	Essential Readings in Environmental Law **IUCN Academy of Environmental Law (www.iucnael.org)**

SHALE GAS EXTRACTION/HYDRAULIC FRACTURING ('FRACKING')

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OVERVIEW OF KEY SCHOLARSHIP

General environmental impact, policy and scientific reports

1. Council of Canadian Academies (2014), Environmental Impacts of Shale Gas Extraction in Canada, Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction.
2. Broderick J., K. Anderson, R. Wood, P. Gilbert , and M. Sharmina (2011), *Shale gas: an updated assessment of environmental and climate change impacts*. A report commissioned by The Co-operative and undertaken by researchers at the Tyndall Centre, University of Manchester. Retrieved in May 2016 from http://www.tyndall.ac.uk/sites/default/files/coop_shale_gas_report_update_v3.10.pdf

Health and water related scientific technical reports and articles

3. Broomfield, M. (2012), *Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe* (Report No. ED57281-17c). European Commission DG Environment. Retrieved during May 2016 from http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf
4. US Environmental Protection Agency (2012), Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources Progress Report, Retrieved during May 2016 from https://www.epa.gov/sites/production/files/documents/hf-report20121214.pdf.

5. Vengosh, A., R.B. Jackson , N. Warner , T.H. Darrah, and A. Kondash, A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States, Environmental Science and Technology**,** 2014, 48 (15), pp 8334–8348

Energy and Climate

6. Dernbach, J.C., and J.R. May (ed) (2016), Shale Gas and the Future of Energy Edward Elgar
7. McJeon, H., J. Edmonds, N. Bauer, L. Clarke, B. Fisher , B.P. Flannery, Hilaire J., V. Krey, G. Marangoni, R. Mi, K. Riahi , H. Rogner, and M. Tavoni, 'Limited impact on decadal-scale climate change from increased use of natural gas' (2014) 514 (7523) *Nature* 482.
8. Howarth, R. (2014), *A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas.* Energy Science and Engineering **2** (2), 47–60

Public Trust, human rights, environmental principles and sustainable development

9. Dernbach, J. C., J.R. May and K.T. Kristl (2014), Robinson Township v Commonwealth of Pennsylvania: Examination and implications, Environmental Law Center, Widener University.
10. Grear A, E. Grant, T. Kerns, K. Morrow, and D. Short (2014), Human Rights Assessment of Hydraulic Fracturing and Other Unconventional Gas Development in the United Kingdom, Global Network for the Study of Human Rights and the Environment.
11. Glazewski, J., "Sustainable development and proposed shale gas extraction in South Africa: prospect and challenges", Chapter 10 in *Shale Gas and the Future of Energy,* Dernbach J.C., and J.R.. May (eds) (2016), Edward Elgar, pp. 209-229.
12. Glazewski, J. and L. Plit 2015(1) Stellenbosch Law Review, *Towards the Application of the Precautionary Principle in South African Law* 190.

Background

Unconventional Gas Extraction, Shale Gas Extraction, or Hydraulic Fracturing ('fracking') is an "unconventional", (see Terms and Definitions below), mining technology in which hydraulically pressurised water containing a chemical mixture is pumped into deep boreholes to create sufficient pressure to fracture rocks, thereby allowing the recovery of gas. The potential environmental, social and health impacts associated with fracking are broad ranging and include possible increased seismic activity, impact on water quality and quantity, health risks and social disruption. The potential benefits of fracking include energy security by the generation of cheap gas (fracking accounts for 40% of US natural gas supply and is projected by the US Energy Information Administration to be the dominant source of domestic gas for the foreseeable future (EIA 2014)); employment creation and others. Exploration and actual fracking activity typically entails multi-disciplinary studies, there currently being no dedicated legal texts on the subject; rather a multi-disciplinary approach is required, drawing from a vast body of law from human rights law to governance as well as monitoring, enforcement and compliance systems.

General environmental impact policy and scientific reports

1. The main environmental technical report and study which describe the underlying science and provides an insight into the potential environmental impact of fracking is the one produced by the **Council of Canadian Academies**, titled **Environmental Impacts of Shale Gas Extraction in Canada.**. While focussed on Canada it provides an invaluable insight into the overall issues which the shale gas extraction raises from shale gas technology, to well integrity, to water quality and quantity concerns, to climate change as well as regulatory and social issues.

2. ***Shale gas: an updated assessment of environmental and climate change impacts*** is a report undertaken by a group of researchers at the Tyndall Centre at the University of Manchester. **J. Broderick *et al.*** provide a comprehensive overview of the development of shale gas in the UK. It includes chapters on shale gas production and reserves in the UK; an estimation of GHG implications of shale gas; human health and environmental considerations. The latter chapter includes sections on fracturing fluids and flowback fluids, groundwater contamination, water consumption and the importance of cumulative impacts. A governance chapter is dedicated to the European regulatory framework where the focus is in great part on groundwater protection and the regulation of substances used in fracturing fluids.

   The report concludes that irrespective of whether UK shale gas substitutes for coal, renewables or imported gas, the industry's latest reserve estimates for just one licence area could account for up to 15% of the UK's emissions budget through to 2050. As such, emissions from a fully developed UK shale gas industry would likely be very substantial in their own right. If the UK Government is to respect its obligations under both the *Copenhagen Accord* and the Low Carbon Transition Plan, shale gas offers no meaningful potential, even as a transition fuel. Moreover, any significant and early development of the industry is likely to prove either economically unwise or risk jeopardising the UK's international reputation on climate change. Against such a quantifiable and stark evaluation, the report concludes that the UK needs to invest in very low carbon energy supply if it is to both abide by its international obligations *and* support economically sustainable technologies.

