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Abstract

The US and Canada have been at the forefront of shale oil and gas development via hydraulic fracturing. Understanding public perceptions is important given the role that they may play in future policy decisions in both North America and other parts of the world where shale development is at a much earlier stage. We review 58 articles pertaining to perceptions, published between 2009 and 2015. Studies report mixed levels of awareness of shale operations, tending towards higher awareness in areas with existing development. While individuals tend to have negative associations with the term 'fracking', views on shale development are mixed as to whether benefits outweigh risks or vice versa: perceived benefits tend to be economic (e.g., job creation, boosts to local economies) and risks more commonly environmental and/or social (e.g., impacts on water, increased traffic). Some papers point to ethical issues (e.g., inequitable risk/benefit distribution, procedural justice) and widespread distrust of responsible parties, stemming from perceived unfairness, heavy-handed corporate tactics, and lack of transparency. These findings point to the contested, political character of much of the debate about hydraulic fracturing, and raise questions of what constitutes 'acceptable' risk in this context. We compare these results with research emerging in the UK over the same period. Future research should focus on nuanced inquiry, a range of methodologies and explore perceptions in varied social and geographical contexts. Both this and future research hold the potential to enhance public debates and decisions about shale gas and oil development.

INTRODUCTION

Shale rocks are widely distributed globally, and many countries have started to investigate their potential for shale gas and oil. The US and Canada have been at the forefront of development, where exploitation of shale oil and gas has been made possible by favorable market conditions and government investment, alongside the development of directional and horizontal drilling, 3D seismic imaging, and importantly by hydraulic fracturing ('fracking') techniques, whereby pressurized liquid and sand are injected deep into the earth to fracture the shale and to facilitate the flow of oil and gas. Such techniques have been deployed for up to 20 years in some US states, and shale development has grown significantly in the last ten years, leading the US to become the world's largest producer of oil and gas.[1] In some cases full-scale extraction is taking place (e.g., Pennsylvania, Wyoming, Texas). In others, proposals to implement have been surrounded by significant environmental and legal controversy, on occasion leading to local, regional or state-wide moratoria and bans (e.g., New York, Maryland). In Canada, rapid development has concentrated in the western provinces of British Columbia and Alberta,[2] while the practice has been the subject of moratoria and bans in eastern provinces (Quebec, Nova Scotia, New Brunswick).

Proponents argue that shale gas, being cleaner burning than coal, provides a superior 'bridge fuel' to a lower carbon economy. They also argue that, as conventional reserves decline, domestic production can be one way to reduce future dependency on imported gas/oil. On the other hand, scientists forecast that much of the world's known fossil fuel reserves must remain in the ground if global warming is to be limited to 2^{o}C above pre-industrial levels.[3] More localized concerns relate to

impacts including potential risks of water contamination and induced seismicity[4, 5] as well as social and health effects.[6-8]

Public perceptions of energy technologies have been a topic of significant academic and policy research in Europe and North America for over 30 years[9-11]. That work has investigated in detail public attitudes towards issues such as nuclear power and radioactive waste storage, renewable energy proposals including marine and onshore wind, the use of fossil fuels with carbon capture and storage, and latterly shale gas and oil exploration. Such research is stimulated by a desire to gain fundamental knowledge about the social and political processes that underlie publicly available discourses and representations of a risky technology, alongside the factors that drive individual attitudes. We know for example from previous work on perceptions of energy and other controversial technologies, that people's attitudes to environmental and technological risks involve a range of concerns and value-based questions that go beyond the formal measurement of risk.[12] These include not only any perceived risks and benefits, but also individuals' cultural values and worldviews, spontaneous associations and affective responses, concerns about both distributional and procedural equity, levels of trust in risk governance and regulation, and concerns relating to such things as the protection of valued landscapes.[13-16] Indeed, the emergence of intense local risk controversies is rarely, if ever, solely about risk alone, but typically involves a combination of dynamic social and political issues that pose severe threats to locally valued places and identities, and in turn serve to amplify existing risk perceptions.[17, 18] Although the notion of risk 'acceptability' is in itself a complex and contingent concept[13, 16, 18] knowledge of public views about energy options such as unconventional hydrocarbons should contribute to wider debates within society about what choices and options might eventually lead to more environmentally sustainable and publicly acceptable future energy systems – as when, for example, a publicly acceptable technology is not the most sustainable long-run option for society, or vice versa.

The empirical studies reviewed here are all aimed at gaining an understanding of various publics' perceptions of shale developments, and are important for three principal reasons. First, some will have been explicitly designed to explore and test key social science hypotheses derived primarily from existing theory and research with other controversial technologies regarding the preconditions and processes which might also underlie developing perceptions of shale gas and oil developments, whilst also recognizing that every new issue may have its own subtle contextual differences. Second, and as a more critical project, such studies can serve to provide properly-grounded empirical evidence of the varied views of communities and individuals who are faced with risks (both social and environmental) from shale development and how these views can, in turn, be given effective voice alongside the framings and discourses of other actors in the debate The latter are often outside corporate or government interests seeking to push forward shale gas development in a local area or community. The differing framings of actors often become key points of debate in major risk controversies, serving to anchor options and either to close down or open up an issue to wider public scrutiny and debate[19, 20] (e.g. should shale development be framed as a 'contribution to national energy security', as a 'risk of environmental contamination', or as both?). Properly-grounded evidence of public views, through conducting studies such as those reviewed here, is one means by which local publics can themselves become actors in the framing of such debates, and is in turn one way of ensuring that the frames of powerful external actors do not come to dominate both debate and decision-making. Finally, and as a matter of transparency in public policy, we need to know the extent to which knowledge of the many publics' perceptions, and the deeper values and

concerns that they often represent, can be useful for guiding better policy engagement and decision-making as part of more deliberative approaches to shale risk governance[21, 22, 23]. This is the case for both the US and Canada, where development is ongoing, and in other regions where shale development is at the earliest stages. In Europe, a number of countries have already banned fracking for shale gas and oil (e.g., France) or implemented a moratorium (e.g., Germany).[24] Conversely, the national UK and Polish governments have taken a different stance, and openly support shale development. Poland is at the most advanced stage of the EU nations, with over 100 exploratory wells drilled, although these have yielded disappointing results so far.[25] In the UK, while there are a number of active petroleum exploration and development licenses (PEDLs), progress has been slow, with just one shale well having been drilled and hydraulically fractured.[26] Here, future development may largely hinge on public acceptability, and while the number of studies exploring the social dimensions of shale development in the UK are growing,[24] the topic remains under-explored.[27]

