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Debating Unconventional Energy: Social, Political, and Economic Implications

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Abstract

The extraction of unconventional oil and gas—from shale rocks, tight sand, and coalbed formations—is shifting the geographies of fossil fuel production, with complex consequences. Following Jackson et al.'s (1) natural science survey of the environmental consequences of hydraulic fracturing, this review examines social science literature on unconventional energy. After an overview of the rise of unconventional energy, the review examines energy economics and geopolitics, community mobilization, and state and private regulatory responses. Unconventional energy requires different frames of analysis than conventional energy because of three characteristics: increased drilling density, low-carbon and "clean" energy narratives of natural gas, and distinct ownership and royalty structures. This review points to the need for an interdisciplinary approach to analyzing the resulting dynamic, multilevel web of relationships that implicates land, water, food, and climate. Furthermore, the review highlights how scholarship on unconventional energy informs the broader energy landscape and contested energy futures.

Contents

1. INTRODUCTION

Technological innovations over the past two decades—from horizontal drilling to high volume (slickwater) hydraulic fracturing—have altered the global fossil fuel industry by enabling the expansion of unconventional oil and gas extraction. Unconventional fossil fuels are hydrocarbons contained in low-permeability formations, which include natural gas and oil from shale rocks, oil from tight sand, and natural gas from coalbed formations (1, 2).[1] Such developments have enabled access to and fueled exploration of fossil fuel resources across the world that were previously technologically inaccessible and financially unviable, in turn reordering the geographies of production and trade and catalyzing public debate.

Social science scholars have documented and analyzed the multiscalar impacts of the expansion of unconventional oil and gas production and technologies on the environment, society, and political economy. Efforts to compile research findings on hydraulic fracturing (HF) have occurred at the intersections of natural, social, and health sciences (3, 4), often with a focus on risk and risk governance (5, 6, 7, 8), and with a commitment to informing policymakers tasked with evaluating and regulating these developments (e.g., 9, 10, 11). Social science research on unconventional energy has expanded rapidly across disciplines, including political science and policy studies, economics, geography, anthropology, sociology, and law, and ranging from local (12) to national (13) to global scales (14). Building on a previous review of the environmental costs and benefits of HF (1) and other early contributions to the scholarship of regulation and governance of shale gas development and HF (15, 16), this review provides a synthesis of social science research on

[1]Although additional technological developments include steam-assisted gravity drainage to access oil/tar sands bitumen and drilling techniques to extract ultra-deepwater oil and gas resources, and some public debates use the term unconventional more loosely, we follow the US Environmental Protection Agency's technical definition of unconventional for this review.

unconventional energy governance, focusing primarily on HF (often referred to as fracking),[2] while referencing a broader range of fossil fuel resources when appropriate.

We argue that the frames of analysis generally used for conventional energy—which have typically taken a geopolitical and security-oriented approach, with a focus on energy independence—are insufficient for understanding the sociopolitical and economic dynamics of unconventional energy. Three reasons underpin the need for an analytic shift: increased density of wells and new technologies of drilling, which alter environmental impacts; the low-carbon and "clean" energy narratives associated with natural gas; and differing ownership and political economy structures (especially in the United States, with small-scale companies leading natural gas expansion). Our analysis indicates that we should not see the surge in unconventional energy sources as a simple increase in oil and gas supplies; rather, their role in the energy system involves a dynamic, multilevel web of relationships at the food-energy-water-land nexus, and poses interrelated questions of security, sovereignty, and environmental protection. Shale gas exploration, for example, requires water for production, and in turn, water diverted for energy may undercut food production and result in sociopolitical conflicts over how best to use water resources and protect landscapes. Notably, shale gas exploration and production in both the United States and China is constrained not only by water availability but also by the effects of exploration and production on water quality (18). Furthermore, we argue that current scholarship on unconventional energy offers insights that help reformulate our understandings of the broader energy landscape, as well as state-society relationships over contested energy futures.

The analysis begins with the rise of unconventional energy (Section 2) and then turns to shifting global markets and geopolitics (Section 3), patterns of social mobilization and resistance (Section 4), and rethinking regulation and governance (Section 5). In the final section (Section 6), we clarify how emerging social science research into unconventional energy offers new ways of linking debates over energy, land, water, security, and justice, and consequently challenges scholars to work across scales and sectors. Throughout, we offer empirical insights from across the world, including examples from Algeria, Argentina, Australia, Canada, China, Poland, South Africa, the United Kingdom, and the United States.

2. THE RISE OF UNCONVENTIONAL ENERGY

The development of HF in the United States in the early 2000s set the stage for the rapid expansion of shale development, colloquially referred to as the "shale revolution." This increase triggered heated debates over environmental impacts and regulation, particularly given the rapid growth of production: By 2014, gas from unconventional sources represented just under 50% of total US natural gas production, with a projected increase to nearly 70% by 2040 (19). Proponents justify unconventional energy through reference to security narratives that highlight increased supplies and diversified sources; many also employ environmental narratives that point to lowered carbon emissions from natural gas compared with coal. In contrast, opponents point to both confirmed and suspected environmental and social impacts, including higher greenhouse gas emissions, water contamination, landscape disturbances, human health impacts, and breaches of Indigenous peoples' rights (see sidebar Differentiating Environmental Impacts of Conventional and Unconventional Energy; 1).

[2]Definitions remain blurred in work on fracking, which, varyingly, refers to the specific phase of high-pressure extraction (hydraulic fracturing, which can be done in vertical wells); fracturing efforts combined with horizontal drilling (horizontal hydraulic fracturing); and the more recent innovations of combining fracturing, drilling, and specific water and chemical mixtures (high-volume, slickwater, horizontal hydraulic fracturing) (17).

DIFFERENTIATING ENVIRONMENTAL IMPACTS OF CONVENTIONAL AND UNCONVENTIONAL ENERGY

Conventional and unconventional energy projects share many environmental impacts—most notably contamination associated with wastewater (8, 25) and with methane leakages into the atmosphere from both active and abandoned wells (1, 8). However, unconventional energy projects intensify several of these impacts. The rapid drop in the rate of fossil fuel production from shale gas and tight oil wells during the first few months of operation results in the need for extensive drilling and well installation to maintain production levels (25). Hydraulic fracturing operations require the transport and mixing of chemical additives (some of which are toxic) at drilling sites, the construction of large drilling rigs, and the transportation and management of a large volume of wastewater. Thus, the high rate of well drilling and fracturing results in intensified landscape disturbances, high cumulative water use, increased risk of wastewater spills, and induced seismicity from wastewater disposal into deep-injection wells. Although to date only a few studies report direct groundwater contamination from hydraulic fracturing chemicals and stray gas leakages to nearby drinking water wells (1, 2), several studies have revealed surface water contamination and legacies of radioactivity from the accidental and intentional release of wastewater to the environment (e.g., 27).

