1. Shale gas extraction in a nutshell – technology, issues, benefits

1.1 INTRODUCTION

For a meaningful discussion on the regulation of shale gas extraction in Europe and its Member States some understanding of the technical processes is required. This chapter aims to provide this essential background information on shale gas extraction. However, the explanations do not progress beyond a basic level and are not meant to provide a comprehensive overview. Instead, the current chapter zooms in on those aspects of shale gas extraction that are most relevant for its legal appraisal.

It will be demonstrated that the techniques which are currently in use for the extraction of shale gas are not new in themselves. However, new threats might arise when some of those familiar technologies are applied to a different geological set-up (so called unconventional reserves),[1] as opposed to the geological circumstances in which conventional gas extraction takes place.

Oil and gas (generic term: hydrocarbons[2]) are formed from the soft parts of microscopic organisms that are preserved in certain sediments.[3] Over time these parts are gradually buried deeper and deeper in the ground, moving towards the Earth's interior, where they are gently cooked (matured) by exposure to heat.[4]

The preservation of this organic matter from early destruction requires an oxygen-free environment, the source rock; mudstone and shale are the most common and suitable source rocks for hydrocarbons.[5] Oil and gas is

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[1] For a general introduction to petroleum exploration, see Robert Stoneley '*An Introduction to Petroleum Exploration for Non-Geologists*' (Oxford University Press, Oxford 1995) (hereinafter: Stoneley). For specifics of unconventional hydrocarbon production see particularly pages 100–102.

[2] See footnote above.

[3] Stoneley 27.

[4] Ibid.

[5] Ibid.

formed at considerable depths and then slowly squeezed out of the source rock.[6] In conventional hydrocarbon extraction this process is called 'primary migration', migration out of the, commonly tight and dense, source rock.[7]

The hydrocarbons then make their way up into layers of more permeable reservoir rocks like sandstone or limestone ('secondary migration') and gather in minute holes, gaps or pores between the grains of these rocks.[8] These naturally occurring reservoirs or 'traps'[9] are supervened by caps of impermeable rock. From these reservoirs conventional gas may be produced.[10]

Shale gas is commonly referred to as an *unconventional* gas.[11] The difference between *conventional* and *unconventional* gases is the ability of the gases to migrate *in situ*.[12] As opposed to *conventional* gas, *unconventional*

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[6] Ibid.

[7] Understanding just how hydrocarbons move through the extremely fine-grained and tight source rock is one of the outstanding problems of petroleum geology. We cannot normally get a fluid or a gas to enter or move through it at all and yet it is clear that, somehow or other, the hydrocarbons just must have migrated. For more, see Stoneley 35.

[8] Stoneley 27.

[9] For this term, see Stoneley 35.

[10] Engineers accordingly tap into these reservoirs to extract *conventional* gas, which flows with comparative ease from the reservoir rock as a result of its permeability, see Stoneley 35 and SRU Faulstich 7.

[11] See, for instance, the use of terminology by the European Commission in Commission Recommendation 2014/70/EU of 22 January 2014 on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing [2014] OJ L 39/72 preamble 3 and 5. In addition, numerous scientific reports from the EU and its Member States clarified this point; for instance: Milieu Ltd., '*Regulatory provisions governing key aspects of unconventional gas extraction in selected Member States*' (2013) available at: http://ec.europa.eu/environment/integration/energy/uff_studies_en.htm [accessed 4 September 2014]; Energy and Climate Change Committee of the House of Commons 'Shale Gas' Fifth Report of Session of the House of Commons 2010–12, Vol. I and Vol. II (Crown 2011) Ev. 24 (hereinafter: UK report I and UK report II).

[12] Hydrocarbons are chemical substances (gaseous or fluid) that are essentially composed of carbon and hydrogen atoms. These atoms can bind in various ways and, depending on the arrangement of atoms, either simple structures like paraffins (most commonly methane, ethane and butane) or more complex structures like naphthenes and aromatics are created. Only the four simplest forms of the paraffins, containing 1 to 4 carbon atoms, are hydrocarbons that occur as gas at atmospheric temperature and pressure; the rest are liquids (different forms of oil). For this and more, see Stoneley 28 and 113.

gas is 'trapped'[13] in the source rock and does not migrate out of it without stimulation (no 'primary migration');[14] the 'unconventional bit' is hence the impermeability of the source rock and the fact that no 'primary migration' can take place.[15]

The term shale gas as such refers to natural gas (mainly methane), which is present in very small pores of organic rich shales.[16] The gas is encapsulated in fine grains of shale rock.[17] Besides shale, several other rocks may 'host' unconventional gas, most prominently coal and sandstone.[18] However, the production methods for all types of *unconventional* gases are quite similar because the different rocks that hold unconventional gas are all low permeability structures.[19]

The structure of the current chapter reflects the title of the book and it is separated in three parts concerning shale gas, the environment and energy security. First, the technical process of shale gas extraction is explained. This part of the chapter assesses the individual stages that are required to make shale gas extraction happen. These technical explanations provide the necessary backdrop for the legal appreciation.

In the second part potential issues and benefits of shale gas extraction are demonstrated, which centre around the two concepts of environmental protection and energy security. Only the most salient potential environmental threats of shale gas extraction will be discussed.[20] In a third part,

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[13] Note that this terminology might be deceptive as it is also used in the context of conventional gas extraction, but with a slightly different meaning, see explanations in the previous text.

[14] An apt explanation of the terminology has been provided by Mark Miller, CEO Cuadrilla Resources – Statement to the UK Commission, see UK report I Ev. 24: 'Unconventionals are only a term that we as an industry coined years ago to describe a type of reservoir. It is not the process. There is no such thing as an unconventional well or a conventional well; there is only an unconventional reservoir, and that only means that the gas is stored in the same place that it is generated.'

[15] Stoneley 101 and 11; SRU Faulstich 7/8. Permeability is a measure of the ease with which fluids or gases can move through a rock: one may force them through and see how far they come out of the other end of a sample to determine permeability of the structure, see Stoneley 38.

[16] Knut Bjorlykke *'Petroleum Geoscience – From Sedimentary Environments to Rock Physics'* (Springer Verlag, Berlin 2010) 464 (hereinafter: Bjorlykke).

[17] Ibid.

[18] Ibid. and SRU Faulstich 8.

[19] Lars Dietrich and Till Elgeti '*Rechtliche Implikationen der Aufsuchung und Förderung von unkonventionellem Erdgas*' (2011) 127 (7–8) Erdöl Erdgas Kohle 311; Pearson et al. 56/57.

[20] This is an approach that closely follows the most authoritative technical studies on shale gas extraction in Europe, see for instance SRU Faulstich 8;

these concerns are juxtaposed with the most important potential energy security benefits that shale gas extraction might bring about for Europe and its Member States.

1.2 THE TECHNOLOGICAL PROCESS OF SHALE GAS EXTRACTION[21]

A major difference between conventional and unconventional gas extraction is the number of geological prerequisites that have to be fulfilled for successful extraction. With conventional gas extraction broadly speaking five essential requirements must be met before gas extraction can start. Requirements are: a source rock, heat, a reservoir, a cap rock or seal and a 'trap'.[22] For unconventional gas, however, the existence of three components suffices: a source rock, heat and a cap rock or seal.[23] Unconventional gas should be more abundant in the world than conventional gas, inter alia because fewer geological conditions (three compared to five) have to be met. However, given that the research into the extent of recoverable unconventional gases is just beginning, verification of that hypothesis is still to surface.[24]

Shale gas may be encountered at varying depths, depending on regional geological circumstances; thus, generalizations about 'shale gas extraction' have to be made very cautiously, as each formation has its unique characteristics.[25] In Europe, shale formations that contain gas can be found at depths of 2 km or more and they may be as thick as 100 metres.[26]

Stefan Lechtenböhmer et al. 'Impacts of shale gas and shale oil extraction on the environment and on human health' (European Parliament, 2011) 11 (hereinafter: Lechtenböhmer et al.); Maximilian Kuhn and Frank Umbach *'Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU'* (2011) European Centre for Energy and Resource Security (EUCERS) Strategy Paper No 1 http://www.eucers.eu/2011/05/06/eucers-strategy-paper-no1/ [accessed 24 April 2012] (hereinafter: EUCERS).

21 A good overview of the process may be found at: Rick Rickman et al. '*A practical use of shale petrophysics for stimulation design optimization: All Shale plays are not clones of the Barnett Shale*' (2008) Society of Petroleum Engineers SPE 115258 available at: http://www.onepetro.org/mslib/app/Preview.do?paperNumber=SPE-115258-MS&societyCode=SPE (accessed 20 March 2012) (hereinafter: Rickman et al.).

22 Stoneley 54.

23 Ibid.

24 For more details see further below in this chapter.

25 Stoneley 54.

26 Ibid.

However, the layers of shale rock (or shale 'plays'[27]) are not fixed at certain depths as they are progressively buried under further layers of sediment or may be uplifted over the course of geological time.[28]

1.2.1 Innovative Drilling and Well-Integrity

Two different technologies are required for industry-scale shale gas extraction: first, so called innovative drilling and second, hydraulic fracturing.[29] The first aspect, innovative drilling, actually includes three features with relevance to shale gas extraction: horizontal drilling, multi-well pad drilling and improved well-casing/well-integrity.[30] Horizontal drilling constitutes an innovation in the way a drill may be brought down: until 30–40 years ago, only vertical drilling of a well, from the surface to the targeted rock formation, was technically feasible.[31] Today horizontal drilling is used for all sorts of pipe and cable-laying, including the laying of electricity cables to renewable energy facilities, like windmills.[32] Thus, horizontal drilling may not only be used for shale gas extraction but also to enable the transmission of renewable energy.

Horizontal drilling means that the drilling trajectory diverts in a

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[27] A 'play' is a group of fields or prospects in the same region that is controlled by the same set of geological features, for instance similar types of source rock or reservoirs, see Stoneley 54–59 and 106. The term shale play is used by the oil and gas industry to refer to a geographic area that has been singled out for exploration due to favourable geoseismic survey results, well logs or some other factor.

[28] Stoneley 3 and 11.

[29] Ivan L G Pearson et al. '*Unconventional Gas: Potential Energy Market Impacts in the European Union*' (Joint Research Centre of the European Commission, 2012) 59 available at: http://ec.europa.eu/dgs/jrc/downloads/jrc_report_2012_09_unconventional_gas.pdf [accessed 20 May 2014] (hereinafter: Pearson et al.); Harald Andruleit et al. *Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) 'Abschätzung des Erdgaspotenzials aus dichten Tongesteinen (Schiefergas) in Deutschland'* (Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover 2012) 35 (hereinafter: Andruleit et al. BGR Abschätzung); Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) 'Schieferöl und Schiefergas in Deutschland Potenziale und Umweltaspekte' (Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover 2016) 13 (hereinafter: NIKO).

[30] See the text immediately below.

[31] Stoneley 83; Pearson et al. 60.

