based in Boston, August 02, 2012.
[70] In-person interview with a best-practices expert from the Marcellus Shale Coalition, Shale Insight Conference, Philadelphia, PA September 21, 2012. In the eye of the public, there is not much difference between the supplier and operator (Interview with a water scientist from Water Resources Institute, Ithaca, NY, August 22, 2012). On the FracFocus website, you can only search by the operating company, not the service company.
[71] It is important to note that only 4 out of 64 companies in the Marcellus Shale voluntarily participated to the FracFocus initiative prior to enactment of this law (In-person interview with a Cornell academic, Ithaca, NY, August 22, 2012).
[72] As of May 2013, eight producing states, namely Colorado, Mississippi, Montana, Louisiana, North Dakota, Oklahoma, Pennsylvania and Texas, use FracFocus as a part of their regulatory requirements (fracfocus.org).
[73] As of May 2013, 525 companies agreed to disclose chemicals on FracFocus (fracfocus.org). This is a dramatic increase from 68 participating companies in October 2011 (Liroff 2011).

Equally, reputational risks were critical in the industry's decision for voluntary disclosure. At a local industry conference in Philadelphia, a senior executive at a prominent Texas-based gas company operating in the Marcellus Shale made the following remarks on the reputational aspects of the FracFocus initiative:

> PA [The state of Pennsylvania] was first to start conversation about what was in the fluid. We did not react soon enough; we just thought *New York Times* is asking for it. Then ordinary citizens began asking questions (…) In 2011, we started disclosing well-by-well basis. We set up a website and go through service companies to re-check our confidentiality agreements for 3-4 months. By mid-2011, we announced it. Since then we have zero question on that!
>
> (Keynote Speech, Shale Insight Conference September 20, 2012)

These remarks point to the significance of the public disclosure of chemicals in the fracturing controversy, identifying reputational risks associated with keeping proprietary information away from the public. As indicated in the quote above, increased public awareness about fracturing chemicals made it difficult for operating companies to maintain non-transparency by citing economic reasons. The controversy affected operating companies' ability to obtain a social license to operate, forcing the industry to find a collective solution to contractual barriers which made it impossible to compromise supplier information and publicly disclose the most disputed chemicals (Cahoy et al. 2013). As pointed out in the keynote speech, establishing FracFocus required intense negotiations between operators and suppliers. Though FracFocus allows for a class of chemicals to be labelled as trade secrets and for supplier information to be removed, companies now have to justify why they choose to keep certain chemicals secret due to their confidentiality contracts with the service companies.[74]

[74] In-person interview with a shale gas expert from Environmental Defense Fund, NYC, NY, November 16, 2012.

While the industry might view FracFocus as an effective way of resolving the controversy surrounding public disclosure, critiques of the initiative focus on the inadequacies of self-regulation which relies on negotiations between state regulators, operating and service companies. As the prominence of the website as an alternative to federal regulations grew, several critical articles were written on the drawbacks of industry self-regulation replacing a federal framework (see Cahoy et al. 2013; Konschnik et al 2013; Wiseman 2013). Perhaps the most striking critiques target the accuracy and format of data. In particular, the industry's decision to disclose on a well-by-well basis via individual PDF files was criticised for blocking public access to the underlying database, rendering it difficult to trace cumulative data about the operator, geographical location, name of chemical or date.[75] While GWPC acknowledges that their initial intention was not specifically to provide cumulative data to the public, a system update in 2013 was purported to allow searching by chemical and date of disclosure.[76]

The politics of voluntary public disclosure remains unsettled after several critical assessments of accuracy of the data posted on the FracFocus website. In 2012, *Bloomberg News* economists published one of the first critical analyses by compiling FracFocus data and comparing it with available data from eight producing states,. The analysis identified discrepancies in disclosed information in all eight states[77] as well as gaps in naming certain "trade-secret" chemicals by the operators (Haas et al. 2012). There were also numerous concerns raised by data inaccuracies by environmental

[75] Telephone interview with a policy analyst from PennEnvironment, September 09, 2012.
[76] http://www.energyindepth.org/tag/fracfocus/
[77] For instance, Bloomberg's analysis of FracFocus disclosures in Texas, Oklahoma and Montana shows that more than half of the wells were unreported on the website (Haas et al. 2012).

organizations such as Natural Resources Defense Fund and Sierra Club,[78] which insisted on a federal programme on the regulation of fracturing chemicals disclosure (McFeeley 2012). Using FracFocus data processed by an activist group called SkyTruth[79], a policy review paper by the Harvard Environmental Law Program pointed out compliance issues in the use of FracFocus as a mandatory disclosure platform (Konschnik et al. 2013). The study defined inaccuracies in the timing and substance of disclosures and the inconsistent assertions of trade secrets made by companies (Konschnik et al. 2013).

In May 2013, concerns over data inaccuracies and restricted access to cumulative data were also raised at the US Congress Committee on Natural Gas Oversight Hearing on the "DOI Hydraulic Fracturing Rule: A Recipe for Government Waste, Duplication and Delay".[80] Following the Obama Administration's proposed federal regulations on public lands,[81] the Congressional Committee hearing considered whether additional hydraulic fracturing regulations would be a waste of federal resources and time, as suggested by the industry (Sgamma 2013). Responding to inaccuracies found at the FracFocus website by environmental groups, the Independent Petroleum Association of America (IPAA) claimed that none of these faults "diminishes the success of FracFocus or justify a new, costly federal reporting system" [82]. Conversely, the IPAA claimed that submitting false information

[78] In May 2013, NRDC and Sierra Club jointly testified at the Congress Hearing, arguing against the adequacy of FracFocus as a mandatory disclosure tool. See http://www.sierraclub.org/pressroom/downloads/SC-NRDC-Sen-Wyden-Responses-06-05-2013.pdf
[79] SkyTruth is a nonprofit organization that has first gathered a compiled data list on fracking chemicals, using the information on individual company disclosure data sheets. See more about the mission of SkyTruth at http://skytruth.org/about/#sthash.Kgq0EoLI.dpuf
[80] http://naturalresources.house.gov/calendar/eventsingle.aspx?EventID=332157
[81] For further details of the proposal, see: http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/hydraulicfracturing.Par.91723.File.tmp/HydFrac_SupProposal.pdf
[82] Full content of IPAA testimony at the Oversight Hearing could be reached at http://www.ipaa.org/wp-content/uploads/downloads/2013/05/Testimony_IPAA-EID-Regarding-May-23-ENR-Roundtable-5-31-13.pdf

purposely to the site would not benefit the industry from a regulatory point, since an increasing number of state regulators required disclosure of chemicals at this website and heightened federal attention would force the industry to be more careful about its reporting.[83]

Whilst countering the industry's view of FracFocus as an adequate regulatory compliance tool, the following witness testimony[84] by the owner of Sky Truth also suggested there were design and implementation issues with the website:

> Several states have since passed laws requiring varying levels of public disclosure of the chemicals used in hydraulic fracturing, and some have directed operators to use FracFocus as the means of accomplishing public disclosure; a legal use of the FracFocus site that it was not designed to accommodate. It was also not designed to allow aggregating and analyzing information. Indeed, the site's operators have publicly stated that FracFocus was intentionally designed to thwart that use. This design, in both its philosophy and implementation (for example, the publication of data in PDF files, a format that is not "machine-readable"), violates key elements of the Administration's Open Government Directive of December 8, 2009, guidance to agencies regarding the management of federal information resources, and the Open Government initiative, rendering the site noncompliant as a public disclosure platform.
>
> (SkyTruth testimony May 8, 2013)

Here, SkyTruth's owner questions the FracFocus website as a reliable regulatory compliance tool, pointing out technical problems regarding its design and ramifications for regulation of the industry. For him, the acceptance of FracFocus as a viable public disclosure platform by federal agencies would violate the rules of the Open Government initiative, making it impossible to generate aggregate data on fracturing chemicals to study environmental and health impacts. Indeed, he argues that the design and form of disclosure at this transparency platform only generates a restricted public view, and hence negates the principle of openness. In his terms,

[83] IPPA Testimony, US Congress Committee on Natural Gas Oversight Hearing, Washington, DC, May, 2013.
[84] http://naturalresources.house.gov/uploadedfiles/amosdisclosure05-08-13.pdf

enforcing transparency in the industry requires federal oversight, or else this restricted disclosure registry would continue to yield inaccurate disclosure.

As more data on chemicals becomes available on the website, these criticisms target what is made visible and what is hidden from the public eye, interrogating the development of practices of transparency in the sector. It is highly likely that FracFocus will continue to generate some transparency on the contents of chemicals, while not being so transparent about the way it functions and protects proprietary information due to commercial reasons. Far from limiting the controversy over the regulation of chemicals disclosure, FracFocus website will be a key site of contestation for corporate transparency, complicating regulatory discussions between the industry and regulatory agencies, research institutions and activist organizations.

5.5.2 Regulating corporate disclosure in the UK

While regulatory debates on corporate disclosure of fracturing chemicals took a different course in the UK, the operating company, Cuadrilla Resources, and regulators were quite aware of the bad publicity associated with non-disclosure. On one hand, the discourse of "learning from the American experience" has been pervasive in the technological and regulatory collaborations between two countries. On the other, there has been a visible effort to distinguish the course of development in the UK from that in America, especially on the issue of fracturing chemicals disclosure. As discussed earlier, the existing regulatory framework adopts a case-by-case risk approach to the regulation of chemicals and requires full disclosure before approving a shale gas site. Unlike the federal regulators in the US, British regulators

repeatedly stressed that they know the content and volume of the chemicals used in the fracturing process.[85]

Indeed, this became a significant point of inquiry at the parliamentary Select Committee hearing, when the company pointed that they voluntarily disclosed the contents of chemicals, including trade secrets, to the regulators. For Cuadrilla Resources, the circulating list of dangerous chemicals used in the US misrepresented what the company had proposed to use in Lancashire gas sites. At the hearing, a high executive from the company claimed that they use "simpler" chemicals, naming 4–5 typically used chemicals in the fracturing fluid:

> You were talking about the dilution of the toxic chemicals. I talked about a friction reducer, and the main compound in that is polyacrylamide, which is used in facial creams and contact lenses and also as a bonding agent to seal soil. It is a product that isn't toxic (…) The biocide is really a product that is – as I said there is a number of them out there, but we will be selecting one from a list that is used in treating drinking water. A third additive is one that is not really mixed into the frac fluid but is a diluted weak concentration of hydrochloric acid and muriatic acid… It is very dilute going in and then it is chased by the 12,000 cubic meters of water and becomes really diluted at that point. It is the same product that is used in the food industry.
>
> (HC Committee May 10, 2011)

Responding to the Select Committee member's questions about the toxicity of fracturing chemicals, the company argued along the same lines as most American companies did in the immediate aftermath of the chemicals controversy. The company did not only refer to a common industry communication strategy of simplifying the toxicity of chemicals, they also act as "agents of translators" (Callon 1986) by drawing parallels to the daily use of these chemicals to the public. Since the public disclosure of information about the fracturing chemicals was a key reputational issue with important regulatory implications, the company had to clarify which chemicals

[85] In-person interview with a senior regulator from the Environment Agency North West Region, Bamber Bridge, UK, March 7, 2013.

were used, while distinguishing itself from its American counterparts. Apart from what is said publicly, the company justified their use of fewer and simpler products in terms of cost, risks to the site and the geological features of the shale play.[86] These reasons are not necessarily made public, as they refer to the financial, technical and environmental risk management structure of the company rather than the public relations side.

Equally, the trust relationship between the company and regulators defines their assessment of the company in regulatory oversight over the fracturing chemicals. The regulatory regime governing groundwater risk assessments in shale gas sites leaves room for random site checks,[87] which could compromise the company's permit if regulators catch any misreporting about the content of fracturing fluids. With the purpose of protecting them from any liability or reputational risk, Cuadrilla Resources made full disclosure to regulators even in sites like Lancashire, where the Agency declared there was no groundwater risk and had not issued a requirement to report. As a company employee said,[88] demands for transparency had a significant effect on their conversations with regulators. Knowing that their operations were under close public scrutiny, the company was careful about exposure and about structuring their talks with the regulators. Transparency, therefore, had a critical impact on the entirety of their operations, but most importantly on the disclosure of chemicals.

[86] In-person interview with sustainability/risk management specialist from Cuadrilla Resources, Lichfield, UK, February 26, 2013.
[87] Although announced inspections could be done in theory, it becomes quite difficult considering the relative short time frame of fracturing operations. That is why the Environmental Agency had only made announced field visits to the Lancashire sites so far (In-person interview with a senior regulator from the Environment Agency North West Region, Bamber Bridge, UK, March 7, 2013)
[88] In-person interview with sustainability/risk management specialist from Cuadrilla Resources, Lichfield, UK, February 26, 2013.

An important step towards public disclosure taken by the company was the voluntary disclosure of the chemicals used in fracturing at the Preese Hall-1 well[89] on the company's website. Acknowledging the possible reputational risks stemming from restricted public disclosure in the US, Cuadrilla Resources decided to do a detailed disclosure that included both the volume and concentration of chemicals used at Preese Hall-1. For Cuadrilla, the availability of more information on their website meant less controversy on the chemical contents and a better company image. Although regulators and the company repeatedly assured the public about full disclosure, there were series of criticisms regarding oversight issue in the initial shale gas wells in Lancashire (Hill 2012). These critiques pointed out regulatory gaps and oversight issues considering a possible extension of shale gas development in the UK, yet they were not taken seriously in the year-long moratorium on shale gas development.

In July 2013, anti-drilling protests nearby Balcombe, Sussex, brought public attention to hydraulic fracturing and its possible environmental impacts. As reported by the *Guardian*, this issue recaptured "public reimagination" following the blockage against Cuadrilla's planned drilling sites in Balcombe (Harvey 2013b). After assessing Cuadrilla's initial planning permission application for chemicals, the Environment Agency did not approve one chemical, antimony trioxide, expressing concerns over its hazardousness if there were any contact with groundwater (Harvey 2013a). Since drilling activities in the area would be near viable groundwater water supplies in Balcombe, the Agency's decision to declare the use of the chemical as hazardous at this site drew public attention to Cuadrilla's statements about the safety of fracturing chemicals. As related by the protestors and villagers (Harvey 2013a),

[89] The company's disclosure sheet could be reached from http://www.cuadrillaresources.com/wp-content/uploads/2012/02/Chemical-Disclosure-PH-1.jpg

another substance that raised concerns was the use of oxirane, which the company declared it would not be used its Balcombe site. In response to concerns over fracturing chemicals use, the company underlined that there would not be any fracturing at Balcome at the moment, as their drilling results showed that the geological features of the site were naturally fractured and did not require additional stimulation (Gosden 2014). Yet, the company did not rule out possible future fracturing operations at Balcombe.

As the tiny industry expands in the UK, the government has considered addressing voluntary public disclosure more systematically. On July 30, 2013, it announced[90] that operating companies would publicly disclose chemical constituents in fracturing fluids and additives on a well-by-well basis, together with a brief description of their purpose and possible hazards to the environment. In this step towards the institutionalisation of corporate disclosure for future operations, the government encourages two venues for disclosure: "company websites or on third-party developed websites".[91] This decision reflects industry lobbying efforts in the UK and Europe, as shown in a series of best practice recommendations outlined by the UK Onshore Operators Group (Macalister 2013) and the format of disclosure at the newly formed London-based chemicals disclosure website called NGS Facts[92]. As with the ongoing debate surrounding FracFocus in the US, the format and design of

[90] Document was reached at https://www.gov.uk/government/publications/about-shale-gas-and-hydraulic-fracturing-fracking/about-shale-gas-and-hydraulic-fracturing-fracking

[91] Document can be reached at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268017/About_shale_gas_and_hydraulic_fracturing_Dec_2013.pdf

[92] As stated at the NGS Facts website, it is "a voluntary natural gas from (NGS) Hydraulic Fracturing Fluid and Additive Component Transparency Service, managed by the International Association of Oil and Gas Producers (OGP). So far 10 wells from Poland have been disclosed on the website. See http://www.ngsfacts.org/about/

public disclosure will probably be under close scrutiny if this initiative becomes a viable disclosure platform for the UK industry.

5.6 Conclusion

The controversy surrounding the fracturing chemicals disclosure has risen to political prominence in the US and UK, becoming a key site for political debate regarding the behaviour of the industry and governing regulatory regimes. Failure to disclose in the public domain has been shaped and critiqued by a range of actors, including activists, local communities, academics, and investors, who saw transparency as an indispensable component of good governance despite having different views on the shale gas industry and what transparency means. Information about chemicals eventually became a subject of scientific inquiry in both countries, putting a spotlight on the safety of hydraulic fracturing technology and the adequacy of governing legal regimes for the growing industry. Consequently, newly formed voluntary disclosure initiatives made some information visible to the public, though they generated more controversies regarding the format and design of these new disclosure initiatives.

This chapter approached the transparency controversy from a different angle, taking a comparative perspective to the complex relations between science-policy interaction, reputational concerns, and economic reasons behind the formation of a new regime of transparency in the shale gas industry. On the treatment of scientific evidence, comparative study has shown that the institutional and procedural traditions have affected science-policy relations in two countries (Jasanoff 2005). In the US, the EPA has to go through immense scrutiny regarding its findings on fracturing chemicals, providing justifications at each and every step in its review. Responding to public concerns about its 2004 study, the agency decided to conduct a second study on

hydraulic fracturing technology that would also have an impact on federal regulation of fracturing chemicals disclosure. Since it announced the second study, however, the agency found itself once more at the centre of attention. Critics attacked the study's scope, the selection of sites and the industry's influence on the interpretation of field findings. For instance, when the EPA announced it would drop its findings on water samples from Pavillion, Wyoming, leaving the inquiry to the state of Wyoming, this was perceived as the result of direct industry influence on the agency. For industry lobby groups, the second study was also full of design flaws, from selection of samples to interpretation of results. Confronting the agency at every step of the inquiry, the American business community repeatedly attacked any scientific evidence, expressing their dissatisfaction with the possible introduction of environmental controls by the federal agencies. For the industry, the new study also constituted a reputational concern regarding the claims of the shale gas industry, bringing nationwide attention to controversial sites where water contamination constituted a major concern for the public and investors. The inquiry itself became another source of debate about who has control over the agency, whether its findings are legitimate, and how scientific evidence is treated and interpreted in discussion over federal regulation of shale gas development. The debate over corporate transparency, therefore, has expanded into a larger debate about the transparency of the EPA, its process of scientific evidence collection and the industry's influence over the agency.