Notwithstanding the significant differences in the operating environments, we can learn much that will help to anticipate the emergence of public representations and debates about shale development in other contexts by reviewing what has already occurred in North America where operations are more established. It is important also, in reviewing what is currently known about perceptions, to recognize the plural nature of 'publics' – and that there can never be one single public attitude or belief about 'risk', just multiple publics with differing worldviews, knowledges and experiences concerning the technology in question and its impacts upon them[13]. Equally, attitudes and preferences towards (often unfamiliar) technologies, not only shale gas development (e.g. [133,134]), are rarely simply fixed entities, but are often conditional, ambivalent, labile, and even seemingly contradictory for the same individual[17]. Attitudes, on this reading, become sensitive to the methodology of their elicitation as much as to the wider questions of socio-political context that drive preferences. Under such circumstances, the task of studying what counts as 'acceptable' risk becomes as much a matter of exploring through different methods the varied boundary conditions that a person places upon 'acceptability'[16, 127] as it is one of revealing the more fundamental values through which people and society construct their beliefs about a technology more generally[13]. The value of a review such as the present one is that it begins to document some of that variability across locations, communities and various empirical methodologies.

In this chapter we first present the methodology used in this review, before discussing the findings of the articles that we reviewed - including findings relating to attitudes around shale development and environmental impacts, climate change, and energy systems. We then make comparisons between emerging UK perceptions of shale development and those of US and Canadian publics, before considering future research needs in this field.

Systematic literature review

Articles were selected for review in two phases. First, the literature was tracked using various news websites, academic feeds and website 'search alerts' during the 18 months prior to the review taking place in the summer of 2015. Second, in July 2015, we carried out a systematic search for terms such as 'hydraulic fracturing', 'fracking', 'shale', 'energy and public opinion' and 'drilling and public opinion' using Google Scholar and the UCSB Social Science Database, which is hosted by Web of Science and includes all major English language social science journals. We began by searching the University of California Santa Barbara (UCSB) Social Science Database for these terms within the

abstracts of articles only, to find the most relevant to our review. We also searched for specific authors who we were aware had been active in the field, and those citing them. We followed this by searching for the same terms within the full text of the articles to ensure no relevant articles were overlooked, and by searching Google Scholar, which includes a greater variety of publications. For all relevant articles, we reviewed the included citations, and those who cited the articles, to search for other articles, publications, and documents that may have been overlooked or not included in the database search.

From the thousands of returned search results that included non-relevant literature and research on a wide range of topics and energy issues, we aimed to balance comprehensive cover with a specific focus on public perceptions of hydraulic fracturing for shale gas and oil in the United States and Canada. Thus for this literature review, we included all articles found that were directly about public perceptions, attitudes, or opinions about fracking. Additionally, we included articles that used fracking as a case study of some larger, theoretical concept, but included data about public perceptions of fracking. We excluded articles that analysed media reporting alone, or ones which discussed fracking or used fracking as a case study if there was no original data about public perceptions. Once selected, the articles were analyzed for themes based on our initial reading of the articles and those relating to wider energy perceptions. These themes included awareness, attitudes, risk/benefit perceptions, and comparisons with other energy options. The articles were then examined for the details of how these topics manifested, and other emergent themes were recorded. We finally synthesized the findings to form the basis of our discussion below.

We primarily focus on peer reviewed academic literature, but also include relevant reports from think tanks, NGOs, governmental departments and universities (termed 'grey-literature'). We use the term 'public' broadly, and the review includes the perceptions of other stakeholders such as landowners, educators and government officials. It is worth noting however that most of the articles use broader 'lay' publics as their samples. We include perceptions of both shale oil and gas in the review, but do not differentiate between the two in our analysis because the reviewed articles often do not make a clear distinction. Throughout the review we use the terms 'shale development' and 'shale operations' as short hand for the process of extracting shale gas and/or oil via hydraulic fracturing, encompassing the range of terms used to describe the issue.

PERCEPTIONS OF SHALE OPERATIONS IN THE US AND CANADA

Overview: research in the US and Canada

The articles that we reviewed are summarized in Table 1. More information can be found in the supplementary material, which describes the type of source article (e.g., refereed journal, research report) as well as the study locations, methods and sample details for each publication.

[Table 1 about here]

As shown in Figure 1 (below), the frequency of publications about shale perceptions in the US and Canada has increased steadily in recent years. While research in this field can be charted since 2009,

the vast majority has been published since 2013, reflecting a growing interest in the field. Table 1 shows that research in this area has been both qualitative and quantitative in nature (particularly interviews and surveys) but with a stronger focus on quantitative research, particularly within the grey-literature. Notably, qualitative research has focused on interested and affected parties -such as landowners, farmers and local educators- while quantitative research has focused more on the general population, often using representative and/or national samples. Research in North America has focused mainly on the US, with a particularly strong emphasis on the Marcellus shale area, a large play in the northeast of the country that has experienced some of the most intensive development.

[Figure 1 about here]

Awareness of hydraulic fracturing for shale gas and oil

More than half of the publications in our review gauged awareness of shale operations in some way. Research in this area was commonly quantitative, but did include some qualitative data from interviews and focus groups. Mass media[28] and particularly newspapers[29-31] were important sources of information on the topic of shale operations, with additional key information sources identified as: industry and conservation/environmental groups,[30] landowner coalitions,[32] and peers via word of mouth.[33] It is worth noting that level of awareness is likely to depend on question wording, as shown in a US survey study by Evensen et al[34] in which substantially more survey respondents were able to recognize the phrase 'shale gas development' compared with the term 'fracking'. Levels of reported awareness and knowledge are also likely to depend on the style of questioning; the majority of the publications reported here used self-reported measures (e.g., refs [30, 35-38]) as opposed to independently assessing knowledge in some way (e.g., ref [39]). While self-report measures are easier to administer and pose less risk of respondents declining to complete a 'knowledge test', they can lead to biased responses.[40]

Broadly, findings indicate that close to 50% of individuals in areas exposed to shale operations, or with the potential for such activity, are aware of the issue.[41-43] Nevertheless, research frequently highlighted variations in levels of awareness. In surveys drawing on national US samples, awareness was shown to be much lower than in surveys of areas proximate to development.[36, 44, 45] Indeed, numerous studies found that awareness differs across regions, typically asserting that awareness is higher in states, counties, or regions either closer to development or with higher density development.[30, 31, 33, 41, 42, 46, 47] However, Stedman et al.[37] found no significant differences between New Yorkers and Pennsylvanians in levels of perceived knowledge of Marcellus-related impacts or procedures, despite different levels of development in each state (although we may expect knowledge to be relatively high in New York due to media coverage of the state's shale moratorium). In the only repeated survey analysis of awareness in our sample, Brooks[48] showed that awareness in the US increased moderately over time (from 32% to 42% over one year).