[32] For examples from Scotland and Germany see: Community Energy Scotland '*Horizontal directional drilling*' available at: http://www.communityenergyscotland.org.uk/news/10-mar-2015-horizontal-directional-drilling.asp [accessed 28 June 2016]; H Schmidt GmbH '*Horizontalbohrtechnik*' available at: http://www.schmidt-rohrleitungsbau.de/leistungen/horizontalbohrtechnik/ [accessed 28 June 2016].

horizontal direction at a 'kick off point'.[33] The drill commences on the surface in a vertical direction and is brought down approximately 2 km, intersecting various layers and types of rock.[34] Once the drill approaches the targeted shale layer, it is diverted horizontally to follow the route of the shale play.[35]

The horizontal drills may follow the path of shale layers over long distances: in the US, horizontal drills of up to 6 km length have been reported.[36] But this technique is also commonly used for conventional extraction, where it enables the development and production of hydrocarbons from particular fields that would otherwise be too expensive to produce.[37]

Multi-well pad drilling allows for synergy effects: several subsurface areas can be developed from one surface spot, that is to say one surface location ('pad') can be used to drill multiple wells.[38] Drilling from single surface 'pads' is not unique to shale gas extraction, but it is considered to be indispensable for European shale gas extraction.[39] As Europe is a densely populated region of the world, the advantages of the multi-well pad technology (reduction of land-use, environmental surface impacts and infrastructure costs)[40] are deemed to be key factors of successful shale gas extraction.[41]

Some understanding of the drilling process itself is required to grasp particular potential environmental threats that may arise. A typical drilling derrick stands over the well that is drilled; it lowers a string of steel drill-pipe, which carries the bit (drilling head), into the hole and draws it out again.[42]

From time to time it is necessary to protect the bit and line the well bore with steel casings. These are 10–15 metres long, strengthened steel pipes that are screwed together, lowered into the hole and cemented into position.[43] Once this has been accomplished, the well is drilled further with a smaller bit, which will pass through the casing and the next string of

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33 Ibid.
34 Ibid.
35 Ibid.
36 Stoneley 83.
37 Ibid.
38 See Pearson et al. 62 for more details on the process.
39 UK report I, 49.
40 Pearson et al. 62.
41 UK report I, 49.
42 Stoneley 81.
43 Stoneley 82; UK report I, 39.

casing will be smaller still.[44] This process is similar for conventional and unconventional gas extraction.

The particular issue with a view to shale gas extraction is well integrity. Well integrity is a delicate topic and deserves particular attention, due to technical difficulties and non-unified procedures in Europe.[45] Well integrity includes the planning, design and execution of well completion (cementing, casing and well head placement).[46] Well integrity is fundamental to the security of shale gas wells because hot and cold fluids will be pumped through the wellbore with particularly high pressure during shale gas extraction.[47]

The aim of the casing programme is to optimize cementing operations.[48] Poorly cemented wells can offer pathways for leakage.[49] Casing and cementing programmes should be designed to provide optimal isolation of the gas-producing zones from overlying formations.[50] Multiple engineered barriers are needed to prevent communication between hydrocarbons and potable aquifers.[51]

'State of the art' is the use of a three casing system, consisting of one steel case, an inner cement case and a third additional internal steel case, to insulate the well against the geological layers it intersects.[52] However, in

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44 Ibid.

45 The attention given to wellbore integrity was kick-started in the US but it is also becoming a focal point of the debate about shale gas extraction in Europe, see Jennifer Morrissey and Jason Schumacher 'Water quality, water use and wastewater issues related to hydraulic fracturing' in Vivek Bakshi (ed.) '*Shale Gas: A Practitioner's Guide to Shale Gas and Other Unconventional Resources*' (Globe Law Publishing, London 2012) 78; Cecile Musialski 'An External Comment on the UK/England & Wales: Towards an even more refined legal & regulatory framework by imposing A.O. additional and specific requirements for mitigating the risk of induced seismicity?' in Cecile Musialski et al. (eds) '*Shale Gas in Europe*' (Claeys & Casteels, Deventer 2013) 524 (hereinafter: Musialski UK chapter).

46 For more details on the process, see Stoneley 81–7.

47 Spencer Ferguson and Matthew T Gilbert '*Hydraulic Fracturing and Shale Gas Production: Issues, Proposals and Recommendations*' (Nova Science Publishers, New York 2013) 114 (hereinafter: Ferguson/Gilbert). Nonetheless, well integrity is, of course, also important with regard to conventional extraction. The reasons why hydraulic fracturing puts particular strain on a well will be explained in the next sub-section below.

48 Ibid.

49 Ibid.

50 Ibid.

51 Ibid.

52 International Energy Agency (IEA) '*Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*' (International Energy Agency, Paris 2012) 23/24 (hereinafter: IEA Golden Rules); Yi Wang et

many European countries no unified standard for shale gas casing exists and operators are currently applying their own security standards.[53] There is a wide range in procedures for casing placement and cementing in shale gas drilling.[54] The lack of common leakage criteria for intervention in a well that exhibits damage and an absence of unified standards could pose risks concerning the nature of the intervention.[55]

1.2.2 Hydraulic Fracturing

After the well has been successfully established by innovative drilling technologies and lined with casings, the next step towards shale gas extraction is hydraulic fracturing (commonly referred to as fracking).[56] Hydraulic fracturing distinguishes itself from the above mentioned processes insofar as it is not a drilling method, but a stimulation treatment of an existing shale gas well.[57]

Pressure from the overlying rock and the natural movements of the Earth's crust create small extensional fissures or fractures in the shale layer, which concentrate in fracture swarms.[58] Hydraulic fracturing uses those fractures as 'highways' to extract gas[59] because the 'trapped' shale gas accumulates in these fractures.[60] Although gas could be produced from the naturally occurring fractures without stimulation, the gas would flow at a very low rate and so stimulation becomes key to the economic viability of a shale gas well.[61]

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al. 'Study of borehole stability of Marcellus shale wells in longwall mining areas' (2014) 4 *Journal of Petroleum Exploration and Production Technology* 64.

53 For example, Germany: Meiners et al. Bund C 70.

54 Ferguson/Gilbert 115.

55 Ibid.

56 Details on hydraulic fracturing may be found at: Ralph W Veatch Jr 'Overview of Current Hydraulic Fracturing Design and Treatment Technology–Part 1' (1983) *Journal of Petroleum Technology* 677 (hereinafter: Veatch Part 1). Veatch Part 1, 677.

57 Andruleit et al. BGR Abschätzung 35.

58 Joseph H Frantz and Valerie Jochen '*Shale Gas – When your gas reservoir is unconventional so is our solution*' (2005) White Paper Schlumberger Ltd. at 4 http://www.pe.tamu.edu/wattenbarger/public_html/Selected_papers/--Shale%20 Gas/shale_gas-%20schlumberger.pdf (accessed 20 March 2012) (hereinafter: Schlumberger).

59 Ralph W Veatch Jr 'Overview of Current Hydraulic Fracturing Design and Treatment Technology–Part 2' (1983) *Journal of Petroleum Technology* 853 (hereinafter: Veatch Part 2).

60 Veatch Part 1, 681.

61 Schlumberger 4 and 6.

Hydraulic fracturing thus aims to enlarge the naturally occurring fissures in the shale layer or to create additional ones to allow the gas to flow more readily.[62] Starting at the 'kick off point', where the vertical wellbore turns horizontal, segments of the wellbore are being isolated.[63] The casing in those isolated sections is perforated and fracturing fluid is pumped under high pressure (up to 8000 psi[64]/1000 bar)[65] into the ground.[66] The process of isolating a particular segment of the well and fracturing it will be repeated on a segment-by-segment basis. Up to 25 fracture stages can occur and the amount of fracturing fluid required for 'completion' of the whole well[67] varies considerably.[68] Careful calculation of the amount of fracturing fluid and the pressure with which it is pumped into the ground allows engineers to determine the length, extent and propagation of fractures.[69]

The fracturing fluid typically consists of 99 per cent water and proppants[70] and up to 1 per cent chemical additives.[71] However, most fracturing fluids will be mixed individually, in accordance with the geological structure and pertaining circumstances of a given well.[72] Because of this case-by-case approach that the industry is taking, generalizations about the fracturing fluids and their chemical compositions are hard to make.[73]

The fluids that re-surface after injection are referred to as 'flow back'. While a considerable amount will find its way back to the surface immediately after injection, remnants of the fracturing fluid emerge from the

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62 Bjorlykke 464.

63 Ching H Yew '*Mechanics of hydraulic fracturing*' (Gulf Publications Co., Houston Texas 1997) 6 (hereinafter: Yew).

64 Schlumberger 4.

65 That number has been named for shale gas extraction specifically in the European context by: SRU Faulstich 8.

66 Yew 6.

67 'Completing a well' means installing equipment in the well to allow a safe and controlled gas flow from the well, see Mohd Fauzi Hamid and Wan Rosli Wan Sulaiman 'Fundamentals Of Petroleum Engineering Well Completion and Stimulation' available at: http://ocw.utm.my/file.php/12/Chapter_6-OCW.pdf [accessed 27 February 2014]; Meiners et al. Bund A 48/49.

68 Veatch Part 1, 677; SRU Faulstich 24.

69 Veatch Part 1, 681/682.

70 Proppant is the technical term for sands or ceramics; their task is to prop up the fractures and to keep them open, see Veatch Part 2 858; Rickman et al. 6.

71 UK report I, 8.

72 Veatch Part 2, 854.

73 Rickman et al. 2; Meiners et al. Bund A 42 and A 64.

ground throughout the entire lifecycle of the well.[74] However, numbers differ widely: while some reckon that 20–30 per cent returns,[75] others estimate that the number might be as high as 60 per cent.[76] The wide variation in figures has been explained by the characteristics of the individual wells and the variety in processes leading to re-surface of 'flow-back'.[77]

One single well can produce gas for 30 years or more at a relatively constant level.[78] This, however, may only be achieved by occasional re-stimulation of the well,[79] which basically means repetition of the hydraulic fracturing process.[80] One single well might be re-stimulated five times or more, but fewer than 10 per cent of the shale-gas wells drilled in the United States have, so far, been subjected to re-stimulation.[81]

Hydraulic fracturing is not only deployed for shale gas extraction: it may be used for all sorts of oil and gas extraction and even for geothermal purposes.[82] This is not a new development. Hydraulic fracturing was initially developed and introduced for such uses in America by 1949.[83] In Europe, hydraulic fracturing has been used, at least since 1961, when the first well on German soil was hydraulically fractured.[84]

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74 Meiners et al. A 76; Mark Miller, CEO Cuadrilla Resources – Statement to the UK Commission, see: UK report I, Ev.24.

75 Mark Miller, CEO Cuadrilla Resources – Statement to the UK Commission, see: UK report I, Ev.24.

76 WWF-UK – Statement to the UK Commission, see: UK report I, Ev. 104.

77 Energy Institute of the University of Texas 'Fact-Based Regulation for Environmental Protection in Shale Gas Development' (2012) in Part 4 at page 22 '*Environmental Impacts of Shale Gas Development*' at 107, available at: http://barnettprogress.com/media/ei_shale_gas_regulation120215.pdf [accessed 14 June 2012] (hereinafter: Energy Institute Texas). Note: This study has come under intense criticism and will hence merely be used in this book to illustrate points of view and minor aspects. For the debate see: Revkin A, *The New York Times* 'Damning Review of Gas Study Prompts a Shakeup at the University of Texas' available at: http://dotearth.blogs.nytimes.com/2012/12/06/damning-review-of-gas-study-prompts-a-shakeup-at-the-university-of-texas/ [accessed 16 April 2013].

78 Schlumberger 5.

79 Ibid.

80 M C Vincent 'The next opportunity to improve hydraulic-fracture stimulation' (2012) *Journal of Petroleum Technology* 119/120 (hereinafter: Vincent).