In the UK, on the other hand, experts enjoyed relative freedom and less scrutiny from the public in the parliamentary inquiry about shale gas development (Jasanoff 2005). Demands for further review of science were met with doubt from Committee members, questioning the political salience of the EPA's second study and

anecdotal evidence from shale gas sites in the US. The existing regulatory regime, as the HC report argued, was perceived to be adequate for emerging small business. Although regulators require fracturing chemicals disclosure, Committee members and critics raised important questions about regulatory oversight as shale gas development proceeds in the country. Upon the request of the UK government, the expert committee behind the Royal Society report pointed out possible areas of environmental risks related to fracturing, but met with criticism from the government who believed in the regulatory capacity of the EA, HSE and DECC in overseeing the industry operations. Even though the regulatory agencies adopted the discourse of "learning from the US experience", US based studies on risks of fracturing were not factored into the government's decision to go with shale gas development. Unlike the confrontational relations between business and the EPA in the US, the UK industry has been quite cooperative with the Environment Agency about the implementation of possible environmental controls (Vogel 2003). From the very beginning, the tiny industry worked with regulators, who believed in the good faith efforts of the company in complying with environmental regulations. As pointed out by critics, this informal relationship raised some concerns about regulatory oversight, as the regulation of fracturing chemicals depended on truthful reporting from the company. In the UK, therefore, discussions about transparency aimed at regulatory capacity and oversight over operating companies rather than lack of regulation.

Equally, the chapter has underlined the importance of private actors and critics in shaping the transparency controversy over corporate disclosure. As analysed in the second part, the production of new information about chemicals depended on multiple political negotiations, financial dealings and reputational concerns in both countries. In the US, the need for transparency about chemicals emerged in order to remedy

reputational concerns for the entire industry. After a series of negotiations and technical fine-tuning, the FracFocus chemicals registry website was founded as an industry response to community, investors' and regulatory concerns. As this chapter has shown, business members perceived the formation of FracFocus chemicals registry website as a "win-win" technical solution to the informational void regarding chemicals where thousands of disclosure documents could be published on a well-by-well basis. Although chemicals disclosure was less of a concern from a regulatory standpoint in the UK, the operating gas company defined transparency on chemical content as a key reputational issue from the beginning. Observing how secrecy over chemicals transpired in the US, Cuadrilla Resources voluntarily disclosed the contents of fracturing chemicals on its website. In the initial stages of UK shale gas development, there was less contention about chemical content, as regulatory agencies and the company were aware of the public value of disclosed information and collaborated on making some information available to the public. As the protests in Balcombe, Sussex showed, however, the demands for public disclosure of chemicals regained visibility, partly because of the company's repaired image and partly due to perceptions of lack of regulatory oversight in the aftermath of a year-long moratorium on shale gas development. In response to public and regulatory concerns, we observed the beginnings of an industry-led voluntary public disclosure initiative in Europe. In line with the UK government's recent proposal to require public disclosure on a well-by-well basis, these initiatives are likely to create further public debates about the format and design of corporate disclosure in the UK.

The transparency controversy about fracturing chemicals, opened up new venues for contestation, pushing the regulatory agencies and gas companies to publish more information in the public realm. Even though critics have constantly monitored

and attacked the claims of transparency in both countries, they did not necessarily question the principle of transparency or its implications (Barry 2013). Pointing out the transformative effects of transparency demands on regulatory processes and companies, the chapter argues that those who found themselves at the centre of criticism aimed to control the flow of information about chemicals by publishing some form of information on company websites or third-party disclosure platforms. The availability of more information on fracturing chemicals, however, did not mean a reduction in secrecy, as newly disclosed information attached a new value to the information which still remained secret —in this case, a subset of fracturing chemicals labelled as trade secrets (Strathern 2000). When gas companies believed that they resolved the transparency debacle through these newly formed disclosure platforms, they had to face a new set of criticisms regarding design and accuracy that formed the basis of critics' calls for consistent federal regulation. Despite having different national styles of handling the transparency crisis, both the UK and the US governments had to tackle with questions of regulatory oversight. As information about chemicals rose to political prominence in both countries, it amplified the debate on the responsibilities of gas companies and regulatory agencies supporting shale gas development. The next two chapters will make a case for the spill over effects of this particular controversy in generating contestation about the industry and regulatory institutions.

CHAPTER 6: SAFE TO DRINK? THE POLITICS OF EXPERTISE IN WATER CONTAMINATION DISPUTE IN DIMOCK, PA

6.1 Introduction

The shale gas drilling activities in Southeastern Pennsylvania were clearly evident in the busy truck traffic and sounds of heavy machinery filling the otherwise quiet town of Dimock. Between 2008 and 2012, this small town received wide coverage in the national and international media, which peaked when it became the centre of a federal investigation regarding a possible connection between drilling activities and drinking water contamination. Due to its close proximity to New York City, Dimock also turned out to be a quite popular site for the anti-fracking movement, with celebrities Yoko Ono and Mark Ruffalo visiting the town in support of landowners whose tap water turned foul-smelling after drilling activities began. Dubbed the "Ground Zero" in the dispute over the safety of hydraulic fracturing technology (*StateImpact* 2014), the Dimock water contamination case became a high-profile legal, political and scientific battle, overloaded with the production of a vast amount of information on the possible impacts of the drilling activities on local water resources.

If the discussions over the safety of HF technology are examined in the US context, then the production of information regarding the causes of water contamination becomes critical, since this informs the politics around regulating the industry. The proliferation of scientific information on the possible causes of water contamination did not only complicate the much vaunted shale gas expansion in the Northeast US, but also generated a wider political space through which the ramifications of the technology were discussed by the industry, regulators and the activists. From the activists and litigant landowners' standpoint, the link between

shale gas drilling and water contamination was clear from the fouled drinking water wells, which only became a problem after Cabot Oil and Gas began drilling operations in the area. By contrast, the company denied any possible connection between its operations and the water quality, blaming the "naturally occurring" gas found in the lower layers of geological formations for the methane contamination of drinking water supplies. As for the state and federal regulators, the issue of water contamination not only became a challenge to the accountability of public institutions but also fostered a wider political debate about the future of shale gas development in the country.

This chapter uses the Dimock case to focus on the impacts of shale gas drilling in relation to the dispute over water contamination for two reasons. First, the water contamination dispute in Dimock is critical to understanding governance of environmental impacts of fast-paced shale gas development in the US. The expansion of controversy from a local incident to a nationwide concern raised important questions about responsible resource governance at the federal level in terms of 1) whether states were sufficiently well equipped to handle the adverse impacts of this nationally vital and very fast-growing industry, and 2) how the responsibilities of gas companies towards local communities and the environment should be defined. Second, the practices of knowledge-making and professional judgment made by various experts involved in the Dimock controversy afford an invaluable insight into the contested scientific review process in the American context. As the controversy unfolded, the political stakes in choosing an expert vernacular became critical for the resolution of the controversy (Jasanoff 2006a). Although articulations of expertise judgment and counter-statements in lay settings defined the terms of conflict, the measurement of impacts through multiple water tests limited the political discussion

to a set of technical questions about how to fix the water problem in a particular territory (Barry 2013; Callon et al. 2009).

What was at stake in Dimock case was the credibility of claims raised by landowners and the company. These were subjected to a series of water tests conducted by the state and federal agencies, the company and scientists. In what follows, two important observations will be made in regard to the impact of these tests. The first of these concerns the fact that, through their employment in a lawsuit against the company, the water tests became central to the landowners' claims for compensation and restoration of drinking water supplies – and the answer to the question of whether drilling activities led to water contamination or not depended on the comparability of test results performed by different experts (Barry 2013). Basically, as the official test results published by state and federal agencies converged, the lived experiences of landowners were marginalised. The landowners were thus angered by the way in which the dispute was handled by the state and federal agencies, their frustrations aggravated by the politics of knowledge-making practices that shaped the legal dispute in favour of the company.

Second, the political dispute was further complicated by the company's argument about the "complexity" of the geology of underground waters, drawing from historical data of the region and isotopic analysis of methane commonly found in shallow layers. Although this study could be perceived as a strategic use of scientific uncertainty to escape from legal liability (McGoey 2009; Michaels 2006; Oreskes and Conway 2010), it is equally critical to examine the material effects of multiple measurements that had a constraining effect on the political dispute over the water contamination issue (Barry 2013). Considering the importance of these water tests in the legal dispute in relation to corporate liability, experts played a critical role in

identifying (translating) the source of contamination and declaring Dimock water safe to drink.

Developing these two arguments, this chapter examines the role of science in debating the safety of the fracturing technology and in shaping the water contamination controversy through the strategies of the operating company. First part of the chapter will review how the Dimock case attained political significance, together with the state and federal investigations into the operations of the company and the ways in which the complexity of issues and actors involved in the controversy broadened the debate over fracturing technology to other drilling-related problems. Then, the second part will look at the political implications of the Pennsylvania Department of Environmental Protection (PA DEP) and Environmental Protection Agency (EPA) investigations aiming to establish the possible cause(s) of the water contamination. In its strategic deployment of scientific uncertainty as a part of its defence in the federal lawsuit and Consent Order settlements with the PA DEP and not just accepting responsibility for the contamination, the operating company suffered a lot in terms of reputation and license to operate. Overall, the chapter will show that the measuring of shale gas development impacts on water resources was shaped by diverse knowledge practices that are themselves entangled with questions of ethics of responsible development, law and regulation.

6.2 The Politics of Expertise

The role of experts was critical not just in defining the terms of the conflict over the causes of water contamination in Dimock, but also in obtaining compensation for the alleged wrongdoings of the operating company. During the regulatory inquiry over water contamination, scientific knowledge became crucial for landowners; without it,

they could not be counted as eligible for compensation (Petryna 2002). First there was controversy over the reliability of the method of data collection, and then the quantification of risks associated with drilling provided a basis for regulatory decisions at the state and federal level (Jasanoff 1990). It was also for this reason that the multiple water tests conducted in Dimock were performative: they were not just instruments for establishing matters of fact, but depended on and thus called into question the reliability of expertise judgment on which the drilling impacts could be assessed and contested (Shapin and Schaffer 1985). Measuring the impacts of drilling on water resources, therefore, centred on questions of political interest and the objectivity of the experts involved.

The process that transformed a local incident into nationwide "socio-technical controversy" or "public knowledge controversy" requires a careful examination. We need to look at how heterogeneous actors and the sequence of events impacted on knowledge practices around water contamination in this case (Barry 2013; Callon et al. 2009; Latour 2004). As noted in the STS literature, knowledge controversies can yield collective opportunities by admitting the knowledge of non-scientists into the knowledge production process (Callon et al. 2009; Strengers 1996; Whatmore 2009). In the lexicon of Collins et al. (2009: 32), the formation of hybrid forums during controversies provides a deliberative process, in which "plurality of points of view, demands and expectations" are represented. In Stengers' (2005) words, public knowledge controversies are "experimental events", in which citizens may invent new ways to posit questions, demand explanations and participate in the production of knowledge. Developing Stengers' idea of "cosmopolitics" (1996, 2010), Latour (2004) proposed the notion of an "ecological politics," in which a range of technical

competences-sciences, politics, law, economy, contributes to the articulation of contested objects.

This object-oriented account of controversies prioritises the objects of politics by showing the connections between such contested objects, people and institutions in public involvement practices (Barry 2001; Latour 2004; Marres 2007). The literature on knowledge controversies problematises the interaction between science and politics, positing significant questions for the politics of expertise and the role of non-humans, which are often introduced by the world of science and technology (Latour 2004). Although constructivist scholarship makes explicit efforts to distinguish the space of science from politics (Colins and Evans 2002), questions about which expert judgment should be regarded as important or discarded in negotiating public accountability, political power and terms of compensation imply a political act (Demeritt 2006; Jasanoff 2003; Wynee 2003). Going beyond analysis of the claims to "matters of fact" in knowledge controversies, Actor Network Theory (ANT) thus focuses on the importance of "collective experimentation and learning" (Callon et al. 2009:9) and collaborative opportunities to "redistribute expertise between scientists and affected publics" (Whatmore 2009: 592).

However, the question of *how* diverse publics are involved in such collaborative opportunities and *whose* voice has legitimacy in such deliberative processes pose a serious challenge for the knowledge controversies literature (Jasanoff 2003). For Barry (2012), the knowledge controversies literature has further shortcomings. First, as participants often disagree about the existence of a problem, knowledge controversies have indeterminate and contested boundaries; second, knowledge controversies are often portrayed as isolated events, with a concomitant failure to observe connections between controversies; and third, knowledge controversies

provide “a limited account of other aspects of legal and political practice” by focusing on the significance of explicit knowledge claims in political life (Barry 2012: 329). Adding to the object-oriented accounts of socio-technical controversies, therefore, Barry (2012*:* 330) proposes the term “political situations,” which encapsulates the assemblages of material artefacts, contested ideas and practices that are likely to stay uncertain and disputed and animated by other disputes that have occurred or are likely to occur over time and across national boundaries. The notion of political situations becomes particularly useful in understanding the politics of expertise and the assemblages of heterogeneous actors and material artefacts in the case of Dimock’s water contamination.

This chapter gives an account of two related investigations, in which methane migration and contamination by fracturing chemicals became matters of public concern. One occurred following a private water-well blowout incident, which led to a highly contested scientific investigation seeking to establish the causes of the dangerous amounts of methane concentration in the water supplies near to fracking sites. The other followed the popularisation of the Dimock water contamination as a nationwide case and item of common interest, which then prompted federal investigators to examine whether fracturing activity had any impact on water supplies generally. Here, the fracturing chemicals gained particular importance as Dimock was selected as one of the case studies in the EPA’s second study on the hydraulic fracturing technology. With this investigation, Dimock became a critical site in the national debate about regulating the disclosure of fracturing chemicals as analysed in Chapter 5.

In both of these investigations, state and federal agencies, independent laboratories, environmental NGOs and consultants working for the company

concerned investigated and measured the levels of methane and other chemicals in the local water supply. These investigations point to how the Dimock case was influenced by diverse ideas and knowledge practices, which in turn contributed to the discussions over HF safety. Moreover, measuring the impacts of the technology on water resources eventually became entangled with the ethics of responsible development, legal action and regulatory discussions (Barry 2013).

6.3 Methane Migration

Between 2006 and 2008, Cabot Oil and Gas started to acquire leases in Susquehanna County, and began exploratory drilling to assess the potential of Dimock's gas fields. As noted in Chapter 4, the capacity of Marcellus was still largely unknown at that time, but publication of Professor Engelder's calculations in early 2008 followed by the Wall Street craze for shale gas investments enabled Cabot to finance the operational costs of new gas wells in the county. According to a company report, it mainly focused on acreage acquisition and building infrastructure to support its growth in the Marcellus (Cabot 2009). As noted in the report, the growing importance of Marcellus Shale also increased the commercial value of these land acquisitions by its closeness to the eastern seaboard gas markets.[93] In 2008, Cabot expanded its operations in Dimock to twenty wells, turning the town into an open construction site busy with trucks carrying equipment, water, sand, chemicals and flow-back water to and from the site (Wilber 2012a).

After drilling commenced, however, the residents of the town began experiencing problems with their tap water, which sometimes turned fizzy and blurry

[93] Cabot Oil and Gas benefited from low land leasing prices as an early player in the Marcellus development. Focusing primarily on Susquehanna County, the company acquired land leases at 25 USD per acre, higher than the average at the time, but prices then rose to 4,000 USD per acre (Wilber 2012a).

for a couple of days (McGraw 2012).[94] As increasing numbers of residents noticed that the quality of their water had deteriorated more visibly, they contacted the company to fix the problem (Wilber 2012a). According to a landowner involved in the controversy, Cabot did not inform the landowners about the potential environmental impacts of drilling when they began working on exploratory wells.[95] As the leasing contract terms for those who signed early on were unclear in respect of the use of property, for example, there were also several problems associated with on-site spills and waste storage in the vicinity of houses located on leased property (Urbina and McGinty 2011). In the eye of landowners who experienced bad relations with the company, Cabot not only failed to inform properly them about their operations and respond to complaints but also denied responsibility for the water problems related to drilling activities.[96] Staring from this base of mistrust between (some) landowners and the company and then the intervention of environmental NGOs, the water issue grew into a larger dispute about the responsibility of operating companies at the frontiers of shale gas development.

Water problems are not something new to the oil and gas industry, and environmental disturbances in local communities have raised questions about the ethics of responsible development and environmental governance for the industry generally in recent years (Barry 2013; Watts 2005). For shale gas operations, various activities carry potential problems with water resources or water-related infrastructure (Rahm and Riha 2012). It is for this reason that a careful examination of surface activities and the geological properties of underground formations is necessary when

[94] There is no water pipeline infrastructure in Dimock, and residents use ground freshwater pumped out of water wells in their backyards.
[95] Interview with landowner in Dimock, PA, August 24, 2012.
[96] Interview with local journalist from PA, Hoboken, NJ, October 19, 2012.

drilling operations begin.[97] In particular, pre-existing conditions, such as the presence of methane in shallow layers and poor standards of water well construction, is known to complicate locating drilling related problems. For these reasons, baseline studies emerge as an industry best-practice, founded on the assessment of water quality of the region prior to operations, promoted as a legal defence strategy to avoid liability predating the drilling activities.[98] This chapter reveals how post-drilling measurements of water quality became central to the politicisation of the water contamination issue in the absence of baseline studies.