Although few studies discuss the relationship between awareness and support for and/or opposition to shale development, the ones that do suggest that this relationship is either non-existent[39, 49] or tenuous at best.[50] Echoing years of commentary on the 'deficit model' of risk communication,[51] researchers therefore caution against concluding that 'education' can change support/opposition on this issue.[50, 52]

Risk and benefit perceptions

Most of the reviewed articles considered risk/benefit perceptions in some form, usually explored via survey approaches. Particularly widespread were discussions of risk. This may be due to a number of reasons. Firstly, it may be because risks are more prevalent and/or serious than the benefits. It may be a function of the negative effects of shale development being more noticeable, memorable, or impactful than the positive effects.[35] Or, it may be because of the balance afforded to risks and benefits in perception studies: risk perceptions have been given more critical attention than benefit perceptions in the field of nanotechnology for example,[53] and Graham et al.[54] have recently suggested that surveys of public opinion about fracking have tended to address potential risks more than potential benefits. This focus on risk may also be a function of sampling methods, which in qualitative research in particular has focused on interested and affected parties and impacted communities (Table 1). Particular framing of research questions may also play a role: for example Israel et al.[55] asked their participants about 'concerns', thus potentially leading to a focus on risks rather than benefits.

Benefit perceptions

Perceived benefits of shale development tend to be economic.[46, 56] By far the most commonly cited involve jobs[27, 30, 42, 46, 57-60] and boosts to local and individual economies[27, 32, 46, 59] for example due to increased business and investment activity.[30, 42, 46, 58] When asked, people perceive employment benefits to be important or very important,[30] and overwhelming majorities in both Michigan and Pennsylvania believe that hydraulic fracturing is very or somewhat important to their state's economy (82% Michigan, 84% Pennsylvania), despite different levels of fracking in each.[42] However, research by Hudgins[61] and Jacquet[62] suggests the reality is different, in that jobs for local people can be few; findings that reflect a body of work emerging on the negative and limited nature of the economic impacts of shale gas, and reminiscent of historical US boom-bust cycles.[63, 64] Other perceived benefits include poverty alleviation,[60] energy independence,[42] and improvements in services such as local police/fire protection, medical and health care facilities.[58, 60] The potential climate change benefits (of shale gas being a cleaner burning fossil fuel than coal) are relatively lacking amongst the benefit perceptions cited (though see Brooks[48]). Perceptions of potential climate change *risks* are discussed below.

Risk perceptions

Perceived risks tend to be environmental or social.[46, 56] Impacts on water are some of the most commonly cited,[27, 42, 43, 46, 47, 55, 58, 60, 65, 66] and important[30, 41] of risks, and mainly focus on contamination rather than usage (again, a number of findings are from closed survey questions rather than open-ended items or interviews, thus limiting the scope of responses). Other environmental impacts of concern to the publics in this review include generic 'risks to the environment'[47] as well as air pollution,[65] damage to the land and landscape,[27] and associated impacts on wildlife.[46, 67]

The most commonly cited social risks are the impacts of shale exploitation on traffic, road safety and road conditions.[46, 59, 60, 65, 67-69] More broadly, individual and community health and safety were of concern in reports by Ferrar et al.[6], Jaspal et al.[27] and Wynveen[69]. Participants also perceived issues of noise and/or light pollution[58, 65, 67] and changes to the aesthetic value of the landscape/scenic

beauty.[46, 57, 65, 69] Also of concern is the population influx caused by shale development[27, 46, 57, 58, 68] and the associated risks of crime,[46] inconvenience/social disruption,[7, 65, 69] people not sharing the local way of life,[46] strained services/infrastructure,[46, 68] housing availability[27, 46] and stress[46]. Although economic factors tend to be associated with benefits, they are not totally absent from risk concerns, for example through shale development crowding out other industries.[55]

Participants also spoke of threats to rural lifestyles,[46] 'upended community meanings',[7] the industrialization of small towns,[27] and a reduced ability to enjoy local natural amenities.[67] Perry[70] discusses how the psychological and sociocultural impacts of shale gas development on Bradford County, Pennsylvania, may evidence a phenomenon called 'collective trauma' in which a community's bonds are slowly but substantially weakened. Evensen[71] ties the changes in the character of small, rural communities (and the resulting impacts on place meanings and place attachment) to the concept of philosophical perfectionism, whereby shale operations affect respondents' capacity to live or attain 'the good life'. Several authors also explain how rapid industrialization, increased intra-community conflict, an influx of outsiders, prominent changes in the landscape and associated psychological stress can also lead to threats to place identities and place attachment.[7, 57, 67, 69, 70] As has been illustrated with other technologies[72] at a local level such objections are often denigrated by developers, governments and the media as examples of a NIMBY (not in my backyard) response. This is the idea that people support a development in principle, as a common good, but then object to it near their home because they see local risks and little benefit. However, such a perspective is rarely adequate to understand such disputes – where peoples' everyday experiences, and their notions of morality and obligation, are important to their locally-based identities.[73] As a result, contemporary thinking is that NIMBY is a highly misleading label that both risks denigrating opponents while over-simplifying what prompts local concerns, and at the very real risk of further alienating members of local communities that are being asked to host such developments.[16,74,75] The evidence with shale operations is that likewise NIMBY cannot adequately explain opposition to these operations either.[49, 50, 57] These findings are also consistent with wider literature on local experience of other environmental and technological hazards and risks, where it is commonly observed that people's concerns can raise perfectly legitimate issues (as seen from the perspective of local residents) which are not easily accommodated in formal risk assessments for the technology in question. Seen in these terms local knowledges and perspectives are not something to be challenged by more information provision, or appeals to NIMBYism, but become an important means of critiquing and extending the scope of the more formal assessments of risk.[76, 77]

It is of note that whilst accelerated climate change has been cited as among the most significant impacts of shale exploitation, due to methane emissions and lock-in at the expense of renewable energy sources,[78] it features remarkably little in the articles that we reviewed. Willow (p.147)[79] observes that 'while several people I spoke with did list carbon emissions/climate change as a detrimental outcome of fracking, this issue has not emerged as a major motive for grassroots opposition', and Clarke et al. (p.137)[80] comment that 'very few participants who mentioned environmental associations actually touched on climate change'. This low salience may be because chemical contamination is a more immediate threat while climate change is a 'distant' risk,[81, 82,83] perceived as something that will happen to other places and peoples in a distant time. Indeed, results do indicate that while some media[27] (though see ref [29]), stakeholders [58] and 'interested and affected parties' [55] cite climate change as an issue, public respondents in studies tend to be

concerned with more immediate, localized effects such as social impacts and water contamination. However, the relationship between the localized impacts of climate change and risk perceptions is a complex one, and the research on this issue shows that climate threats can simultaneously hold both localized and global associations.[84] Accordingly, it should not be concluded, from the limited evidence generated so far from perception studies, that shale development does not hold the capacity to raise these more global concerns for people – either in different North American States or in other countries with different regulatory regimes or media reporting environments. Lack of salience of climate change may also be in part due to the way the issue is framed in the studies conducted,[54] or due to many of the samples being based in areas where shale gas development is occurring, suggesting a need for more national-level and 'upstream' studies[85] to explore this issue further.

