Energy (In)security in Poland? The case of shale gas

By: Corey Johnson and Tim Boersma

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Abstract:

The large scale extraction of natural gas from shale rock layers in North America using hydraulic fracturing, or "fracking", has prompted geologists, economists and politicians in various parts of the world to ask whether there are new reserves of this precious resource to be found under their soils. It has also raised a host of questions about the potential environmental impacts of extracting it. Drawing on research on both sides of the Atlantic, this paper assesses the most pressing issues for research and policy makers related to shale gas extraction. The paper first provides a survey of environmental and economic issues related to shale gas. It then turns to a case study of Poland, whose policy makers have been among the most fervent proponents of shale gas development in the European Union. We examine the status of shale gas extraction in that country and what the barriers are to overcome before commercial extraction can in fact take place, if at all.

Keywords: shale gas | energy security | Poland | fracking | natural gas | energy policy

Article:

1. Introduction

This paper examines the shifting center of gravity of the debate over fracking and shale gas development from North America to Europe and assesses the complex mix of market, environmental, and geopolitical considerations that set the tone, and likely the outcome, of this debate in Europe. No European country has a history of commercial development of shale gas, and it is still far from certain that a single cubic meter of gas will be commercially produced. The reasons for this uncertainty lie partly in geologic and geographic realities about the distribution of shale resources, but there are also significant economic, political, and environmental obstacles that would need to be overcome for the emergence of a commercially viable shale gas industry in Europe akin to what has developed in North America over the past decade. Bans on hydraulic fracturing are already in place in France, Bulgaria, Czech Republic, and the Netherlands and the

German federal state of Nordrhein–Westfalen have imposed moratoria pending further research. In Poland, where government enthusiasm for shale extraction is greatest and public opposition least vocal, as of writing only about twenty wells have been drilled, with a handful of private companies researching cores to establish what amount of natural gas can eventually be commercially extracted. The US Energy Information Administration estimates that technically recoverable shale gas reserves in Poland are roughly 187 trillion cubic feet (tcf), or roughly 5300 billion cubic meters (bcm), though the Polish Geological Institute's estimate is far smaller as noted later in the paper. Other substantial basins in Europe are in France and Scandinavia (US Energy Information Administration, 2011).

Because it is at the center of the emerging European discussions over shale gas, the paper uses the case of Poland to assess the emerging issues surrounding shale gas in Europe. The article is based on interviews in Warsaw with senior Polish government officials and natural gas industry representatives, in Brussels with European Union officials, as well as field site visits in northern Poland (see Table 1 for a list of interviews). The paper also draws extensively on published reports, scientific literature, and government documents related to shale gas and hydraulic fracturing, which is currently the favored technology for extracting shale gas. The structure of the paper is as follows. First, an overview of key policy considerations is provided. This includes an analysis of how the "shale gas revolution" in North America and its ripple effects on natural gas markets beyond North America, and an examination of the environmental science of shale gas and hydraulic fracturing in light of existing policies in Poland and the EU. Second, the regulatory, infrastructural, and geopolitical context of energy in and its implications for shale gas development in Poland is described. Third, and by way of conclusion, the prospects for shale gas development in Poland are assessed in light of the available evidence.

Table 1. Overview of interviews conducted.

Interview with	When?	Where?
Private US gas company	November, 2011	Pennsylvania, US
Environmental protection agency	November, 2011	Washington, DC, US
European commission, DG energy, DG environment and DG climate	January, 2012 and May, 2012	Brussels, Belgium
European Parliament, representatives of ITRE committee and ENVI committee	January, 2012	Brussels, Belgium
Private gas company	January, 2012	Gdansk, Poland
Ministry of Environment, Ministry of Economic Affairs,	January, 2012	Warsaw, Poland

Interview with	When?	Where?
Ministry of Foreign Affairs		

2. Key policy considerations concerning shale gas

In North America, the shale gas genie is out of the bottle. Barring some sensational finding on the environmental impacts of hydraulic fracturing ("fracking"), such as extensive groundwater contamination, shale gas will likely remain a growing part of the energy landscape in North America (Boersma and Johnson, 2012). The debate will continue in scientific and policy communities, localities, and the media, about the potential impacts of shale gas extraction on climate, a fledgling renewables industry, groundwater and surface water quality, structural geology, etc., and there are legitimate concerns in each of these realms that shale gas could have detrimental effects. In certain jurisdictions overlying recoverable deposits, these concerns may inhibit the development of shale gas resources. However, the overall political and business cultures in both the United States and Canada have historically valued hydrocarbon development in spite of environmental costs, domestic energy supplies instead of imports, and property owners' rights to exploit subsurface mineral rights versus the collective's wishes to prevent such exploitation. Some have argued that the regulatory framework governing natural gas infrastructure development, transportation services, marketing and minerals rights have been crucial elements in the development of shale gas (Medlock, 2012). Whatever the exact causes may be, they are unlikely to change anytime soon.

2.1. Market and economic impacts

Over the past decade shale gas exploitation has boomed in the United States. In 2010, production amounted to 5 tcf (141.5 bcm) and projections are this number will almost triple by 2035 (US Energy Information Administration, 2012). However, the limitations of these projections must be considered.

First, new technical and/or geological insights have to be taken into consideration. The 2012 Annual Energy Outlook downgrades estimates of technically recoverable resources, largely due to a decrease in the estimate for the Marcellus shale from 410 tcf to 141 tcf (1160 bcm to 400 bcm). When accounting for land use patterns, regulations and policies, much of the shale gas that is likely underground is not in fact recoverable (Blohm et al., 2012). Given this context, it is worth noting here that roughly a decade ago many in industry, government, and academia, had not foreseen the development the US gas industry has experienced. In other words, predicting future developments in shale gas is exceedingly difficult.