81 IEA Golden Rules 27; Vincent 120. For the significance of the United States in shale gas extraction see the part on energy security below in this chapter.

82 SRU Faulstich 6; UK report I, 54.

83 Veatch Part 1, 677.

84 Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V. 'Hydraulic Fracturing-Prozess und Perspektiven in Deutschland' available at: http://www.erdoel-erdgas.de/Themen/Erdgas-aus-Deutschland/Hydraulic-Fracturing [accessed 1 July 2014] (hereinafter: Wirtschaftsverband hydraulic fracturing).

Up until 2011, at least 326 oil, gas and geothermal wells had been subjected to hydraulic fracturing in EU Member States.[85] However, hydraulic fracturing *for shale gas purposes* has been rarely deployed in Europe.[86] If hydraulic fracturing was used for shale gas purposes in EU Member States, it was only used to stimulate exploratory wells in shale plays, but not for shale gas production.[87]

This lack of experience makes it very difficult to predict how much unconventional gas can be produced from a particular well in Europe.[88] Currently there is no other way of quantifying the productive potential of a shale play than to drill and fracture it.[89] Only after application of the hydraulic fracturing technique to the targeted formation may its ability and suitability for shale gas extraction be assessed.[90]

1.3 POTENTIAL ISSUES AND BENEFITS

The outlined technological particularities result in a number of potential environmental threats and energy security benefits, which are discussed immediately below. The assessment starts by outlining the conceptual, abstract meaning of these interests and then focuses on their practical relevance for shale gas extraction. However, the discussion does not explain the legal character of environmental protection and energy security (for instance whether or not these concepts comprise constitutional objectives, principles of law or something else). These, certainly crucial, aspects are discussed in detail in Chapter 4 below, but lie beyond the scope of this introduction to the process of shale gas extraction.

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[85] According to a German study: Lower Saxony State Agency for Mining, Energy and Geology (*Landesamt für Bergbau, Energie und Geologie)* '*Hydraulische Bohrlochbehandlung*' available at: http://www.lbeg.niedersachsen.de/bergbau/genehmigungsverfahren/hydraulische_bohrlochbehandlung/hydraulische-bohrlochbehandlung-110656.html [accessed 17 July 2014]; Bundesrat '*Stenografischer Bericht 904. Sitzung*' of 14 December 2013 Plenarprotokoll 904 available at: http://dipbt.bundestag.de/dip21/brp/904.pdf [accessed 16 April 2014] 579 (hereinafter: Bundesrat Stenografischer Bericht 904. Sitzung).

[86] Three times in German history, for instance see Meiners et al. Bund A 10.

[87] Ibid.

[88] Stoneley 67–80 lists inter alia remote sensing and preliminary studies, geological surveys, gravity surveys, magnetic surveys, seismic reflection surveys and seismic refraction surveys as part of the standard repertoire of conventional hydrocarbon extraction.

[89] Submission of the Tyndall Centre Manchester to the UK Commission, see UK report I, Ev 87; IEA Golden Rules 22.

[90] Ibid.

1.3.1 Potential Environmental Threats of Shale Gas Extraction

There is an interrelation between environmental protection and shale gas extraction. The environment may be defined very broadly as the natural surroundings or all *living* and non-living things occurring *naturally* on *earth*.[91] Although anthropocentric views on the environment (the environment defined from a human perspective) might compete with other views (for instance that the environment has value in its own right), all definitions agree that water, air and soil are part of the environment.[92] Environmental protection, in terms of shale gas extraction, thus, means protecting these elements.

Potential environmental threats in relation to shale gas extraction in Europe have been garnered from experiences with shale gas extraction in America, but observations made there might not be transferrable to the EU and its Member States. This is due to considerable differences in geology and regulation between the USA and Europe.[93]

Despite these differences there are studies which broadly identify four potential environmental threats of shale gas extraction as most salient in Europe as well as in America.[94] These are groundwater contamination/issues with well integrity, irresponsible disposal of 'flow-back', the repercussions of excessive land use in densely populated areas and emission of greenhouse gases/insufficient monitoring.[95]

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[91] Donald L Johnson et al. 'Meanings of Environmental Terms' (1997) Vol 26 No 3 *Journal of Environmental Quality* 581/582.

[92] Ibid.

[93] Bundestag '*Stenografischer Bericht 178. Sitzung*' of 10 May 2012 Plenarprotokoll 17/178 available at: http://dipbt.bundestag.de/dip21/btp/17/17178.pdf [accessed 17 April 2014] 21166 (hereinafter: Bundestag Stenografischer Bericht 178. Sitzung); SRU Faulstich 27; Meiners et al. 'Fracking in unkonventionellen Erdgas-Lagerstätten in NRW Kurzfassung zum Gutachten "*Gutachten mit Risikostudie zur Exploration und Gewinnung von Erdgas aus unkonventionellen Lagerstätten in Nordrhein-Westfalen (NRW) und deren Auswirkungen auf den Naturhaushalt insbesondere die öffentliche Trinkwasserversorgung*"' of 7 September 2012 (Ministry for Climate Protection, Environment, Agriculture, Conservation and Consumer Protection of North Rhine-Westphalia 2012) 56 (hereinafter: Meiners NRW).

[94] In America, this was done by a study, commissioned by then President Barack Obama on 31 March 2011, see Spencer Ferguson and Matthew T Gilbert '*Hydraulic Fracturing and Shale Gas Production: Issues, Proposals and Recommendations*' (Nova Science Publishers, New York 2013) 94 et sqq. (hereinafter: Ferguson/Gilbert). Similar conclusions were then reached by a 2013 study, conducted by an advisory board to the German government on the specifics of German and European shale gas extraction, see SRU Faulstich, particularly 44/45.

[95] Ferguson/Gilbert 96; SRU Faulstich 44/45.

A fifth potential environmental threat has been discussed as belonging to the group of most salient: earth tremors. Although this potential threat attracted some interest in the American context,[96] in Europe earth tremors in the shale gas context are mostly associated particularly with the British geological set-up.[97] As a consequence, the described four potential threats are discussed immediately below, while the potential fifth threat of earth tremors is going to be discussed only in the context of the British regulatory regime, which is one of the focal points of Chapter 3.

1.3.1.1 Groundwater contamination/issues with well-integrity

Due to suspicions in the US about potential impacts of shale gas extraction on groundwater reserves,[98] this possible threat attracted special attention around the globe and also in Europe.[99] Several layers of rock strata have to be bored through in order to reach the shale plays.[100] These strata include groundwater-bearing aquifers in certain locations, as these are commonly situated at shallow depths, way above the shale plays.[101] Methane and noxious substances could reach those aquifers and contaminate them.[102] This could pose a direct threat to human health, since groundwater in Europe is used as a source of drinking water.[103]

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96 IEA Golden Rules 26 and 127.

97 The Royal Society and the Royal Academy of Engineering '*Shale gas extraction in the UK: a review of hydraulic fracturing*' (London, 2012) available at: https://royalsociety.org/policy/projects/shale-gas-extraction/report/ [accessed 11 April 2014] 4–7 (hereinafter: Royal Society); Christopher A Green et al. '*Preese Hall Shale Gas Fracturing Review and Recommendations for Induced Seismic Mitigation Report on behalf of the UK Department of Energy and Climate Change*' available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/15745/5075-preese-hall-shale-gas-fracturing-review.pdf [accessed 11 April 2014] ii/iii and 13/14 (hereinafter: Green et al.).

98 See for instance: US Environmental Protection Agency '*Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*' http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hf_study_plan_110211_final_508.pdf [accessed 25 April 2012] 30 (hereinafter: US EPA Study Plan); UK report I, 39; Osborn et al. 8175. This will be discussed below.

99 SRU Faulstich 23–30.

100 Modern Shale Gas Development ES 3/ES 4.

101 Ibid.

102 Stephen G Osborn et al. 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' (2011) Vol 108 No 20 *Proceedings of the National Academy of Science of the United States of America* (PNAS) 8175 (hereinafter: Osborn et al.); EUCERS 21.

103 SRU Faulstich 23 et sqq.

Technical experts discuss four potential exposure pathways for groundwater contamination by shale gas extraction.[104] First, groundwater contamination may stem from fracturing fluid.[105] During the process of hydraulic fracturing, some components of the fracturing fluid could migrate upwards through particularly long vertical fractures, reach aquifers[106] and contaminate them.[107] Despite considerable research, it is still difficult to accurately predict and control the location and length of fractures.[108]

Second, gases or fluids might ascend diffusely from their point of release in the deeper ground and reach groundwater-carrying rocks.[109] As opposed to the option discussed above, no clear pathway might be pinpointed here, but gases and/or fluids might, nonetheless, reach aquifers.[110] The reasons for such a diffuse ascent are poorly understood. Preliminary findings suggest that the permeability of the segregating rock between shale formations and the groundwater differs considerably from site to site.[111] Groundwater contamination through diffuse pathways might occur when fracturing fluid is physically displaced.[112] Fracturing fluid might not reach the shale plays, but accidentally be pumped into other rock strata and migrate from there into aquifers.[113] In the worst case, fracturing fluid might even be pumped directly into aquifers.[114]

Third, poor well casing and poor well integrity, more generally, has been frequently blamed for groundwater contamination.[115] A good 'casing-job', as discussed earlier, should take prudent account of the fact that various fluids will be pumped through the borehole at varying pressures.[116] If the 'well casing' is done poorly, repeated high pressure fracturing can damage the 'well casing' and contaminating substances might escape from the well and flow into aquifers.[117]

Fourth, leakage on the surface is a possible further source of contami-

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[104] Meiners et al. Bund A 13 et sqq.; Osborn et al. 8175; EUCERS 21.
[105] Osborn et al. 8175.
[106] US EPA Study Plan 30; UK report I, 39; Osborn et al. 8175.
[107] UK report I, 39.
[108] US EPA Study Plan 37.
[109] Meiners et al. Bund A 15 and C 5; Osborn et al. 8175.
[110] Meiners et al. Bund A 15.
[111] Meiners et al. Bund C 5.
[112] Osborn et al. 8175.
[113] Meiners et al. Bund C 5.
[114] Ibid.
[115] Osborn et al. 8175; EUCERS 21.
[116] IEA Golden Rules 22/23.
[117] US EPA Study Plan 38; UK report I, 38; Meiners NRW 56.

nation.[118] All sorts of accidents, equipment and infrastructure failures, as well as improper handling of noxious substances during transportation, processing and storage, might lead to contamination.[119] A storage facility for fracturing fluid, for instance, could leak and release contaminating substances into the soil, from where they trickle down into the groundwater.[120]

It is important to note, however, that these are theoretically perceivable pathways, which have been contemplated by geologists, based on American models.[121] Exposure pathways are site-specific and must be assessed, depending on the unique geological composition of each location.[122] Generalizing statements about the potential threat of groundwater contamination by shale gas extraction in Europe should hence be treated with much caution.[123]

1.3.1.2 Disposal of 'flow back'

A second major issue of shale gas extraction, which is particularly prominent in Europe,[124] is the disposal of 'flow back'.[125] Environmental damage might occur during disposal of this fluid.[126] The 'flow back' may consist of water, proppants, chemicals and other substances and its composition varies considerably, in line with the different geological circumstances of each shale play and the chemical makeup of pre-existing reservoir waters.[127]

It is important to note that 'flow back' disposal differs from country to country: in America 'flow back' is regularly recycled and re-used, a

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118 Meiners et al. Bund A 14 et sqq.; UK report I, 44; EUCERS 21.

