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TITLE

Post-conventional energy futures: rendering Europe's shale gas resources governable

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Abstract

Following the shale gas boom in the United States, unconventional natural gas extracted from organic-rich shale rock formations has generated increasing attention in the European Union (EU). This considerable interest has been spurred by a range of optimistic volumetric appraisals of shale gas resource potential trapped beneath the European continent. The paper critically examines rationalities and practices through which states of resource availability and recoverability are made visible, measurable, intelligible, and thus rendered governable, namely open to new fields of possibilities to act upon. By implementing the concept of socio-technical imaginaries as governmentality approach, the analysis is guided by two objectives: first, to identify visions of shale gas potential contained in a range of resource estimates; second, to scrutinize rationalities of government, that is how shale gas resources are made knowable and purposeful, as well as technologies of government that operationalize these rationalities via practices of calculation, visualisation, and inscription. The paper illustrates that, these highly speculative and uncertain assessments can forge powerful volumetric imaginaries of shale gas potential that yield specific governing effects concerned with securitization of unconventional hydrocarbons availability. Consequently, these imaginaries prescribe and legitimize technological hopes for certain post-conventional energy futures underpinning the fossil fuel abundance narrative.

Keywords

shale gas, sociotechnical imaginaries, governmentality, Europe

1. Introduction

Since the 1970s, a growing number of concerned scientists and experts have been signalling that – due to the unprecedented exploitation of natural resources and unsustainable consumption patterns – humanity was increasingly closer to reaching planetary limits that would not be avoided if exponential economic growth continued (Meadows et al. 1972; Ward and Dubos 1972). Some scholars and practitioners have been particularly concerned with presumably unavoidable depletion of exhaustible energy resources, such as low-cost conventional fossil fuels, that the global economy has vitally relied on (Deffeyes 2001; Hubbert 1971). The fossil fuel scarcity narrative was notably bolstered by assertions raised by M. King Hubbert who accurately predicted that production of crude oil from conventional deposits in the United States (U.S.) would peak around 1970 (Hemmingsen 2009; Bridge 2010). Marking the near end of the 20th-century, Campbell and Laherrère famously warned that the entire world would soon meet the same fate, facing “the end of the abundant and cheap oil on which all industrial nations depend” (Campbell and Laherrère 1998). The looming end of the age of low-cost, conventional hydrocarbons together with the increasing dependence on supplies from a few, often politically unstable countries, have urged policy-makers to revise essential energy resource flows and counter potential scarcity by resorting to the logic of securitization: namely, framing energy as a matter of “security” and deploying a variety of calculative techniques and regulatory practices – e.g.: estimates, indicators, strategic planning and policy-making – to reduce risks and control uncertainty (Bridge 2014, Speirs et al. 2015).

Simultaneously, however, pessimistic claims of inevitable depletion of vital conventional energy resources have been shrugged off by the camp of scholars and industry analysts who maintained that further economic development and application of novel technologies would allow for substitution of more abundant and cheap fuels for scarcer and more expensive ones. Hence, parallel to scarcity concerns raised by the “limits to growth”- and “peak oil”-alarmists

ran the sanguine or “triumphalist”, as Bridge (2000) calls it, fossil fuel abundance narrative of inexhaustible geological possibilities facilitated by improvements in extraction techniques. Since the 1970s, optimistic analysts asserted that, instead of considering only presently *known* and recoverable deposits, most often expressed in reserve estimates, long-term policy planning necessitates inclusion of the *unknown*, namely uneconomic and undiscovered (or overlooked) resources that would be possible to extract in a technologically advanced future (McKelvey 1972). Such a techno-optimistic approach – based on the supposition of a continuous economic growth – would make it possible to surpass limitations of resource availability by broadening potentials of the earth's crust to future discoveries and innovations. This cornucopian narrative was affirmed particularly by energy system analyst Rogner who claimed in his widely cited assessment from 1997 that the potentially dramatic increase in access to fossil fuel resources is possible through the inclusion of *unconventional* hydrocarbons and mobilization of new techniques of extraction (Rogner 1997).

During the last decade, the argument for pushing the boundaries of resource availability outside the limits of conventional fossil fuels has not only returned to the debate on the future of global energy systems but it has also gathered significant momentum. In the United States (U.S.), the recent employment of innovative technologies involving horizontal drilling and hydraulic fracturing (known in short as “fracking”) has made it possible to unlock and extract significant volumes of unconventional natural gas preserved within organic-rich, sedimentary shale rock formations. As a result, the combination of these advanced extraction techniques has allowed the U.S. to increase the share of shale in total domestic gas supply from 1% in 2000 to 20% in 2010 (Kefferputz, 2010).

Following the U.S. shale gas “revolution”, the potential of unconventional natural gas from shale formations have recently appeared on the geopolitical map of the European Union (EU). Since 2009, a growing number of optimistic but uncertain estimates, assessments and future

energy scenarios of possible shale gas resource occurrences, stocks and recovery capacities (McGlade et al. 2013b) have triggered a political debate that epitomises some of the fundamental questions regarding the EU's future energy security and sustainable energy transition. One hand, shale gas has been perceived as a way to diversify energy supplies and reduce dependence from gas imports (COM 2014a; IEA 2011; Kuhn and Umbach 2011). On the other hand, referred to as “clean” fossil fuel, unconventional gas production has been perceived as an option to help reduce greenhouse gas emissions and thus contribute to climate mitigation efforts (IEA 2011; Weijermars et al. 2011). Amid large uncertainties of currently available geological and economic data on shale gas production potential in the European subterranean region, these volumetric assessments and projections have been translated into (supra)national energy security strategies and decisions, consequently fuelling and legitimizing political and technological hopes for certain post-conventional energy futures in the EU and some of its member-states.

In this paper, I use the case of inventorying, anticipating and prescribing the future shale gas potential in the EU to critically analyse devices and practices through which states of resource availability and recoverability are diagnosed, assessed and thus rendered governable, namely strategized and securitized. By applying the concept of *sociotechnical imaginaries* (Jasanoff and Kim 2009, 2013, 2015) as a specific type of *governmentality* analysis (Rose et al 2006; Dean 2010; Burchell et al. 1991; Foucault 2007) capable of interrogating the history of future projections, the study is guided by a dual objective. Firstly, I aim at identifying and mapping visions of shale gas potential contained in a range of resource estimates and assessments. Secondly, the objective is to scrutinize rationalities of government, i.e. how shale gas resources become knowable and their existence made purposeful, and technologies of government that operationalize these rationalities through practices of calculations, visualisation, mapping and

inscription deployed by a multiplicity of agents and institutions to produce evidence for these future claims.