Second, economic conditions of the gas market can change. Abundant production within the United States has caused natural gas wellhead prices to plummet after July 2008 (US Energy Information Administration, 2011). Increasingly there are reports of delayed investments in drilling of new wells for exactly this reason. This development has prompted some to support the reintroduction of a wellhead price-floor, which was abolished in 1989 with the Wellhead Decontrol Act (Weijermars, 2011). However, it appears that the market shall correct the existing mismatch between supply and demand, with for instance BP reporting a write-off of $2.1 billion on shale gas acreage because of lower natural gas prices.1

Despite existing uncertainties, the impacts of the US shale gas boom are substantial. Domestically, wellhead prices for natural gas are expected to remain below $5 per thousand cubic feet at least to 2023. Relatively cheap gas in turn is expected to trigger investments in gas-fired power plants, resulting in an assumed rise of the share of natural gas in the electricity generation portfolio to 27% in 2035 and in some scenario studies an even more substantial rise up to 2050 (Paltsev et al., 2011). More broadly speaking, the future of natural gas depends on a complex set of factors, such as adoption of natural gas for transportation, future climate policies, renewable energy policies or the lack thereof, and geopolitical considerations (Myers Jaffe and O'Sullivan, 2012)

It appears that the effects of US shale gas production on European markets have been indirect to date and there are currently no signs that this will change in the near future. Liquefied natural gas (LNG) from Qatar, other parts of the Middle East and Eastern Siberia intended for terminals in North America is now finding its way to both European and Asian markets. Furthermore increased usage of gas-fired power plants in the US has made coal cheap and available, resulting in an incline of coal-fired electricity generation in Europe (Rühl, 2012). LNG is changing the dynamics of global gas markets and European gas prices on spot markets have been significantly lower than oil-indexed gas during recent years. It is therefore expected that the EU will continue to move slowly away from oil-indexation as long-term contracts are re-negotiated and new contracts negotiated that take into account market developments (Pearson et al., 2012).

Significant shale gas resources have been reported in the European Union (Leteurtrois et al., 2011, Polish Geological Institute, 2012 and US Energy Information Administration, 2011). Yet given the absence of experience with shale gas extraction in most parts of the world and given the number of related uncertainties, reserve estimates should be treated with 'considerable caution' (Pearson et al., 2012). In stark contrast to the US, actual shale gas extraction is still in the embryonic phase. A replication of the US shale gas revolution has been questioned, with reference to less favorable geological conditions, the absence of tax breaks, lack of a well-developed onshore service industry and the possible lack of public support due to the absence of local financial benefits (Stevens, 2010). Some predict that the best case shale gas production scenario for the EU is replacement of declining conventional production and having import dependence not exceed 60% (Pearson et al., 2012).

In Poland a handful of wells have been drilled and companies are examing cores to establish the quality of gas and at what cost it can be extracted. In the United Kingdom shale gas producers got the green light from government to extract shale gas after a pause due to further research on human induced seismic activity. We shall elaborate on this later in the paper. Other countries are awaiting further research such as the Netherlands and Germany, while France, Bulgaria, and the Czech Republic have put outright bans in place to extract shale gas using hydraulic fracturing. The reasons for this are not always clear. French officials justified their ban on the fact that hydraulic fracturing technologies bring too many uncertainties at this stage, while the Czech Republic argues that its current regulatory framework is not sufficient to safeguard shale gas extraction in an environmentally viable fashion. The ban in Bulgaria was put in place in January 2012, but after realizing that the wording of the ban also would have prevented conventional gas production using low-pressure hydraulic fracturing, the ban was partially lifted in June 2012.

2.2. Environmental impacts

Market realities will be an important factor influencing whether and where shale gas resources are developed in Europe, just as they have in North America. But the potential environmental costs and risks associated with shale gas and hydraulic fracturing could end up determining whether shale gas development is stopped in its tracks in the European Union. Within the context of the multilevel governance structures of the EU, the responsibility for developing policies on energy supply and production are largely still the purview of individual member states. However, the governance of environmental and air quality is one realm in which many core competencies now reside in Brussels, and any industrial activity – such as hydraulic fracturing – that has potential impacts on water or air quality will be subject to the environmental impact rules set by the EU. In the case of North America, environmental regulators and the scientific community alike were caught off-guard by the shale gas revolution, and the interviews we conducted in Brussels in the European Parliament and in the directorates for energy (DG Energy) and environment (DG Environment) suggest a similar game of catch-up being played. The major regulatory difference between the North America and the EU involves the precautionary principle, which is enshrined in the Lisbon Treaty and sets the tone for the implementation of any new technology such as hydraulic fracturing. This section of the paper provides an overview of the major environmental questions that currently surround shale gas and fracking.

2.2.1. Carbon footprint and fugitive methane

Fugitive methane emissions, i.e., the gas that is released during the production process, has potential implications for both the atmosphere as well as groundwater. This section addresses the science on the climate impacts of methane and fuel switching from coal, oil, nuclear, to a newfound abundance of natural gas. Methane as a potential groundwater pollutant will be addressed in a subsequent section.

Fugitive methane emissions represent the gas that is leaked during the complete fuel cycle, i.e., from extraction to burning. Methane is more than 20 times more potent (in terms of its "global warming potential" or "radiative forcing") than CO2 as a GHG, but has a much shorter half-life in the atmosphere than CO2 (Alvarez et al., 2012).2 Methane from all anthropogenic sources (e.g., agriculture, landfills, wastewater treatment, natural gas production) represents about 10% of all GHG emissions in the US, and natural gas systems constituted the largest anthropogenic source of methane emissions. Methane emissions from natural gas production have increased by 25.8 teragrams (or million metric tons) of CO2 equivalent (Tg CO2 Eq.), or 13.6%, since 1990 (US Environmental Protection Agency (2012b)). Most of the fugitive methane emissions are "process related," and a majority (58%) come during field production (e.g., from the wells themselves, gathering pipelines, gas treatment facilities such as dehydrators) (ibid.). In short, there are leaks in the production of both conventional and unconventional gas, and a large part of the debate is over how large as a percentage of overall production those leaks are.