119 Meiners et al. Bund A 14 and C 3.

120 UK report I, 44; EUCERS 21. However, this would explain a contamination with chemicals but not with methane, since methane is not an additive to the fracturing fluid, see EUCERS 21.

121 Osborn et al. 8175.

122 Meiners et al. Bund C 3.

123 Ibid.

124 Meiners et al. Bund A 76/77; C Ewen et al. 'Hydrofracking Risk Assessment-Executive Summary' available at: http://dialog-erdgasundfrac.de/sites/dialogerdgasundfrac.de/files/Ex_HydrofrackingRiskAssessment_120611.pdf [accessed 15 June 2012] 68 (hereinafter: Ewen et al.).

125 The treatment of 'flow back', however, is a general problem, see Ewen 46/47.

126 Since 2008 the US Department of Environmental Protection has reported 130 incidents of groundwater and soil contamination by 'flow back', see: EUCERS 22; UK report I, 44.

127 Energy Institute Texas part 4 at page 22.

process which can require on-site storage of the 'flow back'.[128] Leakage from these 'flow back' storage basins has contaminated American soil and water on the surface and sub-surface in the past.[129] By contrast, in a major European country like Germany recycling of 'flow back' is rather improbable, as studies pointed out.[130] The most cost-effective disposal method for 'flow back' in Europe and Germany is disposal in 'dead wells' by deep ground injection.[131]

However, injecting 'flow back' into the deeper ground, as such, could trigger environmental degradation in Europe. As the long-term sealing qualities of 'flow back' disposal wells have never been tested before,[132] contamination might occur in a variety of possible settings: the re-injected 'flow back' could react with pre-existing substances in the disposal wells.[133] Furthermore, the flow from disposal wells could be noxious[134] and, due to potential geological links between the disposal well and surrounding rock strata, soil and water sources could be contaminated.[135] To sum up, the environmental repercussions of the disposal of 'flow back' in Europe are currently under scrutiny and scientific research has started, but no final verdict on the disposal has been reached.

1.3.1.3 Land use

The spatial demands of shale gas extraction are considerable: compared to conventional gas extraction, more shale gas wells need to be drilled to extract the same amount of gas.[136] In addition, the areas in which drill-

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[128] EUCERS 22; Daniel Yergin '*The Quest: Energy, Security and the Remaking of the Modern World*' (Penguin Ltd., London 2011) 331 (hereinafter: Yergin).

[129] Ibid. and UK report I, 44.

[130] Ewen 47; EUCERS 22; Meiners et al. Bund C 54.

[131] Ibid.

[132] SRU Faulstich 45.

[133] Meiners et al. Bund 53.

[134] Karl-Heinz Rosenwinkel et al. '*Gutachten zur Abwasserentsorgung und Stoffstrombilanz* ISAH 2012' available at: http://dialog-erdgasundfrac.de/sites/dialog-erdgasundfrac.de/files/Gutachten%20zur%20Abwasserentsorgung%20und%20Stoffstrombilanz%20ISAH%20Mai%202012.pdf [accessed 25 June 2012] 3 (hereinafter: Rosenwinkel).

[135] SRU Faulstich 45.

[136] For European examples see: Claudia Baranzelli et al. 'Scenarios for shale gas development and their related land use impacts in the Baltic Basin, Northern Poland' (2015) Vol 84 *Energy Policy* 92 (hereinafter: Baranzelli et al.); SRU Faulstich 32. For the American experiences: Andrew Blohm et al.' The significance of regulation and land use patterns on natural gas resource estimates in the Marcellus shale' (2012) Vol 50 *Energy Policy* 358/359; Simona L Perry 'Development, Land Use, and Collective Trauma: The Marcellus Shale Gas

ing takes place are wider in scope.[137] While conventional gas gathers at a certain point and is extracted from there shale plays expand over long distances.[138] On top of this increased need for land, additional spatial pressures arise from the necessity to put into place transportation and processing infrastructure.[139]

This need for land to extract shale gas could aggravate pre-existing spatial pressures in many, densely populated, European countries.[140] An increased competition with other land uses like agriculture, water management, forestry, human settlements and recreation is feared.[141] The overlap of shale gas extraction with these other uses is called 'spatial resistance' (*Raumwiderstand*).[142] Areas with 'very high' and 'high' spatial resistance are generally unsuitable for shale gas extraction.[143]

Recent investigations into 'spatial resistance' for shale gas extraction in Germany and Poland yielded alarming results. In the German state of North-Rhine Westphalia[144] 49 per cent of the land mass had 'very high spatial resistance' and 17 per cent still had 'high spatial resistance' against shale gas projects.[145] The results for this state are especially relevant, since it is deemed to host considerable European shale gas reserves,[146] but it also has an important agricultural industry.[147] In northern Poland between 7 and 12 per cent of land currently dedicated to other industrial activities would be required for shale gas extraction.[148] However, a study into that subject pointed out that these numbers could increase if more intense shale gas extraction should start in Poland.[149]

Furthermore, visual and noise impacts as well as light emissions from shale gas extraction plants could add to the mounting spatial pressures

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Boom in Rural Pennsylvania' (2012) Vol 34 Issue 1 *Culture, Agriculture, Food and Environment* 81–92.

137 UK report I, 7; Corbeau 191; Commission Shale Gas Communication 5.

138 Stoneley 101 and 104; UK report I, 7; Corbeau 191.

139 Commission Shale Gas Communication 6.

140 For examples from Poland and Germany, see Baranzelli et al. 92; SRU Faulstich 33.

141 Ibid.; Meiners NRW 3.

142 Meiners NRW 9.

143 Meiners NRW 10.

144 One of the German areas where shale gas could be produced according to Meiners NRW 1.

145 Meiners NRW 10.

146 Meiners NRW 1.

147 SRU Faulstich 33.

148 Baranzelli et al. 92.

149 Ibid.

in these densely populated European regions.[150] Potential threats and knock-on effects might endanger tourism and recreational uses as well as biodiversity.[151] Natural habitats could be diminished by the removal or alteration of existing vegetation in connection with construction activities; the drilling pad and associated transport links could intersect natural habitats and constitute potential barriers for the distribution of certain species.[152]

1.3.1.4 Climate change/insufficient monitoring

The gas that is being produced from shale is mainly methane, which makes a powerful greenhouse gas.[153] Potential environmental threats could be brought about by its emission during shale gas extraction as well as by emissions from subsequent combustion for electricity production.[154] Regarding shale gas extraction as such, scientific concerns focus on gas that could escape from the well or associated equipment (so called 'fugitive methane').[155] A study into that subject bemoaned that current monitoring arrangements would be insufficient to detect such emissions, as several pathways could lead to 'fugitive methane' emissions and consequent adverse effects on the climate.[156]

The most important source of GHG emissions (Greenhouse Gas),

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150 SRU Faulstich 33. For the particular issue of potential tremors see Chapter 3 below.

151 Ibid.

152 SRU Faulstich 34.

153 Methane is a far more potent greenhouse gas than CO_2; for this and a good overview on the impacts of methane to the climate, particularly from shale gas extraction, see: Robert W Howarth, Renee Santoro and Anthony Ingraffea, 'Methane and the greenhouse-gas footprint of natural gas from shale formations' (2011) Vol 106 No 4 *Climatic Change* 680 and 685 (hereinafter: Howarth/Santoro/Ingraffea); furthermore, SRU Faulstich 6.

154 Howarth/Santoro/Ingraffea 680.

155 Ibid.

156 Fugitive methane could occur when drills penetrate methane deposits and methane flows up the well (John Broderick and Kevin Anderson '*Has US Shale Gas Reduced CO_2 Emissions? Examining recent changes in emissions from the US power sector and traded fossil fuels*' (Tyndall Centre at the University of Manchester, Manchester 2012) available at: http://www.tyndall.manchester.ac.uk/public/Broderick_Anderson_2012_Impact_of_Shale_Gas_on_US_Energy_Emissions.pdf [accessed 20 March 2013] 66 (hereinafter: Broderick/Anderson); EUCERS 22; it could also come to the surface, accompanying 'flow back'; it could leak from the 55 to 150 connections to equipment (Howarth/Santoro/Ingraffea 680/681) and during processing, transport, storage, and distribution of natural gas (Howarth/Santoro/Ingraffea 685).

however, is combustion of extracted shale gas in gas-fired power plants.[157] Emissions from the pre-combustion stage,[158] taken together, account for roughly 10–20 per cent of total predicted shale gas emissions.[159] The combustion of shale gas for electricity generation accounts for up to 90 per cent of total predicted shale gas GHG emissions.[160]

However, studies yielded different results,[161] the validity of which is subject to an on-going scientific debate.[162] A unanimous resolution to this discussion cannot be expected any time soon, given the fact that current studies partly rely on estimates, since no shale gas production is currently taking place in Europe.[163]

Moreover, the level of GHG emissions is not the most contentious point. It is rather the question whether or not GHG emissions actually constitute a potential threat *of shale gas extraction*. Some argue that shale gas extraction could be beneficial for the climate, despite the discussed emission levels, if it could provide a substitute for coal combustion in electricity production.[164] Compared to coal, combustion of shale gas results

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157 Daniel Forster and Jonathan Perks '*Climate Impact of potential shale gas production in the EU*' study of 30 July 2012 (European Commission 2012) available at: http://ec.europa.eu/clima/policies/eccp/docs/120815_final_report_en.pdf [accessed 29 October 2012] Figure 7 at 60 and Figure 10 at 64 (hereinafter: Forster/Perks); Broderick/Anderson 66; SRU Faulstich 35.

158 Including emissions from site-preparation, equipment, actual shale gas extraction, all sorts of transportation and processing and waste water treatment.

159 Forster/Perks Figure 7 at 60 and Figure 10 at 64.

160 Ibid.; Christopher L Weber and Christopher Clavin 'Life Cycle Carbon Footprint of Shale Gas: Review of Evidence and Implications' (2012) Vol 46 No 11 *Environmental Science & Technology* 5693.

161 A comparison of the results of different studies on the lifecycle GHG emissions of shale gas can be found at Forster/Perks 64.

162 The only study on GHG emissions of German shale gas extraction, for instance, found a higher proportion of pre-combustion GHG emissions, compared to other studies, see: Uwe R Fritsche and Jana Herling '*Energie- und Klimabilanz von Erdgas aus unkonventionellen Lagerstätten im Vergleich zu anderen Energiequellen. Endbericht zum Gutachten für Team Ewen im Rahmen des InfoDialog Fracking*' (Öko-Institut, Darmstadt 2012) 13/47 available at: http://dialog-erdgasundfrac.de/sites/dialog-erdgasundfrac.de/files/OEKO_IINAS-Fracking-Energie-Klimabilanz.pdf [accessed 17 July 2014] (hereinafter: Fritsche/Herling).