Although most shale gas exploration has taken place in the United States and Canada, exploration and production is also underway in Argentina and China (the latter a minor producer as of 2016 but expected to become a major player as it has the world's largest recoverable shale reserves; **Figure 1**). Exploration or expression of industrial interest has taken place in several other countries, with varying outcomes (e.g., the United Kingdom, Poland, South Africa; 14).

The large global potential of unconventional hydrocarbons has dramatically changed discussions of resource production and the peak oil concept (already contested in the literature; 20), potentially lengthening the period of fossil fuels exploration (**Figure 1**). However, interest in shale has been accompanied by technical and economic uncertainty, as estimates of reserves vary widely (14, 21), and there is a complex relationship between extraction, transportation, and markets (22). There are disagreements on economically recoverable resources—the key variable in determining the expected production levels—as well as on prices and investments. Analysts differ in their views on the ability of companies to achieve low extraction costs (23, 24) and the infrastructure for natural gas transport, but the sparse information on the evolution of extraction costs tends to be basin- or even operator-specific (21).

2.1. The Study of Unconventional Energy and the Environment

Research in the natural and physical sciences (e.g., 1, 25, 26, 27) has outpaced—and provoked—work in the social sciences on unconventional energy. Technological developments emerged, belatedly followed by an evaluation of their effects on the sociopolitical landscape and a race to develop adequate regulations and policies. However, social scientists bring to the study of unconventional energy a rich literature on science and technology, community responses to development projects, regulation and policy creation, and markets and geopolitics. Even as some scholars point to geological factors and resource availability as determinants of unconventional energy expansion and geopolitical relationships, others contend that "above ground" factors (16)—policies, regulations, institutions, and social responses—influence whether resources are extracted and how they affect politics at multiple levels.

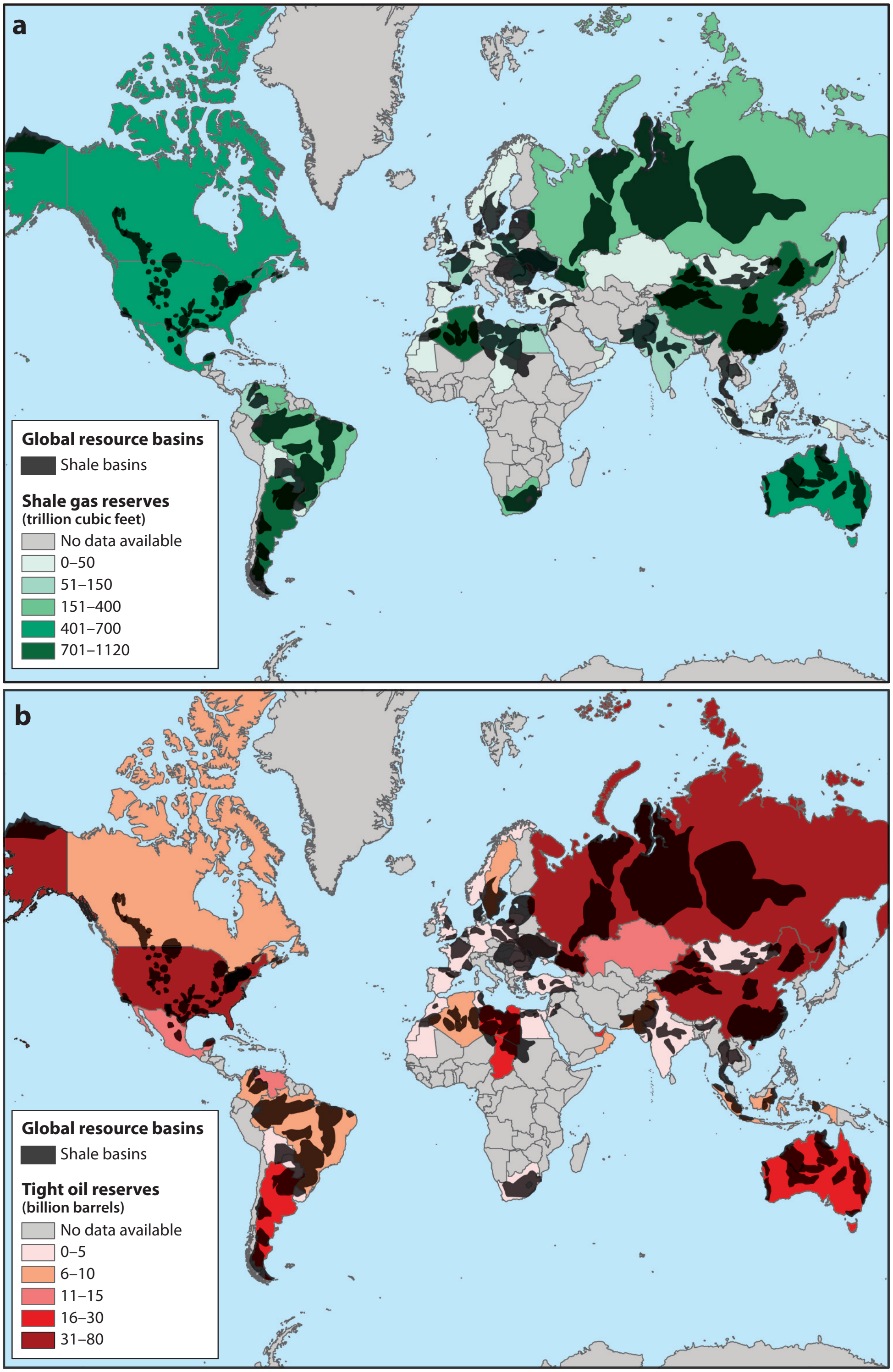

Figure 1

Maps of global distribution of (*a*) shale gas and (*b*) tight oil reservoirs, sorted by the national potential volume of shale gas and tight oil. Data on the location and potential volume of unconventional gas and oil resources were retrieved from the US Energy Information Administration (**https://www.eia.gov/analysis/studies/worldshalegas/**).

The ways in which geography, ecology, and technology shape social relations of production—the materiality of resources—are explicitly recognized by social science scholars (e.g., 28, 29, who call for more attention to this in energy studies). By offering a lens on unconventional energy that places these new energy sources into a broader political and social context, these scholars build on extensive work on the extractive sector and natural resource economies, environment and climate change movements, social justice and siting disputes, local histories and ethnographies, and media and image politics.

Many scholars of energy issues have recognized these intersecting concerns, with some calling for renewed attention to cross-cutting themes in energy governance (30) and others highlighting the need for addressing regional governance—including of energy—as a way to address global environmental challenges (31). Some cluster new technologies and extraction approaches under the label of extreme energy, where the declining availability of readily accessible fossil fuels leads to increasing intensity of the methods used for extraction (32). Unconventional energy resources force us to think critically about the complexity of energy markets, as well as consider linkages across them: for instance, how a decision in the rural US Midwest can affect energy markets in Europe, the Middle East, and Russia through price signals, changing climate policies, labor reshuffling, and community campaigns. Understanding these complex dynamics requires multiscalar, systems-based perspectives that consider cross-cutting issues at the nexus of food, energy, water, and land.