In a widely cited paper, Howarth et al. (2011) estimated that fugitive methane emissions from the life cycle of a shale gas well were substantially higher (between 3.6% and 7.9%) than for conventional gas well (between 1.7% and 6.0%). Other scientists have questioned the data used in that paper (Cathles et al., 2011). Some have argued that there are technical fixes available that could substantially reduce the amount of fugitive methane and carbon (Wang et al., 2011). However, these fixes focus primarily on preproduction emissions, while life cycle estimates are mostly dominated by the combustion emissions of the gas (Jiang et al., 2011). Thus, uncertainties whether shale gas is potentially a viable bridging fuel to a low carbon economy and what can in fact be done about methane emissions during the life cycle. Some concluded that large scale usage of natural gas is not the way forward in the transition to low-carbon electricity, and suggest a combination of conservation, wind, solar, nuclear energy and possible carbon capture and storage instead (Myhrvold and Caldeira, 2012). Ironically, some observers have noted that carbon sequestration sites could be restricted due to large scale shale gas extraction from shale rock layers. In short, shale gas extraction involves the fracturing of shale rock layers in order to increase its permeability to let the natural gas flow up into the well and as such hydraulic fracturing is in conflict with using these rock formations as a barrier to CO2 migration (Elliot and Celia, 2012).

A recent study by Alvarez et al. (2012) assessed the warming potentials of different fuel switching scenarios, using what they describe as "technology warming potentials" (TWPs). They found that at current leakage rates from natural gas production and delivery infrastructure mean that, for example, a switch from petroleum-fuel powered to natural gas powered vehicles would have net negative climate impacts, especially in the short term, while switching from coal-fired to natural gas-fired electricity generation would have climate benefits. They added the major caveat that their modeling assumes a 3.2% overall leakage rate for the US, which is in actuality likely to be higher with better data from actual well sites. The 3.2% average is also likely a lower leakage than for shale produced methane, as cited above. The bottom line is that without substantial improvements in leakage rates, it is difficult to make a convincing argument that the life cycle climate impacts of shale gas are better than for other hydrocarbon fuel sources.

In the absence of a coherent climate policy, it is not clear what regulatory mechanism would be applied in North America to ensure that such technical fixes be required. One area in which federal regulations have been adopted is air quality. In April 2012 the federal EPA used its authority under the Clean Air Act to regulate emissions from drilling activity. From 2015 onward gas companies will be required to conduct hydraulic fracturing according to rules on Reduced Emissions Completions or 'green completions', e.g., the application of capture technology to avoid damaging gases, such as volatile organic compounds or methane to come into the air. Until 2015 companies are required to flare these emissions (US Environmental Protection Agency, 2012b). Further research is needed to identify what share of the wells in the US in fact fall under these regulations, as several exemptions apply. For example, EPA has estimated that "green completions" are not feasible in 87% of the natural gas wells fractured in coal bed methane formations.

2.2.2. Surface and groundwater contamination and other water related concerns

Another concern linked to shale gas development is the contamination of drinking water, by some labeled as the most contentious of issues that have arisen over shale gas development (Groat and Grimshaw, 2012). So far, two cases of contaminated drinking water have been reported that were likely to be directly linked to shale gas exploitation. In Pavillion, Wyoming, EPA began investigating private water wells three years ago, following concerns that were expressed by local residents. After constructing two deep monitoring wells to sample water, EPA found that ground water contained compounds likely associated with natural gas production. The draft report was published in December 2011 and will be open to comments until October 2012 (US Environmental Protection Agency, 2011a). Another individual case stems from Dimock, Pennsylvania, where in November 2011, the EPA issued that four domestic water wells contained inorganic hazardous substances at levels that presented a public health concern. The action memorandum that was released in January 2012 reports the presence of several substances that are known to be common constituents in fracking fluids, i.e., Barium, DEHP, Glycol compounds, Manganese, Arsenic, Phenol and Sodium (US Environmental Protection Agency, 2012a). The first results of a broad study conducted by that same EPA on the potential impacts of hydraulic fracturing on drinking water resources are not expected before late 2012, with final results pending until 2014 (US Environmental Protection Agency, 2011b). Therefore up till now, it proves to be difficult to draw more general conclusions about drinking water contamination and links to hydraulic fracturing and related activities.

Meanwhile, what has widely become known as the “Halliburton loophole” continues to ensure that comprehensive federal regulation of hydraulic fracturing as it relates to potential groundwater contamination remains elusive. In short, an insertion in the Energy Policy Act of 2005 amended the Safe Water Drinking Act and exempted hydraulic fracturing as a technology from the Underground Injection Control (UIC) program, except when diesel fuel was used in the process, making it impossible for EPA to regulate potential groundwater contamination caused by fracking3.

In addition to the risk of fracking fluids leaking during the production process, leaking natural gas itself can potentially contaminate groundwater supplies. One study focusing on the Marcellus and Utica shale formations in Pennsylvania found systematic evidence for methane contamination of shallow drinking-water systems in at least three areas that was linked to shale gas extraction. Methane concentrations were detected in 85% of the wells under study, but concentrations were substantially higher closer to natural gas wells. This study found no evidence for contamination of drinking water with fracking fluids (Osborn et al., 2011). A large study at the University of Texas reported that there was no evidence of chemicals in aquifers as a result of fracking operations. The greatest environmental risk associated with fracking, according to this study, is not from groundwater contamination, but rather from surface contamination caused by spillage of undiluted chemicals (Groat and Grimshaw, 2012). Overall the issue of drinking water contamination remains controversial, with no clear empirical outcome at this stage implying a causal link between fracking itself and contamination of water wells. There are, however, a number of reports of methane leakage from improperly sealed well bores.4

Water issues linked to shale gas are not limited to contamination, but also concern the availability of the resource. According to EPA estimates the water needed to fracture a horizontal well is typically between 4 and 6 million gallons per well, depending on depth, horizontal distance and number of times the well is fractured (US Environmental Protection Agency, 2010). In July 2011, the Texas Water Development Board estimated that the shale gas industry used about 12 billion gallons of water per year in Texas, a number that was expected to grow up to 40 billion gallons per year in 2030 (Nicot et al., 2011). A study focusing on the three major shale gas plays in Texas to quantify the net water usage for shale gas production, found that roughly 10% of annual water use in Dallas is destined for the shale gas industry. For the whole state of Texas, water usage for shale gas is under 1% of total withdrawal, however local impacts vary with availability of water and competing demands (Nicot and Scanlon, 2012).