163 Forster/Perks 58.

164 Stephen Pacala and Robert Socolow '*Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*' available at: http://www.princeton.edu/mae/people/faculty/socolow/Science-2004-SW-1100103-PAPER-AND-SOM.pdf [accessed 26 February 2014] 17/18 and 25/26 of Supporting On-Line Material (hereinafter: Pacala/Socolow); A R Brandt et al.

in a 41–49 per cent reduction in emissions.[165] The climatic benefits of substituting coal with gas combustion is the reason why shale gas has been called a 'bridge fuel' that could power the transition to a decarbonized energy system.[166]

However, emission reduction might only materialize if the redundant coal is left *in situ*.[167] Some scientists point to the United States to show that it is more likely the coal would be extracted and exported to other, non-US countries, resulting in simultaneous use of coal and gas.[168] This would lead to an overall increase of global emissions.[169]

On top of that, the exported coal could possibly end up in combustion plants of developing countries, which lack western environmental standards, contributing even more to an overall increase in emissions.[170] Thus, the whole issue of GHG emissions is subject to an ongoing scientific debate and clear-cut numbers cannot yet be provided with any certainty.

To sum up, suspicions about environmental threats of shale gas extraction are rife. Closer examination reveals that the suspected environmental threats are subject to a lot of uncertainties and estimates. A multitude of factors influence whether or not potential environmental threats would come to pass if US shale gas extraction would be replicated in Europe.

1.3.2 The Potential Energy Security Effects of Shale Gas Extraction and the Energy 'Trilemma'

The second main interest in relation to shale gas extraction is energy security. Shale gas is a global phenomenon with potential repercussions for gas markets and the energy security of countries.[171] If all known shale gas reserves could be exploited, this form of energy alone would add 40 per cent to the world's technically recoverable gas reserves.[172] In North

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'Methane Leaks from North American Natural Gas Systems' (2014) Vol. 343 No. 6172 *Science* 733 (hereinafter: Brandt et al.).

165 Forster/Perks 67.

166 Pacala/Socolow 17/18 and 25/26.

167 Broderick/Anderson 13 and 24.

168 Broderick/Anderson 13–15 and 21–24.

169 Ibid.

170 Broderick/Anderson 23/24.

171 Yergin 329.

172 US Energy Information Administration '*World Shale Gas Resources: An Initial Assessment of 14 Regions outside the US*' (April 2011) 4 available at: http://www.eia.gov/analysis/studies/worldshalegas [accessed 6 June 2012]. For the terminology on recoverable reserves, see Stoneley 90.

America, the 'mother country' of shale gas,[173] only 1 per cent of the overall gas demand was covered by shale gas in 2000; by 2011 that figure had rocketed to 25 per cent.[174] Current estimates show that this form of energy alone could account for 50 per cent of overall North American gas production by 2020.[175] Due to shale gas, the United States overtook Russia as the world's largest gas producer in 2009.[176]

The world's remaining unconventional gas reserves are estimated to be bigger than its remaining conventional gas reserves.[177] The estimates of shale gas reserves are likely to increase even further, due to constant improvements in geological information and test data.[178]

In EU Member States, shale gas reserves are also expected to be of considerable size. To take just two examples: Germany's recoverable shale gas reserves are currently estimated at between 700 000 000 000 m^3 and 2 300 000 000 000 m^3.[179] Polish recoverable reserves were initially estimates to stand at 187 trillion cubic feet, or roughly 5 300 000 000 000 m^3 by the US Energy Information Administration.[180] Two years later these estimates of reserves were reduced to 148 trillion cubic feet of gas or roughly 4 190 000 000 000 m^3 by the same institution.[181] Other estimates see Poland's recoverable shale gas reserves in the region between 346 000 000 000 and 768 000 000 000 m^3.[182]

The breadth of these figures shows that assessments of recoverable reserves appear to be very rough and subject to huge fluctuations. The term recoverable reserves pertains to the volume of hydrocarbons that can actually be produced to surface from an accumulation.[183] The proportion of the gas in place that can be recovered, however, depends on the

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173 Yergin 329.
174 Ibid.
175 Bjorlykke 464.
176 EUCERS 8.
177 Ibid.; however, see Stoneley 90–92 for explanations on the shakiness of such estimates in general.
178 Ibid.
179 Meiners et al. Bund A 7 and D 1.
180 US Energy Information Administration '*Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*' (US Department of Energy, Washington D.C., June 2013) 14 (hereinafter: US EIA 2013); Corey Johnson and Tim Boersma 'Energy (in)security in Poland the case of shale gas' (2013) 53 *Energy Policy* 389.
181 US EIA 2013 at 14.
182 Marynia Kruk *The Wall Street Journal* 'Poland Cuts Estimate Of Shale Gas Reserves' available at: http://www.wsj.com/articles/SB10001424052702303812904577295790442844470 [accessed 25 June 2016].
183 Stoneley 90.

economics – in other words how much money a company is prepared to spend to get gas out of the ground.[184] Moreover, one has to factor in that these are rough estimates and more accurate figures about the shale gas potential of EU Member States will only become available with the conclusion of further research projects.[185]

Despite these uncertainties, some experts reckon that domestic extraction of considerable amounts of gas could have a multitude of important repercussions for the security of energy supplies in EU Member States.[186] To assess these effects, however, one needs to define precisely what security of energy supplies is and what energy security means.

As a starting point, energy security has to be situated in the context of the energy 'trilemma'. Energy 'trilemma' is a term that has been coined by the World Energy Council[187] and adopted by energy law and policy scholars.[188] The 'trilemma' consists of energy security, equitable access to energy/energy cost and sustainability, or in other terms: availability, affordability and sustainability of energy supplies.[189] Energy law and policy is constantly trying to balance all three policy goals.[190] Viewed from this perspective, energy security is merely one of several goals that has to be weighed with environmental protection and equitable access to energy.[191]

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184 Ibid.

185 This has been pointed out by German Federal Environmental Agency '*Statement: Appraisal of shale gas production in Germany*' (December 2011) at 8, (*Bundesumweltamt 'Stellungnahme: Einschätzung der Schiefergasförderung in Deutschland' (Dezember 2011)*) available at: http://www.umweltbundesamt.de/wasser-und-gewaesserschutz/publikationen/stellungnahme_fracking.pdf [accessed 26 October 2012] (hereinafter: appraisal shale gas production in Germany).

186 SRU Faulstich 5 and 19.

187 World Energy Council '*World Energy Trilemma*' available at: https://www.worldenergy.org/work-programme/strategic-insight/assessment-of-energy-climate-change-policy/ [accessed 22 September 2016] (hereinafter: World Energy Council).

188 For instance: Cristelle Maurin and Vlado Vivoda 'Shale Gas and the Energy Policy "Trilemma" in Tina Hunter (ed.) *'Handbook of Shale Gas Law and Policy'* (Intersentia, Cambridge 2016) 369–81 (hereinafter: Maurin/Vivoda); Raphael J Heffron, '*Energy Law: an Introduction*' (Springer International, Cham 2015) 3–5; Raphael J Heffron, Darren McCauley and Benjamin K Sovacool 'Resolving society's energy trilemma through the Energy Justice Metric' (2015) 87 *Energy Policy* 168 (hereinafter: Heffron/McCauley/Sovacool); Neil Gunningham 'Managing the energy trilemma: The case of Indonesia' (2013) Volume 54 *Energy Policy* 184–93.

189 For the 'trilemma' in the shale gas debate see: Maurin/Vivoda 369–77.

190 Ibid.

191 World Energy Council; Heffron/McCauley/Sovacool 169.

It is striking to see that legal treaties do not include precise definitions of the term energy security,[192] so the task of defining energy security has been largely left to scholarly debate. In 2011 Benjamin Sovacool assessed that about 45 different definitions of energy security exist.[193]

According to Haghighi, energy security is 'adequacy of energy supply at a reasonable price', which suggests that energy should be physically available and its price should be reasonable.[194] Barton et al. define energy security as 'the conditions under which a country and its citizens (. . .) and companies have access to sufficient energy resources at reasonable prices for the foreseeable future, without a serious risk of major disruption of service'.[195] Roggenkamp, while agreeing with the main aspects of these definitions, stresses that the reliability of energy supplies is a crucial component of energy security, which has, as yet, been underemphasized.[196]

Cameron provides a working definition of the concept that centres on the EU, stating that energy security means 'the ability of the energy industries (. . .) to provide their services throughout the EU to a high standard and at a reasonable cost in a competitive, fully liberalised, pan-European market.'[197] Talus, in addition, highlights that energy security as a concept could have a different meaning depending on whether it is discussed in the EC/EU or in the national context.[198]

As these different interpretations highlight, energy security can mean very different things to different individuals and different nations.[199] The

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[192] See for instance article 194 (1) TFEU.

[193] Benjamin K Sovacool (ed.) *'The Routledge Handbook of Energy Security'* (Routledge Ltd., London, New York 2011) 3 (hereinafter: Sovacool).

[194] Sanam S Haghighi '*Energy Security The External Legal Relations of the European Union with Major Oil- and Gas- Supplying Countries*' (Hart Publishing, Oxford and Portland 2007) 14 (hereinafter: Haghighi).

[195] Barry Barton et al. (eds) '*Energy Security: managing risk in a dynamic legal and regulatory environment*' (Oxford University Press, Oxford 2004) 9.

[196] Martha M Roggenkamp 'Protecting Energy Infrastructure in the EU – The Impact of External Damages on Supply Security' in Martha M Roggenkamp et al. (eds) '*Energy Networks and the Law*' (Oxford University Press, Oxford 2012) 227 et sqq.

[197] Peter D Cameron '*Competition in Energy Markets – Law and Regulation in the European Union*' (Oxford University Press, Oxford 2007) 518.

[198] Kim Talus 'Security of Supply – An Increasingly Political Notion' in Bram Delvaux, Michael Hunt and Kim Talus '*EU Energy Law and Policy Issues*' (Euroconfidentiel, Rixensart 2008) 129 (hereinafter: Talus 2008).

[199] See for instance: Gail Luft, Anne Corin and Eshita Gupta 'Energy Security and Climate Change – A tenuous link' in Benjamin K Sovacool (ed.) '*The Routledge Handbook of Energy Security*' (Routledge Ltd., London, New York 2011) 44 (hereinafter: Luft/Corin/Gupta); Felix Ciuta 'Conceptual Notes on

concept is highly context dependent, since an energy importing country is likely to have priorities that are different from those of an energy exporting country.[200]

But there is some common ground. From the point of view of energy importing regions like Europe,[201] there are traditional and more recent definitions.[202] Traditional consumer country definitions of energy security often consist of three different aspects, the availability, reliability and affordability of energy supplies.[203]

However, some definitions of energy security also include the environmental sustainability of supplies and their socio-economic impacts as fourth and fifth dimension.[204] These modern definitions are thought to supplement the traditional consumer country definition of energy security as availability, reliability and affordability of energy supplies. Each of

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Energy Security: Total or Banal Security?' (2010) Vol 41 No 2 *Security Dialogue* 124/125; Scott Victor Valentine 'The Fuzzy Nature of Energy Security' in Benjamin K Sovacool (ed.) '*The Routledge Handbook of Energy Security*' (Routledge Ltd., London, New York 2011) 56 (hereinafter: Valentine).

200 Luft/Corin/Gupta 44.

201 Despite a prognosed stagnasis in future consumption, Europe is and will remain heavily dependent on gas imports to meet its demand, see International Energy Agency '*World Energy Outlook 2015*' (OECD/International Energy Agency, Paris, 2015) 195/196 (hereinafter: World Energy Outlook 2015).

202 Jonathan Elkind 'Energy Security Call for a Broader Agenda' in Carlos Pascual and Jonathan Elkind (eds) '*Energy Security Economics, Politics, Strategies and Implications*' (Brookings Institution Press, Washington DC 2010) 121 (hereinafter: Elkind).