Risk and benefit distribution

A major focus in our sample was the degree to which wealth, social costs, and changes in quality of life are distributed (un)evenly or (in)equitably amongst a range of actors exposed to shale operations[46, 52, 55, 62, 65, 66, 68, 69, 71, 86, 87] (see ref [88] for a recent review). Most of these authors provided evidence for uneven distribution of benefits and/or harms associated with development, or for people's concerns about such uneven distribution. These included concerns about: different residents benefiting from those being harmed[46, 62, 65, 68]; gas companies benefiting whilst residents are harmed[66, 69]; and long-term, generational differences in who benefits or is harmed (e.g., benefiting in the short-term, but harming future generations).[52, 68]

Views are mixed as to the overall balance of risks and benefits (e.g.,[58 89]). As would be expected from the literature[13-16], risk/benefit perceptions appear more nuanced than a simple weighing up of gains and losses. For example, while benefits tend to outweigh the risks for Theodori et al.'s[30] participants, 45% worry that there will be some sort of catastrophic accident involving natural gas extraction in the Marcellus Shale, and 46% disagree that any negative impacts of natural gas extraction in this region can be fixed. This parallels work that highlights ambivalence in risk perceptions, whereby seemingly contradictory survey responses in reality reflect the fact that people believe both risks and benefits should be weighed highly at the same time[90] - and in the real world, high benefits do often accompany high risks.[91] Finally, it is also worth noting that the timing of the papers reviewed here is likely to influence results. Now that gas prices have fallen causing a contraction of shale operations in some areas, and considering more recent commentaries about shale boom-bust cycles,[63] perceptions about the sustainability of benefits may change.

Attitudes towards hydraulic fracturing for shale gas and oil

More than half of the publications in our sample offered some degree of attention to overall attitudes of support and opposition towards shale operations. This research was again more commonly quantitative, though some qualitative studies also addressed these issues. When reporting overall levels of support/opposition, most studies relied on percentages or averages of linear scales from surveys. However, this might mask important nuances: for example, Jacquet and colleagues[49, 57] show that while survey respondents exhibited similar average levels of support for shale gas and wind energy, their evaluation of shale gas was substantially more bimodal than it was for wind energy. As well as taking into account study design, we are again reminded of the

importance of framing terminology in this context, with respondents in a national US survey showing overall support for shale gas development, but opposition to 'fracking'.[29, 80]

Studies using US national samples[36, 39, 44, 45, 48] found slightly more support, on average, than opposition. However, they often found that the majority of survey respondents across the US at large are undecided on this issue.[36, 44] One national-sample study demonstrated general support for shale operations in the Midwest and South in the US, but opposition on average in the West and Northeast.[39] Temporal variation in support/opposition was also manifest. Mazur[28] asserted that attitudes have become more divided over time, while two studies showed increased opposition over time.[39, 70] Indeed, both of these can happen when a large number of people are initially undecided and then make a judgement, as has occurred with European perceptions of shale operations recently.[24] Attitudes also vary at regional and local scales: whether this is related to levels of shale development in these regions is a question of considerable interest for countries currently debating shale development, and is discussed in detail below.

A number of factors have been shown to be associated with support/opposition. Causality is not clear, and to our knowledge no published research offers a rigorous analysis of whether such factors lead to attitudes or whether they stem from them (see ref [86] for a discussion). The most commonly cited is the (unsurprising) relationship between beliefs about impacts and overall attitudes. For example, in top of mind (or 'free association') tasks, those who more readily cite economic and energy supply impacts are more likely to support fracking, whilst those who more readily cite environmental impacts are more likely to be opposed.[44, 80]

Public perceptions of regulation, decision making and the institutions responsible for development

Perceptions of regulation and decision making

Reporting national survey data of those aware of fracking, Davis and Fisk[45] find that respondents are equally divided in terms of preferring more regulation (45%) and maintaining existing levels of regulation (43%), while few (12%) are in favor of reducing regulation. In the US public support for regulation varies by state: for example, most Pennsylvanian respondents do not believe that drilling taxes would discourage companies from doing business in the state,[41, 43] but most Maryland participants are concerned that a tax would discourage companies from conducting business there.[66] Regarding whether shale development should be allowed at all, a majority of participants across Canada widely support a moratorium on fracking until the government completes a comprehensive review of the technology.[92]

A number of the articles in this review report a perceived lack of personal control in determining development outcomes, consistent with research showing the importance of agency in risk responses,[93] and the need in turn to view findings about both regulation and institutions (see below) from a critical perspective. Willow (p.247)[79] in particular found that those who oppose shale development associate it with strong feelings of disempowerment, arguing that 'the activities of a powerful industry are infringing on fundamental rights and undermining core democratic values'. Similarly, Wynveen[69] and Israel et al.[55] cite a lack of power and local control, including within government, with respondents claiming that county and municipal governments have little say in these issues. Participants point to development in their community that began without their consent, knowledge, or engagement.[55, 61] Others yielded to the 'inevitable' to allow shale operations

(p. 25, ref [94]) and were afraid to resist pressure because they felt they might be labelled un-American or un-patriotic.[70] Simonelli[95] refers to this as internal colonization, arguing that when industry moves into economically vulnerable rural areas promising financial benefits, communities are often not in a position to resist, despite negative environmental and community impacts. In response to these power struggles, research has found that landowner coalitions are seen as a way of average citizens gaining more power over development decisions by combining collective bargaining power and legal/time/financial resources,[32] with suggestions that possessing a lease could itself be seen as a form of power and/or control.[49]

Perceptions of institutions, organizations and other actors

A dominant theme emerging with regard to public perceptions of various shale stakeholders is mistrust - of industry and government in particular, and to a lesser extent of scientists and environmental groups (see refs [14, 96] for discussions of the importance of trust in public risk perceptions).