3. SHIFTING GLOBAL MARKETS AND GEOPOLITICS

Concerns over energy dependence on imported energy have shaped geopolitics since World War I (30). In response, industrialized countries have pursued greater energy self-sufficiency (the ratio of energy produced to energy consumed). For example, whereas the United States was an importer of energy in the latter half of the twentieth century, since 2013 it has been leading the world in natural gas production. By outstripping Russia as the world's largest gas producer, the United States has asserted itself globally through energy (16). To analyze unconventional energy resources, scholars have begun to explore lessons learned from studies on conventional oil and gas (15), which include concerns regarding oil wars (33) and the so-called resource curse (negative economic and political outcomes in countries highly dependent on oil and gas exports for state revenue; 34). However, patterns of development of unconventional resources differ from conventional energy, in part because they have been positioned as a bridge fuel to a low-carbon economy (given that burning natural gas releases less carbon dioxide than coal and oil).

3.1. Energy Independence and Global Power

Shale gas and tight oil production have been accelerating in the United States; other countries with abundant reserves similarly see unconventional oil and gas as central to their national energy strategies. For example, Poland has been at the forefront of shale gas exploration in Europe in part to lessen its reliance on Russian gas imports (35). Furthermore, Poland's membership in the European Union (EU) has also forced reconsideration of its heavy dependence on coal in light of EU climate commitments (36). This need for a less carbon-intensive energy system influenced the Polish government's decision to move forward with shale gas exploration at the same time that other European countries (e.g., France, Germany) were introducing moratoria (37). Despite being a forerunner in shale gas exploration in the EU, Poland's shale exploration has stalled due to the lower than expected size of technologically recoverable reserves and changing public perceptions; several large international companies have withdrawn, leaving only a few domestic and small international companies to continue exploration (35, 36).

Similar political considerations related to import dependence and high-carbon economies have factored into China's decision making regarding unconventional oil and gas. The discovery of shale gas presents China—the second largest economy after the United States, the largest consumer of coal, and the biggest importer of crude oil—with an opportunity to pursue energy independence and reduce greenhouse gas emissions (38). Achieving energy security is also contingent on a broader set of water-energy nexus issues. For example, both the impact of energy production on water quality and water availability for energy exploration and production will act as constraints on policies to expand HF in China (18, 39).

The literature on global energy security has largely focused on the way in which unconventional energy expansion can enable countries to attain energy independence, thereby reducing reliance on unstable markets and suppliers (40). However, achieving a sustainable pathway to energy security is also contingent on building a strong regulatory culture to minimize environmental and social impacts. Some countries are beginning to recognize the role of regulation in guiding unconventional energy development. In 2015, for instance, China slashed its targets for shale development, shifting away from its aggressive pursuit of energy development and seizing an opportunity to deal with both technical and environmental challenges (38).

The sudden abundance of shale resources in the United States has influenced global oil and gas markets, but the economic implications are complex and uneven. For instance, relatively high gas prices in Asian and European markets are expected to lead to continued interest in shale gas exploration around the world, whereas low oil prices are expected to suppress expansion in Argentina (41). Price signals shift both production and consumption incentives, as discussed below; moreover, political events, such as the Brexit vote in the United Kingdom in 2016[3] and the presidential election in the United States in 2016, can throw geopolitical relationships and markets into turmoil. Global politics, the contested nature of these resources, and quick reversals in policy decisions concerning production add much uncertainty to the economics of the energy sector.

3.2. Financial Flows: Market Dynamics for Shale Gas and Shale Oil

Increased production of both shale gas and shale oil has influenced energy markets and prices, although in different ways. The expansion of shale gas production in the United States has increased the supply of gas in the North American regional market and—without a global market for gas—has reduced US domestic gas prices. As evident in the Henry Hub natural gas price benchmark, US gas prices [in US dollars per million British Thermal Units (BTU)] declined from an annual average of $8.86 in 2008 to $3.94 in 2009, and fell as low as $2.75 in 2012 and $2.62 in 2015, rising slightly by January 2017 to $3.30 (**https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm**). Reduction in US domestic gas prices facilitated the shift from coal- to gas-fired power plants within the United States (42), benefitted consumers (43), and encouraged the expansion of the manufacturing sector that uses gas as a feedstock (44). Gas-fired power plants have the ability to quickly ramp up and down, which can facilitate the adoption of renewable energy, whose costs are becoming more competitive (41). However, the low price of natural gas in the United States,

[3]Brexit is a colloquial term to refer to the United Kingdom's vote in June 2016 to leave the European Union. Although the precise terms of leaving the European Union are still being deliberated, the United Kingdom will have greater authority to determine its energy and environmental policies. As a result, the country is re-evaluating how and to what extent to resume hydraulic fracturing operations.

particularly in the absence of carbon pricing, can also lead to the displacement of renewable energy (45). Some scholars are highly optimistic about the financial benefits of shale resources, especially for the United States (46), whereas others are more cautious in their economic assessments (47). Studies on the net impact of shale extraction on local and regional economies in the short- and long term are in their early stages (47). These net impacts depend on various factors, including the share of revenues that accrue within the region; the extent to which shale developments spur other economic activity in downstream, upstream, and complementary industries; the extent to which these developments crowd out other economic activities by raising labor and input costs; and local and state governments' management of the boom-bust cycles (47).

With the regional segmentation of gas markets to North American, European, and Asian markets, US domestic shale production did not directly cause a reduction in European gas prices (48). However, it did contribute to Europe's shift to greater coal combustion from 2012 to 2013 (coal displaced by shale gas in the US power sector was exported to and combusted in Europe) and to a sharp reduction in coal prices (48). In response to cheaper coal and high European gas prices, some companies delayed investments into—and even mothballed—gas power plants (48). Moreover, power companies in the EU are not discouraged from combusting coal given the low prices of carbon permits in the EU Emissions Trading System (49), although it is anticipated that the impending EU Large Combustion Plants Directive will restrict coal combustion (48).

US shale gas production has also affected global liquefied natural gas (LNG) markets, initially through the reduction in demand for LNG in the United States, and subsequently through growth in LNG exports from the United States (41, 48). Developments in the United States were initially counterbalanced by Japan's increased LNG demand following the government's decision to take some nuclear power plants offline in the aftermath of the Fukushima nuclear disaster, although these changes were temporary (48). At the same time that the United States had discouraged investments in LNG projects targeting US markets (50), the rerouting of LNG from US to European markets contributed to changes in the European wholesale gas pricing mechanisms, with a move away from longer-term oil-indexed contracts (41, 48).