203 See, for instance, Daniel Yergin 'Ensuring Energy Security' (2006) Vol 85 No 2 *Foreign Affairs* 70/71; Elkind 121; International Energy Agency (IEA) '*What is Energy Security*' available at: http://www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity/ [accessed 22 September 2015]; Michael A Toman' International Oil Security: Problems and Policies' (2002) Vol 20 No2 *The Brookings Review* 20/21; Martin Scheepers et al. '*EU Standards for Energy Security of Supply*' (Energy Research Centre of the Netherlands, The Hague 2006) 29 and 35–7; Sovacool 6/7; Ann Florini 'Global Governance and Energy' in Carlos Pascual and Jonathan Elkind (eds) '*Energy Security Economics, Politics, Strategies and Implications*' (Brookings Institution Press, Washington DC 2010) 151.

204 Bert Kruyt et al. 'Indicators for Energy Security' in Benjamin K Sovacool (ed.) '*The Routledge Handbook of Energy Security*' (Routledge Ltd., London, New York 2011) 291 et sqq. (hereinafter: Kruyt et al. 2011); Henrik Bjornebye '*Investing in EU energy security: exploring the regulatory approach to tomorrow's electricity production*' (Kluwer Law International, Alphen aan den Rijn 2010) 71 (hereinafter: Bjornebye); Sovacool 9/10; Asia Pacific Energy Research Centre '*A Quest for Energy Security in the 21st Century*' (Asia Pacific Energy Research Centre, Tokyo 2007)27 et sqq: Bert Kruyt et al. 'Indicators for energy security' (2009) 37 Energy Policy 2167 (hereinafter: Kruyt et al. 2009).

the, in total, five dimensions of the modern definition of energy security is subsequently applied to the concrete example of shale gas extraction to showcase their functioning and meaning.[205]

1.3.2.1 Availability and reliability

Availability refers to the ability of consumers to secure the energy that they need.[206] Since energy demand has increased significantly across the globe in recent decades, future oil and gas developments will involve deposits that are scarcer, farther from existing demand centres and harder to extract.[207]

Reliability refers to the extent that energy services are protected from disruption.[208] This might be achieved by the diversification of supply sources and/or by utilization of a variety of fuels and technologies.[209] For shale gas extraction the question of availability and reliability of energy supplies may, among others, be broken down into the issues of import dependency and problems with the 'Not In My Back Yard' phenomenon.[210]

Import dependency Conventional gas production has been in steep decline all over Europe for quite some time and this process is expected to accelerate in the future.[211] The downturn in domestic gas production must be contrasted with a stable European consumption of gas; the widening gap has to be bridged by gas imports.[212] To give a concrete example: the biggest European country, Germany, is reliant on gas imports for about 90 per cent of its annual gas consumption.[213] Without domestic shale gas

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205 The effect of shale gas extraction on Europe's energy security has been concisely discussed by Rafael Leal-Arcas, Andrew Filis and Ehab S Abu Gosh '*International Energy Governance Selected Legal issues*' (Edward Elgar, Cheltenham 2014) 316/317 (hereinafter: Leal-Arcas/Filis/Abu Gosh).

206 Elkind 121.

207 Elkind 122.

208 Sovacool 9.

209 Ibid.

210 There are of course other aspects of availability and reliability, which will not be discussed here, as they have no direct relevance to shale gas extraction.

211 Eurostat '*Development of the production of primary energy (by fuel type)*, EU-28, 2003–13' available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Development_of_the_production_of_primary_energy_(by_fuel_type),_EU-28,_2003%E2%80%9313_(2003_%3D_100,_based_on_tonnes_of_oil_equivalent)_YB15.png [accessed 26 June 2016]; World Energy Outlook 2015, 206; Lechtenböhmer et al. 11.

212 World Energy Outlook 2015, 200.

213 German Ministry of the Economy and Energy 'Ordinance on the introduction of Environmental Impact Assessments and on mining requirements in deployment of the fracking technology and deep drills' (*Verordnung zur Einführung*

production, imports are likely to rise even further, but there is no guarantee that the required amounts of gas will always be readily available.[214]

A strong reliance on energy imports has always been viewed as problematic under energy security aspects.[215] The European Commission assessed in 2014 that the EU needs to reduce its dependency on imported fossil fuels in the long-term if it wants to guarantee energy security for its citizens.[216] Two examples from Europe immediately show the issue: around 40 per cent of German gas demand is met by deliveries from Russia.[217] This is even worse with the Baltic States Latvia, Lithuania and Estonia, which used to be entirely (100 per cent) dependent on Russian gas imports.[218] This non-diversified supply structure poses a risk, if failing infrastructure or other causes interrupt Russian gas supplies.[219]

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von Umweltverträglichkeitsprüfungen und über bergbauliche Anforderungen beim Einsatz der Fracking-Technologie und Tiefbohrungen) 12 available at: http://www.bmwi.de/BMWi/Redaktion/PDF/V/verordnung-zur-einfuehrung-von-umweltvertraeglichkeitspruefungen,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf [accessed 7 April 2015]

[214] This issue has been analysed by the German parliament: Bundestag '*Beschlussempfehlung und Bericht des Ausschusses für Umwelt, Naturschutz und Reaktorsicherheit (16. Ausschuss) a) zu dem Antrag der Abgeordneten Frank Schwabe, Ingrid Arndt-Brauer, Dirk Becker, weiterer Abgeordneter und der Fraktion der SPD – Drucksache 17/7612 – b) zu dem Antrag der Abgeordneten Oliver Krischer, Hans-Josef Fell, Bärbel Höhn, weiterer Abgeordneter und der Fraktion* BÜNDNIS 90/DIE GRÜNEN – Drucksache 17/5573 –' of 26 April 2012 Bundestagsdrucksache 17/9450 available at: http://dipbt.bundestag.de/dip21/btd/17/094/1709450.pdf [accessed 16 April 2014] 5 (hereinafter: Beschlussempfehlung Fracking moratorium).

[215] Pietro S Nivola and Erin E R Carter 'Making Sense of "Energy Independence"' in Carlos Pascual and Jonathan Elkind (eds) '*Energy Security Economics, Politics, Strategies and Implications*' (Brookings Institution Press, Washington DC 2010) 105 et sqq. (hereinafter: Nivola/Carter).

[216] European Commission '*European Energy Security Strategy*' (Communication) *COM (2014) 330 final* at 2/3 (hereinafter: European Energy Security Strategy).

[217] German Ministry of Economy and Energy 'Erdgasimporte und Eigenproduktion' available at: http://www.bmwi.de/DE/Themen/Energie/Konventionelle-Energietraeger/gas,did=292324.html [accessed 18 June 2014]; EUCERS 33.

[218] Agnia Grigas 'The Gas Relationship between the Baltic States and Russia' (Oxford Institute for Energy Studies, Oxford 2012) 2 available at: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/10/NG_67.pdf [accessed 26 June 2016] (hereinafter: Grigas).

[219] Luciani 8; Grigas 6; Sascha Müller-Kraenner '*Energiesicherheit*' (Kunstmann, München 2007) 24 (hereinafter: Müller-Kraenner 2007); Clingendael International Energy Programme 'Study on Energy Supply Security and

Previous experience highlights that this is not a purely hypothetical consideration. In the winter of 2011/2012 Member States ran close to a gas 'blackout' as Russian gas supplies fluctuated.[220] Due to declining pressure in gas supply pipes, gas fired power plants in some regions were unable to operate.[221]

Actually, this was not the first time that scientists feared Russian gas supplies to Europe could be cut off. This threat was also immanent during the Russian-Ukrainian energy crises of 2006 and 2009 and continues to play a role in the current armed conflict between Russia and the Ukraine.[222] These instances highlight the role that political influences can play in gas security.[223]

Russia's conduct during the gas disputes with Ukraine damaged the country's reputation as a reliable supplier of gas.[224] European domestic shale gas production would enable instant and uninterruptible access to gas,[225] which could potentially make Europe more energy-independent.[226]

Energy independence of a nation has been defined as meeting the

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Geopolitics Final Report' (2004) available at: http://www.clingendael.nl/publications/2004/200401000_ciep_study.pdf [accessed 25 April 2013] 38.

220 Bundestag Stenografischer Bericht 178. Sitzung 21169; German Federal Network Agency (*Bundesnetzagentur*) 'Bericht zum Zustand der leitungsgebundenen Energieversorgung im Winter 2011/2012' available at: http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2012/NetzBericht_ZustandWinter11_12pdf.pdf?__blob=publicationFile&v=2 [accessed 26 June 2014] 80 et sqq.

221 Ibid.

222 For elaborations on the two Russian-Ukrainian energy conflicts, see Jonathan Stern '*The Russian-Ukraine Gas Crisis of January 2006*' (Oxford Institute for Energy Studies, 2006) 9, 14; Simon Pirani, Jonathan Stern and Katja Yafimava 'The Russo-Ukrainian gas dispute of January 2009: a comprehensive assessment' (Oxford Institute for Energy Studies, 2008) 8, 19–25, 55 (hereinafter: Pirani); Matthias Neumann, Heiko Pleines and Henning Schröder '*Russland Analysen Erdgaskonflikt mit der Ukraine*' [2009] No 176 Forschungsstelle Osteuropa an der Universität Bremen available at: http://www.laender-analysen.de/russland/pdf/Russlandanalysen176.pdf [accessed 18 July 2013] 4/5.

223 Kruyt et al. 2011 at 295.

224 Pirani 33.

225 Commission 'An Energy Policy for Europe' (Communication) *COM (2007) 1 final* at 3/4; Andruleit et al. BGR Abschätzung 48.

226 Commission 'An Energy Policy for Europe' (Communication) *COM (2007) 1 final* at 3/4; UK Energy and Climate Change Committee '*UK Energy Supply: Security or Independence? Volume 1*' (Crown, London 2011) 6, 13; Bundestag Stenografischer Bericht 178. Sitzung 21169; BVerfGE 30, 292 (294); Edward N Krapels 'Oil and Security' in Gregory Treverton *'Energy and Security'* (Gower Publishing, Westmead 1980) 41–42 and 44–46; Friederike Anna Dratwa et al. '*Energiewirtschaft in Europa*' (Springer, Berlin 2010) 23.

respective country's energy needs without depending on any foreign sources.[227] However, the idea of energy independence has come under twofold criticism in recent times: one, at a conceptual level and two, in concrete relation to shale gas extraction.

Regarding the first aspect, energy independence has been described as an outdated concept. Scholars like Elkind, Nivola and Carter argue that energy security is not so much about achieving energy independence, but about realizing and, above all, managing existing dependencies.[228] But even from that point of view, shale gas could make a contribution, as it could help to counterbalance energy imports with domestic energy supplies, and thereby opening up options for the management of energy dependencies.

Second, the factual ability of shale gas extraction to reduce a given country's dependence on gas imports has been disputed.[229] Some scientists argue that the amount of shale gas that is actually recoverable in European countries is too small to have any substantial impact on the overall supply situation.[230]

Current projections are based on the American experience about how much gas might be recovered from a given well, but these figures cannot simply be transferred to Europe, as they disregard special features of certain regions, as discussed earlier.[231] The existing appraisals of European shale gas potential have been criticized for not, or not sufficiently, taking into account areas that are generally excluded from gas extraction under environmental regulations.[232] These constraints would also impact upon the economic viability of shale gas projects.[233]

In any case, estimations are rough figures as long as no exploratory drilling takes place to test the contradictory hypotheses on recoverable reserves.[234] Thus, a potential opportunity to increase Europe's domestic gas production might present itself with shale gas extraction, but the extent to which this potential might materialize cannot currently be pinned down.