Another environmental concern linked to shale gas and water is what to do with wastewater, once it has been injected in the well together with sand and chemicals. The most quoted options are reinjection in the well, discharge to surface water after treatment or application to land surfaces. Data from 2011 from the Pennsylvania Department of Environmental Protection suggest that about half the wastewater was treated; about one third was recycled to be used in other hydraulic fracturing operations, while less than one tenth was injected into disposal wells (Hammer and vanBriesen, 2012). Wastewater handling has been reported as a key problem for environmental opposition in several cases (Rahm, 2011). Some studies have suggested that federal and state regulations have not kept pace with the shale gas industry and should be strengthened to reduce risks of hydraulic fracturing for current regulatory frameworks are 'inadequate' to do so (Hammer and vanBriesen, 2012). Alternative fracturing fluids and the use of non-fresh water are part of ongoing research activities (Pearson et al., 2012). In Canada, over 1,200 successful simulations have taken place of what is called Dry Frac, a process that uses liquid CO2 as the carrier fluid in fracturing operations without using water or any additional treatment additives (Kargbo et al., 2010), but there are certain to be cost and logistical concerns of such techniques.

2.2.3. Anthropogenic seismicity

The US Geological Survey published a study that documents a seven fold increase in seismic activity in central US since 2008, largely associating this increase in seismic activity to the large increase in waste water disposal well injections (Ellsworth et al., 2012). In June 2012, the National Research Council published preliminary findings of an examination of scale, scope and consequences of induced seismicity during fluid injection and withdrawal activities related to amongst other shale gas extraction. The report concludes that the process of hydraulic fracturing does not pose a high risk for induced seismicity. In addition injection of waste water derived from energy technologies such as hydraulic fracturing does pose some for induced seismicity, but ‘very few events have been documented over the past several decades relative to the large number of disposal wells in operation’ (National Research Council, 2012).

In April 2012, in the United Kingdom the shale gas industry received the green light to resume operations after research had been concluded into seismic events near Blackpool in 2011 with 2.3 and 1.5 magnitude. Though geologists determined it was highly probable that the seismic events were induced operations were allowed to be resumed with the proviso that a traffic light system be implemented to govern operations. Should new seismic activity occur with a magnitude over 0.5, then operations would be suspended.5 Yet in June 2012 the Royal Society and the Royal Academy of Engineering published their review of scientific and engineering evidence regarding risks associated with hydraulic fracturing. It concludes that ‘seismic risks are low’ and leaves the carbon footprint of shale gas as the only contentious issue related to shale gas extraction on the table for further research (The Royal Society and The Royal Academy of Engineering, 2012).

A number of industrial activities has been linked to induced seismicity, including reservoir impoundment, mining, construction, waste disposal, and perhaps most prominently in recent years, fluid injections for geothermal energy exploitation (Majer et al., 2007). The US Department of Energy has stated that most the induced seismic activity qualifies as an ‘annoyance,’ not a risk, and argues that proper engineering can minimize the chances of seismic activity. Yet so far it is unclear where the threshold between acceptable nuisance and unacceptable risk is, particularly considering fracking is being done in a range of geographical contexts, from sparsely populated desert areas to suburban areas where an earthquake of 4.0 or above (of a magnitude that has been linked to fracking) could entail risks. In addition it is unclear whether and if so what from a regulatory perspective can be done to minimize the risks.

2.3. Limiting environmental risks

The foregoing concerns raise the obvious question of whether it is possible to limit the environmental risks of shale gas development. In the US, a wide variety of approaches to regulating shale gas and hydraulic fracturing can be pursued, from the warmest embrace of the technology (e.g., Texas) to outright bans (e.g., Vermont). Regulators and legislators have been struggling to keep up with the industry’s technological advances, as the environmental concerns outlined here demonstrate. Proposed regulatory interventions have been subjected to heavy lobbying by the gas industry, and the US Environmental Protection Agency has have also encountered outright hostility, such as for instance in Texas. In 2010, the Texas Commission on Environmental Quality (TCEQ) became the only state to refuse to implement the EPA's greenhouse gas regulations, while the Texas Railroad Commission was cited for its lax enforcement of the Safe Drinking Water Act (Rahm, 2011).

The disclosure of chemical constituents used in hydraulic fracturing fluids is still largely not required under federal and most state laws (Jackson et al., 2011). At first this information was claimed by the industry to be proprietary, but an increasing number of states has installed different forms of regulation, requiring companies to partially disclose what chemicals are used and how much of which chemicals are used. Other states are reported to be struggling with the exact formulation of these disclosure rules. Again, significant differences between states have been reported (Davis, 2012). On the federal level, water quality protection is arranged under the Safe Drinking Water Act. It focuses mainly on what is called "underground injection control" (UIC) program, regulating the subsurface emplacement of fluids. However, while hydraulic fracturing has been excluded from UIC regulation under a 2005 provision amending the Safe Drinking Water Act,6 the use of diesel fuel is not, making all hydraulic fracturing activities that include the usage of diesel subject to UIC regulations. Next to several states' initiatives to regulate drinking water quality, the federal EPA is currently investigating the potential impacts of hydraulic fracturing on drinking water quality. In June 2009, the Fracturing Responsibility and Awareness of Chemicals Act was introduced in the US Senate and House, aiming to define hydraulic fracturing as a federally regulated activity under the Safe Drinking Water Act and to impose companies to disclose the quality and quantity of the chemicals that they use while exploiting shale gas, yet passage appears unlikely in the near future (Jackson et al., 2011). In May 2012 the US Department of the Interior published proposed rules for gas companies working on public and Indian lands that require the disclosure of chemicals used in hydraulic fracturing operations, yet only after operations have been completed (US Bureau of Land Management, 2012).