Economic patterns for shale oil differ from those of shale gas. US domestic shale oil production contributed to the decline in domestic crude oil prices, but did not directly reduce US gasoline and diesel prices, which are determined by world prices (21, 51). Without the reduction in domestic fuel prices, the US economy did not enjoy the large expansion from shale oil that it did from shale gas (21). The expansion of US domestic shale oil production caused a decline in West Texas Intermediate crude prices, when the supply exceeded the capacity to refine shale oil, resulting in processing and transportation bottlenecks (21). In December 2015, the US Congress lifted the ban on unprocessed crude oil. Nevertheless, US crude oil exports are anticipated to grow slowly, because of the relatively weak demand for oil globally.

World crude oil prices (Brent crude oil price benchmark) declined to $55 in January 2015 and as low as $30 in January 2016, but rebounded gradually to $53 in January 2017, after staying relatively stable at $110 per barrel between January 2011 and June 2014 (41, 52; see also **https://www.worldbank.org/en/research/commodity-markets**). US shale oil production, which accounts for half of US crude oil production, contributes 5% of world crude oil production (21). Although US shale oil production contributed to declining world crude prices (41, 53), the extent of its contribution is difficult to isolate, in light of the variety of demand and supply factors (53). Other factors include the decline in global demand for oil, notably from China (41, 53, 54), as well as the Organization of the Petroleum Exporting Countries (OPEC) sustaining high production levels (41, 53). Under low crude oil prices, shale oil production holds little interest for companies around the world, but these incentives can shift rapidly.

3.3. Changing Patterns of Global Security Relationships: The Global South

Along with geopolitical security goals from countries across the Global North, the pursuit of unconventional energy resources is also driven by growing demand for oil and natural gas from fast-growing economies, particularly China and India. These emerging players are shifting patterns of production and consumption, and prompting domestic exploration and production.

In Africa, unconventional resources have been identified as a key future source of energy production growth. Shale gas in the southern African Karoo Basin and coalbed methane in source rocks in Algeria and Libya have been identified as having underexplored potential (55). Other potential unconventional resources include oil sands in the Congo Basin and Madagascar, and coalbed methane across southern Africa, especially in Botswana and South Africa, but also in Zimbabwe, Namibia, and Mozambique (55). However, market forces, especially uncertainty in the price of oil, have served as constraints on development. Furthermore, political volatility and domestic pressures shape resource extraction activities.

For some countries, analytic frames familiar to conventional oil and gas resources seem to fit. Algeria, for instance, has decades of heavy reliance on conventional oil and gas exports to fund its state budget, which motivates its search for unconventional resources. The prospects are significant, given the country's vast estimated resources (56), but are uncertain in light of the post-2014 price environment, security risks, infrastructure gaps, local protests, and questions about corporate partnerships with the national oil company Sonatrach (57). The resource curse literature helps illuminate the intersection of hydrocarbon development, resource revenue distribution, and discontent with popular exclusion from government decision making.

However, for other countries, unconventional resources require distinct analysis. Perhaps reflecting the limited development of these potential resources, there is little social science literature on African unconventional oil and gas, with the most extensive work focused on HF in South Africa. South Africa offers a case where clean energy and environmental security narratives are highly salient, as a country embroiled in controversy over plans for the Medupi Power Station, which would be the world's seventh largest coal-fired power plant (58). The impetus for exploring shale gas has been generated in part by the government's energy supply concerns (59). The need for both climate solutions and new local energy supplies has been particularly salient for countries of the Global South (60).

Debates over whether to develop unconventional resources remain politically and socially thorny. Developments in unconventional energy across Africa echo a general trajectory across the Global South, where continued investments in fossil fuels ensure a perpetuation of what Di Muzio (61) has described as a "petro-market civilization"; however, the challenge of alleviating energy poverty requires the expansion of local access. In regions where hundreds of millions of people lack reliable access to basic amounts of energy, governments have made it clear that they will not compromise development for other goals. Along with competing environmental narratives, energy poverty has been a justification for unconventional energy development, particularly in sub-Saharan Africa—but many citizens point to emerging scientific evidence that questions the climate benefits of natural gas, raises concerns about water resources, and highlights environmental and public health concerns.

4. PATTERNS OF SOCIAL MOBILIZATION AND RESISTANCE

Existing social science tools prove useful for examining responses to unconventional oil and gas developments, drawing on a deep literature on issue linkages, alliance formation, countermovements, and the limits of activism. However, civil society responses to unconventional energy are distinct from conventional oil and gas protests in three ways: (*a*) The use of clean and low-carbon energy narratives for natural gas challenges those opposing HF; (*b*) unconventional energy involves scale-crossing issue expansion with place-based appeals in new ways; and (*c*) the density of development, often in proximity to suburban communities in the United States, provokes the engagement of new actors at multiple scales.

Catalyzed in the Global North, and the United States in particular (62), early protests against HF were muted: Natural gas was actively promoted as a low-carbon alternative to coal, and a bridge or transition fuel to a renewable energy future. However, increasing production drew public attention. Furthermore, as scientific evidence questioned the life-cycle carbon footprint of shale gas (the emissions from not only burning natural gas but also extraction processes; see 63) and concerns grew over impacts on water resources, landscapes, and seismicity—catalyzed by high-profile fossil fuel disasters such as Deepwater Horizon and amplified by activist efforts (62)—communities began to organize against these developments. Activism against hydraulic fracturing has subsequently taken hold with such intensity in communities around the world that it has garnered its own label, “fractivism” (64).

As activist efforts expanded, an uneasy relationship developed between civil society actors and the professional community, with the scope and terms of debate under question, exacerbated by mistrust of scientists and science funding (65). Moreover, research on contested unconventional energy developments has led to new forms of protest and research, where the two often intersect. Innovative visualization methods have enabled a more sophisticated understanding of public controversies and also have provided new tools for engaging publics (66, 67). Nonacademic literature—including literary and investigative journalism (68)—offers contemporary accounts of resistance campaigns (69), and scholars and scholar-activists speak back to those engaged in resistance through both academic literature and more popular media forms, highlighting lessons learned from protest (70). In addition, in some regions—especially Australia and Canada—debate over unconventional energy confronts questions of Indigenous land claims and sovereignty. In these cases, Indigenous leaders are at the forefront of land, water, and environmental movements, shouldering the burden of the corporate and state backlash and innovating alternative governance approaches that recognize traditional knowledge, engage in holistic approaches, consider cumulative effects, and acknowledge rights beyond those held by humans (71).

4.1. Clean Energy Narratives and Strategies of Protest

Environmental activists have often been reluctant to protest against energy sources that could be alternatives to coal (72)—such as natural gas, which has been promoted as a bridge fuel to a low-carbon future. However, unconventional energy development results in landscape disturbances (5), methane emissions from equipment leaks and well completions (1), and risks of surface water contamination in local waterways (8, 73). Increasing awareness of HF has sparked concern over these damages, which reflect broader problems associated with oil and gas production in general, as many of these harms also result from conventional developments. These debates have opened opportunities for linkages across issues and places, with the very terms of debate contested (74).