The analysis is based on critical, in-depth reading of expertise concerned with estimates of shale gas resource potential in Europe. The point of analytical entry consists of key reports, assessments and technical papers issued by researchers, public institutions and private agencies (i.e. ARI 2009; BGR 2011; EIA/ARI 211, 2013; Medlock 2011; Rogner 1997; WEC 2010). Resource estimates that were not publically available (i.e. CERA 2009; Medlock 2012; Wood McKenzie 2009) were appraised through the scholarly work on unconventional gas in Europe (e.g. Weijermars 2013). Particularly helpful in collecting estimates as well as discerning definitions and methods of calculation were reviews of regional and global shale gas resource estimates by McGlade et al (2013a, 2013b) and UKERC (2012). Additionally, the analysis also draws upon close reading of national geological surveys, national policy documents and energy analyses in selected EU-member countries.

The following study benefits from and contributes to two burgeoning strains of critical social science scholarship within the vast ocean of energy research: one related to the approach of sociotechnical imaginaries scrutinizing (in)ternational energy policy visions and futures (Ballo 2015; Eaton et al 2014; Engels and Münch 2015; Jasanoff and Kim 2009, 2013, 2015; Kuchler 2014; Korsnes 2016; Levidow and Papaioannou 2013; Moezzi and Janda 2014; Smith and Tidwell 2016; Wentland 2016); the other increasingly concerned with interrogating powerful fossil fuel narratives and practices of resource estimates (Barry 2013; Bridge 2010; Hemmingsen 2009, 2010; Kama 2013; Huber 2011, 2012; Mitchell 2011; Valdiva 2015; Weszkalnys 2015).

The following pages are organized as follows. In Section 2, I outline the analytical concepts of sociotechnical imaginaries and governmentality, by exemplifying how these two approaches are combined and deployed in the paper. In Section 3, I discuss the analytical findings in three

subsections: the first examines how unconventional natural gas resources are made visible; the second scrutinizes how the shale gas extraction potential in Europe is made calculable; and the third discusses how powerful shale gas imaginaries are made governable, i.e. securitized and strategized. Finally, the conclusions are presented in Section 4.

2. Sociotechnical imaginaries and governmentality

In recent years, the concept of *sociotechnical imaginaries* – introduced and developed by Jasanoff and Kim (2009, 2013, 2015) – has proliferated as an analytical approach in critical social science studies scrutinizing (inter)national energy policy visions and futures concerned with, e.g. nuclear power (Jasanoff and Kim 2009, 2013, 2015), bioenergy (Eaton et al 2014; Kuchler 2014; Levidow and Papaioannou 2013), smart grids (Ballo 2015; Engels and Münch 2015), offshore wind industry (Korsnes 2016), building energy use (Moezzi and Janda 2014), and national energy transitions (Smith and Tidwell 2016; Wentland 2016). This scholarship has drawn attention to the significant role of new energy imaginaries – frequently shaped by energy choices of the past – in the challenge of reconfiguring both the surface and subsurface infrastructures of global energy systems.

The concept of sociotechnical imaginaries serves as an interpretative envelope that lets us consider *power to imagine futures* as a fundamental and productive element of the socio-political life, capable of facilitating and/or influencing techno-scientific trajectories through projections of what is considered desirable and attainable in terms of current and anticipated knowledge (Jasanoff and Kim 2009). Such powerful visions, then, serve political ends and legitimate specific technological choices or responses to innovation (Jasanoff and Kim 2013; Kuchler 2014). Hence, imaginaries do not only have *descriptive* capabilities of projecting desirable and attainable futures but – as virtue of their performative dimension (Geels and Smit 2000) – they especially possess *prescriptive* powers by envisioning “futures that states believe

ought to be attained” (Jasanoff and Kim 2009, p. 120). Jasanoff and Kim (2009) emphasize that – unlike issue specific and goal-oriented policy agendas – sociotechnical imaginaries are inexplicit and unfixed, “as they reside in the reservoir of norms and discourses, metaphors and cultural meanings out of which actors build their policy preferences” (p. 123). Simultaneously, such imaginaries underpin grand societal narratives as they “offer a rationale for a society’s long evolutionary course while also committing that society to keep performing the imagined lines in the story” (Jasanoff and Kim 2015, p. 20) Furthermore, these scholars associate their concept with “active exercises of state power” (Jasanoff and Kim 2009, p. 123), affirming the significant role of governments in stabilizing specific visions and mobilizing resources to attain desired techno-scientific trajectories.

However, while useful for identifying and illuminating visions that describe and prescribe desirable futures, the concept coined by Jasanoff and Kim (2009, 2013, 2015) gives us few clues as to how such imaginaries come to existence, how they become visible, intelligible and accounted for, and how they are operationalised, transformed into practice and therefore made governable. In this sense, the approach lacks epistemic tools to answer the questions on: what type of prescriptive powers can make the state believe that some futures ought to be attained or how specific visions and expectations become ingrained in social practices and organization.

I argue that the concept of *governmentality*, introduced by Michel Foucault (Burchell et al. 1991; Foucault 1978, 1983, 2007), can provide us with valuable epistemic assistance. On a general level, the governmentality lens lets us perceive power to imagine futures as “a complex strategic situation” (Foucault 1978, p. 93) that has to be analysed in relational terms. In his analytics of novel forms of government that arrived with the emergence of the modern Western state, Foucault notably defines a relationship of power as the *conduct of conduct*, meaning “action upon action, on existing actions or on those which may arise in the present or future”

(p. 220). Power, in this sense, is “a way in which certain actions may structure the field of other possible actions” (Foucault 1983, p. 222).

Governmentality, then, is not an investigation of grand political ideas and decisions but, rather, it is a “micro-political analytics of power” (Lövbrand and Stripple 2015, p. 95) that calls our attention to the seemingly soft and unpretentious range of various tactics, techniques and dispositions through which power can operate and be productive; or as Miller and Rose (2008) note, “mundane mechanisms which appear to make it possible to govern: techniques of notation, computation and calculation; procedures of examination and assessment; the invention of devices such as surveys and presentational forms such as tables” (p. 32). Hence, like the concept of sociotechnical imaginaries, governmentality requires our attention to language to analyse the multitude and mundane ways through which power to imagine futures is conceptualized, explained, calculated and inhabited (Miller and Rose 2008). This discursive character of governmentality, as Foucault (1978) contends, stems from the fact that “it is in discourse that power and knowledge are joint together” (p. 100). By shedding light on this reciprocal effect of the knowledge-power relationship, the governmentality approach asks not only about what makes this conjunction necessary but especially about how it is deployed in practice and thus constitutes a given subject governable, e.g. administrable and manageable (Foucault 1978, 1983, 2007; Rose-Redwood 2006). In other words, Foucault’s analytics of government lets us expose linkages between the production of knowledge – e.g. speculative apparatuses of describing, estimating, and appraising to let us know the potential of a given geological resource – and ways of acting upon this knowable resource by prescribing its future potential in different forms of administering, regulating and strategizing. .