While regulatory agencies in the United States have been in a reactive posture – and have struggled to keep up with industry developments – the European Union seems poised to take a more proactive approach in applying existing environmental legislation and formulating policies specific to shale gas extraction. In early 2012 the European Commission published a commissioned study on the existing legislative framework with regard to hydraulic fracturing (Philippe & Partners Law Firm, 2011). The study examined four case studies (France, Sweden, Germany and Poland) to assess what rules are in place in terms of licensing/permitting, including environmental law. The report does not assess whether all existing legislation has in fact been transposed into national law. The most important findings of the report, focusing in particular on the Polish case, can be found in Table 2. We will discuss this table in more detail in the subsequent section on the case of Poland.

Table 2. Summary of rules in place in Poland regarding shale gas in terms of licencing / permitting and environmental law (based on Philippe and Partners Law Firm, 2011).

Legislation	**Brief description**	**Link to shale gas**	**Relevant concerns/issues**
Hydrocarbons Directive 94/22/EC	General principles for granting and authorizing exploration and production of hydrocarbons.	Basic legislation regarding hydrocarbons extraction in the European Union. Member States have sovereign rights over their resources.	– In Poland mining usufruct with State Treasury is required next to relevant permits
Environmental Impact Assessment Directive 2011/92/EU	Procedure to ensure that projects that are likely to have significant effects on the environment are subject to an assessment, prior to approval.	Overall environmental impacts form basis of ongoing academic disputes, regarding drinking water, methane emissions and seismic activity.	– EIA is not mandatory, only subject to so-called Annex II projects – Polish Environment Ministry states that generally deep drilling methods require an EIA
Water Framework Directive 2000/60/EC, Ground Water Directive 2006/118/EC and Urban Waste Water Treatment Directive 91/271/EEC	These directives all aim to contribute to water protection in the Member States, transposed in Poland in the Water Law Act and the Environment Protection Act.	One of the contested areas of environmental impact of hydraulic fracturing and related activities.	– In Poland, there are no specific requirements regarding the prevention of contamination of ground and surface water
Mining Waste Directive 2006/21/EC	Waste from extractive industries requires prior permitting.	Links predominantly to the disposal of waste water after fracking has occurred	– While the more general Waste Directive 2008/98/EC may apply, but has not yet been transposed in Poland.
Directives related to the Emissions Trading Scheme (2009/29/EC and others) and Atmospheric Pollutant Directive 2001/81/EC	Legislation safeguarding air quality and monitoring a wide range of emissions, including carbon, methane, nitrogen oxides, volatile organic compounds and sulfur dioxide.	Methane leakage forms one of the most prominent disputes in academia, influencing the overall carbon footprint of shale gas (that proponents see as a bridging fuel).	– In case of exceeding the national emissions ceiling, the relevant authorities have to make a plan how to limit or revoke emission permits.
Environment Protection Act and the	Soil protection is a jurisdiction of the member	Certain land areas may be designated for other	–

Legislation	Brief description	Link to shale gas	Relevant concerns/issues
Act on Protection of Agricultural and Forest Land.	States, in Poland arranged through two laws. No specific permits relate to soil protection.	purposes than resource extraction	For shale gas extraction, it may be necessary to change the use of land as defined in so-called 'land development plans'.
Habitat Directive 92/43/EEC and the Wild Bird Directive 2009/147/EC	Directives form the cornerstone of European nature conservation policy, linked to the Natura 2000 network of protected sites.	With many protected nature conservation areas in Poland, regulation following from these Directives can apply to envisaged shale gas extraction sites.	– Activities in protected areas require prior assessment. In Poland projects could still be authorized *'for imperative reasons overriding public interest only'*. Unclear whether and if so how this linked to shale gas extraction.
Noise legislation, i.e., 2009/42/EC and 2000/14/EC	Activities related to shale gas are submitted to noise limitations. In Poland, hydrocarbon related activities fall in the scope of existing regulation.	As all industrial activity, shale gas extraction is submitted to noise limitations. This is expected to apply mostly to the drilling phase.	– Outdoor equipment noise standards are set not by the Ministry of the Environment but their colleagues on Economy.
Existing legislation with respect to the transport of chemicals 2008/68/EC and their registration 2006/1907/EC (REACH)	Legislation aims to regulate safe transport of dangerous good in the Member States. REACH regulates chemicals and their safe usage, dealing with registration, evaluation, authorization and restriction of chemicals.	Chemicals are a very small but crucial element of the fracking fluids used when extracting shale gas. Amongst others, chemical substances have been added to prevent corrosion or enhance viscosity.	– Implementation of directive on inland transport of dangerous goods has not been carried out in Poland. – No specific disclosure procedure on hydraulic fracturing fluids is currently in place in Poland. Relevant authorities may however require disclosure. – Operators seem to fall under REACH, yet is it not clear whether used chemicals meet relevant thresholds

In September 2012 the European Commission published three sizeable reports about the impacts of shale gas on markets, environment and climate (AEA, 2012a, AEA, 2012b and Pearson et al., 2012). The report on the environmental impacts of shale gas extraction concludes that shale gas extraction generally imposes a larger environmental footprint than conventional gas extraction (AEA, 2012b). It identifies environmental pressures in terms of land use, releases to air, noise pollution, surface and groundwater contamination, water resources, biodiversity impacts, traffic, visual impact and seismicity. Currently, nineteen pieces of European Union legislation are relevant to all or some of the stages of shale gas extraction. The study on climate impacts suggest that greenhouse gas emissions from shale gas generation are 2% to 10% lower than emissions from electricity generated from sources of conventional pipeline gas located outside of Europe, and 7% to 10% lower than that of electricity generated from LNG (AEA, 2012a). However, these results are entirely contingent upon effective control of emissions during the production phase (‘venting’). Questions remain as to what regulation would be appropriate to regulate emissions from shale gas extraction. The authors name the Environmental Impact Directive, the Directive on Industrial Emissions and the European Emissions Trading Scheme as possible vehicles.