In the Dimock case, establishing the causes of the water contamination became a highly contested issue on which state agencies, scientists, the operating company and landowners held differing opinions. In particular, methane migration emerged from the PA DEP investigation as one of the key areas of contestation. Although other water issues related to surface spills were reported in Dimock, the real turning point came with the state investigation of Cabot operations following a private water-well explosion, the explosion of Norma Fiorentino's water well on New Year's Day, 2009. The incident was described in a *ProPublica* article:

> Norma Fiorentino's drinking water well was a time bomb. For weeks, workers in her small northeastern Pennsylvania town had been plumbing natural gas deposits from a drilling rig a few hundred yards away. They cracked the earth and pumped in fluids to force the gas out. Somehow, stray gas worked into tiny crevasses in the rock, leaking upward into the aquifer and slipping quietly into Fiorentino's well. Then, according to the state's working theory, a motorized pump turned on in her well house, flicked a spark and caused a New Year's morning blast that tossed aside a concrete slab weighing several thousand pounds. Fiorentino wasn't home at the time, so it's difficult to know exactly what happened. But afterward, state officials found methane, the largest component of natural gas, in her drinking water. If the fumes that built up in her well house had collected in her basement, the explosion could have killed her.
>
> (Lustgarten 2009)

[97] Interview with senior expert at Water Resources Institute, Ithaca, NY, August 22, 2012.
[98] Water Management Workshop, Unconventional Gas and Oil Summit, Warsaw, Poland, 27-29 March, 2012.

This media report detailed the incident in plain language that clearly linked the drilling activities to a dangerous accumulation of methane in one private water well– and presumably others, at least potentially. The report went on to dub Dimock the "Ground Zero" of Marcellus Shale development, according to which view the promised economic benefits of shale gas development were outweighed by environmental dangers that put residents at risk.

Mentioning the documented cases of methane migration into water resources across North America, the report claimed that existing studies done in drilling states, such as Ohio and Colorado, had suggested possible flaws in well casing as the possible cause of methane leakage to water resources. According to this report, however, the occurrence of methane contamination incidents was considered to be "statistically insignificant" by the industry. Industry representatives often found such cases complicated by existing territory conditions, with methane naturally occurring in shallow geological layers or seeping into the water resources due to biological processes. The official position taken by the industry was that methane contamination in water wells located on or near drilling sites was not necessarily the result of the drilling activities; even faulty wellbore casing was not necessarily the cause of such incidents in drilling sites (Lustgarten 2009).

Until Dimock, the methane contamination issue had received little attention in environmental impact studies of shale gas drilling (Pifer 2011). Here, though, in the absence of a baseline study, the identification of the causes of methane migration became central to the dispute that followed. In this controversy, analysis had to be grounded upon the knowledge, speculation and experience of scientists, supported not just by their observations of local conditions during the post-drilling phase but also by

their speculation concerning the prior conditions of the underground and surface layers in the history of Susquehanna County.

On the basis of multiple measurements conducted by various scientists, it came to be accepted that the paths of migration to water resources were not necessarily shown by isotopic identification of the "fingerprint" of methane (Prud'Homme 2014). Isotopic analysis is used to differentiate between biogenic and thermogenic types of methane, according to which methane might be "biogenic as a result of bacteria acting on organic material that could be found in landfills, septic systems, storage tanks; whereas methane from shale gas is thermogenic, formed by millions of years of cooking of organic matter deep within the earth under pressure and heat" (Wilber 2012). In other words, the type of methane revealed responsibility for contamination as human activities or natural processes.

Yet, unexpected faults in wellbore integrity and human errors in cementing the wellbore, it was argued, could create an unwanted path linking water reservoirs and shale gas layers and resulting in the methane contamination of water wells, even if the water reservoirs and shale gas layers were separated by thousands of meters (Wilber 2012). Early in the debate over fracturing technology, activists argued that the highly pressurised stimulation of underground geology could trigger the migration of fracturing fluids and methane to water reservoirs – against the industry and geologists, who agreed that the possibility of such migration through geological layers across such distances was impossible (Geological Society 2012). Thus did the differences among expertise judgments on the causes of methane migration come to be central to the politics of water contamination associated with shale drilling and the HF technology.

Following the Fiorentino well blow-out incident, the PA DEP started to investigate possible causes of methane migration to water wells in Dimock. They tested 60 samples collected from private water wells.[99] The agency concluded that "the presence of dissolved methane and/or combustible gas in the 10 affected water supplies occurred within six months of completion of drilling of one or more of the Cabot wells" (*StateImpact* 2014). As baseline studies did not exist, the agency speculated that the methane migration could have resulted from a possible path opened by a faulty gas well casing and which contributed to unintended migration of methane eventually affecting the 19 families relying on these water wells (Wilber 2012).

With the results of the DEP investigation confirming Cabot's faulty wells as the likely cause of methane migration, in September 2009, the company was ordered to stop its drilling operations in Susquehanna County (Rubin 2012) and forced to sign a Consent Order Form (COF) to remedy the water situation (PA DEP 2010). The COF required the company to provide bottled water and filtration systems to the affected families, as well as to fund the building of a 1.25 mile water line south from the adjoining borough of Montrose to Dimock to rectify the drinking water situation (Legere 2010c). With the affected families reliant on bottled water, the proposed water line project effectively meant penalising the company for not operationalising the environmental costs of drilling and cutting corners in operations (Sinding 2010).

[99] PA DEP officials worked in collaboration with the company in gathering data from the water wells. The agency and company split between houses to collect water samples. Some landowners rejected the company and only allowed state and federal agencies, as well as scientists from independent laboratories, to take samples from their water wells for measurements (Field notes, Dimock, August 24, 2012).

Before the seat of the PA state changed from the Democratic to Republican Party, in November 2010, the water line project for Dimock was dropped.[100] According to Natural Resources Defence Council (NRDC), the administration's decision to drop the proposed water line project was frustrating, as water contamination was officially linked to drilling operations and this water line would solve drinking water problem in Dimock (Sinding 2011). Against this, the company argued that there was no relation between their operations and the reported water contamination incidents.[101] Although forced to sign the agreement guaranteeing compensation, the company never accepted responsibility for the water contamination.

The company claimed that it had been made to sign the COF agreement "under duress", namely, under the threat of their operation being closed down, as made during the state investigation (Campbell 2010). The company disputed the DEP findings and the proposed water line project in two ways. First, it argued that methane migration was a natural phenomenon in Susquehanna County even before drilling began in Dimock; second, it benefited from an unclear definition of what constituted a defective well as outlined in the existing oil and gas regulations: any responsibility that it might have had was mitigated since these did not specify "what constitutes a defective, insufficient or improperly constructed well."[102]

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[100] This seat of change became central to negotiations between the state and industry in regards to the terms of compensation outlined in the Consent Order Form. Attempting to come to a resolution in Dimock on anticipation of a failure in upcoming elections (the Republican candidate, Corbett, was known to be sympathetic to the industry), Democrat Mendell's administration made a deal with the company to drop the water line requirement. (Telephone interview with a former senior PA DEP official, November 1, 2012).

[101] As narrated by John Hanger, PA DEP Secretary at the time, the company did not welcome the department's announcement of a water line plan during a public meeting in September. As the water line was costly, Cabot Oil and Gas encouraged a counter opposition group who protested the DEP's decision and supported continuation of Cabot's operations in Dimock.http://johnhanger.blogspot.com/2013/07/gasland-2-and-dimock-water-line-real.html

[102] Telephone interview with senior officer from the Office of Oil and Gas Management, PA DEP, November 01, 2012.

After revisions to the agreement, the DEP required Cabot to pay 4.1 million USD in compensation to the families and half a million USD in penalties to the DEP, as well as to cap the wells which were the source of the leaks (Wilber 2012a). According to this second agreement, Cabot also offered to pay for the installation of whole-house gas mitigation devices to prevent any further gas concentrations in the affected homes (Legere 2010b). Seven of the affected families accepted monitoring of their well-head space and sampling of the well water by Cabot, but 12 families denied the company access and appealed the 2010 Agreement to the Environmental Hearing Board (Wilber 2012). As the company installed gas filtration systems, notified families and the DEP about compensation monies and deposited these in the accounts of the affected families who had accepted Cabot's offer, the obligations of the agreement were met, and, in December 2011, the DEP lifted the requirement for the company to deliver drinking water to the affected families (*StateImpact* 2014).

In this respect, the Dimock case recalls Andrew Barry's (2013) work on the case of Dgvari, where the object of modes of governing was "measured environmental impacts." According to Barry (2013), the consultant report, which concluded that the Baku Tbilisi Ceyhan (BTC) pipeline would not have any impacts, was called into question through the evidence of visible cracks on the walls of Dgvari homes. In Barry's account, the geosciences were instrumental in the spatial constitution of Dgvari outside of corporate social and environmental responsibility, by omitting the borders of the village from the company's environmental impact assessment.

In Dimock, although the water tests conducted by the PA DEP were critical to declaring Dimock water unsafe to drink, the presence of excessive amounts of methane in the water supplies had predated drilling activities, in the company's view. At the time, the lack of a detailed regulatory framework to address the fast growing

industry and impact of state elections were also critical in reaching the final agreement between the state and company, despite the fact that the Republican party took a different view on the source of methane contamination and spatial limits of corporate environmental responsibility to that of the Democrat administration. Indeed, methane continued to play a critical role in scientific debates in the aftermath of the PA DEP investigation.

During the course of the Dimock controversy, NGOs and activists were not the only outsiders to debate the issue of methane contamination associated with drilling activities. In 2011, a team of geoscientists from Duke University published a paper entitled "Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing" in the Proceedings of the National Academy of Sciences. This paper presented the results of an initial experiment to "document evidence for methane contamination of drinking water associated with shale gas extraction" in "aquifers overlying the Marcellus and Utica shale formations of north-eastern Pennsylvania and upstate New York" (Osborn et al. 2011). To quantify the methane level concentration related to drilling, the scientists involved in this research, known as the "Duke Study", collected water samples from 68 private groundwater wells in five counties in northern Pennsylvania and New York, including some wells from Dimock.

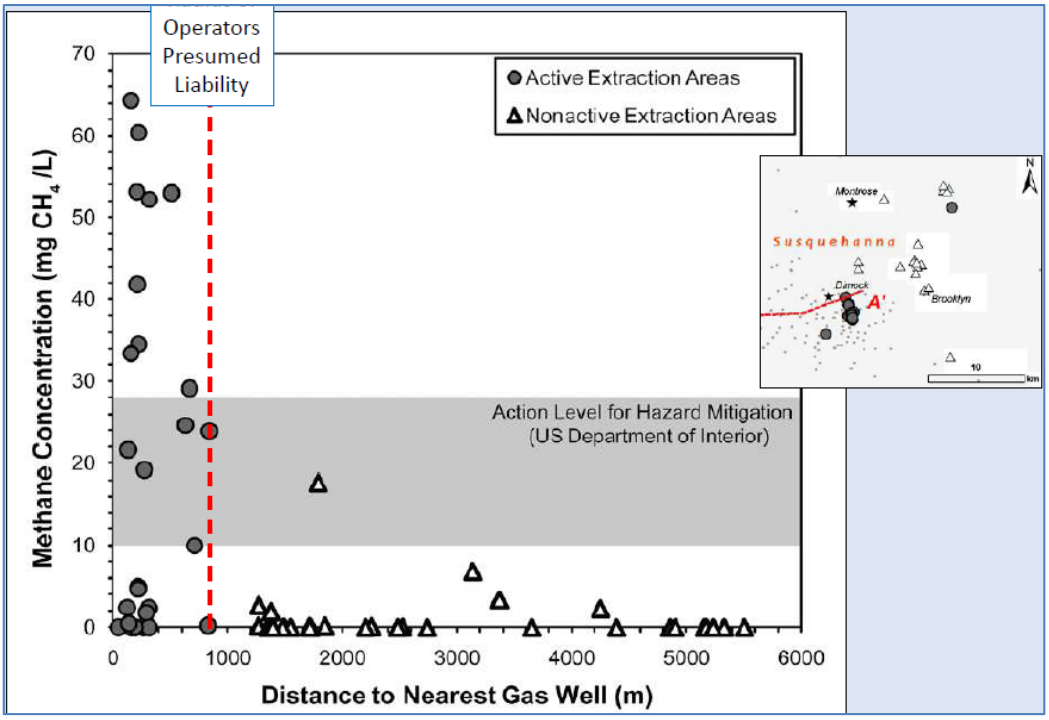

Figure 6-1: Elevated methane levels above Marcellus and Utica shale formations linked to drilling activity by distance
(Source: Osborn et al. 2011[103])

As shown in Figure 6-1, taken from that paper, methane concentrations within 1000 feet (304.8 metres) of active extractive areas showed hazardous levels, stemming from drilling activity in the region. Introducing the distinction between biogenic and thermogenic gas as a way of distinguishing the source of methane found in water wells nearby drilling sites, chemical analysis gave support to the argument that drilling activities and higher levels of methane concentrations were causally linked. According to the study, thermogenic gas, often found in deep formations, could migrate to the underground resources of drinking waters. For Dimock, this study had major ramifications, as it presented scientific evidence for (dangerous levels of) methane migration to water resources as a direct result of the increased drilling activity in the region.

[103] Access to full article is public and available at http://www.pnas.org/content/108/20/8172.full

This study came under countless attacks from the industry and supporters of shale gas drilling. A series of questions were raised against the methodological tenets of the study, pointing out the lack of baseline testing, of random sample collection and of fracturing chemical fluid measurements – which were rebutted (Robert et al. 2011). The Duke paper became a critical test in discussions of the issue of methane migration among scientists, industry geologists and environmental consultants working for the industry. While the PA DEP water tests had constituted the first formal measurements of drilling impacts and water quality, the Duke study was recognised as introducing into the debate the idea of isotopic analysis of methane, which aimed to link methane concentrations and drilling activities, and hence to determine the spatial limits of corporate environmental responsibility.

To counter this study's findings, Cabot hired an environmental consultant to study the methane geochemistry of the region.[104] The resulting Molosky et al. (2011) study prepared by the external consultant with company geologists took issue with the Duke study's correlation between methane concentration and drilling activities. Based on pre-drilling data sampled from 1701 water wells at nearby gas drilling sites, this paper argued that methane was naturally present in shallow groundwater. The isotopic analysis run by the Molosky et al. (2011) claimed to capture a methane gas footprint in water wells in Dimock unlinked to drilling activities.

The consultant paper was vital for the company, not only in refuting the Duke Study but also in countering the results of DEP investigation, since it held that the thermogenic gas in Dimock water wells originated from a shallower layer, not from the Marcellus Shale. The paper concluded:

[104] The role of environmental consultant in the methane dispute was critical for the company, not only in presenting compelling scientific evidence for the liability case, but also in remedying the reputation of the company (Interview with Cabot Oil and Gas external relations officer at Marcellus Summit, State College, PA, October 11, 2012).

> [T]he assertion by the Duke Study that hydraulic fracturing of the Marcellus Shale is contributing to the thermogenic methane to local water wells and shallow regional groundwater is unsubstantiated given the lines of evidence.
>
> (Molosky et al. 2011)

Subsequently to become a key strategic defence in the industry, the idea of "naturally-occurring" methane became key to the company's denial of any responsibility for water contamination in the Dimock case. Thus, in the absence of a baseline study, the company used the "complexity" of pre-existing conditions as the leading cause of methane migration.[105] Even though the DEP made the company abide by the terms of the revised agreement reached between them, Cabot never did accept liability for the water contamination.

The debate over whether the methane had migrated to the water wells in Dimock from the Marcellus Shale became critical in the governance of the shale gas industry in the PA state. In the company's view, the consultant paper established sufficient grounds for scientific uncertainty and came to play a key role in determining the industry's understanding of the spatial and temporal limits of corporate environmental responsibility. In the absence of baseline studies, the uncertain timing of the methane migration became critical in generating doubts about how groundwater methane accumulated and went beyond accepted levels (Drajem and Efstathiou Jr. 2012). Essentially, the consultant report benefited from "the complexity of underground" argument in geosciences to cast a doubt on source of methane contamination (Oreskes and Conway 2010).

Here, the case of Dimock shows resemblance to the work of McGoey (2009a) on the strategic use of uncertainty by pharmaceutical companies to avoid liability. For McGoey, the strategic use of uncertainty can strengthen the authority of those advancing such a position. In Dimock, the absence of baseline studies allowed for the

[105]Interview with local (PA) journalist, Hoboken, NJ, October 19, 2012.

possibility of temporal and thus spatial uncertainty regarding the geology of drilling sites, supporting the position of the company on the possible source(s) of methane contamination. A review of the course of events in Dimock reveal the company as benefitting from known public relations strategies, such as generating doubt on findings of experts and producing counter-evidence (McGarity 2009; Michaels 2006; Oreskes and Conway 2010), so as to direct the public dispute. Even though the PA DEP water tests showed failures in the company's operations and determined the amount of compensation for affected families, the use of uncertainty as a strategic defence to avoid corporate environmental responsibility reinforced the industry's position on shale gas drilling – to which ends, of course, it was motivated in the first place.

6.4 Fracturing chemicals

As the tests conducted by the PA DEP, Cabot and other scientists were focused on methane migration as the primary cause of water contamination, several families believed that hazardous levels of thermogenic methane were not the only dangers in their water. Opposing the settlement and agreements made between the state and the company, the 17 families that refused to accept water filtration systems argued that these did not eliminate dangerous fracturing chemicals (*StateImpact* 2014). While DEP tests detected contamination in some water wells due to surface diesel spills on a nearby drilling site, the compensation scheme focused on elimination of methane migration more than any possible contamination related to the fracturing activity itself (Wilber 2012; McGraw 2012a). With Dimock was portrayed as a Ground Zero, there was a strong support from activist groups, such as Damascus Citizens for Sustainability, and from *Gasland*, whose director, Josh Fox, followed up the legal

case opened against the company and pushed to extend media coverage of the Dimock dispute to a national audience.[106] These activist groups were primarily concerned about the safety of fracturing technology and the secrecy around fracturing chemicals, which thus became a leading issue in the Dimock case and with other shale gas sites.