Anti-extractive movements focused on keeping “oil in the soil” (75) connect protests over fossil fuels, from gas flaring in the Niger Delta to pipelines in the United States and Canada to oil extraction in Ecuador. As unconventional energy is incorporated into existing campaigns over the fossil fuel industry, activists often intentionally collapse distinctions across extraction methods to challenge the industry more broadly. Although derived from the term HF, fractivism is not defined by the technical limits of the hydraulic fracturing process, or even of unconventional energy, instead encompassing an expansive range of resistance to fossil fuel extraction and development.

Furthermore, many opponents have linked debates over unconventional energy with long-standing political and social grievances over sovereignty and land rights, climate, water, and environmental justice. For instance, in Argentina, protests against HF in northern Patagonia emerge out of decades of Mapuche community efforts to defend Indigenous lands against resource development projects (76).

Campaigns against unconventional energy have varying success across place and time. Some of the differing outcomes can be explained through an analysis of the narratives, or storylines, used by opponents, and a growing body of work considers these discourses. Some scholars have argued that anti-HF frames have been more successful than pro-HF frames in the United Kingdom (77), although the debate over HF in the United Kingdom is far from over, given the uncertainty in policy directions of the UK government in the wake of the Brexit vote as well as the resumption of shale exploration in 2016. Anti-HF messages may be successful also because direct economic benefits to communities in which HF takes place do not accrue in the United Kingdom as they do in the United States, given different legal regimes relating to resource ownership and royalty payments. Drawing on a variety of case studies, often involving media analysis and interviews with key actors, the detailed tracking of shale discourses and frames has led to insights into the development of discourse coalitions (78), the role of intended audiences in shaping activists' discursive choices (79), the exercise of state and corporate power through strategic framing (74), and the role of contested terminology in exacerbating mistrust and confusion (17).

Beyond documenting competing frames, scholars have made inroads into understanding their varying resonance, finding that state structures and laws shape the political opportunities available for activists (80), especially when deploying different frames in policy debates (81), and that trustworthy messengers and the provocation of issue expansion contribute to frame success (77). Frames shape ideas about appropriate responses (82), and framing can reflect and advance particular concerns to catalyze public attention and action. Still, not all framing efforts and discursive techniques are equally powerful, and a range of factors beyond framing influence risk perceptions (83).

In keeping with the wide range of discourses, campaign goals, and forms of unconventional energy, strategies of action and mobilization are also diverse and often overlapping. These include participation in policy processes and public hearings, social media and "hashtag politics" (84), shareholder activism over HF (85), and protests, rallies, and direct action (70). Documentary film—a medium used by those on both sides of unconventional energy debates, from the antifracking *Gasland* to profracking *Truthland* and *Frack Nation*—has been widely used as a tool of communication, information provision, and opportunity creation (86). However, some research has found that these films have limited impact on public perception (87).

4.2. Protest and Scale-Crossing Issue Expansion

Unconventional energy developments create concerns at the food-energy-water-land nexus in ways distinct from their conventional counterparts. Research on the rescaling of protests against unconventional oil and gas has emerged, drawing on contentious politics and transnational social movement literature (88). Both movements and countermovements can actively shift the scale of a particular debate over unconventional energy. In fact, scholars of energy and environmental governance have analyzed how industry and civil society actors strategically use issue containment and expansion strategies, respectively, to shift the scale of debates and regulatory venues (13, 89). Anti-fracking activists can scale up protest by linking local extractive debates to regional and national environmental justice movements, and profracking interests can use counterscale frames, such as dismissing local protest as narrow "not in my backyard"—NIMBY—concerns (81).

Beyond frames, activists can also shift the scale of resistance through the use of visible, concrete energy projects to draw attention to more distant, abstract concerns about unconventional energy extraction (90).

Beyond the direct focus on unconventional energy extraction, scholars have also turned to the broader context of resource development. This involves negotiations for land and resource rights, the provision and transport of materials and labor for extraction, water access and wastewater management, and pipelines and other commodity transport structures—activities that implicate multiple communities and interests. Such connections are vividly illustrated through ethnographic work on local communities' sense of place (91), and this research reveals the need to consider social impacts, especially resistance to HF, within the broader industrial complex. Furthermore, affected communities are themselves in need of additional scholarly attention, as there are diverse and divided views within communities (92). The varying receptivity of communities to unconventional energy developments shapes protest, and may sustain or challenge emergent movements (93).

Importantly, mobilization around unconventional energy developments need not take the form of public protest. Public responses are mounted in the context of slow-moving, cumulative, and often-invisible harm—such as groundwater contamination, methane leakages, and silica dust—in situations of uncertainty associated with complex environmental systems. Industrial developments may also bring economic benefits to particular regions through influxes of investment, employment, and political attention. Communities respond in a range of ways to concerns over risk, vulnerability, and unintended harm. In some cases, communities participate in monitoring efforts, such as civil society water monitoring programs in response to perceived gaps in government environmental oversight (94). Alternately, they use legal and regulatory tools to hold governments and corporations to account on environmental and social harm (95). And debate may take place through the press, where media can shape the shale gas agenda (35, 96).

4.3. Fractured Movements and Limited Protest

Although much action against unconventional energy draws on existing environmental, climate, and justice campaigns, not all activism emerges from already mobilized populations, and not all development engenders resistance. A burgeoning literature focuses on unexpected participants and the recruitment of those who do not otherwise identify as activists, as well as on cases where protest against unconventional energy appears not to emerge, remains at a low intensity, or is actively contested or contained (97, 98).

In cases where protest is low-level or absent, the literature suggests multiple possible explanations. In some cases, the state may repress protest or silence potential resistance through violent police action (99), and in other cases, proponents of developments might actively mount campaigns of their own to promote extractive industries (100). Some communities find it difficult to identify the specific threats of a new industry, especially in regions already reliant on extractive industries (101); in those places where social identities and economic opportunities are tied to extractive industries, citizens might also feel conflicted about industrial developments (97, 102). In some cases, this leads to the emergence of "reluctant activists," where counterextractive campaigns emerge involving citizens who do not otherwise see themselves as activists—that is, middle class and politically conservative communities—finding they are mobilized by felt impacts, perceived threats to health and family, and disruption of place-based identities (98). Examining impacts at the household level offers some insight that extractive literature focused on broad state-society relationships tends to miss. That is, the increased visibility of unconventional energy, with its density of wells and proximity to suburban and semirural neighborhoods, downscales the impacts of development to individuals, changing community judgments of the costs and benefits of the sector (103).

The absence of high levels of contention in some regions is surprising: Although there is a rich history of resistance to extractive industries in Latin America, the issue of HF has not yet provoked much attention (with a few exceptions in Argentina; see, e.g., 76, 104). While Argentina is estimated to have the world's third largest shale gas and fourth largest shale oil reserves, shale development has been slow, which may explain the limited protest. However, some insight might be found by bringing the literature on place and personal narratives into conversation with work on financial flows to local governments. In the United States, Raimi & Newell (105) find that local governments benefit from shale development, which might also offer local incentives for limiting protest. Protest in Argentina might shift over time, given claim-making incentives and opportunities could change as extraction intensifies; however, even without widespread active protest, it is useful to recall that lack of visible protest is not equivalent to local support (97). As labor politics, investments, and contractual relationships change, we expect to see changing patterns of resistance.