Mistrust of industry is widespread. For example, Ladd[58] notes that four in ten respondents were skeptical of gas industry promises, while Stedman et al.[37] note that many respondents had very little or no trust in the natural gas industry (48.8% in New York versus 37.2% in Pennsylvania). Our review shows that this mistrust may stem from various factors, including industry exposure, perceived unfairness, lack of information provision, and heavy handed corporate tactics, or 'bullying'. For example, in the Marcellus Shale, over half of participants (72% in New York, 69% in Pennsylvania) agreed that the gas industry benefits from natural gas extraction at the expense of local communities and citizens.[41] Ferrar et al.[6] discuss experiences of being denied information or being provided with false information, or having their concerns ignored, and Israel et al.[55] cite concerns relating to the availability and quality of information both by industry and political leaders. Interviewees in Pennsylvania's Marcellus Shale described being bullied or intimidated by gas industry employees and their agents.[97] This bullying is not restricted to companies: interviewees also described being bullied or intimidated by their neighbors when there were disagreements about the pros and cons of gas development; and even by local politicians.[97] Similarly, Israel et al.[55] describe the withholding of information from affected parties by neighbors and medical personnel under 'gag orders'.

A number of studies also describe negative perceptions of government with regard to shale operations. For example, Stedman et al. [37] found that many respondents had very little or no trust in state departments of environmental protection/conservation in the Marcellus shale region, and Borick et al. [41] found that both Governor Cuomo's (New York) and Governor Corbett's (Pennsylvania) handling of the shale gas issue drew more negative reviews than positive appraisals. Other research indicates that views are mixed. Brown et al.[42] found that participants tended to be uncertain about governor- and legislature actions on hydraulic fracturing in Pennsylvania and Michigan, and Perry[70] finds that many citizens express the belief that the Pennsylvania Department of Environmental Protection would not allow shale development if it were truly dangerous, suggesting trust in this governmental organization at least.

In line with research showing that (independent) scientists are consistently amongst the most highly trusted sources of scientific information (e.g., [98]), Stedman et al.[37] and Theodori et al.[30] found high levels of trust in scientists and 'experts'. However, the picture is again mixed. In the US,

Pennsylvanians have significant doubts about the credibility of scientists on this issue.[43] Some residents believe that experts have intentionally avoided researching cases of cancer close to wells, fearing the implications of potential findings,[65] and others raised concerns about possible bias in scientific studies funded by industry[55]; a concern also voiced in the UK recently.[99] 'Trust' in experts does not of course necessarily translate to attitude change, and whilst Lachapelle and Montpetit[50] note that Quebecers adjust their perceptions of risk when provided with new scientific information, they found that even a strong signal from credible experts was unlikely to alter negative attitudes to such an extent as to produce overall support. In both Pennsylvania and Michigan some segments of the population suggest their perception of hydraulic fracturing will not change in response to an expert saying that the risks are either high or low.[42] These authors suggest that respondents are more likely to believe an expert determination of high risk than low risk associated with shale operations[42]; and it is apparent that, in line with wider risk perception research[100], trust in scientists is contingent upon factors such as whether the experts' views align with the dominant discourse or with their own views.[101]

The limited coverage in our sample suggests that levels of trust in environmental groups are also mixed. Respondents in Pennsylvania and Michigan would more likely turn to environmental groups for reliable information on drilling in their state rather than government, industry, or the media,[42] but others[37, 43] found that many Pennsylvanians have little trust in environmental groups on this issue. Whilst little of the research here focused on media coverage, indications are that Pennsylvanians have significant doubts about the credibility of the media on the issue of shale operations,[45] even though Theodori[87] and Evensen et al.[29] report that local newspapers are the most commonly consulted source of information on this topic in Pennsylvania.

Comparisons with other energy options

Findings are consistent with research elsewhere[102, 103] that consistently show public preference for renewables over fossil fuels. For example, local leaders' support for shale operations ranks near last when compared with a range of Michigan-specific energy sources that could be developed in the state, well behind renewable sources such as wind and solar, and other sources including nuclear power.[49] Consistent with this, a majority of US respondents in a national survey (58%) say it is more important to develop alternative energy sources (e.g., wind, solar, hydrogen technology) compared to 34% who think expanding exploration and production of oil, coal and natural gas is the more important priority.[39] Related to these findings, Israel et al.[55] cite interested and affected parties' concerns about gas development hindering the development of renewable energy resources and technologies.

At the local level, Jacquet and Stedman[57] found that although the perceived magnitude of positive and negative impacts is greater from natural gas drilling, the types of perceived impact from wind and natural gas are similar overall, with traffic perceived as among the most adverse impacts from developments. However, wind still proves more popular: Jacquet[49] found that landowner attitudes towards natural gas drilling tended to be negative, while attitudes towards wind farm development were much more mixed, becoming more positive when development occurred, as opposed to more negative when drilling began.

While renewables tend to be the most preferred option, some research shows that natural gas (per se) remains more popular than other fossil fuels. In one study this includes the Keystone XL pipeline

for tar sand oil,[48] although Baldassare et al.[104] found that even support for this was higher than for 'fracking'. Higher support for gas than other fossil fuels is consistent with research in the UK (RSPB Market Research 2001, cited in ref[105]), and may in part be due to fewer people seeing natural gas as a culprit of climate change than oil and coal.[48] However, in Pennsylvania fracking for shale gas is seen as more negative than even coal in some ways. This stems from the social aspects of development, as described by Hudgins[61] who notes that unlike coal miners who are a more localized, populous, networked labor force with deep roots in the area, much of the labor associated with natural gas drilling is diffuse and transient.

WHAT SHAPES PERCEPTIONS OF SHALE OPERATIONS?

Prior experience of shale operations

A key question of interest is whether perceptions of shale operations are related to levels of development. A number of the papers we reviewed do find that people within states with more extensive shale development are more positive. Several studies revealed support, on average, for shale operations in Pennsylvania (where shale operations are happening),[30, 41, 42, 50, 66] while the majority of research on New York (where shale operations are *not* happening) showed overall opposition[41, 66] - although one study of residents in New York's Marcellus Shale region revealed more support.[37] The one study that explicitly examined California (where shale development is relatively small scale) found more opposition than support[104]; the same was true of the one study of Maryland (where there is a moratorium).[66] While two studies showed overall support in Michigan[42, 50] (where large scale extraction is taking place), one suggested overall opposition.[47] In Canada, the limited research on Quebec (where there is a moratorium) showed decided overall opposition,[50, 89] and Nova Scotians (where there is a ban) were also found to be more likely to oppose (53%) than support (39%) hydraulic fracturing in the province.[106] Notably, while there has been unrest over shale development (and a moratorium) in New Brunswick, there is a shortage of published research on public perceptions there. On a more local scale in the US, Kriesky et al.[33] found that in a Pennsylvanian county with more shale activity (Washington County), residents were less likely to perceive environmental threat, and more likely to perceive the Marcellus shale as an economic opportunity, than in a Pennsylvanian county with less activity (Allegheny County).