The concept of governmentality can also turn our attention to the multiple, mundane and dispersed ways through which power to imagine futures “is exercised ‘at a distance’ beyond the narrow confinements of state policies” (Methmann 2013, p. 4). Contrary to sociotechnical

imaginaries, the governmentality lens lets us look beyond the state as the sole point or source of power and, instead, sheds light on heterogeneous loci and multiple origins of calculation, estimation, inscription and diagnostics of shale gas potential (Lövbrand and Stripple 2015). In this sense, power to imagine futures is dispersed among different state and non-state actors assembled in loose networks and constellations of experts, practitioners, private consultancy agencies or international institutions, at different levels of governance (Miller and Rose 2008, p. 33–34).

My analytics of shale gas imaginaries in the EU draws inspiration from several studies in political geography that have implemented governmentality to illustrate how the deployment of power through various apparatuses of geographical knowledge production, render territory and its natural landscape a governable domain prone to practices of economic calculations and political regulations (Rose et al. 2006; Rose-Redwood 2006). For example, Ó Tuathail (1996) argues that central to the formation of modern governments were spatial practices of “geopower”: an ensemble of geographical knowledge and technologies of landscape “geo-coding” that made management of territorial space possible and effective. In his study of Canada’s 19th-century exploration and appropriation of minerals, Braun (2000) shows that geological surveys were a significant governmental technology that “involved bringing the qualities of the state’s territory into the domain of political rationality, and in turn into proximity with other bodies of knowledge (...) so as to put the state’s resources to their most full and profitable use” (p. 28). By studying forest management in the 19th-century colonial India, Agarwal (2005) illustrates how modern surveys and inventories – that rendered forested lands as statistical and volumetric representations – made it possible to commensurate forest resources and thus manage them in terms of economic yields and revenues. In his work on governmental practices of “geo-metrics” in modern Europe, Elden (2007) argues that territory “is more than merely land, but a rendering

of the emergent concept of 'space' as a political category: owned, distributed, mapped, calculated, bordered, and controlled" (p. 578).

In this paper, I propose that the concept of sociotechnical imaginaries can be understood as a specific type of governmentality analysis able to interrogate the history of future estimates, visions and projections that have not yet materialized but that make Europe's future shale gas potential governable, i.e. strategized and securitized in the EU's energy policy. Hence, in my micro-political analytics of power to imagine futures I turn my attention to "the institutions, procedures, analyses and reflections, the calculations and tactics that allow the exercise of this very specific albeit complex form of power" (Rose and Miller 2006, p. 27). More specifically, I focus on two key aspects of governmentality: *rationalities of government*, namely how shale gas resources become knowable and their existence made purposeful; and *technologies of government* that operationalize rationalities through a myriad of mundane, soft, dispersed and speculative practices of calculations, visualisation, mapping and inscription that are deployed by a multiplicity of agents and institutions (Miller and Rose 2008).

Certainly, this is not the first analytical attempt to unpack and scrutinize various methods of discovering and estimating that underpin often highly contentious and uncertain claims about the availability and depletion of hydrocarbons. This paper benefits from and contributes to the growing body of critical scholarly work that has embarked on the task to study these powerful fossil fuels narratives (Barry 2013; Bridge 2010; Hemmingsen 2009, 2010; Kama 2013; Huber 2011; Mitchell 2011; Valdiva 2015; Weszkalnys 2015). For example, Kama (2013) illustrates the contested nature of "unconventional" oil shale in Estonia and how the resource classification is entangled within a combination of geo-scientific, economic and political calculations. In her analysis of Alberta's oil sands, Hemmingsen (2009) demonstrates how geological occurrences of bitumen deposits become estimated and categorized as "reserves" and therefore made intelligible to the market. Weszkalnys (2015), on the other hand, studies

how the phenomenon of “first oil” produced by different forms of speculative and often incomplete knowledge infuses the powerful imaginary of petroleum exploitation in maritime zones surrounding a tiny island nation of São Tomé and Príncipe.

3. Analysis

The analytical section begins by examining how the European shale gas imaginary has been made visible, describable and knowable. The second section of the analysis turns its attention to the question of how the shale gas extraction potential in Europe has been made calculable, measurable and thus intelligible. The last section discusses the ways the power of shale gas imaginary opens up new fields of opportunities for strategic actions that are translated to and prescribed in specific energy security policies.

3.1. Making shale gas imaginaries visible

Geologists, energy experts and industry practitioners have long speculated that the earth’s crust across the world concealed organic-rich shale rock formations which could potentially become a massive source of natural gas (Kuuskraa and Meyers 1983; Masters et al 1990; Rogner 1997). It is argued that, until late 1990s, these hypothetically abundant unconventional resources were overlooked or simply ignored as just an accidental by-product of conventional fossil fuel exploitation, particularly crude oil (IEA 2009; Smil 2015). However, the process of rendering unconventional natural gas imaginaries visible and knowable has been, to paraphrase Foucault (2002, p. 154), accomplished by two rationalities of government – one of *arrangement* and one of *designation* – that, by insisting on shale gas appraisal and prescription, set out a range of technologies of government: i.e. mundane, dispersed and speculative practices of measuring, visualising, outlining, classifying, inventorying, and persuading and so on.

The arrangement – operationalized by techniques of calculation, classification, inscription, systematisation, and stocktaking – has its beginning long before the recent U.S. shale gas “revolution” and emanates from two opposite but mutually reinforcing narratives of abundance and scarcity. In light of increasing awareness raised in the 1970s by researchers and experts concerned with the global limits to growth and potential risks associated with the scarcity of vital but exhaustible resources, such as cheap crude oil (Hubbert 1971, 1977; Meadows et al. 1972; Ward and Dubos 1972; see also: Bridge 2010; Hemmingsen 2010), other researchers and industry practitioners argued that it is necessary to transcend the constraints of known amounts of mineral deposits. Against the gloomy neo-Malthusian visions of a finite nature of exhaustible fossil fuels, McKelvey (1972) advocated that energy experts should break with thinking only in terms of resources categorized as discovered and recoverable reserves “consisting merely of materials in known deposits producible under present economic and technological conditions” (p. 34). He insisted that, in order to make long-term policy planning and decision-making more effective, energy outlook should be broadened by the magnitude of *potential* supplies and “take account both of the extent of undiscovered deposits as well as deposits that cannot be produced now but may become workable in the future” (p. 34). To make the assessment of those yet-to-be discovered and economically viable mineral deposits somehow possible, McKelvey (1972) proposed “a system of resource classification and terminology that brings out the classes of resources” that must be considered in apprising future global energy supplies (p. 34). His system of classification, systematization, visualisation and inventorying (Figure 1) would then render the *unknown* as a knowable, visible and intelligible phenomenon that can be further appraised, calculated, estimated and therefore also constituted governable, i.e. manageable and administrable. Despite large in-built uncertainties populating proposed practices of assessing the future *potential* of energy resources, such as crude oil and natural gas, the imaginary of a hidden abundance was made probable, visible and thinkable by rationalizing the unknown.