The sheer volume and diversity of development proposals might also constrain protest. In many places, as exemplified in areas targeted for coal seam gas extraction in Australia (106), rural and Indigenous communities are fielding multiple simultaneous and iterative proposals for resource extraction. These communities—often small and resource-constrained—face challenges with capacity for evaluating project proposals, assessing cumulative impacts, and navigating divided views about different resource development projects within overlapping and complex governance regimes. Although many local residents might have concerns about specific projects, such grievances might not translate to widespread resistance. In analyzing resistance, we must recall that it is not only political and public sentiment that shapes extractive industry developments: Geologic and market conditions also influence corporate exploration and extraction decisions (35).

4.4. What the Study of Protest Reveals

Research on patterns of mobilization interrogates fundamental questions of competing worldviews and political ideologies, particularly in the context of critical perspectives on neoliberal ideals and the link to extractivist development strategies of states. Anthropologists and critical geographers have responded to Boyer's call for ethnographic work to investigate a field he terms energopolitics (107), where emergent energy technologies can be understood through social institutions and political and cultural perspectives on the meaning of energy. Some scholars link the socially embedded nature of energy to questions of the construction of risk (108). Such views align with an understanding of unconventional energy as part of the broader political economy. A body of work explores the intersection of economic systems, state power, and unconventional energy developments with attention to challenges to corporate power and a neoliberal agenda (109, 110). Along with individual projects, scholars have drawn connections across social science studies of the interaction between economic systems, social construction of space, cultural identities, and social movements (111).

Experiments in social science have led to detailed understandings of place-based impacts of unconventional energy and also furthered participatory research processes (74). The intersection of worldviews and ideologies with local community analysis reveals more fully the need for political ecology approaches to understanding mobilization around unconventional energy. Recalling that the specific character of a resource lends itself to particular forms of politics (112), the differentiation among types of unconventional energy becomes of central importance to understanding mobilization and resistance.

5. RETHINKING REGULATION AND GOVERNANCE

Unconventional energy developments—especially HF—have been met with mixed reactions in the governance realm. Divergent policy debates on how best to regulate and govern shale development have taken place throughout the world, with some countries opting to ban HF and others moving ahead with different forms of regulation. We identify three factors that explain HF regulatory variation across and within countries.

First, the relative prioritization of energy security versus environmental issues is a key driver. In countries where energy security eclipses environmental protection, HF has proceeded in the absence of new regulatory frameworks. In the United States, shale gas has been framed as providing an opportunity for improving economic recovery and domestic energy security (discussed in Section 3) while simultaneously enabling a transition beyond coal (37). Similarly, China's top-down approach to shale development is moving ahead before specific environmental regulations are in place to address water and air quality impacts, especially treatment of wastewater generated through HF (40, 113). Energy security discourses have also been prevalent within the EU, notably with respect to reducing dependence on Russian gas imports (37). However, concerns about environmental issues have had a relatively higher priority, including the question of how shale development would contribute toward achieving climate goals and a transition to renewable energy options (114); in consequence, HF is relatively more constrained in Europe to date with the exceptions of Poland, which was a first mover, and the United Kingdom, where some form of HF production seems imminent.

A second factor driving interjurisdictional variation in HF regulation can be traced to frameworks for mineral rights ownership and distribution of royalties. In the United States, mineral rights are tied to land parcels and can be split so that the mineral rights are controlled by someone other than the surface rights holder (6). As a result, licenses for HF can—and most often are—granted to private companies who are not landowners, and who can take advantage of subsurface rights regardless of landowners' opinions. This flexible mineral rights land ownership regime has been cited as one of the key factors enabling shale development in the United States (115), with some US states considering imposing severance taxes or setting up legacy funds to redistribute royalties to communities affected by shale extraction (116). In most other countries, mineral resources are owned by the state (117).

Third, relative risks, and perceptions of those risks, are important factors. Studies have found that risk perceptions vary based on demographic factors, such as gender, age, education level (118), and political affiliation (119). Risk perceptions also vary based on degree of openness to economic development and acceptance of consequent environmental risks, history of extractive industries within a region (120), as well as by proximity to HF extraction (121). Perceptions of shale gas development are also influenced by property ownership with nonmineral rights owners tending to view shale gas more negatively (122). Some studies have found distrust in the oil and gas industry among communities, although trust of the industry has been inversely correlated with respondents' perceptions of risk (123) and with liberal political ideologies (124). The lack of trust in government has extended to governance debates as respondents have expressed concerns about government agencies' abilities to protect communities and to regulate the environmental impacts of shale (123, 124). However, to date, studies have not probed public opinions on how shale development should be regulated (83).

5.1. National and Regional Context for Regulation

The preceding points must be understood with respect to the distinct political and socioeconomic contexts in which HF is taking place. US studies have emphasized federalism as a main driver of shale regulatory outcomes (13, 125), as oil and gas regulation has been devolved to the states since the beginning of oil and gas regulation in the 1930s (126). States also maintained primary regulatory authority with the introduction of federal environmental regulations in the 1970s; moreover, in many instances, industry was able to acquire exemptions to federal environmental statutes (126). Regarding shale regulation, the oil and gas industry received an exemption from the federal Safe Drinking Water Act under the 2005 Energy Policy Act, which has been criticized by environmental groups and concerned citizens (13, 125). Researchers have documented widespread variation in state regulations, as well as differences in transparency, monitoring, and enforcement powers across states (127, 128). Whether the US federal government should play a more active role in addressing regulatory gaps has been a key debate, particularly among legal scholars. Some have argued for state-level regulation, asserting that the impacts of HF are primarily localized, that existing state regulations are stringent enough to prevent a race to the bottom concerning environmental oversight, that federal regulations would prevent states from being laboratories of regulatory learning and innovation, and that federal regulation may impose undue economic costs on private industry (126, 129). Others have argued that the federal government should play a more active role in assessing and mitigating HF risks, claiming that the scale and cumulative impacts of shale development across the United States make this a matter of national interest (130).

In Canada, shale gas governance also occurs at the subnational level, as part of the Constitutional division of powers in which resource development and water governance is devolved to Canadian provinces and territories. "Light touch" regulation was further entrenched by regulatory restructuring initiated by former Prime Minister Stephen Harper (in office 2006–2015; 131). As of 2016, HF is underway in British Columbia and Alberta, but has been banned in Nova Scotia and Quebec (40), in part because of concerns over environmental risks (10). Additionally, various stakeholder consultations have been held throughout the country to assess community and First Nation perceptions of risk. However, many of these consultations have been criticized for lacking transparency, undermining goals of public participation, and strategically fostering mistrust in order to polarize debates (65, 132). The legally binding requirement to consult and negotiate with Indigenous communities has created a further layer of complexity in governance (133).