3. Policy implications for Poland

Not a single molecule of shale gas has been produced in Poland, and many questions remain whether shale gas will actually be produced commercially in the future. Yet this has not stopped “shale gas euphoria” in Poland (Wyciszkiewicz et al., 2011), nor has it prevented active opposition to fracking in Brussels and elsewhere. The reasons for enthusiasm in Poland are numerous, but at the top of the list are concerns over (a) the high prices consumers pay for gas in Poland, and (from a producer’s perspective) the high rents that could be charged for domestically produced gas, and (b) a deep-held and widespread belief that the country is overly beholden to an undependable and unpredictable supplier, that being Russia. This latter concern about what is widely referred to as “energy security,” will be covered in a subsequent section.

3.1. Background on shale gas in Poland

Polish geologists have long known about the organically rich shale deposits stretching from the Baltic Sea southeasterly to the border with Ukraine. The technological innovations that led to the shale gas revolution in North America, however, opened up the prospect that these hitherto untapped reserves could be commercially exploited. The three basins in question, where there is potential for commercial exploitation, are: the Baltic Basin (northern), Podlasie Basin (east and east-central), and Lublin (southeast) (US Energy Information Administration, 2011). Poland is not new to natural gas production, but development of conventional oil and gas deposits in the past had mainly been in the southern Carpathian region (US Energy Information Administration, 2011) and was limited in international comparison. In 2010, Poland’s production of 215 bcf of natural gas was about 2% of the European total production. By contrast, Poland has long been a large producer and consumer of coal. In 2010, it produced 146 million short tons of coal, or about 20% of European production (US Energy Information Administration, 2012).

This rather modest history of natural gas production, then, made the estimates of the US EIA all the more sensational when they came out in April 2011. The US EIA had estimated that technically recoverable shale gas resources are roughly 187 tcf (5300 bcm), or nearly 900 times Poland's 2010 consumption of gas. Less than a year later, the Polish Geological Institute released a preliminary assessment that was much more modest, estimating 1920 bcm of shale gas, of which somewhere between 350 bcm and 770 bcm is likely recoverable (Polish Geological Institute, 2012). It is important to note that since not a single molecule of gas has been obtained from the exploratory wells, these figures represent statistical probabilities based on the known stratigraphy of the regions in question. The US EIA estimates put Poland's shale gas resources as the largest in the EU, with other substantial basins located in France (with over 150 tcf of technically recoverable shale gas spread out over the country) and Scandinavia (with comparable figures) (US Energy Information Administration, 2011).

As of April 2012, seventeen wells have been drilled, two of them horizontal, with several drilling operations underway (Talisman Energy, ENI). The two horizontal wells and a handful of vertical wells had been hydraulically fractured. Cores of shale rock are currently in the hands of geochemists in laboratories in the USA and Canada. Industry officials have told us that the preliminary findings are "very promising," but there have also been indications from 3 Legs and BNK Petroleum that wells drilled in Poland underperformed expectations.7 In June of 2012 Exxon Mobil even decided to end shale gas tests in Poland. All this indicates the embryonic state in which the Polish shale gas sector currently is, though Polish policy makers would love to believe otherwise. Another example is the underdeveloped gas and oil service industry that is present in Poland with only two hands full of drilling rigs. Moreover, there is no clear indication yet whether the economic and political conditions in Poland will be favorable enough for industry players to justify further exploitation of this resource. While all policy makers in Warsaw we talked to are highly in favor of developing Polish shale gas reserves as soon as possible, there are substantial hurdles to be overcome, as we will see in the following sections.

3.2. Infrastructural limitations

Poland could be typified as gas country under construction. Traditionally the share of natural gas has been limited, with a yearly domestic consumption of around 14 bcm, forming roughly 13% of its primary energy consumption. Of this gas one third is produced domestically, while the rest is imported, exclusively from Russia. Given the limited role of natural gas in the Polish energy mix, it is no surprise that infrastructure is not substantially developed. To give an example, only 54.6% of households currently has access to the gas network (Central Statistical Office (Poland), 2012). Most pipelines are located in the south west of the country, where industry is clustered, and around the main urban areas, but not necessarily in the areas where shale gas would be produced. Furthermore large transit pipelines have been built across the country from east to west.

With the emergence of shale gas reserves and continued high dependence of Russian gas imports, increased investments in Polish gas infrastructure can be identified. The demand forecasts used by the national transmission system operator, called Gaz-System, show that maximum gas demand in Poland is expected to double within this decade, to as estimated 30 bcm in 2021. First, Gaz-System is investing in interconnection capacity to get the Polish gas market out of its isolation and connect it to neighboring countries to its west and south. The existing interconnector with Germany in Lasów has been upgraded to a maximum capacity of 1.5 bcm starting January 2012. To the south an interconnector has been launched in September 2011 on the border with Czech Republic at Cieszyn with a capacity of 0.5 bcm, albeit not yet two-directional. These investments are part of the Transmission System Development Program for 2010–2014 in which 1000 km of new pipeline are envisaged.

Next to these commissioned projects, several interconnections are under study. In January 2012, Gaz System and its Lithuanian counterpart Lietuvos started a feasibility study on an interconnector between the two countries. In 2013, Gaz System and Eustream are expected to present their findings regarding an interconnector between Poland and Slovakia. Later this year both existing interconnectors with Germany and Czech Republic may receive green lights for further upgrade as well. Both these projects were substantially financed through the European Energy Program for Recovery (European Union, 2010), i.e., € 10.5 million for the Czech interconnector and € 14.5 million for the German interconnector.

Next to these infrastructural projects that are intended to reshape the Polish gas market and connect it to the European Union, there are several developments that could contribute to further diversification of gas supplies in Poland. Currently the most tangible project is an LNG terminal that is constructed in Świnoujście in the north west of the country. Its maximum capacity is 5 bcm at a cost of € 700 million, of which roughly half is financed by the European Commission (Polish News Bulletin, 2011). In addition the European Investment Bank has loaned Poland approximately € 135 million to realize this project (European Investment Bank, 2011).

Furthermore the so-called Baltic Pipe is in its pre-construction phase, eventually aiming to link Poland and Denmark. It is intended to give Poland access to Norwegian gas, while the Danish have expressed interest in receiving Russian gas from Poland. The European Commission envisages investing € 150 million in this pipeline (European Commission, 2009).