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227 Nivola/Carter 105.
228 Elkind 125; Nivola/Carter 105 et sqq.
229 This has been the case in Germany, see SRU Faulstich 10 and 15/16.
230 SRU Faulstich 15/16.
231 SRU Faulstich 10.
232 See the example of Germany: SRU Faulstich 12.
233 SRU Faulstich 13.
234 Uwe Dannwolf et al. 'Umweltauswirkungen von fracking bei der Aufsuchung und Gewinnung von Erdgas insbesondere aus Schiefergaslagerstätten Teil 2' (Umweltbundesamt, Dessau-Roßlau 2014) AP8 – 1 (hereinafter: Dannwolf et al.); SRU Faulstich 10/11.

'NIMBY' and availability of energy supplies The 'Not In My Back Yard' phenomenon has been named one of the biggest potential threats to the availability of energy supplies.[235] 'Not In My Back Yard' (hereinafter: NIMBY) means that people feel it desirable to site a potentially hazardous facility far away from where they are living.[236] Citizens who are inclined to 'NIMBY' thus tend to advocate the use of energy which has not been produced domestically.[237] 'NIMBY' would make it more difficult, in energy security terms, to guarantee the availability of energy, as a country which adopts strong 'NIMBY' policies might become over-dependent on energy imports.[238]

Regarding shale gas it has been argued that Europe is operating a 'Not In My Back Yard' policy, as it turns a blind eye to environmental degradation resulting from gas production in other parts of the world.[239] Europe is asking foreign countries to produce gas for it, despite the fact that environmental protection and technical as well as public participation standards are much worse there than they are in Europe.[240]

Russian gas production, for instance, has a terrible record of environmental devastation: Siberian soil, air and water, as well as previously pristine forests, fell victim to various contaminations.[241] Corruption, low environmental standards and an outdated infrastructure from the soviet-era make Russian gas production a noxious undertaking.[242] Gas extraction in Europe, by comparison, is rather sustainable.[243] Shale gas extraction in Europe could potentially increase the availability of, relatively sustainable, gas supplies, but this may only materialize if the 'NIMBY' opposition can be overcome.[244]

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[235] Sovacool 10; Elkind 122.

[236] The term originates in political sciences, see: Frank Fischer and Michael Black *'Greening Environmental Policy: The Politics of a Sustainable Future'* (Paul Chapman Publishing, London 1995); 'NIMBY' is criticized as an irrational, emotional, self-interested or unethical response from those who are unwilling to share in the costs of industrial activities, see Dustin Mulvaney and Paul Robbins (eds) '*Green Politics*' (SAGE Publications, London 2011) 285.

[237] Ibid.

[238] Elkind 122; Sovacool 10.

[239] Bundesrat Stenografischer Bericht 904. Sitzung 579.

[240] Ibid.

[241] See for instance: Müller-Kraenner 2007, 147–58; Russian Nature 'Environmental Impact of Oil and Gas Development' available at: http://www.rusnature.info/env/20.htm [accessed 22 August 2013].

[242] Ibid. 148

[243] Bundesrat Stenografischer Bericht 904. Sitzung 579.

[244] Ibid.

1.3.2.2 Affordability

A non-diversified supply structure is putting current gas suppliers in a very strong bargaining position.[245] Ever-increasing gas import dependency might lead to rocketing gas prices.[246] According to the European Commission, this has already contributed to price increases in the past.[247]

The price of gas is a crucial component of energy security: the basic affordability of energy services is elementary to citizens and companies in Europe and all over the world.[248] A reasonable price of energy is thus a vital part of the definition of European energy security.[249]

Price increases could, potentially, be avoided or mitigated by European shale gas.[250] Current suppliers would have to make sure that the price of their gas does not exceed the point of economic viability of European shale gas projects, as gas-importing countries could otherwise be incentivized to switch supplies to these sources.[251] Although unconventional gas production in Europe has not even started, the mere prospect of increased domestic gas extraction could already influence the current gas price.[252]

The ability of European shale gas production to influence gas prices, however, is subject to controversy amongst the scientific community. Some scholars argue that the gas market is primed to become fully globalized in some years.[253] When the gas price is set at global level the, in comparison to other parts of the world, negligible[254] European

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245 Commission Shale Gas Communication 2.

246 Ibid.

247 Ibid.

248 Ibid.; Sovacool 9/10; Kruyt et al. 2011 at 295. To give the example of a legal text in an EU Member State: § 1 of the German Energy Industry Act (*Energiewirtschaftsgesetz) (hereinafter: EnWG)* discusses national energy security and establishes that the German state shall ensure that energy supplies comply with a 'pentagon of aims', one of which is a reasonable price. More on the 'pentagon of aims' may be found at: Franz Jürgen Säcker '*Berliner Kommentar zum Energierecht Band 1*' 2nd edition (Verlag Recht und Wirtschaft, Frankfurt am Main 2010) § 1 EnWG paragraphs 1/2 (hereinafter: Säcker).

249 Leigh Hancher and Sally Janssen, 'Shared Competences and Multi-Faceted Concepts – European Legal Framework for Security of Supply' in Barton B et al. (eds) '*Energy Security: managing risk in a dynamic legal and regulatory environment*' (Oxford University Press, Oxford 2004) 93.

250 Commission Shale Gas Communication 2.

251 Pearson et al. 142; Commission Shale Gas Communication 4/5.

252 EUCERS 42.

253 SRU Faulstich 13.

254 No European country is in the top ten league table of countries with the most technically recoverable shale gas resources, see James R May and John C

shale gas reserves are unlikely to have a perceivable impact on gas prices.[255]

Moreover, large-scale shale gas production in Europe would be a cost-intensive undertaking. Scientists estimate that production costs would range between two and three times the cost of comparable US developments.[256] Although these production costs are likely to decrease in line with increased technological understanding, European production costs will never meet low US levels.[257] To sum up, European shale gas extraction might impact upon the affordability of energy, but that effect is not certain to materialize.

1.3.2.3 Environmental sustainability and socio-economic benefits as fourth and fifth criterion?

Two examples from Europe highlight that the concept of energy security could also include ecological and economic aspects. First, the policy of some Member States to phase out nuclear power generation (the most prominent example being the German '*Energiewende*'),[258] which incites a quest for reliable, non-intermittent[259] substitutes in electricity production. The German government stresses that the additional gas demand for the

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Dernbach 'Introduction' in John C Dernbach and James R May (eds) '*Shale Gas and the Future of Energy Law and Policy for Sustainability*' (Edward Elgar Publishing, Cheltenham, 2016) 4 (hereinafter: May/Dernbach).

[255] SRU Faulstich 10.

[256] Quentin Philippe 'Europe's comparative disadvantage in energy intensive industries: a comparison of shale gas production costs and break-even prices in Europe and the US' in Cecile Musialski et al. (eds) '*Shale Gas in Europe*' (Claeys & Casteels, Deventer 2013) 259–61; SRU Faulstich 16.

[257] Ibid.

[258] See more at: Bundesregierung '*Der Weg zur Energie der Zukunft – sicher, bezahlbar und umweltfreundlich Eckpunktepapier der Bundesregierung zur Energiewende*' available at: http://www.bmwi.de/DE/Themen/Energie/energiepolitik,did=405004.html [accessed 31 May 2012] at paragraph 4 (hereinafter: Eckpunkte Energiewende).

[259] Renewables are discounted here as an intermittent source of electricity production, as wind turbines are only producing when the wind blows and solar panels (mostly) when the sun shines. However, smart alternatives are currently increasing in prominence, but they lie beyond the scope of this book.

Energiewende should be covered by domestic gas production.[260] Shale gas could make a potential contribution here.[261]

Second, socio-economic development has been included by some scholars as a fifth aspect that energy security should take care of.[262] The idea that unconventional gas could help to create new jobs and act as a potential driver of overall economic growth[263] originates from the US.[264] Direct effects of shale gas extraction on the economy might include employment opportunities and increased regional investments in infrastructure.[265] Indirect effects could be the generation of additional public income via taxes and fees.[266]

However, when viewed more closely, it actually works the other way around: one key pre-condition of socio-economic development is energy security, since modern economies are based on a secure and reliable supply of energy.[267] The European Court of Justice stressed this point in drastic words decades ago in the infamous *Campus Oil* case, which illustrated

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260 Bundesregierung '*Energiekonzept 2050*' available at: http://www.bmu.de/files/pdfs/allgemein/application/pdf/energiekonzept_bundesregierung.pdf [accessed 31 May 2012] 16 (hereinafter: Energiekonzept); Bundesregierung '*Der Weg zur Energie der Zukunft – sicher, bezahlbar und umweltfreundlich Eckpunktepapier der Bundesregierung zur Energiewende*' available at: http://www.bmu.de/energiewende/beschluesse_und_massnahmen/doc/print/47465.php [accessed 31 May 2012] 16 (hereinafter: Energiekonzept); Eckpunkte Energiewende paragraph 14.

261 Bundestag Antrag '*Leitlinien für Transparenz und Umweltverträglichkeit bei der Förderung von unkonventionellem Erdgas*' Bundestagsdrucksache 17/7612 of 8 November 2011; Bundestag Stenografischer Bericht 178. Sitzung 21169; EUCERS 6.

262 Kruyt et al. 2011 at 292; Sovacool 11.

263 Commission Shale Gas Communication 3; Northern Ireland Assembly Deb 6 December 2011, Vol 69 No 6, col. 307 (hereinafter: Northern Ireland minutes).

264 This is, however, not undisputed in America, see Patrick Artus '*US reindustrialisation poses challenge for Eurozone*' London: FTSE Global Markets, London 2012) available at: http://www.ftseglobalmarkets.com/blog/european-review/us-industrialisation-poses-challengefor-eurozone.html [accessed 17 July 2014]; Mathilde Mathieu, Thomas Spencer and Oliver Sartor 'Economic analysis of the US unconventional oil and gas revolution' VOX CEPR's Policy Portal available at: http://voxeu.org/article/limited-economic-impact-us-shale-gas-boom [accessed 26 June 2016]; SRU Faulstich 17/18.

265 Commission Shale Gas Communication 5.

266 Commission Shale Gas Communication 3 and 5.

267 Susan Y Noe and George Rock Pring 'The "Fear Factor": Why We Should Not Allow Energy Security Rhetoric to Trump Sustainable Development' in Barry Barton et al. (eds) '*Energy Security: managing risk in a dynamic legal and regulatory environment*' (Oxford University Press, Oxford 2004) 432 (hereinafter: Noe/Pring).

how society could grind to a halt without secure energy supplies.[268] Energy security is thus part of the broader field of economic development and as it is a tiny part of the definition of economic development, economic development is not part of the definition of energy security.

As this work is concerned with the interplay of environmental protection and energy security the following section focuses on the first example and the question whether environmental protection is part of the very definition of energy security. If so, does that mean the interests of environmental protection and energy security cannot contradict each other? How may such a view be reconciled with the realities and the regulation of new energy technologies like shale gas extraction?