When water problems became a common occurrence at nearby gas wells, local residents were not averse to possible cooperation with Cabot to remedy the problem (McGraw 2012). Although the DEP investigation laid out a settlement plan to fix the methane migration issue and required the company to offer compensation under the agreement, however, the company's refusal to accept any liability worsened the community relations. Local residents were further upset by the dropping of the water line plan, some of whom were not convinced about water filtration systems as an effective way of cleaning up water wells. As recounted by Wilber (2012a), the escalation of conflict with the company by these residents led them to become "accidental activists," who were forced by circumstances to agitate and coordinate for what they saw as justice.

Dissatisfied with the settlement and final agreement, 63 families in Dimock and Montrose filed a strict liability lawsuit against Cabot for gross negligence, fraudulent misrepresentation, breach of contract and private nuisance (Fiorentino v Cabot Oil and Gas Corporation 2009). Although Pennsylvania courts did not address "whether gas well drilling was an 'abnormally dangerous' activity that fits the strict liability standard," the US District Court Judge did not dismiss he plaintiffs' request for a strict liability, resulting in further scrutiny over Cabot's practices (Legere 2010a).

During the course of the lawsuit, the burden of proof fell on the plaintiffs, who found themselves among a pile of documents, photographs and reports produced by

[106]Interview with local (PA) journalist, Hoboken, NJ, October 19, 2012.

the PA DEP, Cabot, scientists and the EPA.[107] Having taken on a more active role, it was at this point that the local citizens really needed to understand science in order to follow through on their litigation and maintain their role as agents in the process. This development was impelled in particular by their experience of the company and its bad community relations.[108] Thus, the litigants carefully documented spills, leaks and other changes in their water supply which, in some cases, even led to evacuation due to dangerous accumulations of methane (Bateman 2010).

When the DEP allowed Cabot to halt delivery of water to affected households, in December 2011, attorneys for the litigants joined with the Natural Resources Defense Council (NRDC) and went to the Environmental Hearing Board to get it to overrule the "illegal" parts of the DEP Agreement, those which, in their eyes, did not fulfil state law requiring drillers to "restore or replace" water damaged by drilling activities (Legere 2011). The attorneys argued that the families' drinking water contained heavy metals, solvents and manufactured chemicals at levels above those recommended by the state and federal drinking water standards. In short, they argued that the DEP's decision was not grounded on an assessment of water quality, but on set of conditions imposed upon the company in the settlement (Detrow 2011). The DEP's decision to end water deliveries heightened attention on the Dimock case in the national media, especially when celebrities, along with other environmental groups, began a new campaign to help deliver water to the affected families. As activists took rounds to drive water delivery trucks (see Figure 6-2) to these households, a large

[107] Interview with local (NY state) journalist, New Haven, CT, 15 November, 2012.
[108] Cabot did not have a communications officer at the initial stages of drilling, which certainly seems to have led to communication problems with the local residents (Field notes, Dimock, August 24, 2012). After a series of interviews with litigant families, however, Wilber (2012) and Seamus (2012) reached the conclusion that the litigating families' relations with the company broke down following the company's threats to sue them, its organisation of a pseudo opposition grassroots group and its failure to respond to complaints and fix the problem.

number of journalists flew to the small town, making it into an international case about water contamination and fracturing technology.[109]

Figure 6-2: Water buffalos were utilized to store freshwater, which were carried from other areas by small trucks every week
(Photo taken by the author in Dimock PA, 24 August 2012)

Containers[110] of brown water (Figure 6-3) filled from taps of affected homes became a symbol of the movement, a reminder to outsiders who came to the town and travelled to other places to tell the story of what could go wrong with fracking activity. Contrary to the invisible methane that became the subject of dispute in the PA DEP investigation, these water containers presented visible evidence to outsiders, who could thus appreciate the lived experiences of local residents with undrinkable water in the aftermath of drilling. As noted by one informant, outsiders who came to Dimock were often challenged with the question of "Will you drink this water?" – to which, in the presence of the container of brown water, the immediate answer was a

[109] Interview with landowner in Dimock, PA, August 24, 2012.
[110] Or "jugs."

powerful "No, Thanks". [111] Certainly the water quality issue became a nationwide issue with detailed pictures, documentaries and artefacts, like the containers of brown water, detailing serious damage to drinking water supplies.

A number of brown water samples were collected and sent to independent laboratories for examination, enabling environmental activists and other local and national NGOs to draw attention to the immediate effects of drilling and fracking activity. A "productive collaboration" (Tsing 2005) between residents of rural Pennsylvania and activists in the city was thus fostered by the mobility of the water container outside of Dimock, such as in anti-fracking public forums in New York City.[112] As noted by Tsing, such travelling forms of knowledge practices, made and maintained through collaborations, create new identities and interests among local residents, state regulators, activists and non-humans.

[111] "Will you drink this water?" became one of the striking slogans of the Dimock campaign, as banners outside of litigants' homes reminded visitors about the polluted drinking water. Indeed, one landowner asked me if I would drink the tap water before starting the interview (Dimock. August 24, 2012).

[112] Samples of brown water jugs from Dimock were also shown in multiple anti-fracking public forums and discussions at film screenings that I attended in NYC during the summer and fall of 2012.

Figure 6-3: Container of brown water, Dimock
(Photo taken by the author in Dimock PA, 24 August 2012)

There is also a resonance here with Shapin and Schaffer's (1985) work on the importance of witnessing for the constitution of matters of fact in the public space. In the Dimock case, witnessing was rendered possible by the accessibility of the brown water containers to outsiders, who were not physically there at the time of the drilling activities. The mobility of such artefacts was effective in generating a shared experience of witnessing between outsiders and landowners. As pictures of brown water containers circulated in the national news media, documentaries and reports, the connections between fracking activity and chemical contamination were repeatedly referenced and in a highly immediate and emotive way, these artefacts became politically important during Dimock controversy.

However, to understand why Dimock was portrayed as a "foster child" of fracking in the national media, it is not sufficient to know the relation between drilling activities and water quality and its presentation in the media. The dispute over the water contamination issue rose to political significance at the federal level with the

inclusion of prominent environmental NGOs concerned about PA DEP's decision to the drop water line project and stop water deliveries.[113] In response to the state decision, the NRDC became a key actor in calling the EPA to step in for a new assessment of the water quality in Dimock (Sinding 2013). In a letter written to the EPA, the NRDC asked the agency to make a choice: "(1) to issue an administrative order to Cabot to reinstitute deliveries of potable water to Dimock residents or (2) provide temporary water itself" (NRDC 2012).

The letter also raised concerns about the EPA's questioning of the reliability of data collected by the DEP and Cabot, insisting on a complete review of data and conduct of its own tests to assess contamination of Dimock's underground water for additional hazardous contaminants. Although the EPA lacked the authority to step in if the water contamination was found to be directly caused by oil and gas operations, the agency had the powers under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to provide some relief to affected families if it found any evidence of chemical contamination of water resources as a result of drilling activities (*StateImpact* 2012).

According to the NRDC, the EPA investigation was critical in inquiring about the causes of water contamination beyond the methane dispute.[114] Pointing out flaws in the PA DEP investigation, the NGO raised concerns regarding the reliability of data collected from water wells and failure to test for additional hazardous chemicals (NRDC 2012). First Cabot and the PA DEP collaborated in collecting the data, and then, the NRDC argued, the interpretation of this data was flawed in determining the terms of the settlement. As the state regulatory inquiry was called into question,

[113] Interview with senior expert from the Natural Resources Defence Council, November 14, 2012.
[114] Interview with senior expert from the Natural Resources Defence Council, November 14, 2012.

additional tests became necessary to establish matters of fact for landowners to be counted eligible for proper compensation (Petryna 2002).

Thus, measurement of the impact of drilling activities came to centre on the questions of political interest and the objectivity of experts involved in the state investigation (Shapin and Schaffer 1985). The official request for a federal investigation, therefore, was aimed at the provision of scientific evidence that was specific to "epistemological needs of the law" (Jasanoff 2006a). This was vital in the litigation case against the company, to substantiate landowners' alleged claims for compensation in respect of chemical contamination associated with the fracturing activity.

In January 2012, the EPA took over the Dimock investigation from PA DEP. This decision was based on a scientific review by the Agency for Toxic Substances and Disease Registry, which analysed water sample data from Dimock wells collected by the PA DEP and Cabot and concluded that there could be public health risks related to the prolonged consumption of water from some water wells (Wilber 2012b). In the action memorandum released by the EPA, the agency raised its concerns:

> Historic drilling activities in the Dimock area may have used materials containing hazardous substances. Spills and other releases have been documented by PA DEP from these drilling activities. There is reason to believe that a release of hazardous substances has occurred. The presence of hazardous substances in the four home wells constitutes a release or substantial threat of a release and the situation meets the criteria for conducting a removal action under Section 300.415 of the NCP. The On-Scene Coordinate (OSC) has determined that funds in the amount of 100,000 USD are needed to mitigate the human health concern initially at four homes and therefore proposes the actions included in this Action Memorandum. This action includes provision of alternate water to four homes and home well sampling at approximately 61 homes within the Site area.
>
> (EPA 2012)

In line with the litigants' complaints, the memorandum also stated that gas mitigation systems provided by the company would not remove the hazardous substances

(arsenic, barium, Bis (2-ethylhexyl) phthalate (DEHP), manganese and phenol) observed in some water wells in the aftermath of drilling activities.[115] Meanwhile, a comprehensive EPA study on the effects of hydraulic fracturing on drinking water was announced.

As one of the high-profile cases in the EPA study, the Dimock water contamination dispute became a key site in at the federal level, and the agency soon found itself under pressure from the industry. Between January and June 2012, the EPA conducted tests in 61 water wells to examine the levels of hazardous contaminants in the underground water related to drilling, as well as continuing the delivery of water to affected families (Wilber 2013a). The test results of the EPA investigation were shared with the local residents, who were told not to share them publicly.[116]

In July 2012, the EPA announced that it would close down the Dimock investigation, declaring that there was no (further) need to provide the residents with alternative sources of drinking water (White 2012b). According to the statement it released, the sampling taken from four water wells showed hazardous contaminants, including arsenic, barium and manganese, but which were also known to be naturally occurring substances and could be reduced to acceptable levels after installation of water treatment systems; therefore, Dimock water was not contaminated above federal safe drinking water standards (White 2012b).

The industry regarded this as confirmation that the water was "safe to drink" (Wilber 2013b). In a public statement, Cabot Oil and Gas defended its position thus:

[115] These substances were found in the PA DEP investigation, but the state agency later dropped any action to remedy the water problem resulting from hazardous contaminants and satisfied itself with the provision of the water filtration systems.

[116] Interview with Dimock landowner, August 24, 2012

> As with the three previous sets of water samples compiled by the EPA at private drinking water wells in Dimock, PA, the data released today once again confirms the EPA and Department of Environmental Protection (DEP) findings that levels of contaminants found do not possess a threat to human health and the environment. These findings are consistent with thousands of pages of water quality data previously accumulated by state and local authorities and by Cabot Oil & Gas. As with the other findings, the EPA did not indicate that those contaminants that were detected bore any relationship to oil and gas development in the Dimock area.
>
> (Cabot 2012)

Obviously Cabot was content with this result, although it had not originally welcomed the EPA investigation.[117] According to the company, the multiple tests conducted by state and federal agencies, as well as the company's own tests and now including the EPA check, all pointed to the conclusion that drilling activities did not have any impact on drinking water supplies. The publication of massive amount of information on water quality also had political effects insofar as the company could be selective in the results of the water tests it presented to the public (Strathern 2000; Barry 2012). For the state agencies and EPA, however, the water tests indicated signs of water pollution, which could be remedied by installation of filtration systems.

Since the investigation was under high public scrutiny, the final public statement on Dimock was not only critical for determining the terms of compensation for affected citizens, but also key to the nationwide debate over federal regulation of the industry. For activists, the oil and gas industry and pro-drilling members of Congress had put the EPA investigation under duress, particularly in the period leading up to 2014 presidential elections (Horn 2013). In this respect, they believed that the final results of EPA investigation in Dimock were not based on scientific evidence, but heavily censored due to pressure from the politics of Washington.

[117] In an official letter written by Cabot to EPA administrator (January 26, 2012), the company argued that PA DEP officials and company already gathered enough data to conclude that Dimock drinking water standards met the state standards, and that EPA's concerns were not grounded on credible evidence.

As the EPA came under pressure, the political stakes in choosing expert vernacular were high (Jasanoff 2006a). The agency's wording of its summary of the test results was prone to misinterpretation, which angered activists, landowners and NGOs, who also criticised the agency for omitting important information from the public. According to the NRDC, two pieces of information that the EPA overlooked in its announcement were particularly important. First, the agency failed to mention methane contamination caused by Cabot's drilling activities; second, the discussion about Dimock's water quality was limited to the question of "whether certain federal standards for specific contaminants were exceeded", and failed to mention public health risks due to such contaminants, as referenced in some of EPA's earlier memos. In addition to these issues, the statement did not declare the EPA's decision to hand over the investigation to the Agency for Toxic Substances and Disease Registry for the analysis of short and long-term health risks of drinking Dimock water contaminated with certain chemicals (Sinding 2013).

Further allegations of omissions in the EPA's final statement followed with a leaked internal report of an EPA employee, who was not convinced about the quality of drinking water in Dimock (Drajem 2013). In a news article reported by the *LA Times*, leaked documents of earlier EPA reports indicated that the agency leadership decided to forego tracing the source of pollution, against the suggestions of the ground team of EPA scientists; in fact, the decision to leave the investigation was influenced by the Obama administration's intervention to weaken the role of EPA in the shale gas dispute (Banerjee 2013).

As noted by one informant, landowners were perplexed by the shortcomings of the EPA's public announcement, which was also in stark contrast to the ground

team's instruction to avoid drinking tap water.[118] In other words, the agency's public disclosure on Dimock was only partial. By concealing the internal debates between the ground team of scientists and the leadership in the period leading to the publishing of test results, the EPA became prone to criticisms of lack of transparency regarding the role of scientific evidence in its official position on environmental and health risks of shale gas development.

Irrespective of what environmental impact there might have been on water quality, the drilling operations affected Dimock deeply. For a period, Dimock became a critical site for the anti-fracking movement at a national level. The involvement of environmental groups, activists, scientists and NGOs elevated a local incident to a "matter of concern" for the politics of shale gas development in the US as a whole. These groups helped affected landowners to document pollution in their effort to secure (better) compensation from the company and voluntarily delivered water to affected homes, but they also expanded the subject matter beyond water contamination.

In the aftermath of the EPA announcement, some of the litigants signed a deal with the company – settling for somewhat less than the compensation originally offered in the PA DEP agreements.[119] Moreover, according to the terms of the deal, the company also imposed a silence clause that prevented the litigants from discussing the details of the public dispute against the company (Wilber 2012b). All in all, the water contamination dispute in Dimock came to a silent end.

[118] In-person interview with a landowner in Dimock, PA, August 24, 2012
[119] According to the deal, the plaintiffs had to pay for their own filtration systems (Wilber 2012).

6.5 Conclusion

This chapter has examined the following key questions. In what ways did multiple measurements of water quality have material effects on the governance of environmental impacts of the local shale gas site during the water contamination controversy in Dimock, and what does this suggest about the relationship between science, politics and the environment? I argued that 1) although water tests were critical to the compensation claims of landowners, they were not just instruments for establishing "matters of fact", but depended on expertise judgment in order that the drilling impacts could be assessed and contested (Shapin and Schaffer 1985); 2) assemblages of material artefacts (i.e. methane, fracturing chemicals, brown water containers), landowners, activists, NGOs, state and federal regulators, scientists and the company and the multiple water tests collectively defined the causes of water contamination and the resolution of the dispute (Barry 2013; Callon et al. 2009); 3) the political interests and objectivity of experts were scrutinised in the public space, triggering a debate about reliability of data and expert vernacular in corporation and public institutional accountability in respect of shale gas sites (Jasanoff 2006b); and 4) the company benefited from "uncertainty" in geosciences as a legal strategy (McGoey 2009; Michaels 2005; Oreskes and Conway 2010), while the lived experiences of landowners became less important as a result of the politics of the institutional review process (Jasanoff 2006b).

Theoretically, this chapter has aimed to add to the object-oriented literature on new modes of governing environmental impacts in socio-technical controversies. Expanding the work of Barry (2012, 2013) on political situations, the chapter argued that the dispute around drinking water contamination in Dimock was animated through assemblages of non-humans (methane, chemicals, brown water containers),

contested scientific practices (isotopic analysis, hazardous chemicals analysis) and a range of other actors (activists, NGOs, landowners, the company, scientists, state and federal agencies) that came together across the boundaries of a small town, Pennsylvania state and Washington, DC. Considering other disputes (Chapter 5, 6) around the safety of HF technology in the US, Dimock was not an isolated case but connected to the nationwide debate about the governance of environmental impacts of a fast growing shale gas industry. For a period, Dimock became the epicentre of debate regarding the limits of corporate responsibility in shale gas sites. The terms of the water contamination dispute were also far from settled, as heterogeneous actors involved in the controversy expanded the conflict to a broader set of issues, speculating on the causes of water contamination, as well as other issues, such as climate change (MacKenzie 1990).

The massive amount of information about the causes of water contamination had adverse political effects. Multiple water quality measurements not only expanded the boundaries of the dispute from water contamination by methane to that by fracking chemicals, but also generated confusion regarding the cause of the drinking water problem in the eyes of the public. At the end, both state and federal agencies appear to have concluded their investigations under political duress, limiting the debate about the responsibilities of the company to a fixable technical solution and some compensation for affected landowners. Therefore, water tests were not just scientific instruments for generating "matters of fact" for the resolution of the dispute. On the contrary, the ways in which these tests were conducted and analysed became a "matter of concern" for landowners and activists, who questioned the institutional scientific review process and collectively redefined the nature and scope of the problems (Latour 2004).