While the majority of the above research indicates that greater levels of development are related to higher benefit perceptions and lower risk perceptions (note that we cannot comment on causality), other -generally more localized- research shows that the situation is more complex, and that those in areas with more development hold more polarized, nuanced, ambivalent, or stronger perceptions of both risks and benefits. For example, Theodori[60] found that Texans in Wise County (where the natural gas industry is more mature) were significantly more likely than Texans in Johnson County (where it is less well established), to view one social and/or environmental issue more negatively and five economic and/or service-related issues more positively. Work by Schafft et al.[59, 107] supports this. Schafft et al.'s survey of school administrators for example suggests that the same people are likely to see positive and negative potential and that people who live near sites have greater risk *and* opportunity perceptions than those who live in areas with less activity, with a strong correlation

between perceived risks and opportunity[107]. Malin[94] also highlights that while participants may express support, they may do so because they feel that such development is inevitable.

The situation is complicated by past energy development as well as contemporary shale operations. Interviews by Brasier et al.[46] suggest that a regional history of extraction in the Marcellus area (coal/shallow natural gas) helps explain perceptions of shale development, perhaps more than level of development itself. As an aside, such histories can also complicate the allocation of environmental impacts to shale gas because many of the problems may be the legacy of earlier industrial history, for example coal mining in the Marcellus[108].

Politics, culture and worldviews

Perhaps not surprisingly, environmental attitudes have been cited as important in the case of shale development.[49] For example, amongst aware individuals, those with a pro-environmental policy stance were more likely to oppose fracking than those favoring economic development.[45] Consistent with this, as well as the cultural theory of risk perceptions,[109, 110] Lachapelle and Montpetit[50] suggest that residents of Quebec, being more egalitarian and less individualistic than those in Michigan and Pennsylvania, perceive greater risks in the extraction of natural gas from shale, and tend to be less convinced of economic benefits. Regarding political orientation, research revealed that Democrats were generally prone to oppose development while Republicans were liable to support it.[39, 42, 44, 48, 104, 116] Davis and Fisk[45] also found that Democrats were more skeptical of fracking's practical uses than Republicans, and more likely to favor regulations and disclosure rules.

Other variables were cited as relevant in a more limited sample of studies: age (younger people more likely to oppose)[44]; being a mineral rights leaseholder (more likely to support)[33]; association of shale gas development with energy independence (more likely to support)[70]; and rural/urban residency (urban more likely to oppose)[45]. In their survey of government officials, Crowe et al.[35] found that those with higher educational levels were more likely to favor a ban, as are those leaders in communities that have a strong economy. Several studies also showed men are more likely to support shale operations than women,[33, 39, 44, 45, 48] reflecting emerging patterns in the UK[111] and wider literature on gender effects and local environmental contamination.[112] However, it is important to recognize current thinking, which is that such 'gender and risk' effects are not due to anything inherent to gender per se, but due to the ways in which society regulates individuals of different gender, and in intersection with other social location issues (race, social class etc.), shaping how some men and women participants from different backgrounds construct their understandings of environmental risk and uncertainty differently from each other.[113-115]

Overall though there is a need for more in depth research into the way worldviews and cultural values influence shale perceptions, and how they interact with the more localized questions of identity and sense of place.

Study design

Study design can have a large influence on how risk/benefit perceptions are elicited, how the topic is perceived by participants, and how results are interpreted. Firstly, we highlighted above that the majority of the publications reported here used self-reported measures rather than independently assessing knowledge, and how this can introduce bias. Second, in the articles we reviewed, many of

the studies showing the importance of impacts *outside* the characteristic economic and environmental tropes were qualitative, indicating that survey approaches may constrain the issues that are addressed. This potentially points to why certain impacts were discussed less frequently than others, and highlights the differential role of varied research approaches. Third, terminology is important: Clarke et al.[80] found that the terms 'fracking' and 'shale gas development' elicited different risk/benefit perceptions, with perceptions more positive when the term 'shale gas development' was used. Drawing on the same data, Evensen et al.[34] show how a higher percentage of participants felt that the risks outweigh the benefits when the issue was framed as 'fracking' versus 'shale gas development' (note however that the terms refer to different aspects of the issue and carry different connotations). Interestingly, Kromer[66] found regional differences in the perception of the word "fracking".

COMPARISONS WITH UK PERCEPTIONS

In Europe, where shale development is at a very early stage, public awareness and attitudes have tended to be shaped by the debate around whether or not there *should* be development, rather than by direct experience of development.[25] Although studies of European shale perceptions have been relatively few, the body of research is growing. This is particularly the case in the UK,[24] where a number of studies have recently been published based on media and policy analysis (e.g., refs [117, 118]), deliberative approaches (e.g., refs [119, 120]) surveys including repeated trackers (e.g., refs [113, 121]) and one in-depth experimental study.[122]

This research shows that there has been an increase in awareness and knowledge of shale development in the UK since around 2012,[113] and a large proportion of respondents now have at least a very basic level of awareness. However, few know 'a lot' about shale development,[121] and publics are largely undecided or ambivalent about the issue: when asked whether they support or oppose extracting shale gas, 44% neither support or oppose.[121] Indications are that there has been growing opposition amongst those who offer an opinion[113, 121]. Opposition seems to be influenced both by events such as the high-profile 2013 Balcombe protests within the UK,[113] as well as events and media coverage in the US.[28]

Some broad similarities emerge between North American and UK findings. As there is greater attention paid to risks in US and Canadian research, studies indicate that there is also a greater awareness of potential risks than benefits of shale development in the UK,[122] and more participants feel that the risks outweigh the benefits than vice versa (although 24% 'don't know').[122] Broadly consistent with US and Canadian findings, water contamination is amongst the greatest concerns in the UK.[113, 121, 122] Also consistent with North American perceptions, shale is considered less attractive than other energy technologies in the UK, particularly renewables.[111, 119, 121, 122] UK research also shows that demographics, politics and environmental values are important predictors of perceptions, with women for example being shown to be less supportive of shale development than men.[113, 121, 122]