In his assessment of world hydrocarbon resources – published 25 years after McKelvey’s study from 1972 – energy systems analyst Rogner (1997) continued with a similar criticism of the widespread tendency to overlook the *known unknowns* of the Earth’s geological potential and maintained that the prevailing industry focus on reserves “seriously underestimates long-term global hydrocarbon availability” (p. 217). He then advanced McKelvey’s proposition and pushed the conceptual envelope of undiscovered and uneconomic resource deposits further by arguing that “if the vast unconventional hydrocarbon occurrences are included in the resource estimates and historically observed rates of technology change are applied to their mobilization, the potential accessibility of fossil sources increases dramatically” (Rogner 1997, p. 217). With highly optimistic presumption of “economics, advances in the geosciences, and technological progress in the upstream production operations”, Rogner updated McKelvey’s “ironclad matrix structure” (Figure 1) with more sophisticated classifications and terminologies of reserves and particularly of resources that would render the dynamic nature of geological occurrences and their potential technological recoverability (Rogner 1997, p. 219–220).

Most importantly, Rogner (1997) provided global estimates of unconventional natural gas, including gas from fractured shale rocks. He based his hypothesis on geological information and characteristics of one particular Devonian shale play stretching through the subterranean of Kentucky, West Virginia and Ohio in the U.S. In order to do so, Rogner (1997) had to assume the *continuity* of nature, namely that it consists of an uninterrupted subterranean assemblage of shale rock formations. As Foucault (1970) argues, “only continuity can guarantee that nature repeats itself” (p. 160), and the *analogue* of Devonian shale play in the U.S. was thus employed by Rogner (1997) to extrapolate its specific features to other parts of the world. If Devonian shale – with its excellent geological properties to extract natural gas with help of technological tools available now – can be found and successfully appropriated in one place beneath the

Earth's crust, it is assumed that similar conditions can occur in other parts of the subterranean world, including Europe.

For the entire world, Rogner (1997) assessed the amount of unconventional original gas in place (OGIP) to be in amount of approximately 454 trillion cubic meters (Tcm). This impressive volume – however, vastly uncertain because OGIP is a very crude or, colloquially speaking, “wet-finger-guess” estimate of the total amount of natural gas initially present in a prospective areas (Figure 2) - would roughly equal the amount of conventional gas resources projected at the level of 475 Tcm. Hence, not only the Earth's crust was abundant in natural gas extracted with conventional methods but it would also provide ample resources of gas requiring more advanced, unconventional technologies. In terms of shale gas potential in Europe, without access to geological data Rogner (1997) estimated OGIP for Western Europe to account for 14.5 Tcm and for Central and Eastern Europe roughly 1.1 Tcm (Rogner 1997, p. 242; McCelvey 2013b). Together, the European continent would presumably hold a substantial 15.5 Tcm of total shale gas in place. However, the top-down global-gaze nature of Rogner's assessment, with one successful U.S. shale play as analogue extrapolated to other parts of the globe, ignored the regional and local geological conditions.

The second significant rationality of government making shale gas imaginaries visible is one of designation, employed through discursive techniques of rendering unconventional gas resources purposeful, meaningful and important for achieving specific goals and desires. Bridge (2009) aptly points out that “what qualifies as a resource can vary over time and space, because it is technology and culture (in its widest sense) that confer utility and value onto materials” (p. 1219–1220). In this sense, resources are not but rather they become (Zimmerman 1933) when their purpose and role in a given society are facilitated by specific techno-scientific developments and societal aspirations. Hence, mineral occurrences are classified by society as

useful resources when they match existing socioeconomic and technological arrangements, and can help resolve particular challenges or problems (Bridge 2009).

Since the 1980s, energy researchers and industry practitioners have projected a steadily growing role of natural gas in the global energy mix (IEA 2001; IEA 2011; Kuuskraa and Meyers 1983; Smil 2015). Considered as “the most important alternative to crude oil” (Masters et al. 1990, p. 48), the prominence of natural gas has been increasingly rising. Indeed, as the International Energy Agency (IEA) noted in 2001, “natural gas is the second fastest growing energy source after non-hydro renewables. Gas demand rises at 2.7% per annum over the projection period, and its share in world primary energy demand increases from 22% today to 26% in 2020” (IEA 2001, p. 27). The growing significance of natural gas in the future of global energy mix was particularly affirmed by the IEA’s special report “Are We Entering a Golden Age of Gas?” published in 2011. In this paper, the Agency maintained that natural gas not only “can help diversify energy supply, and so improve energy security” but – due to growing concerns over climate change and air pollution – it can also offer important environmental benefits, such as lower greenhouse gas emissions when replacing other, less clean fossil fuels (IEA 2011, p. 7-9). In its 2011 Golden Age of Gas Scenario, the IEA thus projects that “the share of natural gas in the energy mix increases from 21% to 25%, pushing coal into decline and overtaking it by 2030” (IEA 2011, p. 13).

Nevertheless, while vast conventional resources are relatively equally distributed globally, more than half of such gas occurrences are located in only three countries – Russia, Iran, and Qatar (IEA 2001, 2011). Availability of conventional gas deposits in Europe, however, has been much less abundant and the region has remained the largest importer of natural gas, with Russia as the main supplier (IEA 2016). Therefore, as has been suggested by some energy experts and industry practitioners, a more equally distributed unconventional gas from organic-rich shale rocks could potentially play an increasingly important geopolitical role in securitizing the long-

term availability of supplies and managing future energy resource constraints, particularly in Europe (Kuhn and Umbach 2011; Kuuskraa and Meyers 1983; Masters et al. 1990; Medlock et al. 2011; Rogner 1997, Weijermars et al. 2011).