In contrast to the United States and Canada, the EU has taken a proactive approach to shale risk governance, driven primarily by principles of precaution and prevention (134). Both principles require member states to anticipate, mitigate and, when possible, eliminate sources of pollution at their origin (134). Regulatory responses stemming from these principles may include bans or moratoria on technological diffusion if possible risks are anticipated to outweigh benefits. For example, France enacted a moratorium on HF on the basis of both the precautionary and preventative principles (134). Germany introduced a draft HF regulation in 2015 that engendered widespread community protests as well as criticism from a consortium of scientists for not sufficiently recognizing scientific research gaps and not fostering independent research and oversight to address scientific knowledge gaps (135). The final bill, passed in June 2016, enacted strict limitations on HF and will only allow for test drilling with permission from relevant state governments and with oversight from independent scientific experts (136). After initially planning to permit and regulate HF as part of conventional oil and gas development, the Netherlands enacted a moratorium on HF until 2020 as a result of an independent review of risks and stakeholder consultation processes (136).

Experiences in Poland and the United Kingdom have been distinct from France, Germany, and the Netherlands. Poland was the most active proponent of shale exploration in the EU, and government concerns over potential energy security improvements were prioritized over potential environmental risks (96, 137). The United Kingdom enacted a temporary ban on HF in 2011 to study the links between increased seismic activity and shale test drilling in North England.

Industry-sponsored studies confirmed links but deemed the risk of future earthquakes to be low. A government-sponsored review found that the industry reports understated potential future risks (138). Although the UK government lifted the ban in 2012, drilling did not begin again until the fall of 2016, in part because of widely publicized public protests during the summer of 2013 and because of low public support for HF (77).

In China, energy development plans are determined by the national government and carried out by state-owned enterprises, a characteristic that defines the regulatory culture and context of shale gas development. Shale gas development targets were first set in its twelfth Five-Year Plan (2011–2015), with a National Shale Gas Development Plan, released in 2012. With the goal of reducing dependence on imported natural gas and transitioning away from heavy reliance on coal, the plan set specific production targets, although these were subsequently lowered in the thirteenth Five-Year Plan (39, 139). Although the Ministry of Environmental Protection has followed debates over regulation of environmental impacts in the United States, it has been slow to issue shale gas or HF-specific environmental policies and regulations (113). This may be explained in part by the priority the government has placed on other pressing environmental issues, including air pollution from industry and transportation, and water and soil pollution from industry, agriculture, and mining (140). Environmental regulators also lack expertise on the technical aspects of oil and gas development, including HF. Furthermore, provincial and local governments generally welcome the jobs and tax revenue provided by oil and gas sector investment, providing them with an incentive to favor development over more cautious environmental regulation (113). As a result, development of shale gas and HF-specific regulations has been slow in coming, and government oversight of the state-owned oil and gas companies' shale gas development is relatively weak (113). To a degree greater than their counterparts in the United States and Europe, China's oil and gas state-owned enterprises—Sinopec, China National Petroleum Corporation, and the Chinese Offshore Oil Corporation—are largely responsible for developing and enforcing their own safety and environmental standards, which are not publicly disclosed (140), and are relatively lightly regulated by environmental authorities.

5.2. Addressing Regulatory Gaps

Various approaches have been forwarded to address existing regulatory gaps in these different political contexts. Researchers have suggested frameworks to better integrate risk identification and possible regulatory responses (141), as well as frameworks for facilitating comparative governance research (40). Specific to the US context, some legal scholars have advocated for a cooperative federalism approach whereby the federal government sets baseline standards and gives states flexibility in implementation (142). Under one suggested scheme, the federal government could act as a clearinghouse for regulations and industry performance standards in order to help states to design regulatory approaches (143). Others have documented increased use of severance taxes and permanent trust funds in the United States as a way to manage potential risks of shale development (116, 144). The proposed UK Community Engagement Charter, sponsored by the UK Onshore Oil and Gas industry association, is a variant of such an approach (**http://www.ukoog.org.uk/community/charter**). Part of this plan would include sharing a portion of royalties via payments to councils or individual land owners to help address safety concerns.

Most prominent among alternative governance approaches is the emergence of private regulation, particularly within the United States, that relies on industry voluntarily engaging in information disclosure. A variety of such private regulation schemes have been documented, ranging from best practice standards to certification schemes (128). One of the most notable private regulation schemes concerns fluid disclosure, one of the most controversial areas of shale governance

(145). To address concerns over variation in fluid disclosure requirements across US states, two national quasigovernmental entities, the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission, established a voluntary online chemical disclosure registry, FracFocus. The site functions as a national repository for chemical usage on a per-well basis (**https://fracfocus.org/**). As of 2016, 23 states have mandated using FracFocus for HF fluid disclosures. Although state regulators have expressed positive views of FracFocus as a regulatory compliance tool (146), researchers have criticized FracFocus because of wide variation in reporting requirements across states, which complicates efforts to aggregate and monitor disclosures across regions (147). Furthermore, FracFocus does little to mitigate concerns over trade secret exemptions to HF disclosures, which is one of the key focal points in HF regulatory debates in the United States.

Scholars have questioned the contribution of private regulation to addressing key concerns over transparency, enforcement, and consistency (128, 145), as well as to addressing broader socioeconomic concerns of affected communities. As with activism around fossil fuels in much of the Global South, a push for transparency is part of the US-led anti-HF movement; however, the subject of transparency demands differs. For the former, the focus is on revenue flow disclosures, as demanded by Publish What You Pay and the Extractive Industries Transparency Initiative (148). In contrast, the push for disclosure for the latter tends to be focused on frac fluid composition, involving concerns about the synthetic chemical additives used as part of HF processes, and subnational governments are often involved in coregulatory systems for these transparency efforts, with varying outcomes (149). Furthermore, much of the opposition to HF has not only revolved around issues of transparency, but also around environmental externalities and socioeconomic impacts. For the conventional oil and gas industry, corporate social responsibility programs were launched to respond to prior contestation and to gain a social license to operate (148). For the unconventional oil and gas sector, some research suggests that communities are asserting greater agency in defining the terms of that social license than has been the case for the conventional sector (150).

6. INTERSECTIONS, SYNTHESIS, AND LOOKING AHEAD

As explored in this review, social science scholars of unconventional energy bring together multiscalar and multidisciplinary approaches, combining local studies with global economics and geopolitics, regulatory and legal studies with work on contested politics and the political economy of extractives, and political scholarship with activism, storytelling, and even art. These scholars challenge the industry narrative of unconventional energy as a technology-led field. Rather than viewing political mobilization against unconventional energy as a momentary eruption in response to a novel resource sector, analyses suggest that much social resistance emerges out of existing, ongoing conflicts between communities, states, and corporations. Similarly, regulatory responses are not merely reactive, but also the result of new technologies emerging into policy frameworks with established and competing interests. Unconventional fossil fuels, then, are framed as connected to—yet distinct from—conventional energy, and implicated in existing struggles over governance, economic growth, land rights, water resources, climate change, and environmental justice. Insights from work on unconventional energy in turn contribute to the social sciences more broadly, offering insight into new forms of resistance and responses, challenges to traditional regulatory action, and geopolitical relationships in the context of changing markets.