Also in line with perceptions in North America, public perceptions of decision makers and regulators in the UK are commonly negative: participants feel that important decisions have already been taken without adequate public consultation, citing for instance that the government has already

committed to shale development and granted licenses.[119, 120] This is alongside negative perceptions of energy companies,[119] and widespread low trust in both industry and government,[120] with doubts raised about government's ability to adequately regulate shale gas,[122] and benefit offers perceived by some as being akin to bribes.[119]

In more subtle ways, UK and North American perceptions may differ, and more research is needed to explore this. Generally, the perceptions of risks and benefits in North America appear more localized, with less attention to debates around issues such as climate change and energy security than in the UK. For example, the most commonly cited reasons for supporting shale development in the UK include needing to use all available energy sources, reducing dependence on conventional fossil fuels, and energy security (i.e., reducing dependence on other countries for the UK's energy supply),[121] as opposed to the most commonly cited benefits in North America centering around local economies and jobs. However, these differences are likely to be at least in part due to a more regional/localized focus of many of the North American studies and the more advanced (i.e., downstream) stages of development there, whereby localized concerns come to the fore. It is important to understand how the framing of the debate at different scales in the US compares to the emerging situation in the UK where issues of energy security and climate change are increasingly paramount, and thus this is a question that warrants further research.

FUTURE RESEARCH NEEDS

In some ways, the US and Canada provide a relatively straight forward comparison with other countries experiencing or anticipating shale development. The UK, for example, bears many similarities in fossil fuel supply technologies, the energy systems currently deployed, and pressures to develop reserves of shale gas and oil. There are however a number of important differences, including different stages of development, as well as differences in mineral rights ownership, geology, population distribution and regulatory contexts. Such differences may have important implications for how risks are interpreted in these different contexts, and therefore ultimately whether shale development will obtain - and maintain - a social license to operate. So while we can learn much that will help to anticipate the emergence of public representations of shale development by reviewing what has already occurred in the US and Canada, these studies are not a substitute for further research elsewhere. Future work should therefore build upon recent research exploring perceptions in other countries, and include cross-national studies to facilitate more direct comparisons between national contexts.

Within North America, most of the reviewed research focused on the US rather than Canada, with a strong emphasis on the Marcellus shale formation (particularly in Pennsylvania) and much less attention to other shale plays. Future research in North America should therefore focus on regions outside of the Marcellus, particularly Canadian provinces and areas in the US where shale development is still at relatively early stages (i.e., upstream), for example in California. A focus on national contexts and upstream locations may elicit considerations of wider concerns such as climate change and energy security, which in downstream settings may be overshadowed by more localized concerns like water contamination and traffic.

A mix of qualitative and quantitative approaches were used in the papers we reviewed, both of which offer their own merits, and together provide a more thorough exploration of the issue than any one method can alone (see ref [123]). However, there is a strong focus on quantitative surveys and qualitative interviews, with much less of the research utilizing techniques such as focus groups,[124] deliberative workshops (c.f. [85, 119, 120]) or ethnographic approaches.[70, 79, 94, 97, 125] Such approaches can offer more insight into co-produced meanings and slow-thinking judgements, and would be expected to add further layers to current understandings of public perceptions of shale operations.

More longitudinal research (c.f. [6]) is also required to chart perceptions over time, as well as research that aims to better understand how personal characteristics such as life experiences affect beliefs.[35] There is also a need for more studies using independent knowledge measures rather than relying on self-report measures. This has been done to a limited extent in the UK,[111] but we support calls for further research in this area,[122] perhaps with the development of tailored knowledge scales to gauge public knowledge of emerging energy issues (see ref [126] for an example pertaining to climate change). Comparative analyses that seek to understand how shale perceptions differ, or are similar to, those from other controversial energy technologies[127,128] is also a research priority as our understanding of this area develops further and the available data grows.

Finally, the literature reviewed here is about a shale gas industry that expanded rapidly in the last decade.[1] This period of boom has been followed by a recent decline in activity in some areas due to falling oil prices in 2015.[1, 129] Alongside this, there is growing evidence of negative environmental impacts such as water contamination[130] and seismicity associated with waste water injection.[131, 132] In line with these more recent developments, we can expect attitudes to be changing, and more recent studies -including those currently being conducted- may reflect an environment of more negative evidence. Research should therefore chart these more recent developments.

CONCLUSION

We carried out a systematic review of 58 research articles published between 2009 and 2015, which investigated public perceptions of shale gas/oil extraction via hydraulic fracturing ('fracking') in the US and Canada.

Broadly, the literature shows mixed levels of awareness, tending towards higher awareness in areas with shale operations. Perceived benefits tend to be economic (e.g., job creation, boosts to local economies), while perceived risks tend to be environmental/social (e.g., impacts on water, traffic), and public views are mixed as to whether the benefits of shale operations outweigh the risks or vice versa. Levels of support and opposition differ across regions within the US and Canada. Views on regulation also vary spatially, but there is widespread distrust of the parties responsible (particularly industry and government), stemming from perceived unfairness, heavy-handed corporate tactics, and a lack of transparency. A number of papers also point to ethical issues concerning risk/benefit distribution, procedural justice, trust in risk managers and risk governance, and impacts upon quality of life. In common with many other environmental risk issues that have seen intense controversy over the years, this combined evidence points to the conclusion that aspects of local context, alongside the various dynamics of the interactions over time between affected communities and other actors such as developers and regulators, will be critical to the way this technology is

ultimately viewed in any particular location or nation. Under such circumstances, and as we have argued above, the acceptability of risk, alongside any social license to operate, can only ever be regarded as conditional at best (see[16, 127]), while the issue of shale development provides yet another powerful demonstration that the acceptance (or ultimately rejection) of environmental and technological risks involves a range of concerns and value-based questions that go well beyond simple knowledge of the science, or for that matter formal measurement of the risk itself. This is hardly a surprising conclusion as seen from the perspective of the social sciences, since four decades of research has revealed how the question of acceptable risk is always bound up with our values and, ultimately, our political choices[13, 91]. Shale developments seem to bring this consideration to the fore in a particularly acute way. In the language of the cultural theory of risk[13, 109, 110], the politics of hydraulic fracturing centers around whether it should be viewed simply as an efficient outcome of global energy markets seeking to exploit the earth's resources to meet an ever increasing energy demand, or alternatively as the latest incarnation of global capital and large fossil fuel corporations taking forward the unsustainable exploitation of the earth's resources to the long-term detriment of communities, the environment and the global climate. And while legitimate doubts can be voiced over the suitability of simple market-based approaches to ever resolve chronic environmental risk issues such as global climate change[135, 136], our own view is that that public perception research helps take forward an important set of issues which should in principle help to improve both the debate about the appropriateness of hydraulic fracturing and ultimately societal decision-making itself.