Hence, with growing significance of natural gas in the global energy mix, unconventional gas resources have been rendered purposeful and important for achieving two goals: one related to geographical diversification of energy supplies and reduction of import dependence in some regions less abundant in conventional deposits; and the other concerned with environmental benefits of replacing clean gas with other fossil fuels in order to combat climate change and air pollution.

3.2. Making shale gas imaginaries calculable

Despite large uncertainties and unreliability of data provided by Rogner (1997), his assessment enacted a powerful volumetric imaginary of global abundance that emerged as a foundation for subsequent estimates and prospects of unconventional gas worldwide, including the European continent (McGlade et al. 2013a). Yet compared with the U.S., to date only a small number of research and bottom-up exploration data on unconventional resource potential in Europe has been published and made available. Primarily due to the immature nature of shale gas industry in the EU, national-level geological information related to shale plays is still scanty or outdated (McGlade et al. 2013b). Nevertheless, since 2009 a modest number of assessments, that include the European shale gas potential, has been made public (Table 1). There are three characteristics of this new wave of estimates.

First, following Rogner's (1997) top-down, global-gaze estimates of original shale gas in place, the preoccupation with resource abundance and more equal geographical distribution has continued. For example, whereas the report by Advanced Resource International (ARI), published in 2009, estimated the potential of gas extraction from shale rock formations in three

EU member-states – Sweden, Poland and Austria – the 2011 report prepared by ARI for the U.S. Energy Information Administration (EIA/ARI 2011) included prospects for shale plays in 14 European countries, including 11 EU-member states. The presupposition of nature as a geological continuum – namely that it consists of an uninterrupted subterranean assemblage of shale rock formations that can be distinguished from other geological futures by means of some particular characteristics – has been the basis for employing practices of identification and extrapolation. More specifically, the crude volume of original gas-in-place (Figure 2) has been estimated by classifying and dividing the territory into prospective areas, based on a set of unique futures resembling a given analogue – a shale play with optimal geological properties for drilling and fracking operations (ARI 2009; EIA/ARI 2011, 2013; McGlade et al 2013a; Medlock et al 2011, WEC 2010).

The set of variables used in delineating, inventorying and inscribing the most promising fields on the cartographic outline consists of expert judgment on aerial extent, structure, overall thickness, permeability, total organic content, and thermal maturity of shale rock formations. Such an optimal collection of diagnostic indicators – which, through analogizing, guarantees that some uncertainty can be excluded – is then applied to different regions globally, including Europe. This diagnostic data is further assessed through the probability of a “success factor” based on how much is known or unknown about geology of appraised regions. In other words, shale plays are rendered suitable when they meet an optimal combination of variables, based on availability of geological data. In order to provide imaginaries of prospective, productive and thus manageable spaces central to resource extraction, ordering of the subterranean space must be based on some intelligibility, even if this set of measuring and inventorying practices of “geo-coding” concerned with a “spatial regime of inscriptions” (Rose-Redwood 2006, p. 470) have a highly uncertain character (Speirs et al 2015).

Second, however, despite the prevailing attention paid to abundance of organic-rich but low-permeability shale rock formations, the critical issue for unconventional natural gas extraction is not the speculated magnitude of gas-in-place and its geographical spatiality. Rather, the key question – of interest particularly for policy-makers in pursuit of energy security strategies – is how much of this ample resource, that is trapped in a multitude of tiny pores within sedimentary shale rocks, can actually be released now or in near-term, with what drilling and extraction technologies, as well as at what economic cost. As Kuuskraa and Meyers (1983) pointed out in their assessment, “the critical issue for these resources is not their size – as focus on the unarguable massive size of the in-place resource is neither relevant nor productive” (p. 410). The reason behind this disdain for the gas-in-place volumetric is related to unusual or rather unconventional geological properties of shale gas that make its extraction different from conventional types.

In its report from 2009 (also co-authored by Kuuskraa), ARI labelled unconventional gas, including gas from shales, as a “game changer” due to the significant recognition that now “one could *create* a permeable reservoir [emphasis added]” (p. 4). Hence, rather than discover a reservoir of natural gas trapped in discrete rock pockets and traps – as it is typically the case with conventional gas resources – two key technological advancements in extraction methods, i.e. horizontal drilling and hydraulic fracturing, have now “enabled the numerous deep, low permeability gas shale formations to become highly productive” (ARI 2009, p. 4). In its survey of world energy resources from 2010, World Energy Council (WEC) aptly called to attention the fact that “the transformation of thinking about the shale gas potential (...) is not attributable to the discovery of new resources or the assessment of old resource estimates but to the development and application of new technologies that in effect ‘create a permeable reservoir’ and achieve high rates of production” (p. 7). In other words, the role of extraction technology

in manipulating underground rock strata in a way that natural gas from created fractures could be liberated is a crucial element in estimating the recoverable potential of shale gas resources.

Innovative methods of extraction help us unlock unconventional gas but, due to particular geological properties of shale rock formations, not all amount of estimated resources in-place can be successfully tapped. Thus, the question of estimating the recoverability measure requires methods of calculation and quantification that, paradoxically, turn attention from abundance back to scarcity (Fisher 1981). The visual and dynamic representation of plenitude under the inscription of known unknowns – as illustrated by McKelvey's box (Table 1) and Rogner's (1997) upgrade of it – have to be converted into a virtual category of a reduced magnitude that is rendered through a fixed, volumetric number and inscribed in a cartographic delineation of shale plays. Consequently, from the abundant and geographically spread perspective, the visual sphere is narrowed down to a limited stock of recoverable deposits and their most potent parts with entry points not coincidentally called sweet spots. In this sense, shale gas resources are forged as a calculable volume from which a recovery factor can be deduced and estimated by means of combining and manipulating different parameters (e.g. mineralogical and geological characteristics of a given shale play), from which a probabilistic ratio ranging between 20% and 40% is calculated (EIA/ARI 2011, 2013; McGlade et al 2013a,b).

Due to a more complex and heterogeneous nature of shale rock occurrences on the European continent (McGlade et al 2013b), the majority of shale gas estimates for Europe is focused on calculating and quantifying the volume of technically recoverable resources (TRR) that, similarly to the process of commensuration denoting economic feasibility, could be labelled as *techno-mensuration* because it focuses on the *technological feasibility* of extraction from a given shale rock environment, i.e. what volume of gas-in-place might be most probabilistically recovered by means of existing technologies (Figure 2). Table 1 demonstrates that volumetric imaginaries of shale gas recoverability in Europe differ, often greatly, from one assessment to

another. As McGlade et al (2013b) point out, the TRR indicator has an ambiguous character because some estimates obscure whether it includes undiscovered resources in the calculation. Indeed, to transparently measure recoverability of known unknowns would be a significant challenge. The calculative efforts of estimating TRR-volumes through a common denominator of technological feasibility can be related to what Barry (2002) refers to as “metrological regimes” that – despite their presumably intelligible and legible apparatuses of measurement and quantification – are inevitably much more unreliable than it first appears and thus still largely uncertain (Figure 2).