In regard to corporate liability, scientific uncertainty surrounding the objects of dispute became central to the legal defence strategy in Dimock. Here, there is a resonance with works of Michaels (2005) and Oreskes and Conway (2010) on corporate public relations tactics that focus on, for example, attacking scientific studies, funding counter studies and the strategic use of scientific uncertainty in socio-technical controversies. Although these works have closely detailed the tactics of corporations in influencing scientific disputes, they failed to give an account of the role of non-humans in the scientific review process. These scholars share a common assumption about the relations between science and politics: as their works are based upon a dualistic understanding of science and politics, they blame the intrusion of private actors with political interests into the scientific process for generating information that belongs to the realm of "pseudo-science." In this regard, they fail to account for the ways in which actors (including non-humans) and sequences of events can impact knowledge practices in socio-technical controversies (Callon et al. 2009: Latour 2004).

While this chapter acknowledged similar corporate public relations strategies, it departed from these works by accounting for the active role of methane in the water contamination dispute. In Dimock, since there was no baseline study mapping methane levels prior to the drilling activities, the company benefited from general historical data about the geology of Susquehanna County, claiming that methane existed naturally in the shallow layers close to aquifers long before drilling operations had begun. The isotopic analysis of methane thus became critical to the dispute about the temporal and spatial constitution of corporate responsibility. The consultancy report magnified scientific uncertainty regarding the presence of methane in order to undermine the drilling-related water problems in Dimock. Therefore, this report had a

material impact for the company through its support for the case against legal liability in the federal court.

By analysing the role of experts throughout the methane contamination and fracturing chemicals dispute in Dimock, this chapter has aimed to contribute to the literature on the politics of expertise in public knowledge controversies. As Callon et al. (2009) described, the water contamination controversy was characterised by a lengthy deliberative process involving a plurality of perspectives, demands and expectations of affected groups, scientists, consultants, the company and officials. As the political interests of experts were called into question in the debate about the public accountability of the company and state institutions (Demeritt 2006; Jasanoff 2003; Wynee 2003), the expert vernacular was powerful in handling the politics around the negotiations of the settlement and agreements.

Following the critique of Jasanoff (2003) on the politics of expertise in deliberative environments, this chapter has shown that despite the involvement of diverse publics in the water contamination dispute, the question of whose voice had legitimacy posed a challenge that directly influenced the outcome of conflict. Echoing Petryna's (2002) work, I have argued that litigant landowner activism was geared towards obtaining expert judgment to be eligible for compensation, whereas the institutional scientific review process operated to limit the extent of liability claims. In the end, the company and landowners signed a deal that not only to restricted landowner disclosure about the details of the case, but also forced them to settle for less compensation than originally offered.

Finally, it is not sufficient to think Dimock as an isolated case that did not have any impact on environmental governance of shale gas sites. The water contamination dispute had regulatory effects at the state and federal level, triggering a broader

review of the responsibilities of gas companies. Although the company gained a favourable outcome from the legal case, it suffered a lot in terms of reputation.

CHAPTER 7: GOVERNING ENVIRONMENTAL IMPACTS IN THE UK

7.1 Introduction

From the start, environmental arrangements had to be negotiated in the background of the British government's resource imaginary of scaling up shale gas investments in the UK (See Chapter 4). After coming to power in 2010, the Conservative-led coalition government abandoned the rhetoric of "greenest government ever",[120] putting economic growth and energy security ahead of the environmental agenda (Wilkinson 2015). As reflected in his notorious phrase, "get rid of all green crap", David Cameron's energy policy based on rolling back "green costs" on energy bills had adverse effects on the UK's environmental commitments (Mason 2013). Prime Minister Cameron's "all out for shale" strategy also had significant ramifications for environmental governance. For British government and industry, the ongoing movement against hydraulic fracturing risked slowing down shale gas projects.

In the UK, the environmental governance of hydraulic fracturing technology and shale gas drilling took place at multiple levels: the central government in London was responsible for developing an energy strategy with tax breaks and economic incentives; local authorities were in charge of authorising planning permissions for drilling sites; and national public agencies oversaw environmental protection and health and safety at drilling sites (Cairney et al. 2015). In addition, developments within the EU provided additional impetus for managing the environmental risks of shale gas drilling and hydraulic fracturing technology. As the various agencies of UK government began reviewing shale gas projects, these legislative discussions at the

[120] Although Conservatives had not been traditionally considered a green party, the rebranding of the party as "greenest government ever" during the 2010 elections was reversed along with controversial projects such as selling off England's public forests, going all out for shale and cutting down green costs on energy bills (Wilkinson 2015).

EU level[121] became critical for developing policy in line with the UK's commitments to the EU on environmental protection and decarbonisation, as well as UK legislation including the Climate Change Act.

Although most of these practices were grounded in scientific research on hydraulic fracturing in the US, they had to be negotiated within a specifically national understanding of the role of science and experts in society (Jasanoff 2006). As Jasanoff's work suggests, differences in the culture of civic engagement and scientific rationality in the UK and US affected the way in which technical disputes unfolded in the UK.

While this chapter directs us to consider the translation of hydraulic fracturing, the chapter also speaks to the object-oriented accounts in the STS literature, drawing attention to the ways in which physical and political processes become entangled in the governance of environmental impacts (Barry 2013; Bridge 2009; Mitchell 2013). Here, I argue that the technical disputes and the technology and environmental impacts of extraction have to be understood in the British context. In the seismicity controversy, for instance, disputes about failures in the monitoring system and the installation of a traffic-light control system were connected to questions of corporate transparency, environmental impacts and responsible development that had a particular salience in the UK. I highlight, in particular, the significance of disputes about the environmental impacts of shale gas. In Barry's terms (2013), "the informational space" generated by the measurement of environmental impacts

[121] In October 2013, the European Parliament voted in favour of Environmental Impact Assessments (EIA) at all stages of shale gas development in the European Union (European Parliament Press Release October 09, 2013). In fact, there were serious concerns regarding the safety of hydraulic fracturing and the environmental risk associated with shale gas drilling among EU member countries. In January 2014, the European Commission published a Recommendation, aimed at bringing clarity to the regulatory framework which set the minimum principles for the management of environmental impacts in member countries. Based on two years of research and public consultations, the framing of environmental and health risks was carefully construed in relation to the economic production of the resource (European Commission Recommendation 2014).

depended upon the abstraction of seismicity in multiple informational forms. In the British case a great deal of effort was geared towards monitoring and controlling seismic impacts, whereas other legitimate technical questions, such as well integrity and water contamination were side-lined by experts and the UK government, and remained relatively marginal to public debate.

As I have argued earlier, the demand for transparency necessitates some form of public staging of science through which the authority is both construed and contested (Callon et al. 2001; Ezrahi 1990). Moreover, just as the performance of transparency generates a constitutive vision of "objectivity" (Dalston and Gallison 1992; Scott 1998), it also requires the constitution of publics who can witness and assess the technical information presented to them (Shapin and Schaffer 1985). Different forms of witnessing generate multiple representations, yet only some are labelled "objective" (Jasanoff 1998). In practice, transparency might be rendered through contested spaces of information production (Barry 2013; Latour 2004; Strathern 2000). In making things transparent, some objects, technologies, and problems become more visible than others (Barry 2013).

In this chapter, I present the making of shale gas resource and transparency in the UK in two parts. In the first part, I discuss how the informational space of environmental impacts was created and the implication of their formation for making of the resource. I detail the ways in which the government's vision of fast-paced development was impeded by other social and environmental negotiations in the UK. I then turn to explore the Lancashire seismicity controversy itself, one of the first tests of the operation of both the UK monitoring machine and the operation of corporate strategy in practice. As we shall see, the failures in seismic controls triggered a nationwide debate about responsible resource development, leading to calls for more

transparency on environmental impacts and the operational practices of the UK shale gas industry. Together, these sections map out the complex and "contested topology" of making the scale in the UK, and underline the critical role of things in the politics of resource making (Barry 2013; Latour 2004).

7.2 Governing environmental impacts: the role of experts

The narrative of "sound science" thus prevailed the framing of environmental risks associated with UK shale gas projects (Jasanoff 2005). Commissioned by the Government's former Chief Scientific Advisor, Sir John Bennington, a report on the environmental, health and safety risks of shale gas exploration in the UK was published jointly by the Royal Society and Royal Academy of Engineers in 2012. This detailed a wide range of environmental impacts, from water contamination to seismic risks. The report was one of the first to acknowledge the inadequacy of the existing regulatory framework for environmental impacts. It emphasised the lack of coordination between regulatory agencies and insufficient government funding in the likely scenario of large-scale shale gas development. It added that these impacts could be managed effectively only if the government followed the report's recommendations for safe exploration and production.

In response, the UK government claimed that the regulatory framework was adequate for governing the environmental impacts of shale gas development.[122] In a speech at the Royal Society in London, Edward Harvey, the Secretary of State for Energy and Climate Change, said:

[122] In fact, the industry also agreed that the existing regulatory framework was adequate to govern environmental impacts (In-person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013). However, officers at the Environment Agency regarded this as unfounded, arguing that there had to be a lot of restructuring to address shale gas operations specifically and to clarify the roles and responsibilities of different agencies overseeing the operations (In-person interview with a junior policy analyst from Environment Agency, Oxford, February 19, 2013).

> We must make sure that the recommendations the Royal Society made in your report are in place and the regulations we have imposed are followed to the letter. As you proposed, we have now set up the Office of Unconventional Gas and Oil to co-ordinate the cross-government work on shale gas…These may be early days for onshore shale gas exploration – but I'm determined we have tough regulations in place, from the start.
>
> (Speech by Edward Harvey, September 09, 2013)

While the British government put some of the Royal Society recommendations into practice (in the new DECC regulatory roadmap published three months later), this speech restated the government position on adequacy of the existing framework's ability to oversee shale gas operations. In fact, the government was opposed to a more extensive scientific review[123] of the environmental impacts of shale gas than the Royal Society report represented, as it was seen as an expensive and lengthy process which would impede rapid large-scale development. Although the report raised concerns about the regulatory safeguards, the government also interpreted it as a credible scientific verdict in favour of the safety of hydraulic fracturing and the low environmental risks posed by shale gas exploration. As Harvey's speech at the Royal Society suggested, the report was nonetheless was seen to establish "sound scientific facts" about the impacts of shale gas development, and this preliminary scientific review by experts from two prestigious institutions gave the government a much-needed appeal to authority to dispel concerns about this new "resource imaginary".

In the period leading up to the lifting of the moratorium in December 2013, scientific and administrative inquiries hindered fast-paced shale gas development. On the one hand, the regulators and scientists had to familiarise themselves with the technologies and methods of extracting this unconventional gas in order to develop a robust regulatory science. On the other, the systems of oversight and monitoring had

[123] As opposed the EPA's lengthy review of impacts of hydraulic fracturing technology in the US, the scientific review was relatively short and based on consultations with experts rather than original research in the UK. Chapter 5 discusses the ramifications of this in detail.

to be revised so as to deliver adequate supervision for large-scale development. Although the government claimed to have a robust regulatory system in place, regulators and scientists agreed there was a need for a regulatory update and coordination between different state agencies for public assurance.[124] Subsequently, the British government's efforts became largely focused on assuring the public about the ability of state agencies to oversee environmental and health risks. In turn, state agencies had to engage with the public in informal settings to discuss matters of concern relating to the safety of the shale gas technologies and risks of fast-paced resource development.

As Fischer argues, the level of public trust in administrative agencies and the ability to participate in decision-making is influenced by public perceptions of environmental risks and science (Fischer 2000). In Jasanoff's words (2005), the credibility of the state's shale gas policy relied on citizens' general tendency to accept knowledge claims and the demonstrations of its usefulness by the state. For Jasanoff (2005), cross-national variation in politics and policy-making regarding new technologies could also be understood by looking at different patterns of civic engagement and governmental reasoning. In the UK, the broad acceptability of technologies of extraction and safety concerns did not depend on quantifiable demonstrations by regulatory agencies as was the case in the US (Jasanoff 1990). As opposed to the lengthy and controversial scientific review process in which regulatory science was scrutinised by citizens and journalists in the US, scientific institutions have much greater public legitimacy in the UK (Jasanoff 1990). Accordingly, in the UK, informal consultations with experts on risks of new technologies were much more important for policy-making and accountability of public institutions. Indeed,

[124] In-person interview with a policy analyst from Environment Agency, Oxford, February 19, 2013.

UK policy on environmental impacts was also heavily influenced by knowledge claims made by elite scientific institutions, such as the Royal Society and the Geological Society.

Nonetheless, public forums became critical venues for the articulation and testing of authoritative knowledge-making practices in a range of technical matters related to the governance of environmental impacts (Callon 1998; Marres 2007; Whatmore 2009). In June 2012, for example, a team of geologists, regulators and independent engineers considered the experts in their fields held a public briefing meeting at the Geological Society in London. The purpose of the meeting was to discuss "the geoscience relating to shale gas, the extent and nature of the potential resource and whether or not it could safely be extracted" (The Geological Society 2012). The aim was to give technical information on the potential risks and benefits of extracting unconventional gas. The timing of this meeting, soon after the imposition of a moratorium, was critical. It was held at a moment of uncertainty about the future of shale gas projects in the UK, when seismic events in 2011 had raised public concerns regarding the safety of shale gas projects, the ability of state agencies to monitor environmental and seismic risks, and the scale of the shale gas development that might transform the English countryside into an open industrial site. In these circumstances, this event became one of the first public engagements where expert and lay interaction took place on the subject.

Yet, there was more to making information public and holding state agencies accountable. The Geological Society Briefing Meeting resembled "a public experiment in transparency" (Barry 2013) where a body of elite experts demonstrated the safety of this new form of extraction in a public space. In Barry's terms, the operation of transparency depended on "the constitution of a public that is interested

in being informed" (Barry 2013: 73). The credibility of state policy depended on the ability of experts at this meeting to make a convincing case for the public, whose presence was necessary for witnessing knowledge-making practices on the techno-scientific aspects of shale gas extraction. Thus, the briefing meeting was intended to manage the discussion of publicly disclosed information on the processes and technologies of shale gas extraction. After all, the experts believed that the public could assess the disclosed information on the potential risks of extracting a mineral resource. It was also assumed that the public could judge how these risks could be managed properly when regulations were put in place. Three areas of potential risks,[125] which became "matters of concern" in the US (Latour 2004), were also addressed at the meeting: "groundwater contamination; water sourcing and disposal; induced seismicity".[126] The experts attempted to address the controversial nature of these areas but also believed that public understanding should be based on independent scientific research.[127]

Most publicly available information on shale gas extraction was grounded in US-based scientific research. However, for the experts at the briefing event, it was critical to explain the local circumstances within which these knowledge claims were generated and circulated among the scientific community. Anna Tsing (2005) convincingly argued that knowledge claims often surfaced in relation to tangible problems, 'a friction', in a local context. Yet global interconnections might create new

[125] Although other issues, such as disputes about carbon emissions and reserve estimates, were discussed in the meeting, they did not made to the briefing note which emerged from the meeting (Field notes, the Geological Society Meeting, London, June 16, 2012). These issues were also priority areas for updating the regulatory framework on risk assessment of shale gas development in the UK (In-person interview with a regulator from Environment Agency, Bamber Bridge, Lancashire, March 07, 2013).

[126] The Geological Society Meeting Briefing Note, June 2012. Accessed at https://www.geolsoc.org.uk/~/media/shared/documents/policy/Shale%20Gas%20briefing%20final%20%20%20new%20format.pdf?la=en

[127] Field notes, The Geological Society Meeting, London, June 16, 2012.

transformations that morph a friction into a globally travelling knowledge. During the public briefing event, there were critical moments when controversial US-based knowledge making practices were treated with suspicion in the UK context. For instance, on the highly disputed issue of methane contamination of groundwater resources (see Chapter 6), a geologist explained how technical disputes could be confusing for the public given the conflicting research findings.[128] For the geologist, this stemmed from a lack of disclosure by gas companies that generated a new field of independent research on an unexplored area in the aftermath of drilling activities at the US shale sites. Drawing on the British Geological Survey's baseline study of groundwater resources, the geologist emphasised how independent research could account for the isotopic composition of underground before substantive drilling began. The lack of baseline studies in the US context had generated a controversy over the sources of methane in groundwater resources, whereas the BGS' preliminary study was considered sufficient to settle the issue in the UK. The expected result of this intervention was to restore public confidence in the state agencies' ability to regulate environmental risks related to drilling activities.

Two general observations may be made about this public meeting[129]. First, it is difficult to isolate knowledge-making practices in a single territory, as they are entangled across disparate geographies, technological zones of measurement and environmental assessment. This entanglement could easily result in the blurring of territorial boundaries of knowledge making (Barry 2006; 2013). When experts cited US-based research on the environmental risks of shale gas extractions, they were well aware of the cultural and historical context within which particular scientific information was produced and disseminated (Jasanoff 2005). The geologist, for

[128] Presentation by Mike Stephenson, BGS, The Geological Society Meeting, London, June 16, 2012.
[129] Field notes, the Geological Society Meeting, London, UK, June 26, 2012.

example, noted how the object of inquiry, methane, had to be rethought in Britain.[130] Methane was thus no longer an inert material object, but was informationally enriched through scientific contestations over water contamination cases in the US (Stengers 1996; Barry 2005).

The proliferation of new scientific ways of measuring methane had further material effects on regulatory assessment and became critical to the politics of shale gas and governance of environmental impacts. Moreover, it was evident that public involvement was limited to this meeting. In fact, the articulations of matters of concern were tied closely to the fields of technical competences, such as geosciences, seismology, and environmental science (Latour 2004). Yet there was little room for admitting non-scientists into the knowledge making processes (Whatmore 2009). In Ezrahi's terms (1990), the public meeting was held to satisfy the public by the act of "attestive witnessing" as experts demonstrated to them the legitimacy of state policy. Such witnessing acts were in fact public experiments in demonstrating that transparency and disclosure was possible (Barry 2013; Jasanoff 2005; Shapin and Schaffer 1985). As the next section will show, however, convincing the public about the safety of shale gas technologies and their environmental impacts was not an easy task.