And then there might be shale gas. The verdict of private companies is out regarding the potential future development of the reserves. The lack of sufficient infrastructure is certainly one consideration potential investors are considering in light of the geographical location of shale resources stretching in a band from around Gdańsk to the Ukrainian border in the south east. Additional investments in infrastructure may be necessary to ship large amounts of shale gas, either domestically or internationally. Even without those additional investments, ongoing infrastructural projects may well occupy at least the first part of this decade. With substantial new supplies coming online from then onward – with for instance the commissioning of the LNG terminal in Świnoujście – the pressure is on for Polish transmission system operators and policy makers to prepare its domestic market for either gas consumption or significant gas imports and exports.

3.3. Regulatory hurdles

Next to infrastructural challenges, Poland also has regulatory hurdles to overcome. A report commissioned by the European Commission in January 2012 seemed to buoy Polish ambitions, as it concluded that the regulatory framework was appropriate for the current state of exploration of shale gas in the four countries under study, including Poland (Philippe & Partners Law Firm, 2011). The study did not, however, provide any guidance in terms of under what conditions commercial-scale development would occur. As Table 2 demonstrates, under current circumstances the Polish authorities have not fully implemented all existing European guidelines related to shale gas, e.g., the Waste Directive or the Directive on inland transport of dangerous goods. Furthermore, several issues are not part of the regulatory framework but, referring to current debates in the United States, would deserve attention in case of commercial exploitation of shale gas. The most obvious examples of this are the lack of specific requirements regarding the prevention of contamination of ground and surface water or the absence of specific disclosure procedures on hydraulic fracturing fluids. Needless to say, these elements are not in place anywhere in the European Union at this stage, but they seem valuable lessons learned for Poland to become a responsible front runner in shale gas extraction.

Next to environmental and procedural regulations, Poland will have to meet the obligations as laid down in the European legislation for the internal market of gas (European Union, 2009). Though theoretically the Polish market is open to competition since 2007, some serious obstacles remain. State-owned incumbent company PGNiG represents 97.5% of gas sales in the country and is also responsible for all distribution networks in the country. Therefore short term competition in the market is difficult to envisage. It remains to be seen when natural gas price regulation will be abandoned, but this is not expected before 2013.

So what can the European Commission do when regulations have not been implemented? Formally, under the Treaty of the Functioning of the European Union, the Commission guards over proper implementation of European law in the Member States and can start infringement proceedings in case of non-compliance. Ultimately the Commission may also refer the case to the European Court of Justice. History has shown that the Commission sometimes struggles to compel Member States to implement European law, despite its formal powers to do so. These cases mostly involve non-compliance of large Member States or non-compliance of a large number of Member States. Examples are the partial implementation of unbundling regulations by France and Germany or the delayed implementation of biofuels regulations in almost all Member States. Regarding shale gas however, it seems that Poland is increasingly becoming isolated, in that its officials are practically alone in Brussels advocating of shale gas exploitation, while representatives of other Member States are either silent or are simply opposing. Therefore, despite its importance in Brussels, the European Commission is expected to have substantial leverage to motivate Poland to implement relevant legislation promptly.

4. Energy (in)security and the geopolitics equation

When energy becomes an instrument, or even weapon, it stops being an economic issue and becomes a matter of national security," … [it cannot] "simply be resolved by pressing several free-market buttons labeled 'liberalization,' 'competition,' etc." (Radek Sikorski 7 May 2008, quoted in Roth, 2011).

While industry balances economic with geologic realities in assessing the potentials for shale gas development in Poland, our interviews with government officials in Poland revealed an even more pressing agenda impacting their interest in shale gas: energy security. Traditionally, energy security policy agendas have been rooted in a merger of national security and energy supplies, and are based on the assumption that a core function of a state's domestic and foreign policy is to ensure access to reliable and affordable energy sources. As is well-documented (see, e.g., Yergin, 2006), however, the definition of energy security is highly context-dependent. While the

US experience – and nearly forty years of government policy – is still influenced by the oil embargoes of the 1970s, current EU policy focuses on stability, affordability, and sustainability (European Union, 2007). For the purposes of this paper, we are less interested in putting forth our own interpretation of energy security than in presenting how this essentially contested term frames the debate over shale gas in Poland and the EU.

Poland's energy security agenda is colored by profound distrust of Russia, and even of Poland's fellow EU member states, on questions of energy resources. This is perhaps not surprising, given the history of war, subjugation, hegemony, and mistrust in this part of Europe, historically often under the yoke of Russia and Germany. But alongside the tragedies of history is a seemingly unacknowledged reality that Russian companies have been stable suppliers of both natural gas and crude oil to Poland for many decades. During the oft-cited price dispute between Russia and Ukraine in January 2009, which caused supply interruptions to European consumers and caused some in Southeastern Europe to actually go without gas for several days, Gazprom actually increased shipments substantially to Europe via the Yamal pipeline (which traverses Belarus and Poland), so that consumers in Poland and Germany did not feel the interruption (Le Coq and Paltseva, 2012).

Energy security has special meaning for Poland ("geopolitical vulnerability"). Energy policy discourse in Poland exhibits a high degree of "securitization," meaning that the topic of energy is often framed in terms of national security and an existential threat (Roth, 2011). The security aspects of the current shale gas discussions in Poland are noteworthy, and the securitization of the debate stands in contrast to energy discussions in other parts of Europe. This is in contrast to other EU member states, e.g., Germany, which has traditionally treated energy as primarily economic considerations not strategic ones, and has viewed Russia as basically adhering to market norms (Umbach, 2010). Since joining the European Union in 2004, Poland has been a strong voice in bringing energy to the fore of discussions of European external relations amid widespread perceptions in Central and Eastern Europe that energy policy in the EU prior to the 2004 enlargement had not sufficiently addressed Europe's overdependence on energy imports (Roth, 2011). While Poland's efforts to create an "energy NATO" in the EU, whereby supply threats to one member state constituted a threat to every member (the "Musketeer" principle) were ultimately not successful, it was largely Polish efforts that led to "energy solidarity" language being inserted into the Lisbon Treaty and Poland has very actively pursued additional funding for new energy infrastructure (Roth, 2011), the latter for obvious reasons as we will argue later. While the securitization of shale gas in certain circles of the Polish elite is perhaps understandable, it is also very likely counterproductive given the actual administrative and legislative hurdles that could impede the development of this resource.