Third, these powerful but highly ambiguous volumetric imaginaries of shale gas availability and recoverability are not only generated by a particular state- or supranational-actor (i.e. the EU), but, rather, they are primarily produced by a multitude of different state- and non-state actors alike, such as: global private consultancy companies, think-tanks and research centres, federal agencies, national geological surveys, industry practitioners, and international agencies. Some of these agents work together in private-public partnerships in which a national agency (i.e. EIA) delegates the role of assessing global shale gas resources to a private consultant (i.e. ARI), whereas other actors work in loose and dispersed networks. Furthermore, the majority of estimates for shale gas potential, particularly in Europe, is not a scientifically-grounded or peer-reviewed material. Rather, some projections are more of an insider industry expertise that circulate in form of multi-client studies and presentations outside the public domain (CERA 2009; Medlock 2012; Wood Mackenzie 2009; see also: McGlade et al 2013b; Weijermars 2013). Yet, despite this myriad of different sources and agents, the shale gas imaginary is made possible through, what Miller and Rose (2008) call, translation “in which one actor or force is able to require or count upon a particular way of thinking and acting from another, hence assembling them together into a network (...) because they have come to construe their problems in allied ways” (p. 34).

3.3. Making shale gas imaginaries governable: securitizing a post-conventional future?

Since 2009, there has been a growing number of estimates for the European shale gas potential that are characterized by large uncertainties (Figure 2) and diverse volumetric appraisals (Table 1). Due to the embryonic stage of exploration, lack of appropriate geological data and no actual production in place, all European assessments provide speculative resource inventories in form of gas-in-place and/or recoverable resources (McGlade et al 2013b). This is also the case with national efforts to capture in the net of measurements the potential of unconventional natural gas awaiting to be extracted from organic-rich sedimentary shale rocks. For example, the Polish Geological Institute tentatively reports recoverable resource estimates for the Baltic-Podlasie-Lublin basin in Poland (PGI 2012), while the British Geological Survey provides crude gas-in-place volumes for the Bowland-Hodder Shale area in the United Kingdom (BGS 2013). It is important to emphasize that, to this day, there has been no European estimates of shale gas *reserves* that could offer a higher degree of certainty dimension (Figure 2). This is because measurements for technical and economic recoverability of unconventional gas reserves require continuous evaluations of actual production patterns and gas flows from wells, and thus cannot be based solely on probabilistic appraisals analogizing to the productivity of one shale plays located in the U.S. In this sense, our scanty knowledge about the shale gas potential in Europe continuous to occupy the vastly ambiguous, virtual, and dynamic sphere of resources outside the reserves category in McKelvey's box (Figure 1).

Yet, drawing upon Foucault's governmentality lens understood in this paper as power to imagine futures, these highly speculative and uncertain assessments have, nevertheless, forged powerful volumetric imaginaries of resource abundance and recoverability, thus rendering the European continent with a specific territorial attribute: a previously unknown or omitted source of energy that has only recently been rationalized by rendering it knowable, intelligible and even desirable. The existence of this unconventional potential in Europe has been further made

describable and measurable by means of mundane and dispersed technologies of government, i.e. practices of quantification, extrapolation, mapping, inscription, and deduction deployed by a range of different actors. Moreover, by making the resource visible and calculable it has also been made *governable*, that is open to new fields of opportunities to act upon. In this sense, the known unknown of Europe's shale gas potential is not powerful because it could, someday, actually yield impressive volumes of gas, but because it has been made knowable, visible and intelligible for political rationalities concerned with disposition, optimization and securitization of resources (Braun 2000; Foucault 2007).

In light of projected depletion of the EU's indigenous conventional gas deposits and its increasing dependence on natural gas supplies from Russia (IEA 2016), the emergence of shale gas resource estimates have triggered a considerable interest from European policy-makers and industry experts that have been particularly in pursuit of energy security strategies. As a result, the geological probability of rich shale gas deposits has been translated into an economic and geopolitical language of *possibility* (Braun 2000), rendering it a matter of the post-conventional energy securitization strategy aimed at seizing the hope for abundance of unconventional gas resources in the near future. Already in its Energy 2020 strategic paper published in 2010, the European Commission (EC) affirmed existence of "the potential for further development of EU indigenous fossil fuel resources, including unconventional gas" (COM 2010, p. 3). A year later, the EC noted in its report on Energy Roadmap 2050 that "shale gas and other unconventional gas sources have become potential important new sources of supply in or around Europe" (COM 2011, p. 12). Furthermore, in its communication on the exploration and production of hydrocarbons issued in 2014, the Commission described the role of natural gas production from shale plays as an interim step in the transition to a low-carbon economy (COM 2014b). In its Energy Security Strategy published the same year, the Commission also

recognized the prospect of shale gas extraction as a securitizing strategy that could diversify energy resources (COM 2014a).

Since 2009, a number of shale gas estimates (e.g. ARI 2009; EIA/ARI 2011, 2013) pointed to Poland as one of the EU-members with the largest volumetric potential of technically recoverable resources. Highly dependent on natural gas imports from Russia and thus exposed to energy supply insecurity (Johnson and Boersma 2013), Polish policy-makers rushed to develop strategies and policies for reducing this dependence by exploring the prospect of domestic unconventional gas production (Godzimirski 2016). In July 2012, Poland noted more than 100 valid concessions for exploration wells granted to both domestic operators and foreign companies (ME 2016). Adopted by the Council of Ministers in 2012, the National Development Strategy 2020 paper assumed that – based on estimates provided by the Polish Geological Institute (PGI 2012) – “it is possible to obtain a significant increase in the supply of gas from domestic sources” (CM 2012, p. 87). In the Strategy for Energy Security and Environment issued in 2014, the Ministry of Environment identified shale gas resource potential as a new opportunity for Poland in terms of both energy security and climate change mitigation. The Ministry argued that the prospect of domestic natural gas production from unconventional sources could fundamentally change the country’s energy mix and also contribute to carbon dioxide emissions reduction (ME 2014, p. 28). The shale gas resource potential has also spurred various changes in legal instruments and regulations (Godzimirski 2016). Most notably, in 2015 the Polish government amended the Geological and Mining Act to establish suitable legal structure for extraction of unconventional hydrocarbons. Despite disappointing results from early exploratory drillings and no production in sight, the Polish decision-makers have not abandoned hopes for shale gas. In 2015, the project of Poland’s Energy Policy until 2050 presented by the Council of Ministers, reaffirmed the role of shale gas resource potential in securitizing the country’s energy supplies (CM 2015). In the most recently announced project of Strategy for Responsible Development, the Polish government

included exploration of unconventional natural gas from domestic shale deposits on the list of strategic projects for preparation and implementation until 2020 (MD 2016).