7.3 Seismicity

The correlation between seismicity and the fracturing process turned out to be a critical issue which slowed down shale gas development in the UK. In fact, the

[130] Field notes, the Geological Society Meeting, London, UK, June 26, 2012.

majority of regulatory discussions took place during the temporary moratorium[131] following the seismic events caused by hydraulic fracturing of an exploration well operated by Cuadrilla Resources. Between April and June 2011, several minor earthquakes occurred in Preese Hall, Lancashire, the strongest having a magnitude of 2.3 on the Richter scale (Styles and Baptise 2012). Cuadrilla suspended fracking operations on May 31, 2011 in order to assess seismic information from the Preese Hall well (Richards 2012). As the company reached an agreement with DECC to investigate the causes of these seismic events, a series of studies were commissioned from third party assessors to examine the relationship between hydraulic fracturing operations and earthquake activity using extensive data on geology, fault lines and fracture treatment in Bowland Shale.[132] According to the company, these studies showed that minor earthquakes were "unforeseen events" at the time of the fracking. They contended that they lacked the extensive knowledge about the geology of the region required to identify existing faults, nor did they have guidelines that would set barriers between faults and the wellbore.[133] As explained by the company[134], 10 hours after pumping at Preese Hall, the fault was lubricated. However, because of the lag between actual pressure and the seismic event, it was difficult to establish the exact cause of the earthquakes. Cuadrilla's commissioned report on seismic events,[135] published on November 02, 2011, concluded:

> The seismic events observed after two treatments in the Preese Hall well are therefore quite exceptional. Two events were reported by BGS (with magnitude 2.3 and 1.5) and 48 much weaker events have been detected, and it

[131] Cuadrilla argued that there was never a moratorium imposed by the UK government. In fact, the company claimed that they voluntary stopped its operations after they reached an agreement with DECC (Interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013).
[132] In-person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.
[133] In-person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.
[134] In-person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.
[135] Commissioned by Cuadrilla in June 2011, this report was in fact a synthesis report from independent technical reports prepared by small assessment companies such as Seismik, Q-con, StrataGen and Baker-GMI (de Parter and Baisch 2011).

> is therefore hard to dismiss them as an isolated incident. The observed events are already 2 orders of magnitude stronger than normally observed from hydraulic fracturing induced seismicity and if future stimulation treatments again induce seismicity, it is imperative that the maximum magnitude can be estimated.
>
> (De Parter and Baisch 2011)

The assessors recognised that these seismic events were a rare combination of geological conditions and the pressure exerted by hydraulic fracturing operations. As opposed to natural seismicity, induced seismicity is caused by stimulation of rock. Induced seismicity in Preese Hall was purported to be caused by stimulation of pre-existing stress in the rock through high pressure injection of fluids during fracturing process (Styles and Baptiste 2012). In lay terms, these seismic events are also called "man-made" earthquakes, and are often caused by impoundment of water in reservoirs, mining and extraction of oil and gas, and injection of fluids (Ellsworth et al. 2014). Although these minor earthquakes were not isolated events and the seismic response at the Preese Hall indicated a failure close to a "worst case scenario", they concluded that there was low probability that such geological factors would recur at future sites (De Parter and Baisch 2011). Published on the company website, the conclusion of the report was interpreted as an admission of failure in monitoring of fracturing operations (White 2011). In response, Cuadrilla adopted new mitigation strategies to prevent future earthquakes. In line with the report's recommendations, the company proposed the installation of a seismic monitoring system, and a gradual release of fracturing fluid to decrease the pressure at the well.[136]

What was not revealed in the course of events following the earthquakes was a critical rift between DECC and Cuadrilla during the investigation of seismic events. Exposed by a *Guardian* media report (March 13, 2013) based on a Freedom of

[136] In person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.

Information request, the investigation process was subjected to multiple negotiations between the department and company. According to internal papers released by DECC,[137] Cuadrilla was warned about its weakness in "performance as a licensee over failure to recognise the significance of the damage to a gas fracking well in 2011 and did not report it to government officials for six months" (Harvey et al. 2013a). As pointed out by the environmental movement,[138] these internal communications stood in stark contrast to the British government's rhetoric of the adequacy of existing regulations to ensure safety of the fracturing operations.[139]

It was undoubtedly a challenging task to determine the exact correlation between induced seismicity and the fracturing process. Baseline measurements were deemed necessary to assess the geology of the region in order to identify pre-existing factors. A conceptual geomechanical model of the Bowland Shale was developed based on available geological and geophysical data, but the analysis failed to identify the fault line that caused seismic events, and did not provide a detailed knowledge of faulting in the region (Green et al. 2012). Although a 3-D seismic survey of the basin could have characterised other potentially stressed faults in Bowland Shale, this technique was not used due to its high cost.[140] The seismicity analysis provided by the company was therefore rather limited in terms of identifying the fault line structure in the Bowland Shale. Meanwhile, DECC commissioned another study by independent geologists[141] to review the Cuadrilla report and recommend measures for appropriate mitigation of seismic risks for future hydraulic fracturing operations. While the DECC

[137] The Guardian accessed to these internal papers via the Freedom of Information Act (Harvey et al. 2013a).
[138] The Friends of Earth is an active participant of anti-fracking movement. Greenpeace and Green Alliance also played a critical role in campaigning against shale gas development in the UK.
[139] In-person interview with a local activist, Southport, Lancashire. March 07, 2013.
[140] In person Interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.
[141] The Cuadrilla report was reviewed by Prof Peter Styles from Keele University, Dr Brian Baptise from BGS and Dr Christopher Green from GFrac.

report (Green et al. 2012) did not agree with the findings of the original study, which emphasised that seismic events were unlikely to occur in the future, it discussed an effective monitoring system to automatically record the location and magnitudes of seismic events in real time (Green et al. 2012). Subsequently, the DECC report claimed, the seismic events like those at Preese Hall could be effectively managed and operations could resume. With a threshold magnitude for seismic events of 0.5[142] to halt hydraulic fracturing, the report argued that a "traffic light monitoring system" (See Figure 7-1) could be effective to prevent the reoccurrence of future seismic events.

[142] As explained by Peter Styles at the Geological Society Event, this threshold was very low in comparison to mitigation thresholds for seismic events caused by geothermal and coal mining activities. However, it was above the level expected from hydraulic fracturing operations and was therefore treated as an early sign of a possible larger earthquake (DECC 2014a).

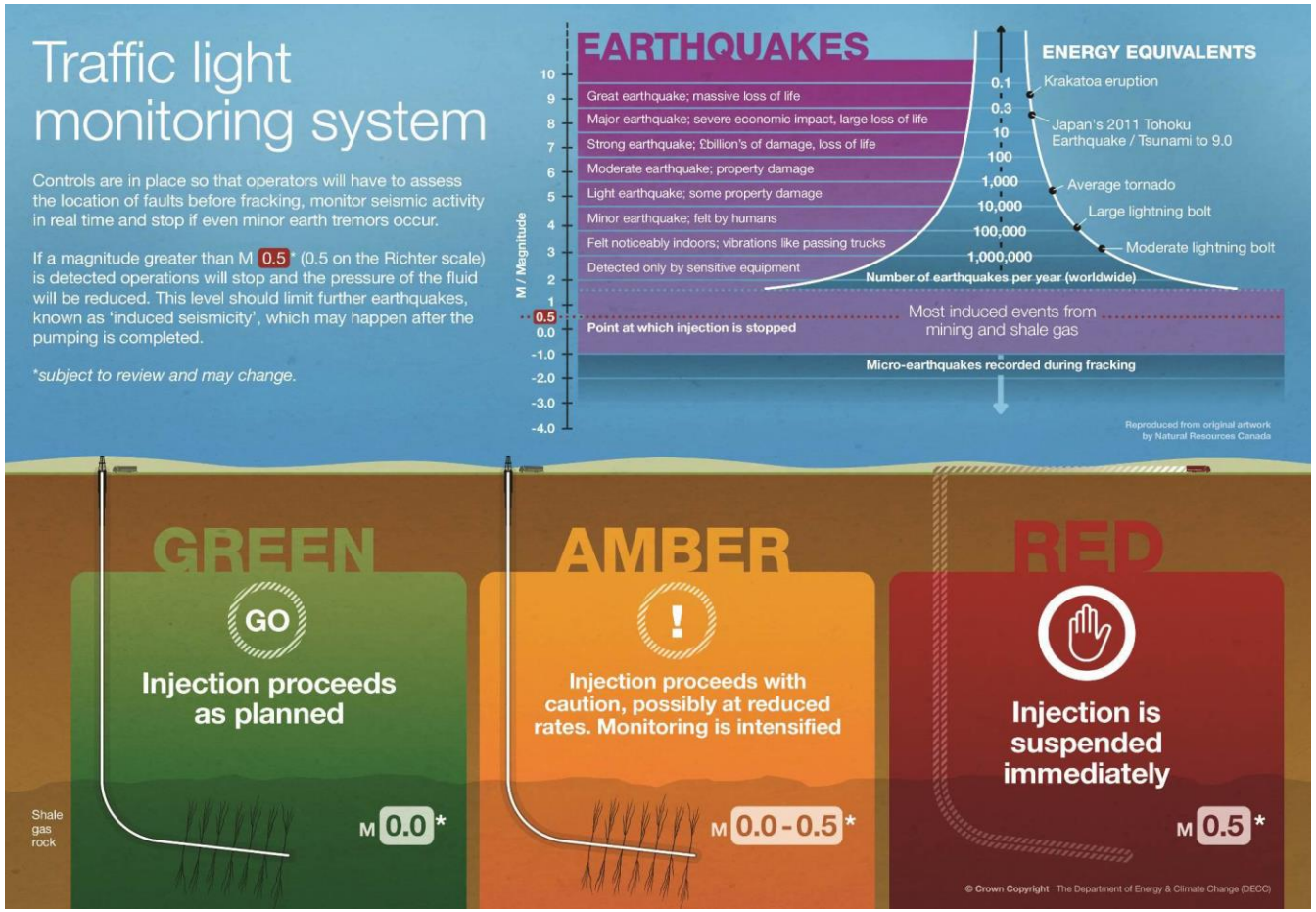

Figure 7-1: Traffic light monitoring system
(Source: DECC 2013c)

The traffic light monitoring system was not just a technical protocol devoid of contention. Already applied as a standard protocol in other parts of the world,[143] it required a network of monitoring devices to observe underground activity before, during and after fracturing. These seismometers[144] had to be buried in quiet locations at the surface near the injection well or in boreholes at greater depths (Green et al. 2012). Once buried, they could only work if other sources of seismic noise such as truck and train traffic were eliminated (Horleston et al. 2013). As Cuadrilla explained, 104 additional seismic monitors around the drilling site would have no surface impacts when buried and would be "an effective way of demonstrating to the public that the fracturing process is indeed safe" (Cuadrilla Resources 2012b). The company presented these monitoring devices as new instruments of transparency which would generate a massive amount of information about the fracturing process:

> As part of Cuadrilla's commitment to transparency, the company will make the results of the fracture monitoring available to the public on their website. This technology will offer unparalleled levels of information, therefore providing even greater transparency for the community.
>
> (Cuadrilla Resources, 2012b)

Two points in this press release require a careful analysis of the intended effects of installing the monitoring devices. First, the installation of "no impact" monitoring devices and routine measurements was anticipated to respond to public concerns about the fracturing process, and recording seismic activity near shale gas sites was expected to end political contestation (Barry 2005). Second, the release of the measurements into the public space would create an image of an ethically responsible company willing to share "unparalleled information" about a

[143] At Cuadrilla's website, traffic light system was described as a proven protocol used in the Netherlands and Germany. Accessed at http://www.cuadrillaresources.com/protecting-ourenvironment/seismicity/prevention-and-safety/

[144] According to the company, these seismometers have no visible impacts as they are buried deep underground or near surface at the drilling site (Interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013).

controversial process (Barry 2013). Therefore, installing these monitoring devices was not just a technical intervention, it also had direct impacts on the politics of fracturing technology and the future of shale gas projects by fostering an idea of corporate transparency and good community engagement.

As Barry (2005) rightly argued, heightened attention to routine monitoring and measurement often has "anti-political effects". With much of the British government and Cuadrilla's efforts geared towards increasing the quantity of environmental data, a whole set of other questions about the environmental impacts of shale gas drilling were displaced. Similarly, the resumption of hydraulic fracturing operations in the UK depended on increasing monitoring and generating more data about the seismic activity in nearby shale sites. In its response to the 2011 shale gas report of the Energy and Climate Change Committee, the UK government (2012) had announced that they did not find a lengthy moratorium necessary to assess the environmental impacts of shale gas drilling, as new monitoring devices would remedy public concerns about the safety of fracturing technology and shale gas drilling. Nevertheless, despite the government's rhetoric about the adequacy of the current regulation grounded in science, most regulatory practices were in fact focused on measuring and monitoring (Latour 1999). The Royal Society report (2012) was a good example of how installing these devices was seen as a proper response to mitigate seismic risks associated with shale gas drilling. The UK government took one of the recommendations of the report as the scientific seal of approval to respond to questions of legitimacy over its regulatory regime.

To understand why these seismic events played a critical role in the shale gas controversy, it is not sufficient to understand the technical details of the monitoring devices. We also need to understand its specific relation to a new set of questions that

had not been considered by the British government, the scientific authorities or Cuadrilla. From the beginning, the introduction of new monitoring devices and their standardisation were subjected to contestation by local communities who put enormous pressure on their local councils. It was difficult to measure seismic activity near drilling sites, due to the lengthy environmental impact assessment required to get planning permission to install such devices (*BBC News* February 25, 2015). Public concerns over the location, cost and potential impacts of these environmental monitoring devices became a new source of contention between local community and the company (Vaughan 2015). In 2013 alone, approximately 14,000 residents wrote to their local councillors to demand that the council not grant Cuadrilla the right to drill for seismic monitoring devices and obtain permission for new drilling sites, expressing concern about possible pollution and environmental damage from increased drilling activity (Vaughan 2015). After a series of meetings to discuss the new environmental impact assessment plans submitted by Cuadrilla, on June 29, 2015 the Lancashire County Council Development Control Committee halted the company's application for new drilling activities. According to the council, the proposal was not acceptable due to its possible impacts on road networks and cumulative effects, which might lead to the industrialisation of countryside and the destruction of its landscape (Vaughan 2015).

Following seismic events, local communities raised a whole set of new questions about the impacts of shale gas drilling in Lancashire. The foremost issues of contention were earthquakes, destruction of the countryside and the potential for water contamination. These local concerns made their way into planning decisions which slowed down shale gas development, and were reflected in the council's decision to reject Cuadrilla's proposal. Yet, there was more to the public mistrust in

company's operations. The majority of local communities were not aware of the existence of drilling activities prior to the seismic events.[145] In a public meeting organised to address these concerns, a wide range of local people, including large property owners, farmers and environmental protesters, took issue with Cuadrilla's lack of public disclosure about their operations.[146] In practice, locals were angry about not being informed properly. Although the company put signs on their site, the local argued, these were barely legible from a distance.

Seismicity was a concern for the local population for a variety of reasons. Some landowners claimed damage had occurred to their houses as a result of the earthquakes. However, the BGS argued that only a magnitude 3 tremor at the depth of 2–3 km would be felt by residents, and only in rare circumstances might this lead to superficial damage. Hence, the BGS argued that hardly any structural damage could result from the earthquakes triggered by the hydraulic fracturing at Preese Hall.[147] Nevertheless, landowners were worried about the company's denial of any association between the earthquakes and fracking. One informant from the area claimed that small earthquakes had indeed caused damage to local properties. He noted that although the company did not want to associate itself with the earthquakes in the beginning, it later paid compensation to some landowners.[148] Actually, both the company and geologists at the BGS stipulated that any serious damage was unlikely to have been caused by the shale gas drilling, given the small magnitude of seismic events observed in 2011. While claims of structural damage were dismissed officially, the installation of seismic monitors for traffic control regime generated further

[145] In-person interview with local activist, St Annes on the Sea, Lancashire, March 07, 2013.
[146] In-person interview with a policy analyst, Manchester, March 06, 2013.
[147] Presentation by Mike Stephenson, BGS, The Geological Society Meeting, London, June 16, 2012.
[148] In-person interview with local activist, St Annes on the Sea, Lancashire, March 07, 2013.

complaints due to the need for explosives[149] which constituted a serious environmental impact for locals. This became a factor in the local council's decision to halt Cuadrilla's application to install seismic monitoring in Lancashire. In short, the measurement of environmental impact itself had an environmental and political impact.