We find broad similarities between perceptions in the US and Canada and those emerging in the UK, where shale development is at the earliest stages. However, we also identify potential differences, which may pertain to different research foci and/or levels of development. We suggest that future research should further explore these nuances, particularly through in-depth qualitative research, longitudinal and cross-cultural studies with national and upstream samples.

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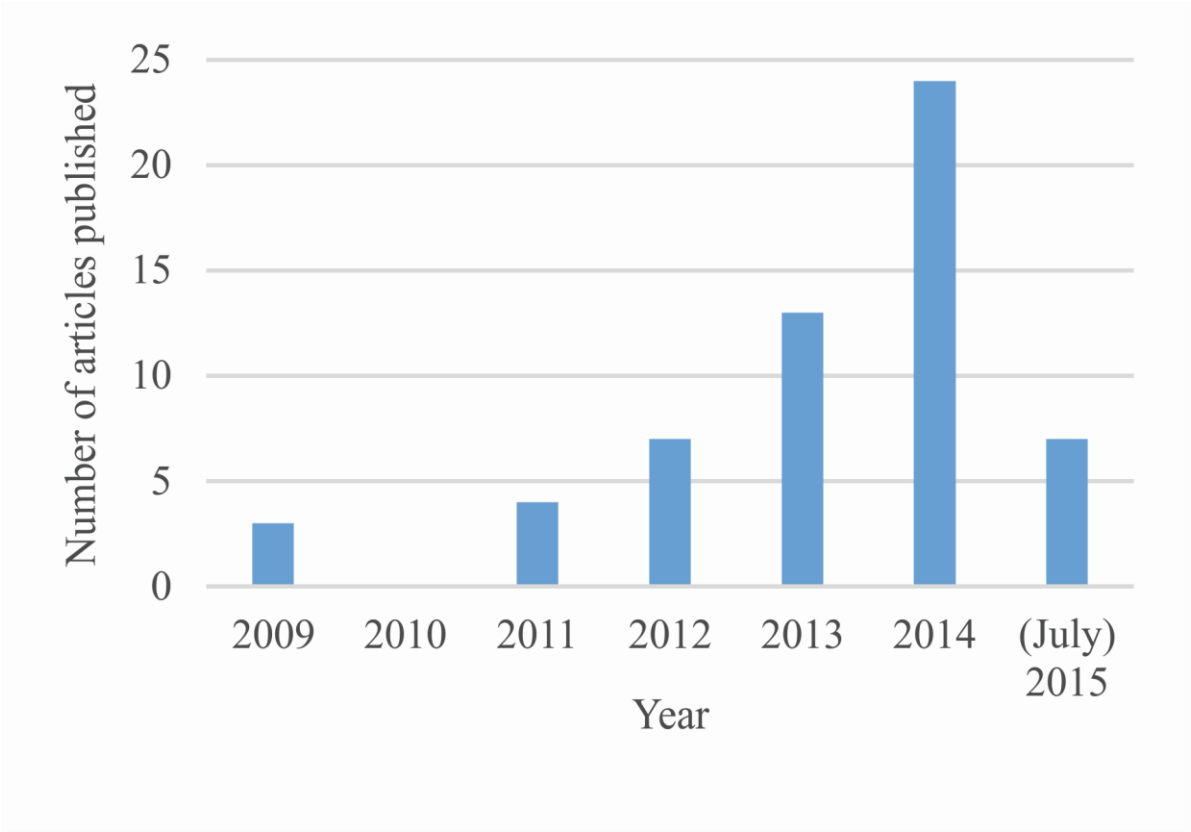
Table Caption
Table 1: Summary Table of all sources aggregated by types of methods

Figure Caption
Figure 1. Reviewed articles: publication frequency 2009-July 2015

Methods	Study citations	Type of study	Location including shale play and associated states/provinces	Sample	Method
Qualitative (N=20)	Refs [6, 27, 29, 32, 46, 55, 58, 61, 65, 67-71, 79, 94, 95, 97, 124, 125]	18 peer reviewed 2 grey literature	17 USA 11 Marcellus (New York, Pennsylvania, Michigan, Maryland) 2 generic (multiple plays) 2 Barnett (Texas) 1 Haynesville (Louisiana) 1 Marcellus & Utica (Ohio) 2 USA & Canada 1 Marcellus (New York, Pennsylvania), Frederick Brook Shale (New Brunswick) 1 Marcellus & Utica (Ohio) & non-shale comparison (Ontario) 1 USA & UK	10 IAPs* 7 Communities/residents 3 Media	8 interviews 6 mixed qualitative methods 3 interviews & focus groups 2 media content analysis & interviews 1 interviews & ethnographic research 2 qualitative analyses of open ended survey items 2 ethnographic research 1 focus groups 1 media analyses
Quantitative (N=30)	Refs [30, 31, 33-39, 41-45, 47-50, 56, 57, 60, 66, 80, 87, 92, 101, 104, 106, 107, 116]	16 peer reviewed 14 grey literature	26 USA 14 Marcellus (New York, Pennsylvania, Michigan, Maryland) 7 generic (multiple plays) 4 Barnett (Texas) 1 Monterrey (California) 3 Canada 1 generic (multiple plays) 1 Utica (Quebec) 1 Horton Group (Nova Scotia) 1 USA & Canada 1 Utica (Quebec) & Marcellus (Michigan, Pennsylvania)	24 general population 6 IAPs	13 telephone surveys 7 hard copy / mail surveys 4 online surveys 4 mixed quantitative methods 2 online and hard copy surveys 2 telephone and hard copy surveys 1 analyses of roll call votes 1 unspecified survey
Mixed methods (N=3)	Refs [28, 59, 123]	3 peer reviewed	2 USA 1 Marcellus (Pennsylvania) 1 generic (multiple plays) 1 USA, UK & Australia	2 IAPs 1 media & polling data	1 archival and focus group 1 media analyses & polling data 1 online survey, interviews, focus groups
Review (N=5)	Refs [7, 52, 62, 86, 89]	3 peer reviewed 2 grey literature	3 USA 3 generic (multiple plays) 1 Canada 1 general overview of new energy technologies	5 reviews	5 reviews
Totals (58 articles)		40 peer reviewed 18 grey literature	48 USA 4 Canada 3 USA & Canada 2 USA & other 1 general overview of new energy technologies	24 general population 18 IAPs 7 communities / residents 5 reviews 3 media 1 media & polling data	

* IAPs: interested and affected parties including government officials, landowners, farmers, and education professionals.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