In the United Kingdom, the government proclaimed a moratorium on hydraulic fracturing operations after seismic activities had been caused by initial exploratory drilling in May 2011. The ban was removed in December 2012 and, simultaneously, the government established the Office of Unconventional Gas and Oil (OUGO) designated to develop the shale gas industry in the country. In the Annual Energy Statement 2014 presented to the British Parliament, the Secretary of State for Energy and Climate Change claimed that: “developing our onshore shale gas resources could enhance our energy security, create jobs, support economic growth and be part of the transition to a greener future.” (p. 19). This ambition for developing domestic potential of unconventional gas resources was further affirmed by the UK government in the Shale Gas and Oil Policy Statement published in August 2015 (DECC/DCLG 2015). In this document, the policy-makers expressed “national need” to explore the UK’s shale gas deposits by arguing that fracking “could potentially bring substantial benefits and help meet our objectives for secure energy supplies, economic growth and lower carbon emissions” (DECC/DCLG 2015). Whereas the emphasis was particularly placed on “developing home-grown shale resources” because it “could reduce our (and wider European) dependency on imports and improve our energy resilience”, the environmental component of “clean” natural gas as a “bridge fuel” was also conspicuously stated. In the Guidance on fracking: developing shale gas in the UK, published in January 2016, the government expressed its belief that “shale gas has the potential to provide the UK with greater energy security, growth and jobs” (BEIS, 2017), thus legitimizing the political desire to attain the prospect of securitizing the UK’s energy supplies via domestic unconventional gas production in the near future.

As it can be observed, despite large uncertainties of resource estimates the European shale gas imaginary is powerful because it yields specific governing effects, namely it opens up the field of various opportunities for regulations, planning, and strategizing by policy-makers. The

mundane practices of visualisation, quantification, classification and inscription – involved in producing speculative knowledge about the shale gas potential – create a world in which, as Bridge (2015) argues, “certain new forms of political capacity and agency” as well as “certain forms of strategic action” are possible (p. 336). In other words, this unconventional imaginary does not only have descriptive capabilities but, most significantly, it also possesses prescriptive powers for envisioning “futures that states believe ought to be attained” (Jasanoff and Kim 2009, p. 120) and thus inscribing them in rules, laws, policies, strategies, institutions, and other forms of apparatuses of government.

4. Conclusions

In 1972, McKelvey argued that “better methods for estimating the magnitude of potential mineral resources are needed to provide the knowledge that should guide the design of many key public policies” (p. 32). Almost half a century later, various practices and techniques of visualisation, calculation, systematisation, inventorying, and deduction are perhaps much more sophisticated than in the past, but their outcomes are still plagued with large uncertainty and speculation. What is rather new, however, is that in the world constrained by the finite nature of exhaustible conventional fossil fuels, energy security policies and strategies increasingly rely on and relate to the highly unreliable and ambiguous estimates of *potential* supplies: the virtual abundance of known unknown that is either undiscovered and omitted but will be found and extracted in the future thanks to technological developments or is uneconomic to produce now or in near-term but can become cost-effective in the long-term perspective.

By taking the stock of unconventional resource estimates in Europe, the paper illustrates that not only the scarcity, as Huber (2011) seems to suggest, but particularly abundance “has to be socially produced” (p. 817) and sustained through a myriad of speculative practices and a loose network of calculating actors engaged in these techniques. The fossil fuel abundance

narrative is produced and sustained because – each time a number of ambiguous estimates of potential supplies is generated – it opens new fields of possibilities for “the politics of nature” (Mitchell 2013, p. 252) and yields governing effects concerned particularly with securitization of unconventional hydrocarbon resources availability, consequently fuelling and legitimizing techno-political hopes for certain post-conventional energy futures. Hence, these novel forms of energy flow anticipation, inventorying and estimating are part of, as Bridge (2015) argues, the emerging “science of energy security” (p. 334)

While this study is concerned with estimation and securitization of unconventional gas resources, the question of how to extract shale gas without disadvantaging the environment or the society (Fleming and Reins 2016; Sovacool 2014) calls for more research on other rationalities and technologies of governance spurred by the fracking frenzy in Europe.

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Figure 1. Classification of minerals and reserves according to McKelvey (1972).