The traffic light system also became a subject of contention for not controlling other structural damages to shale gas well integrity. As opposed to the highly descriptive regulatory regime of the US, the UK's well examination scheme was quite prescriptive. The UK regime set out guidelines on self-reporting by the operators and on-site monitoring by independent well examiners.[150] However, the HSE lacked the funds to undertake frequent on-site inspection and the majority of monitoring was conducted as desk research using analysing data submitted by the operating companies.[151] Following seismic events, the issue of well integrity became one of the key public concerns about monitoring the operations of Cuadrilla on the ground. The company had denied loss of well integrity due to fracturing at Preese Hall, and the 2011 DECC report also failed to acknowledge any damage to the cement around the well bore, when deformation could have occurred due to the earthquakes (Hill 2012). According to the Royal Society report, the integrity of a well depended on "preventing shale gas from leaking out of the well by isolating it from other subsurface formations" (Hill 2012*:* p. 24). The compromise of well integrity could have immediate impacts for groundwater resources if a methane leakage occurred. As seen in Figure 7-2 below, a shale gas well consists of a series of wellbores in

[149] In-person interview with local activist, St Annes on the Sea, Lancashire, March 07, 2013.
[150] Telephone interview with a senior employee from Health and Safety Executive (HSE), New York, NY, March 13, 2013.
[151] Telephone interview with a senior employee from Health and Safety Executive (HSE), New York, NY, March 13, 2013..

decreasing diameters, going down to different depths. Typically, well failure could result in the leakage of fluids either to the surface or surrounding rock formations.[152]

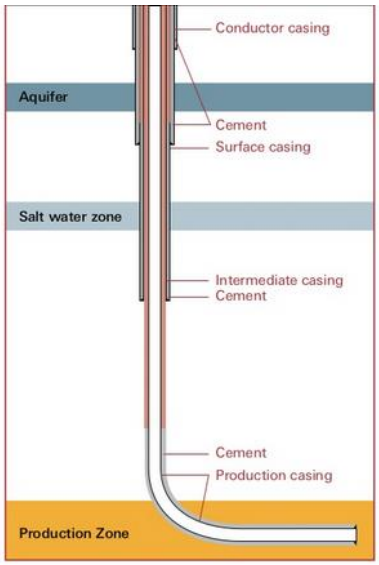

Figure 7-2: Shale gas well design example
(Source: Royal Society and Royal Society of Engineering 2012)

Greenpeace and Friends of Earth were vocal about the inadequacy of the existing regulatory regime to carry out proper monitoring of well integrity in the aftermath of seismic events. According to the exchange between Cuadrilla and the then Energy Minister Charles Hendry, the operator failed to acknowledge deformation in well casings, which was a serious concern given the possibility of leakage (Harvey et al. 2013b). In fact, the prospect of structural damage to the Preese Hall site was not discovered until early 2014. Disclosed email exchanges[153] between the company and the HSE in 2015 revealed that there were serious concerns regarding cement

[152] Blow out will lead to unwanted escape of fluids from the well to the surface; annular leak results from poor cementing between casings or casing and the formation, resulting in movement of fluids vertically in the well; radial leak results from horizontal leakage out of the well to the surrounding formations (Royal Society Report 2012: 24).
[153] Internal emails were obtained under FOI request (Clarke and Ottery 2015). The original document could be reached from the UK government site: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/429262/FOI_2015_0548 7_annex.pdf

evaluation and annular pressure at Preese Hall, and indicated a failure of the UK government's assurances about the safety of the fracturing process (Bryant 2014).

Although the company worked towards remediation of the well after the earthquakes, it eventually decided to abandon the well. In November 2014 the Preese Hall site was plugged (Clarke and Ottery 2015). As the email exchange with HSE on the status of the Preese Hall site demonstrated, the procedure required an additional cement plug to reduce the annular pressure in the abandoned well. This further added to concerns about possible leakages resulting from annular pressure. As a local campaigner put it, the timing of the discovery of annular pressure was critical. Three years after the damage to well integrity by seismic events, there was increased uncertainty about whether such a leak had actually occurred (Clarke and Ottery 2015). Although the HSE confirmed that there had not been any leakage underground, public disclosure of this finding added to concerns about the safety of the hydraulic fracturing process (Bryant 2014).

This minor dispute over seismic events was entangled in the generation of information about the geology of shale formations, safety of the fracturing process, and well integrity. This dispute also became a subject of a broader debate about the limits of monitoring and measurement devices for governing environmental impacts. Indeed, the dispute between the opposition and the company started as a technical question of whether or not seismic events were caused by the fracturing process, and then expanded into a series of questions about the responsibilities of operating companies and governance of environmental impacts. Although environmentalists and local activists scrutinised the adequacy of the regulatory regime in monitoring the impacts of fracturing – including minor damage to houses and leakage into underground formations – these questions were not considered significant by the

company or regulatory agencies. Indeed, the company viewed the monitoring of environmental impacts as a public exercise in transparency (Barry 2013). The seismic monitoring devices and traffic light regime were expected to generate unparalleled information about the fracturing process and seismic activity, which would ultimately (and hopefully) remedy the reputation of company. Both geologists and regulators recommended new procedures for monitoring seismicity. These focused on the immediate impacts of the fracturing process on fault lines. In the aftermath of seismic events, Cuadrilla expanded its organisational structure by hiring new professionals to oversee environmental impacts and public relations in London and Lancashire.[154] Yet the local opposition criticised these new developments as public relations exercises in an effort to restore trust in the operating company and at best to create an image of a responsible company.[155]

As scholars (Barry 2013; Power 1997; Strathern 2000) have observed, there is more to transparency than making information public and transforming the institutions to be able to deliver such information. While disclosing some information about the environmental impacts generated a vision of responsible development, Cuadrilla actually hid away some essential information about the organisational structure of the company and their correspondence with regulatory agencies (Strathern 2000). As Freedom of Information requests later revealed, these internal exchanges between Cuadrilla and HSE pointed to serious concerns over the governance of seismic risks. Despite the rhetoric of a regulatory regime grounded in science, most of these concerns were hidden from the public. Therefore, this division between what is made visible about the impacts of the fracturing process and what is hidden regarding

[154] In-person interview with Cuadrilla Resources, Lichfield, Birmingham, February 26, 2013.
[155] In-person interview with local activist, St Annes on the Sea, Lancashire, March 07, 2013.

the operational practices became critical to the governance of environmental impacts (Barry 2013).

7.4 Conclusion

Here we have seen how making the scale became entangled with multiple technical debates over seismicity, well integrity, the traffic-light monitoring system, water contamination and the destruction of countryside, all of which became politically important and constituted key areas of contestation. The production of information on these technical matters was thought to create transparency regarding the operations of government and the operating gas company. If economic and environmental impacts of shale gas development were to be managed transparently, by informing the citizens through public relations campaigns and technical forums, then creating a vision of responsible resource development was not seen, in the early stages at least, as a particularly difficult task. In effect, however, the disclosure of large quantities of information only made certain aspects of shale gas development visible, whilst hiding others from sight (Barry 2005; Power 1997; Strathern 2000) until they were revealed, much later, by Freedom of Information requests.

Nevertheless, the public, scientists and activist groups tested this vision of transparency on various occasions. I have shown that these performances of transparency require some form of public staging of science, where the public could witness and assess technical information presented to them (Shapin and Shaffer 1985). Even though the experts, in these public forums, articulated a vision of "objectivity", their claims were contested in multiple ways (Callon et al. 2001; Ezrahi 1990). As we have seen in the UK case, however, witnessing became instrumental to the labelling of specific scientific information as "objective" (Jasanoff 1998). While

the government dismissed other concerns, the articulation of multiple objects, technologies and problems in these public forums were critical to understanding how transparency was constituted and contested in the UK context.

When Cuadrilla started drilling operations in Preese Hall, there was not much public awareness about fracking or shale gas. After the seismic events, we saw a proliferation of new monitoring regimes to govern the environmental impacts of shale gas drilling. Governing environmental impacts was seen by both the industry and the government as a technical matter, demanding a great deal of investment in seismic devices, enhanced monitoring and the organisation of a new regulatory regime around a traffic-light control system (Callon 1998). As the controversy over installation of monitoring devices in Lancashire shows, however, the immediate impact of confining the seismicity issue into a fixable technical solution disregarded other legitimate matters of concern (Latour 2004).

In sum, this chapter analysed the making of scale in British shale gas projects in contested spaces of information production, and, in this way, contributing to theoretical discussions of both transparency and the materiality and spatiality of environmental impacts (Barry 2013; Bridge 2009; Callon 1998). Situating the UK's experience of making of scale in the context of knowledge controversies, the chapter reveals a complex topography of informational spaces in their local condition of production.

CHAPTER 8: CONCLUSION

8.1 Introduction

This thesis has examined contested spaces of transparency and resource making in the shale gas projects of the US and also the UK. As the US was the first country to realise a large-scale shale gas development, I focused primarily on this case, but I also considered the differences between the UK and US experiences. Presenting a comparative analysis of multiple transparency disputes, the empirical chapters have shown that the making of the shale gas resource depended on contested resource materialities in different regulatory regimes. These empirical chapters have outlined the contestation of resource materialities across a range of expertise domains in law, finance, environment and geosciences. I have argued that disparate geographies of transparency and regulation in the US and the UK stemmed from culturally specific, institutionally varied and materially informed knowledge and regulatory practices. In doing so, this thesis empirically grounded the STS oriented literatures on transparency and regulation, showing their connectedness in making of the shale gas projects in distinct geographies.

The analysis was based upon in-depth study of technical reports, legal texts, interviews and media resources. I undertook field visits to various drilling sites and company offices and conducted conference ethnography at a number of geographical sites, with six months of interviews, drilling site visits and participant observation in industry conferences in Pennsylvania, New York and Texas (US) and three months of interviews, short field-site trips and conference ethnography in Birmingham, Lancashire, Manchester and London (UK) and also Warsaw (Poland). Thus, this

thesis follows recent political, economic, legal and scientific knowledge controversies associated with the UK and the US shale gas projects.

Three main findings are identified. First, the narratives presented in the chapters connect different geographies of knowledge that characterise national shale gas debates in their historical, legal and cultural contexts. I have argued that shale gas development was not same everywhere. Situating the development of technologies and financialisation of the US shale gas sector in a historical context, I have shown that American shale boom depended on various geoscientific, economic and political interventions to make it an economically feasible and politically desirable resource. In the UK, on the other hand, national aspirations for large-scale shale gas development have been impeded by geophysical limits, high operational costs and regulatory constraints. Therefore, the political debate about how to regulate fast-paced shale gas development was contingent on complex techno-scientific interventions required to fit the resource to the local conditions.

Second, the environmental impacts of the industry have been the subject of knowledge controversies involving gas companies, regulators, landowners, scientists, consultants, environmental groups and NGOs. This thesis has contributed to the literature on knowledge controversies by analysing the regulatory discussions on environmental impacts in disparate geographies, engaging theories of transparency, STS and legal geographies. In particular, the case studies considered in this thesis have shown how information production and its contestation have become entangled with assemblages of materials, technologies, reports and a range of actors involved in the shale gas debate. These techno-social disputes have had important implications for the political future of the shale gas projects and corporate responsibility near drilling sites and also more widely for the development of the sector nationally, in the US and

UK. I have argued that the debate over environmental impacts was not confined to the realm of politics, but also became a source of contention in various scientific and technical networks embedded in the industry, scientists, environmental organisations and the universities. Thus, this thesis has shown the contested and fluid boundaries of science and politics in the debate over governance of environmental impacts.

Last, transparency demands placed the administrative agencies and companies under intense public scrutiny, generating new forms of disclosure and stagings of science in the public space. Although the US and the UK have different administrative and scientific practices and procedures, measuring the environmental impacts became critical for shale gas governance in both countries. New metrics of disclosure and monitoring devices, such as the fracturing chemicals disclosure registry (US) and traffic light system for seismic impacts (UK), aimed at creating a vision of responsible development. However, the informational space generated by the measurement of impacts was limited to the governance of certain specific environmental problems, and other legitimate technical questions were left unaddressed.

Overall, this thesis has made important empirical contributions to the academic scholarship on transparency, regulation and resource making. Based on empiricist study of the industry, scientific networks and regulatory agencies, I have argued that the resource matters and regulatory contexts were critical to the formation of shale gas policy in distinct geographies of the UK and the US. In fact, this thesis has shown that both the industry and regulators believed that regulatory framework should be attentive to the geophysical and other technical matters relating to the shale gas development. In the following sections, I summarise the principal findings of the empirical chapters, showing that these chapters empirically grounds the object-oriented and co-productionist literatures of resource geographies, science and

technology studies (STS) and legal geographies. I then discuss some of the broader implications of this research for the economics, politics and science of shale gas development in the two countries (US and UK). Finally, I clarify the limitations of this research and indicate possible avenues for future research.

8.2 Findings and Contributions to the Literature

Giving a spatial account of transparency in different geographies, this thesis speaks to the broader theoretical debates in geographies of knowledge, resource making and transparency from the STS, economic, legal and resource geographies literatures. The empirical chapters have portrayed the boundaries of transparency as fluid, contested and specific to disparate geographies. Unlike positivist accounts of transparency as a universal, normative concept characterising democratic states, this thesis questions how transparency, as a practice, varies in space and time. Thus, I have argued that transparency has a legal and political geography and has to be traced in multiple spaces of information production. In doing so, this thesis empirically grounded the critical academic literature on geographies of transparency and regulation, showing their connectedness in the making of shale gas projects.

On the issue of resource making and transparency, the materially informed accounts from resource geographies and STS (Baker and Bridge 2006; Barry 2013; Bridge 2009) provide a useful framework with which to understand the role of materials and technologies in the politics of fossil fuels. Following Barry (2013), Bridge (2009) and Latour (2004), this research has aimed to account for the making of material realities and the role of things through various knowledge practices. In this account, I have shown that reserve estimates, fracturing chemicals, seismicity, methane, well-casings and the hydraulic fracturing (HF) technology has played a

critical role in the politics of shale gas development in both countries. Subsequently, this story of shale gas projects follows the contestation of these objects in their technical networks of law, economics and geoscience in the US and UK (Callon et al. 2001; Latour 2004).

After introducing the thesis, subject area and case studies and the associated literature, Chapter 4 started by looking at the industry's narrative of the American shale boom as a successful story of wildcatter entrepreneurship. While this account applauds the wildcatters, such as George Mitchell, as key actors behind the shale revolution (Hinton 2012; Kutchin 2001; Zuckerman 2013), it was argued, the entrepreneurial tale is rather limited and simplistic. It does not tell us anything about the role of public and private sector collaborations or, more broadly, the economic, political and technological interventions that enabled shale gas development over a period of six decades. In other words, the modern-day story of capitalist success is actually founded on a rather long history that needs to be filled out with a complex range of crucial factors making up the bigger picture for a more realistic portrayal of the early development of the shale industry.

This chapter also adds upon the academic literature on shale gas by analysing the relationship between geoscientific practices, technological development and the speculative forms of financial appraisal in the commercialisation of the shale resource. I started with Mitchell's (2013) observation on the making of the shale boom in the US. In the afterword of *Carbon Democracy*, Mitchell argued that the shale boom depended on two kinds of technologies: first, the technological advancements in drilling and fracturing technologies, and second, the industry's ability to extract funds from investors. Here, I empirically grounded and expanded Mitchell's claim by showing that the making of the shale resource had to be

understood in relation to multiple spaces of information production in technologies of extraction, reserve estimates and land leasing markets.

Subsequently, this chapter utilised from a "materially-informed" analysis of resource-making in the resource geographies literature (Bakker and Bridge 2006; Bridge 2009; Kama 2013) by acknowledging the importance of resource materialities that make a difference in the way economic and social relations unfold. In this study of materials, my approach was guided by empiricist accounts from STS in focusing on particular characteristics of shale geology, the history of drilling technologies and the impact of economic and political actions in rendering such large-scale resource transformations (Barry 2013). I showed how the shale reserves became classified as a resource as a result of geographically different knowledge-making practices and technological development in the American and British contexts (Bridge 2009; Kama 2013).

Specifically, the emergence of shale gas as a resource was contested in multiple conflicting practices of resource assessment and speculative valuation in the financial and land leasing markets (Kama 2013; Labban 2010). I argued that the hype around the shale technologies and investments could be understood in relation to the historical contingencies and the force of economic and political action. A network of geoscientists, petroleum engineers, gas companies and private investors was critical to resource estimation practices and financialisation of the sector (Barry 2008), and transparency demands over reserve estimates generated a controversy about the techniques of resource estimation employed, corporate misreporting and speculation in the financial markets.

Indeed, despite the rising costs of developing shale gas fields and declining returns associated with falling gas prices, partly as a result of the shale boom, Wall

Street investors continued to fund gas companies, creating massive profits from mergers and acquisitions and other transactional fees related with operational costs (Rogers 2013). In fact, it may be stated, the American shale boom was premised on the circulation of reserve estimates as a virtual commodity to be exchanged in the financial markets (Labban 2010). Following Labban, I have thus shown how the speculative nature of American shale gas boom derived from the separation of material production from the financial valuation of the resource as a potential.

In the case of the Marcellus Shale, initial reserve estimations generated a rush for land in New York and Pennsylvania states. I showed that how "inscriptions," such as written records of a geologist's communications with the industry and investors, maps and back-of-the envelope calculations, became mediators of converting the matter into an economically viable resource (Latour 1987). Borrowing Latour's (1999) notion of "circulating references," I argued that the resource estimations for the Marcellus Shale went through a series of transformations and translations, which had a direct impact on the commercialisation of the resource once published in a geoscience journal. These estimations articulated in various forms in the financial markets and led to a rapid industrialisation of the region. However, administrative agencies in the two states responded differently to the environmental impacts understood to be associated with this large-scale drilling. In effect, two different governance systems were described: political interventions stalled shale gas development in the state of New York while enabling a rapid expansion of the industry in Pennsylvania.

Introduction of the recent regulatory debates in Britain served to contextualise the American case so as to understand how national knowledge making practices have affected the making of shale gas projects in different geographies. With a view to

generating a large-scale resource development, the UK government adopted an "all-out-for shale" policy, which proposed new economic incentives for the industry and local economies. This new policy was subjected to national political and geoscientific practices, which affected the making of scale in the British context.

Chapter 5 examined regulatory debates related to the disclosure of fracturing chemicals in the US and UK. As a starting point of contention between the industry, activists and governments, the controversy over transparency in respect of fracturing chemicals occupied a central role in regulatory discussions regarding environmental impact and reputational concerns about industry practices. The initial reluctance of the American shale industry to disclose information about the chemical composition of fracturing fluid raised doubts as to whether the environmental risks of the fracturing process could be successfully governed.

In particular, the federal regulatory exemptions from the Clean Water Act exacerbated public concerns about the monitoring of fracturing chemicals and their impact on water resources in the country. Corporate disclosure is subject to some regulation in the UK legal context, but increased public awareness about 'toxic' fracturing chemicals there generated a parliamentary discussion on how to monitor and foster public disclosure to ensure the efficacy of regulation. This transparency controversy over the fracturing chemicals raises a key question central to the study of science-policy relationship in general: how do national knowledge making practices generate different material worlds and regimes of environmental governance?

Drawing insights from materially informed and co-productionist accounts in the STS scholarship (Barry 2013; Jasanoff 2005), I gave a spatial analysis of the regulation of fracturing chemicals in distinct geographies of knowledge-making and environmental policy. Following Jasanoff (2005, 2011), I empirically showed that

national characteristics define how scientific evidence and 'objectivity' is differently treated according to the specific legal and political geographies of the US and the UK.