Some scholars point to the focus of much of the literature on HF on US case studies, raising concerns that conclusions on shale regulation and governance are single-country focused (40); however, this critique should be scrutinized in two ways. First, literature beyond the United States is growing rapidly, especially if we incorporate social science work on unconventional energy more broadly. Although the United States has led the field on shale production, questions of resistance, governance, and economics of new oil and gas resources have been asked by scholars around the world. In this review, we considered literature spanning the globe—noting that mobilization and resistance, in particular, are documented and analyzed on nearly every continent (with the exception of Asia; work in China, especially on social resistance, remains limited; 69). Second, although the United States may not be representative from a policy perspective, many of the studies on HF in the United States address themes that are not limited by country or region. Scholarly work on unconventional energy has led to innovative data visualization, supported new methodologies for ethnographic study, theoretically questioned the ideologies underpinning development, advanced the study of public perceptions on energy developments, categorized storylines and competing justifications, interrogated social movement strategies and mobilization tactics, challenged geopolitical analyses, and provoked creative collaborations among scholars and artists. Although many of these studies have been undertaken through examining US communities and institutions, this work contributes to a broader understanding of the intersection of global markets with local communities, clashes of values, structures of alliances and organizations, and challenges of governance.

Given the breadth and depth of attention to HF, with recognition of the need for additional and ongoing work with global scope and a governance focus, we propose an agenda to scholars who are not studying unconventional energy in detail. First, for scholars of geopolitics and political economy, we urge those making claims about the revolutionary geopolitical potential of shale resources to pay particular attention to the role of local conditions—especially involving community resistance, national politics and priorities, and subnational regulation—for enabling or hindering extractive industries. Furthermore, political events in 2016—notably the US presidential election and UK Brexit vote—create uncertainty for both national energy policies and geopolitical relationships. Equating technical capacities with extraction and production is tempting, but the careful scholarship on policy and regulation, public perception, resistance and activism, and boom-bust economies provides the analyses needed to contextualize and temper such global claims. Economic analyses of oil and gas markets benefit from the incorporation of place-based, community-oriented, and locally sensitive work that abounds in the study of shale and other unconventional resources.

Second, for scholars of mobilization and social movements, unconventional energy researchers have used concepts from contentious politics to understand the resistance mounting around the world to shale, coalbed methane, and more. Scholars working on protests around other extractive industries might draw on new insights from the study of unconventional energy, particularly on issue linkages, alliances, and focusing issues. The attention in research on unconventional energy to the intersection of place-based concern over land and water with global concerns over climate might inform broader work on resistance and protest. Additional work on reluctant or absent activism, as well as the specific tactics of countermovements, could further inform research on unconventional energy, where such work is in early stages (although see 97, 98).

And third, for scholars of policy and governance, the literature on unconventional energy has broken open the field of energy studies to incorporate multiple "nexus" areas of work, linking food, water, land, climate, urban-rural relationships, transport, and more. In policy studies, the temptation with new resources is to consider their governance in the context of their specific policy sphere—HF within oil and gas. However, work on shale, among others, highlights the need to take a holistic approach to understanding these new governance challenges, integrating concerns about climate, water, landscapes, and communities.

Finally, across scholarship on unconventional energy, and conventional energy more widely, we encourage diversity not only of disciplines, but also of worldviews and epistemologies. For example, largely absent from the literature is the perspective of conventional energy communities, particularly in the coal mining industry, on transitioning to unconventional energy economies (with a few exceptions, e.g., 101). As another important example, some social science work on HF, especially on resistance and response to these developments, is beginning to engage with the actions, perspectives, and methodologies of Indigenous scholars and communities. Such approaches can challenge the foundation of academic disciplines, for instance, requiring a responsibility- instead of rights-based approach to law, as invoked in Haudenosaunee legal traditions (151). Given the environmental justice challenges associated with industrial and societal transformation, we suggest there is significant value to a greater inclusion of diverse voices in the scholarship on energy systems. Integrating conventional energy community perspectives, and more fully considering Indigenous worldviews, will allow scholars to better understand how and why unconventional energy developments create new challenges for communities, governments, and corporations. Unconventional energy developments challenge existing epistemologies in scholarship and regulation; work on unconventional energy thus can provoke deeper unsettling in academia and society.

SUMMARY POINTS

1. The frames of analysis for conventional oil and gas, focused on energy independence, security, and geopolitics, are insufficient for understanding the dynamics of unconventional energy.
2. A multiscalar, interdisciplinary analytic approach is needed to understand the dynamics and implications of unconventional energy developments.
3. Technological constraints or capacities are insufficient for explaining the rate and scale of unconventional energy development; the intersection of social, political, and economic factors must be considered.
4. Shale gas has had a strong impact on world gas prices, whereas shale oil has not significantly influenced world oil prices, as a result of differing market types (integrated oil markets versus regional gas markets) and substitutability of fuels (the impact of gas on coal exports and prices).
5. Regulatory variation across and within countries can be explained by the relative priority of energy security over environmental concerns, mineral ownership and royalty regimes, and risk perceptions.
6. Although often linked to broader antifossil fuel movements, mobilization against unconventional energy is distinct from protest against conventional oil and gas because of the density of drilling, low-carbon and transition fuel narratives of natural gas, and issue linkages across scales from local place-based to global climate concerns.
7. The United States has led developments in global shale resource exploration and extraction, and this is reflected in the abundance of social science literature on US case studies, particularly on regulatory variation and protest; however, the global literature on unconventional energy is growing rapidly.
8. Scholarly work on unconventional energy has led to advances in social science methodologies and theories through both globally oriented and place-based analyses, ranging from data visualization to ethnographic studies, discourse analysis to geopolitics, and Indigenous approaches to comparative legal assessments.

FUTURE ISSUES

1. Energy studies scholars must look to "nexus" areas in their research, linking food, water, land, climate, urban-rural relationships, transportation, and more.
2. Governance challenges of shale gas and other unconventional energy cannot be assessed through a single sector or policy sphere, instead needing holistic integration of resources, landscapes, communities, and levels of governance.
3. Advances in science and technology will continue to present new challenges to communities and policymakers; social science scholarship can help stakeholders address emerging issues by offering insights about social trade-offs, the political dynamics of economic systems, and approaches for addressing risk and uncertainty.
4. A plurality of perspectives—particularly from those most affected by unconventional energy developments—is needed when evaluating the risks and benefits of energy transitions; these include the worldviews and epistemologies of Indigenous peoples, as well as communities traditionally embedded in conventional energy production.

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