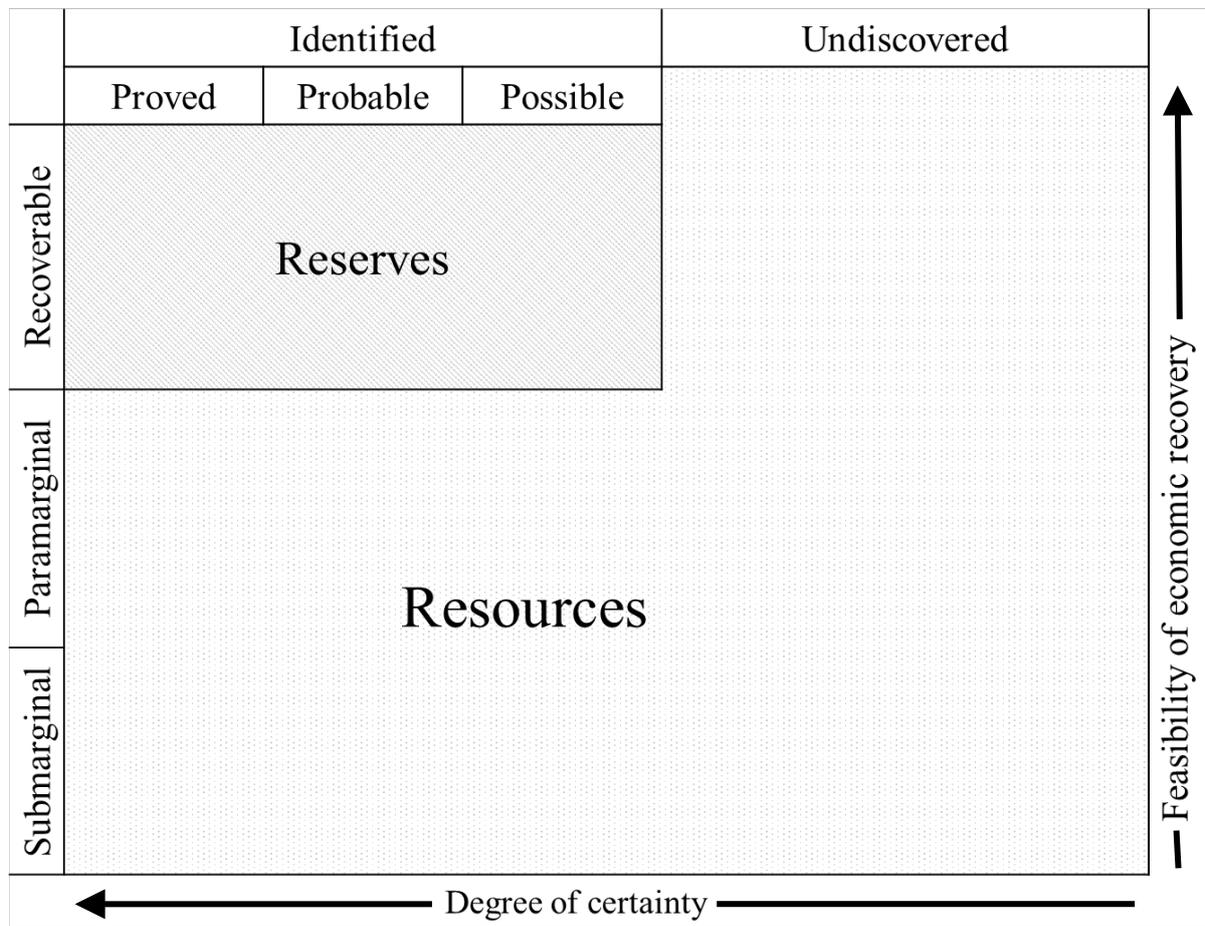
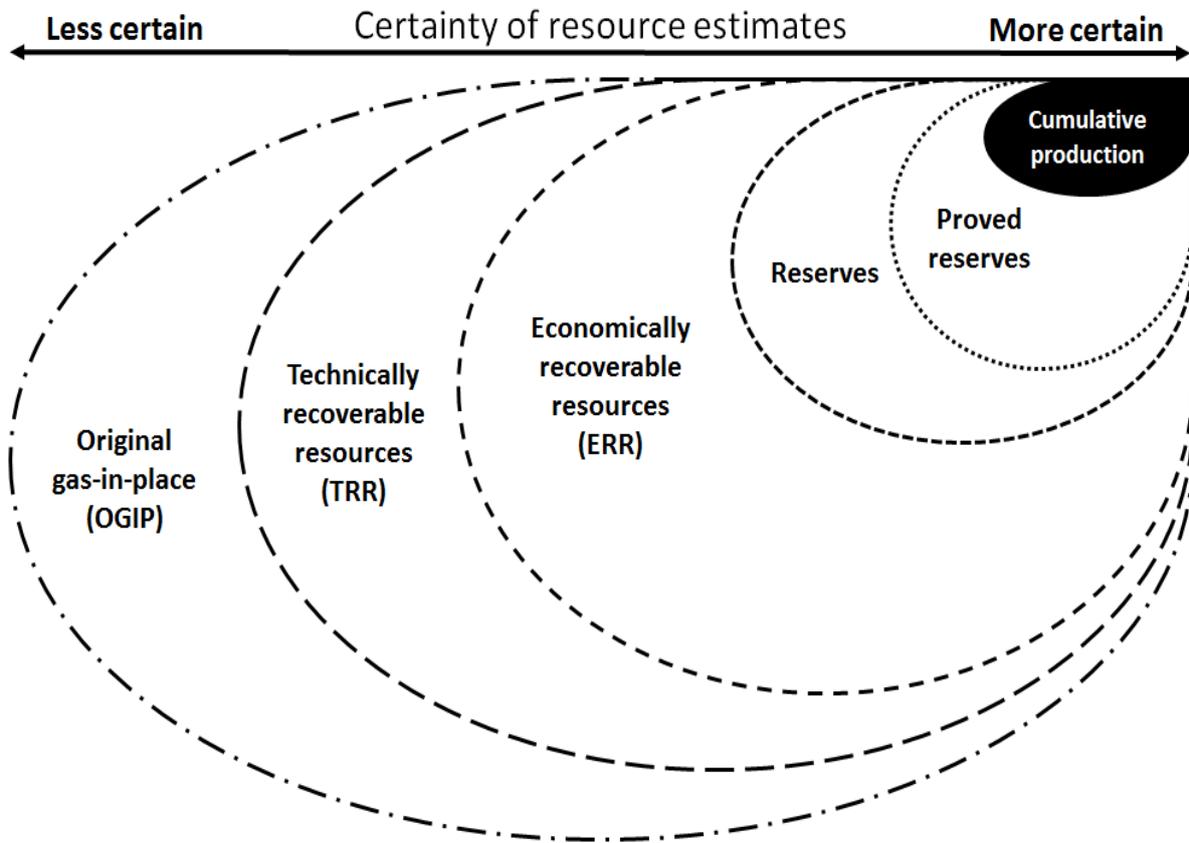


Figure 2. A simplified visual classification of shale gas resource and reserves estimates, with their level of certainty.



Source: based on U.S. Energy Information Administration, McGlade et al (2013b) and Speirs et al (2015);

Notice: scales do not represent any actual sizes of resource estimates; for example, volumes TRR and ERR can be similar or even overlapping (McGlade et al 2013b);

Table 1. Estimates of the original gas-in-place (OGIP) and technically recoverable resources (TRR) of shale gas in Europe, including WEC’s economically recoverable resources (ERR).

Author/organisation	OGIP in Tcm	TRR in Tcm
Rogner (1997)	15,5	-
Wood Mackenzie (2009) ^a	-	4,2–5,6
CERA (2009) ^a	-	3–12
ARI (2009)	30	4
WEC (2010) ^b	31,7	12,7
EIA/ARI (2011)	73,2	17,6
Medlock et al (2011)	-	6,2
BGR (2011)	-	17,7 ^c
Medlock (2012) ^a	-	18
EIA/ARI (2013)	30,2	12,3 ^d

^{a)} In Weijermars (2013);

^{b)} Economically Recoverable Resources (ERR) based on a simple assumption that 40% of gas-in-place would be economically recoverable (WEC 2010). No specific methodology is provided;

^{c)} 15 Tcm for EU-27;

^{d)} Excluding Ukraine and Russia;

Source: Data compiled with support from McGlade et al (2013b) and Weijermars (2013).