For American regulators, obtaining objectivity required a lengthy formal scientific review, which was based on the quantification of the environmental impacts of fracturing process on drinking water resources (Jasanoff 2011). The EPA's scientific review of the HF process was not devoid of controversy, since, conducted in response to a federal lawsuit, the review was subjected to immense political pressure from the industry and activists. British regulators, in contrast, deemed informal expert consultations adequate to establish 'scientific objectivity', and did not require a formal scientific review for regulation of the fracturing chemicals. Therefore, this case study of transparency demonstrated how distinct institutional cultures of objectivity informed public policy and regulatory science (Jasanoff 2005).

The secrecy over the characteristics of fracturing chemicals also became critical to the public perception of the industry. Chapter 4 provided a history of the private patent regime, which was developed as an integral part of commercialisation of the HF technology and operations of the field service companies. Faced with liability issues, regulatory threats and reputational concerns, however, the production of information on fracturing chemicals was perceived as a technical challenge for the entire industry. This chapter thus looked at how these chemicals become 'informationally-enriched' through the new, voluntary, chemicals disclosure registry, the FracFocus website (Barry 2010).

For the industry, this registry was expected to put an end to the transparency debate and prevent federal regulation of the industry. In fact, however, while these new disclosure platforms did generate a level of visibility along the supply chain, they also hid information about how these companies adapted to the very process that

placed information in the public domain (Barry 2010; Grossman et al. 2006; Strathern 2000). For the critics of FracFocus, the inaccuracies and gaps in corporate self-reporting provided a counter argument against the utility of this regulatory compliance tools. Therefore, what seems to be a quick technical fix for the regulators and the industry only multiplied the points at which new controversies emerged.

In addition to the nationally specific practices of administrative science and the public disclosure practices of the industry, I have focused the political significance of chemicals in relation to other disputes on methane contamination (Chapter 6), well integrity (Chapters 6 and 7) and seismicity (Chapter 7). Here, I aimed to establish connections between controversies that occurred in the two countries. The industry and regulators treated some of these issues as minor problems that could be fixed with simple technical solutions and generate "lessons" for the industry (Barry 2013). Critics, however, made an effort to relate seemingly disparate events to the wider questions of transparency, corporate responsibility and compensation. For them, these events indicated broader problems associated with gas companies' drilling practices and monitoring of environmental impacts of the rapid shale gas development.

Chapter 6 focused on the water contamination controversy in Dimock, Pennsylvania. As one of the early sites of exploration in the state, landowners witnessed a deterioration of their drinking water supplies after Cabot Oil and Gas started drilling activities in the region. At issue in the Dimock case was the scientific credibility of claims raised by landowners and then counter claims by the company. As a part of a lengthy federal lawsuit against the company, the state and federal agencies, Cabot and independent scientists conducted multiple rounds of water tests. However, pre-existing geological conditions surrounding the water reservoirs – along

with the failure to complete a baseline study prior to drilling – made it difficult to give a definitive explanation of the causes of water contamination.

While Cabot used scientific uncertainty as a successful strategic defence in fighting the federal lawsuit and consent order settlements with the Pennsylvania Department of Environmental Protection (PA DEP), the company suffered significant reputational damage for not accepting responsibility for the water contamination in Dimock (Michaels 2006; McGoey 2009b; Oreskes and Conway 2010). Corporate practices of distorting scientific evidence and attacking counter scientific studies were coincided with confrontational community relations and gag orders on landowners, thereby implying wider, systemic defects in corporate accountability in the development of shale gas in the US.

This chapter made two specific broad arguments about the Dimock case. First, I found that the landowners' compensation claims were affected by interpretations of test results performed by different experts. Multiple water tests were not just instruments for establishing matters of fact, but they were also performative transparency acts: the reliability of experts (state agencies, academics, consultants) was equally established and contested through scientific demonstrations of the relationship between drilling impacts and water contamination (Shapin and Schaffer 1985). When new actors joined the controversy, the scope of contested issues extended from fracturing chemicals to methane contamination and well integrity.

Drawing insights from Petryna's (2002) work, I argued that the ability of landowners to receive compensation was dependent on obtaining scientific evidence for water contamination. As the controversy focused ever more narrowly on the results of official test results and their convergence, the lived experiences of landowners became less important in making an adequate legal claim. The

landowners were angered by the way in which the dispute was handled by the state and federal agencies, their frustration aggravated by the politics of knowledge-making practices that shaped the legal dispute in favour of the company.

Second, this chapter makes a case for the object-oriented analysis of socio-technical controversies (Barry 2013; Callon et al. 2001; Latour 2004) by showing how the measurements of water quality and methane levels had material effects on the governance of the environmental impacts of shale gas drilling. I argued that the Dimock water contamination controversy was a technically complex case study animated by the assemblages of non-humans (methane, chemicals, brown water containers), contested scientific practices (isotopic and geochemistry analysis of the region) and a range of actors (activists, NGOs, landowners, Cabot, scientists, state agencies) located in Pennsylvania, New York and Washington.

The popularisation of Dimock as the Ground Zero of shale gas drilling had adverse effects on public perception of the industry and generated a profound confusion over what had caused the drinking water problem and its relation to the drilling activities. In my analysis of how the use of scientific uncertainty became a key corporate public relations and legal strategy in this case, there is a resonance with the works of Michaels (2005) and Oreskes and Conway (2010) on the role of private actors in generating information that belongs to "pseudo science" in the climate change debate. These scholars are hesitant to destabilise the boundaries between science and politics, because climate sceptics often undermine the arguments of climate change science by using this strategy. Although this is a valid strategic approach in the US context, my analysis here takes the opposite tack, by illustrating that in the Dimock water controversy, the boundaries between science and politics, humans and non-humans were fluid and contested.

Chapter 7 presented the brief history of shale gas projects and transparency debates in the UK, analysing instances of seismicity dispute and public staging of science. Developing on Tsing's (2005) conception of scale, I argued that the making the British shale gas revolved around points of friction arising from the contestation of global knowledge-making claims in the UK context. The UK governed the environmental impacts of the shale gas projects differently from the US. In the brief history of the UK's experience with the shale projects, the terms of existing technical disputes had to be renegotiated, while new issues were introduced to the knowledge-making practices regarding the governance of environmental impacts.

This chapter gives an object-oriented account of contestation of the shale gas projects by analysing the entanglement of physical and political processes behind the governance of environmental impacts (Barry 2013; Bridge 2009; Mitchell 2013). I argued that the seismicity dispute was an early test of the UK government's capacity for monitoring environmental impacts and corporate transparency. Both the government and the operating company, Cuadrilla Resources, supported the installation of a "traffic-light system" as a quick technical fix for the seismicity problem.

Integral to this new monitoring regime, the informational space generated by the measurement of seismic impacts depended on an abstraction of seismicity in multiple informational forms (Barry 2013). The intended effect of this regime was to provide unprecedented information about the underground activities related to the HF process, as well as to foster a vision of responsible resource development. Subsequently, the governance of seismic impacts mainly focused on monitoring and controlling seismic events, whereas other legitimate questions, such as well integrity and water contamination, were discarded as unimportant.

This chapter also showed that the seismicity debate had transformative effects on the public discussions on environmental impacts of shale gas drilling. An increasing range of technical information on the HF technology, geology and environmental risks was discussed in public forums. Developing from the STS literature on public forums and the power of sight, therefore, I empirically showed that transparency necessitates some form of public staging of science whereby its authority is construed and contested (Callon et al. 2001; Dalston and Gallison 1992; Ezrahi 1990; Scott 1998).

In these performances of transparency, witnessing acts become instrumental to the labelling of elite science as "objective" (Jasanoff 1998). Although the UK government dismissed other "matters of concern" as articulated by a range of actors (Latour 2004), the articulation of multiple realities was critical to the formation of a complex topology of informational space surrounding the shale gas development. Overall, this chapter added to the broader theoretical argument of this thesis: transparency is selective in practice, and it is construed and contested in nationally specific knowledge-making practices.

8.3 Research Limitations and Prospects for Future Research

This comparative study of shale gas development tracing disparate geographies of knowledge-making practices, resource making and transparency disputes in the US and the UK was undertaken when the American shale industry was booming and expected to transform the global energy landscape. In examining the economic, geological and political interventions that facilitated the shale boom, therefore, this thesis has presented a critique of the US shale bubble and thus questioned its sustainability in the long term. The hyping of shale investments, despite its declining

profitability, recalls the financial "dot.com" bubble around the information technology sector in the late-1990s (Urbina 2011). In contrary to the industry claims, therefore, emerging economic as well as geological constraints suggest that the shale boom will not last long (Zeller Jr. 2014).

On the geological front, the rush for "sweet spots" was followed by expansion to the lower quality geological formations, offering less productivity per well and thus requiring increased drilling activity to offset reduced productivity. On the economic front, gas companies continue to drill and increase shale gas production despite the plummeting gas prices, shorter capital flows and higher well operation costs, as well as, moreover, the effect on the natural gas sector of the steep and sudden oil price resetting in 2015, resulting in capital expenditure cuts in large-scale upstream investments (IEA 2015). As the IEA gas markets report (2015) suggested, American gas companies have been absorbing the market shocks by cutting down its downstream expenditures, such as well drilling and other field services costs.

Even though shale gas production was scaled back due to low gas prices, however, the debate over the long-term sustainability of the sector continues. The question of whether the US shale industry will sustain growth or bust, in addition to the various issues around its impacts on the environment and economy offer fertile ground for future investigation. In particular, further research may focus on how shale gas projects are managed along the supply chain, and the impacts of cost-cutting measures on the governance of environmental impacts associated with increased drilling activity.

In the case of UK, the majority of this research was conducted during a period in which there was a lot of uncertainty regarding the future of shale gas projects. When I started my research in 2011, the British government announced a moratorium

on shale drilling following the seismic events in Lancashire. Since this research was built around understanding the industry practices and national regulatory frameworks in shaping transparency disputes and resource making practices, the moratorium could either mean the end of shale gas investments or generation of new venues for contestation. As the Chapters 5 and 7 showed, the moratorium actually slowed down the public debate and opened up new areas for public discussion in the UK.

International recognition of the UK's shale gas reserves as an economically viable resource was also affected by the seismicity dispute. In the early days of my research, industry consultants constantly reminded me that there were only three exploration wells in the country, which would hardly generate any enthusiasm among investors if the moratorium continued. At the time, in Europe, Poland's shale reserves were regarded as promising resources, in which American field service companies and multinational oil and gas companies invested heavily but eventually pulled out of due to economic and regulatory constraints. This rapid shift alone shows how potential reserves can easily enter into economic calculations but just as quickly drop out of the resource category as a result of various technical, geoscientific and political interventions.

For Europe, developing shale gas has become important for reducing energy dependence on Russian and Qatari gas. However, as this thesis has emphasised, resource-making requires a process of translation in distinct geographies of knowledge-making and national regulatory frameworks. New research could enlighten how key shale gas developers in Europe, in particular the UK, Germany and Eastern European countries, respond to the recent market shifts in the global shale industry, and it might look at other geophysical and technological challenges associated with developing the resource.

Although the shale gas debate in the UK hardly matches the American in terms of time frame and the range of issues, this research does present an early snapshot of the UK's experience with shale gas projects. From October 2011 to August 2015, the UK government lifted the moratorium and proposed a series of economic and regulatory incentives to ease the entry of new players from the industry. This liberalisation and support for the market conjures up possibilities of a replication of the American shale boom, yet governing the environmental impacts of rapid shale development will be a challenge for the country. This research touched upon various economic, political and environmental ramifications of expansion of shale drilling in the UK.

As industry consultants and policy analysts contend, the lack of well-developed field service companies, the high operation costs, mineral rights regime, dense population and complex environmental regulatory regime will be key constraints for the future of shale gas investments in the country. In response, the UK government set up the Office of Unconventional Gas and Oil (OUGO) to promote the "safe, responsible, and environmentally sound recovery of the UK's unconventional reserves of gas and oil" (DECC 2015). However, it is not entirely clear how this new governing body will address the environmental and economic impacts of a large-scale resource development. Future research could clarify the role of OUGO and its relation to other administrative agencies responsible for monitoring environmental impacts.

At the European Union level, there has been a growing interest in measuring the socio-economic and environmental impacts of European shale gas policy options. In line with the EU Commission's January 2014 Recommendation, new principles are currently being discussed that will complement the existing EU legislation on "environmental assessment and planning, underground risk assessment, well integrity,

baseline reporting, capture of methane emissions and disclosure of chemicals used in each well" (EC 2015).

This thesis has discussed some of these issues in the UK context, and it will be interesting to see whether the EU-level policy discussions will impede the UK's vision of large-scale shale gas development and how this plays out in the context of difficult UK-EU relations and the UK's internal political debate on this matter. Although European shale gas policy is still in the making (Reins 2014), further ethnographic research can open up techno-scientific debates in these policy networks, and examine the influence that the new EU shale gas regulatory regime might have on the making of the shale resources in the EU.

Overall, this thesis has covered a range of environmental, scientific, economic and political interventions that have affected the making of shale gas resources and transparency disputes in the US and the UK. More broadly, the following areas may be pursued for future research. First, a comparative study of climate change impacts of shale gas projects will expand the scope of this study from drilling-related environmental impacts to the impacts of developing shale gas resources on the global carbon future. While the industry argues that natural gas from shale formations would be a transitional fuel for a low carbon future, critics of the industry points to how investing in shale gas would divert funding and research from renewable technologies (WWF-UK 2013).

In the US, the Howarth et al. (2011) study of methane and the greenhouse gas emissions from shale formations triggered a heated scientific debate over the carbon footprint of shale gas projects. In the US context, further research will enlighten how these technical disputes are entangled with the pseudo-science articulated by climate sceptics and the lobbying efforts of the American oil and gas industry. In the UK

context, climate policy discussions have focused on the impacts of shale gas projects on the UK's decarbonisation efforts and the EU level emission commitments. Therefore, further research could provide useful insights into the relationship between shale gas investments and climate policy discussions in distinct regulatory regimes.

Second, another venue for future research will be the financialisation of the European shale industry and the impact of this on the European carbon markets. In the UK, government subsidies and tax breaks have already been introduced to generate a home-grown industry. If shale projects are to be funded by government subsidies and the key European financial centres, such as London, then what impact will this have on the European carbon markets? Future research on the financialisation of the European shale industry could shed light on the impact of shale gas resources on European carbon markets and the technology development of its low carbon energy resources.

APPENDIX

Detailed list of interviewees, conferences and public forums

List of interviews:

1. In-person interview with an environmental consultant working for the industry, New York, New York, July 20, 2012.
2. Telephone interview with a senior economist from International Energy Agency, July 23, 2012.
3. Telephone interview with a senior researcher from an institutional investor network based in Boston, August 02, 2012.
4. In-person interview with a senior expert at Water Resources Institute, Ithaca, NY, August 22, 2012.
5. In-person interview with a Cornell academic, Ithaca, NY, August 22, 2012.
6. In-person interview with a senior hydraulic fracturing engineer, Dimock, PA, August 24, 2012.
7. In-person interview with landowner I in Dimock, PA, August 24, 2012.
8. In-person interview with landowner II in Dimock, PA, August 24, 2012.
9. In-person interview with an energy analyst from an international investment bank, New York, New York, August 30, 2012.
10. Telephone interview with an energy company employee working on upstream portfolio management, Houston, TX, September 03, 2012.
11. Telephone interview with a policy analyst from PennEnvironment, September 09, 2012.
12. Telephone interview with a representative from faith-based investment network, September 10, 2012.
13. In-person interview with the best-practices expert from Marcellus Shale Coalition, Philadelphia, PA, September 21, 2012.
14. Interview with an energy company's senior advisor on environmental strategy and regulatory affairs, Philadephia, PA, September 21, 2012.
15. In-person interview with external relations person from Cabot Oil and Gas, State College, PA, October 11, 2012.

16. In-person interview with Prof Terry Engelder, Penn State University, State College, PA, October 12, 2012.
17. In-person interview with a local journalist from PA, Hoboken, NJ, October, 19, 2012.
18. Telephone interview with a former senior official at PA DEP, November 01, 2012
19. Telephone interview with a senior officer from Office of Oil and Gas Management, PA DEP, November 01, 2012.
20. In-person interview with a senior expert from the Natural Resources Defence Council, November 14, 2012.
21. In-person interview with a local journalist from upstate NY, New Haven, CT, November 15, 2012.
22. In-person interview with a shale gas expert from Environmental Defense Fund, New York, New York, November 16, 2012.
23. In-person interview with a senior regulator from the Environment Agency London Office, Oxford, UK, February 19, 2013.
24. In-person interview with sustainability/risk management specialist from Cuadrilla Resources, Lichfield, UK, February 26, 2013.
25. In-person interview with academic researcher on shale gas, Manchester, UK, March 06, 2013.
26. In-person interview with a senior regulator from the Environment Agency North West Region, Bamber Bridge, UK, March 07, 2013.
27. In-person interview with a local resident from Southport, St Annes on the Sea, Lancashire,UK, March 07, 2013.
28. In-person interview with a local resident from Fylde, St Annes on the Sea, Lancashire, UK, March 07, 2013.
29. Telephone interview with a senior regulator from the UK Health and Safety Executive, New York, March 13, 2013.

Conferences/public forums/field visits:

1. Unconventional Gas and Oil Summit, Warsaw, Poland, March 27-29, 2012.
2. The Geological Society Shale Gas Event, London, UK, June 18, 2012.
3. New York State Senate Hydrofracking Public Forum, NYC City Hall, New York, NY, July 17, 2012.

4. Cabot Oil and Gas drilling site tour in Wyoming County, PA, US, August 24, 2012.
5. Delaware Valley Marcellus Association, Doing Business in the Marcellus Panel, Philadelphia, September 06, 2012.
6. Shale Insight Conference, Philadelphia, PA, US, September20-21, 2012.
7. Marcellus Summit, State College, PA, US, October 21-22, 2012.
8. Local activist groups' event in St Anne on the Sea, Lancashire, UK, March 07, 2013.
9. Field visit to headquarters of a major oil and gas company, Houston, TX, US, June 15, 2013.

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