The European Commission shares some responsibility for the emergence of the view that environmental protection is part of the definition of energy security. The Green Paper of 2000, 'Towards a European Strategy for the Security of Energy Supply'[269] includes a reference to that effect.[270] Less clear, but more authoritative,[271] is the Internal Gas Market Directive,[272] which could also be viewed as discussing environmental protection in the context of energy security.[273]

The latest EU document that has been counted in this category is the Energy Roadmap 2050.[274] Some scholars have assessed that this document is 'fusing' environmental and energy security objectives.[275] While close scrutiny of the text reveals that there are interactions, aims like achieving the Roadmap's '*decarbonisation objective while at the same time ensuring*

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[268] Case 72/83 *Campus Oil Ltd v Minister for Industry and Energy* [1984] ECR 2727 paragraphs 34/35 (hereinafter: *Campus Oil)*.

[269] Commission 'Towards a European Strategy for the Security of Energy Supply (Green Paper)' (Communication) *COM (2000) 769 final* (hereinafter: Green Paper).

[270] Green Paper 2.

[271] As this is a Directive with a clearly defined legal effect, as opposed to a Communication which of itself, does not have any direct legal effect, see article 288 TFEU.

[272] Council Directive (EC) 2009/73 of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC [2009] OJ L 211/94 (hereinafter: Internal Gas Market Directive).

[273] This, however, is ambivalent. While preamble 44 defines environmental protection and energy security as two distinct objectives that the Directive should facilitate, the body of the Directive, in particular articles 3 (1), (2) and (7) and 25 (1) Internal Gas Market Directive, mentions both interests together, without making any perceivable distinction between them.

[274] Commission 'Energy Roadmap 2050' (Communication) *COM (2011) 0885 final* (hereinafter: Energy Roadmap 2050).

[275] Leal-Arcas/Filis/Abu Gosh 303.

security of energy supply'[276] rather imply that two, conceptually different, objectives shall be met at the same time. The Roadmap, therefore, does not state that environmental protection is part of the energy security objective.[277]

Parts of the legal literature are pushing hard for the conceptual inclusion of environmental protection into the definition of energy security, despite the ambiguous signals from the European Commission.[278] Proponents of such an inclusion are putting forward three main arguments. First, energy infrastructure is typically long-lived: if a company decides, for instance, to construct a power plant, this will be an investment based on the presumption of long-term use of that asset.[279] In this sense, current energy decision-making is creating the environmental reality that will shape people's lives around the world for decades to come.[280]

Second, promoting energy security without including environmental aspects incentivizes the use of technologies and practices which exacerbate climate change, for instance by increasing greenhouse gas emissions.[281] Vice versa, an inclusion of environmental aspects in the definition of energy security, allegedly, leads to synergies, as the two examples of energy efficiency and renewables demonstrate.[282] Renewables are a domestic source of energy with an overall positive effect on the environment.[283] The same is true for energy efficiency: if less energy is required, the need for

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276 Energy Roadmap 2050 at 2.

277 The EU's unclarity on this and the possibility that it might view energy security as a pre-condition to the objective of environmental protection apparently caused considerable criticism in the aftermath of the issuance of the Roadmap, see: Leal-Arcas/Filis/Abu Gosh 303.

278 Sascha Müller-Kraennar '*Energy Security: Re-measuring the World*' (Earthscan, London 2008) xi; Kruyt et al. 2009 at 2166; Marilyn A Brown and Michael Dworkin 'The Environmental Dimension of Energy Security' in Benjamin K Sovacool (ed.) '*The Routledge Handbook of Energy Security*' (Routledge Ltd., London, New York 2011) 176/177, 181 and 186 (hereinafter: Brown/Dworkin); Sovacool 9–11 and 33; Elkind 128/129; David F von Hippel et al. 'Evaluating the Energy Security Impacts of Energy Security' in Benjamin K Sovacool (ed.) '*The Routledge Handbook of Energy Security*' (Routledge Ltd., London, New York 2011) 75/76; Kruyt et al. 2011 at 291 et sqq.

279 Elkind 129.

280 Ibid.

281 Ibid.

282 Marilyn A Brown and Benjamin K Sovacool '*Climate Change and Global Energy Security*' (Massachusetts Institute for Technology, Sabon USA 2011) 84 and 122/123 (hereinafter: Brown/Sovacool); Luft/Korin/Gupta 52; Brown/Dworkin 181 and 186.

283 ECJ Case C-379/98 *Preussen Elektra* [2001] ECR I-2099 paragraphs 15, 73, 77 and 81.

energy production and imports, which are both burdening the environment, is reduced.[284]

Third, climate change will affect energy systems profoundly, for example by raising sea levels, a threat that requires adaptations in the transportation infrastructure which serves energy systems, including oil terminals, etc.[285] In addition it is feared that mass migration of climate refugees seeking asylum from ecological disaster could destabilize regions of the world, threatening energy as well as national security.[286]

All three arguments are valid in their own right but, crucially, do not explain why the concept of environmental protection must be a part of the very definition of energy security. Indeed, these arguments indicate that a strong interrelation between both interests exists. However, in order to curtail the use of, for instance, environmentally harmful energy technologies, environmental protection does not have to be a part of the concept of energy security. It may also function as an external corrective if it is viewed as a different interest, existing in its own right.

This reasoning is supported by the energy 'trilemma', mentioned above, which envisages the interplay between the two, structurally separate, interests of environmental protection and energy security. Environmental sustainability is a lone-standing pole in the energy 'trilemma'. If it would be viewed as part of the different pole of energy security, the risk arises that the, already fuzzy, concept of energy security may disintegrate altogether.

Furthermore, an inclusion of environmental protection in the definition of energy security would run into the danger of 'whitewashing' the fact that the two interests can be at odds with each other. This view has, for instance, been put forward by Talus, who describes energy security as the main opponent of a high level of environmental protection.[287] Shale Gas extraction is quite an apt example for this: if the legislator were to pursue the objective of environmental protection in a strict manner, for instance

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284 For that idea see: International Energy Agency '*Energy Security and Climate Policy – Assessing Interactions*' (OECD/International Energy Agency, Paris, 2007) 17, 35, 94/95 and 112; Nathalie Trudeau and Peter G Taylor 'The Energy Efficiency Dimension of Energy Security' in Benjamin K Sovacool (ed.) *'The Routledge Handbook of Energy Security'* (Routledge Ltd., London, New York 2011) entire chapter, but particularly expressed at 225 and 237; Anatole Boute 'Combating Climate Change and Securing Electricity Supply: The Role of Investment Protection Law' (2007) Vol 16 No 8 *EELR* 237.

285 Ibid.

286 Brown/Dworkin 177; furthermore, see Luft/Korin/Gupta 46 for a reproduction of the argument.

287 Kim Talus '*EU Energy Law and Policy – A Critical Account*' (Oxford University Press, Oxford 2013) 186 (hereinafter: Talus 2013).

by a prohibition on shale gas extraction, this would forfeit potential benefits for Europe's energy security. If the legislator strictly adheres to the objective of energy security, this could result in legislation that might incite a rush to extract as much shale gas as possible and as quickly as possible, risking severe damage to the environment.

Moreover, the conceptual inclusion of environmental protection in the definition of energy security could open the 'floodgates' towards hundreds of new variables, which could also be included in the energy security definition.[288] This would complicate international dialogue on energy security and make policies designed to enhance energy security much more difficult to agree upon and implement.[289] It would cause sluggishness, if not total paralysis, in energy security decision-making[290] and further intellectual discord by introducing contentious debates over the weighting of multiple indicators.[291]

The European Commission, maybe because of these arguments, appears to have changed its position on the issue slightly in recent times. By 2014 the EU issued a new Communication, titled 'European Energy Security Strategy'.[292] This Communication asserts that a strong relationship between the interests of environmental protection and energy security exists, going so far to call the two 'inseparable'.[293] However, later in the Communication, it becomes clear that this wording relates to the close relationship between both interests and does not purport that they are the same: the Communication explicitly defines energy security on the basis of eight pillars.[294] None of these eight pillars refers to environmental protection or environmental sustainability.

With specific regard to the security of gas supply in Europe, the European Union established the Gas Security Regulation in 2010.[295] This

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288 Luft/Corin/Gupta 46.
289 Ibid.
290 Luft/Corbin/Gupta 45
291 Valentine 57.
292 European Commission 'European Energy Security Strategy' (Communication) *COM (2014) 330 final* at 2/3 (hereinafter: European Energy Security Strategy).
293 European Energy Security Strategy 2.
294 European Energy Security Strategy 3.
295 Regulation (EU) 994/2010 of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC [2010] OJ L 295/1 (hereinafter: Regulation 994/2010). This Regulation is about to be replaced by a new one which, however, is currently at draft stage, see European Commission 'Proposal for a Regulation of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing

Regulation includes, in its preamble, a comprehensive list of indicators for the security of gas supplies, but none of these indicators refers to environmental protection.[296] The document rather considers that a balance between environmental protection and energy security interests has to be struck.[297]

Overall, the conclusion that environmental protection should not be included in the conceptual definition of energy security is warranted. The examples that have been put forward by the literature do not make a sufficient case for an *inclusion* of environmental protection in the definition of energy security. These examples merely prove that the, *by nature distinct*, interests of environmental protection and energy security may be *reconciled* in individual cases.

1.4 CONCLUSION

Shale gas extraction is not a new technology. First it is not new and second it is not a technology. Instead, it is brought about by the combination of two technologies that have been deployed safely in Europe for over 30 and 50 years respectively:[298] innovative drilling and hydraulic fracturing. The new bit is the application of the combined technologies to unconventional shale gas reserves at a large scale, which was first done around the year 2000 in the Barnett shale play in Texas.[299]

Although shale gas undertakings around the globe rely on the combination of these two technologies, it would be wrong to infer that the potential environmental and/or energy security repercussions of both technologies are similar. Quite the opposite: shale plays and the overall make-up of the subsoil differ from region to region and country to country.

Shale plays are situated at different depths, their permeability and brittleness varies, the layers of rock strata that have to be bored through and the amount of gas that is contained in the shale rock is also widely different. As a consequence, the composition and amount of the fracturing fluid, the pressure with which it is pumped underground, the extent of created fractures and the ways to dispose of the 'flow back' are site-specific.

Shale gas extraction is bringing about a number of potential

Regulation (EU) No 994/2010' *COM (2016) 52 final*. Thus, this book will work with Regulation 994/2010 in its current form.

296 Preamble (7) of Regulation 994/2010.

297 Preamble (14) of Regulation 994/2010.

298 Stoneley 83; Pearson et al. 60; Wirtschaftsverband hydraulic fracturing.

299 US EIA 2013 at 13; May/Dernbach 2.

environmental issues as well as potential energy security benefits. Both, however, are still largely shrouded in scientific uncertainty. Assertions about issues and benefits in studies are often based on a mix of projections, estimations and certain American experiences, which may not be transferable to Europe.

Recent developments in EU Member States, like the *Energiewende* in Germany, are posing a conceptual question about the extent to which environmental protection objectives and energy security interests are intertwined. In this author's view, environmental protection and energy security are separate concepts, although they might interact closely with each other in certain cases. In the case of shale gas extraction both interests actually compete with each other.[300] The main question is not if environmental protection forms part of the definition of energy security, but how both separate, competing interests may be reconciled with each other.

300 Mark R Robeck and Michael Bennett 'Shale Gas in the United States: An Institutional Comparison' in Cecile Musialski et al. (eds) '*Shale Gas in Europe*' (Claeys & Casteels, Deventer 2013) 36/37 (hereinafter: Robeck/Bennett). Same conclusion reached by Robeck/Bennett 36/37.