Dependency on Russia has been a heated topic of discussion in the EU, and Poland in particular. Some have even speculated that the development of unconventional gas resources in Europe is enabled by the unpredictability of Russian supplies (Kuhn and Umbach, 2011). The recent inauguration of the Nord Stream pipeline linking Russia and Germany beneath the Baltic Sea represents a strategy by both governments, Gazprom, and western European utilities to reduce transit risk by bypassing intermediary countries such as Ukraine and Belarus. The reaction in Poland to the Nord Stream fairly predictably was negative, since it was also bypassed by the pipeline, thought that was likely coincidental. This did not prevent some observers from recalling the past, with some calling Nord Stream the “Molotov–Ribbentrop pipeline,” (Le Coq and Paltseva, 2012)—the now foreign minister (then defense minister) Radek Sikorski made allusion to the Nazi–Soviet non-aggression pact in 2006 (Roth, 2011). Since the inauguration of the Nord Stream pipeline, there has been a great fear in Poland that Russia would be in a better position to use gas as a political blunt instrument.

Amid the widespread speculation and conspiracy theories surrounding Russia and framing the need to develop local shale gas resources as a hedge against external threats to Poland’s energy security, there are a few things worth noting. Several assessments of the risk to EU gas supply have highlighted the lack of interconnectivity within the EU, and not Russian aggression, as being the main transit risk (Le Coq and Paltseva, 2012 and Noël, 2009). Contrary to a commonly held view, transit risk did not increase in the period 1998–2008 (Le Coq and Paltseva, 2012). While the Kremlin has obviously used its energy export capabilities as a short-term leveraging tool in the past, historical examples of this underscore the point made by Larsson (2006) that supply interruptions targeted at Poland or another EU member state are highly unlikely, as are long-term cutoffs that would impact Poland or another EU member state for an extended period of time. Moreover, more often than not Russia failed to achieve the political concessions it sought with supply disruptions (Smith Stegen, 2011).

Even if Russia were to use its gas as a political instrument in the future, without significant investment in new conventional gas fields such as Yamal or Shtokman, it is unclear whether Russia is in a position to meet future demand both domestic and abroad (Söderbergh et al., 2010). Several officials in Poland pointed off the record to German and French governments as having anti-shale agendas, whether rooted in the alleged desire of Germany to increase exports of renewable energy technologies, or in France’s powerful nuclear interests. While there is not much evidence for anti-shale conspiracies in other member states, Polish policy makers seem committed to toe a line between engaging other European member states and European institutions regarding this topic, while maintaining rhetorically that exploitation of domestic energy resources has traditionally been treated as the purview of individual member states. Up to date it is unclear why that would not be the case with shale gas. Our interviews with policy makers in Brussels also suggest that the Polish authorities are encouraged to make their own decisions regarding the extraction of their natural resources, within the regulatory framework that is currently in place.

While the securitization of shale gas in certain circles of the Polish elite is perhaps understandable, it is also very likely counterproductive given the actual administrative and legislative hurdles that could impede the development of this resource. Moreover, in lack of coordination, Polish efforts to excite other member states for future shale gas extraction have appeared rather opportunistic. Just before the country took over the six-months presidency of the European Union it suggested that shale gas extraction should be a project of common European interest, while six months later this position had shifted (Wyciszkiewicz et al., 2011). It is worth noting that over the summer France had decided to ban hydraulic fracturing, while other member states had announced further research into environmental concerns. After the French ban, the European Commission reiterated that it 'remains neutral' as regards member states decisions concerning their energy mix.8

Polish officials often argue that Poland's dependence on Russian gas supplies is risky. Even if Russia were not a dependable supplier – which is questionable as just shown – it remains unclear why that would be a problem for a country that uses almost exclusively oil and coal as primary energy resources. One possible scenario is that current attempts by the Polish transmission system operator Gaz-System, Polish government officials, and others involved in the development of the Polish gas market will in fact lead to increased future dependence on Russia. Even when assumed that Polish shale gas will be extracted at some point, the most recent geologic forecasts demonstrate that there will only be sufficient supplies to cover a few decades at present rates of use assuming domestic gas were substituted for imports. Thus, at some point as hypothetical shale gas runs its course in the Poland's energy mix, price will dictate what shall replace it in that pipeline infrastructure, which means likely either LNG or Russian gas.

5. Conclusions

This paper has provided an overview of the geologic, economic, environmental and political-regulatory issues related to shale gas and hydraulic fracturing, and it has used the case of Poland to examine the prospects for a nascent shale gas industry in that country. While certain market conditions are certainly ripe for additional supplies of natural gas coming on stream in this part of Europe, high consumer prices and dependence on a small number of suppliers are by themselves not sufficient to ensure that this resource is developed in the future. Geological realities, coupled with infrastructural limitations, valid environmental concerns, and regulatory uncertainties, pose significant hurdles to shale gas development in Poland. In short, it is far from certain whether the obstacles facing industry and policy makers will be overcome. What stands out in the Polish case is that even under favorable geologic and market conditions, there are substantial infrastructural, political and regulatory hurdles to be overcome. At least part of the key to shale gas development therefore seems to lie in the halls of government of Warsaw.

While this paper has assessed some of the larger-scale issues in the economic and political environments in Poland, the European Union, and beyond, we were not in a position to assess local challenges to shale gas development. North Americans, at least those in places such as Texas, Oklahoma, and Alberta, are largely accustomed to hydrocarbon extraction and the resulting disturbances to the landscape, noise pollution, in combination with substantial royalty checks (at least in the US), but the same cannot be said of those living in the regions where shale gas development would likely take place in Poland. Public opposition there has so far been barely visible, but so has the extent of exploratory drilling. The lack of public opposition is likely related to a combination of factors, including the historical tensions and mistrust between Poland and Russia, but it is too early to assess to what extent the Polish public would welcome large scale shale gas development.

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