Health and water related scientific technical reports and articles

3. **M. Broomfield**'s comprehensive report, titled ***Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe,*** was commissioned by the European Commission DG Environment. It assesses the environmental and health risks associated with the use of hydraulic fracturing for hydrocarbon extraction, particularly shale gas extraction. After outlining the EU setting, the report commences by referring to a US EPA study which identifies four major areas of concern for potential human and ecosystem impacts with regard to the use of hydraulic fracturing for shale gas production, namely: possible pollution of drinking water from methane and chemicals used in fracturing fluids; air pollution; community disruption during shale gas production; and cumulative adverse impacts. Among other things the report includes a legislative review which identifies a number of gaps or potential gaps in European legislation. The report concludes by making a number of recommendations including: the use of micro-seismic monitoring in relation to hydraulic fracturing; determination of chemical interactions between fracturing fluids and different shale rocks, and displacement of formation fluids; induced seismicity triggered by hydraulic fracturing; development of less environmentally hazardous drilling and fracturing fluids; methods to improve well integrity through development of better casing and cementing methods and practices; development of a searchable European database of hydraulic fracturing fluid composition; research into the risks and causes of methane migration to groundwater from shale gas extraction; the development of a system of voluntary

ecological initiatives within sensitive habitats to generate mitigation credits which could be used for offsetting future development.

4. The report of the **US Environmental Protection Agency**, titled ***Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources Progress Report***, is central to the issue of potential impact on water resources from fracking activities. This study which has been on-going since 2012 comprises 18 research projects and examines five big questions relating to water and fracking activities: (1) As regards water acquisition: what are the possible impacts of large volume water withdrawals from ground and surface waters on drinking water resources? (2) As regards chemical mixing: what are the possible impacts of hydraulic fracturing fluid surface spills on or near well pads on drinking water resources? (3) As regards well injection: what are the possible impacts of the injection and fracturing process on drinking water resources? (4) As regards flowback and produced water: What are the possible impacts of flowback and produced water (collectively referred to as "hydraulic fracturing wastewater") surface spills on or near well pads on drinking water resources? and 5. As regards wastewater treatment and waste disposal: What are the possible impacts of inadequate treatment of hydraulic fracturing wastewater on drinking water resources? According to the executive summary the progress report cannot as yet be used to draw conclusions about potential impacts to drinking water resources from hydraulic fracturing as it is an on-going but already very thorough study.

5. A further leading technical paper on the potential risks that shale gas operations pose to water resources, also arising in the U.S. but of general application, is by **A. Vengosh *et al*** titled ***A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States***. The paper identifies and outlines four potential risks for water resources: (1) the contamination of shallow aquifers with fugitive hydrocarbon gases (i.e., stray gas contamination), which can also potentially lead to the salinization of shallow groundwater through leaking natural gas wells and subsurface flow; (2) the contamination of surface water and shallow groundwater from spills, leaks, and/or the disposal of inadequately treated shale gas wastewater; (3) the accumulation of toxic and radioactive elements in soil or stream sediments near disposal or spill sites; and (4) the over-extraction of water

resources for high-volume hydraulic fracturing that could induce water shortages or conflicts with other water users, particularly in water-scarce areas.

Energy and Climate

6. The central focus of the book titled ***Shale Gas and the Future of Energy***, edited by J.C. Dernbach and J.R. May, is on the long term sustainability of shale gas extraction. Apart from an informative introductory and conclusion chapters, the work is divided into five parts which focus on: (1) public health and the environment; (2) community aspects; (3) public participation, public information, and access to justice; (4) governance; and (5) energy and climate change.

7. In an authoritative article titled ***Limited impact on decadal-scale climate change from increased use of natural gas***, **H. McJeon *et al*** survey the thorny issue and debate around whether abundant natural gas substituting for coal could reduce carbon dioxide (CO2) emissions. Some researchers have reported that the non-CO2 greenhouse gas emissions associated with shale gas production make its lifecycle emissions higher than those of coal. The authors point out that assessment of the full impact of abundant gas on climate change requires an integrated approach to the global energy-economy-climate systems, but the literature has been limited in either its geographic scope or its coverage of greenhouse gases. They show that market-driven increases in global supplies of unconventional natural gas do not discernibly reduce the trajectory of greenhouse gas emissions or climate forcing. Their results show that although market penetration of globally abundant gas may substantially change the future energy system, it is not necessarily an effective substitute for climate change mitigation policy.

8. In the same vein and in the same year, **R. Howarth,** in a paper titled ***A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas***, reviews previous literature which analyses the greenhouse gas footprint (GHG) of shale gas. A number of previous studies, based on the poor quality of publicly available data at the time, tentatively concluded that the climate impact of shale gas may be worse than that of other fossil fuels such as coal and oil because of methane emissions. This particular paper reviews more recent research and new studies and finds that previous estimates of methane emission from both shale gas and conventional natural gas were relatively

robust. Using these new, best available data and a 20-year time period for comparing the warming potential of methane to carbon dioxide, the paper concludes that both shale gas and conventional natural gas have a larger GHG than do coal or oil, for any possible use of natural gas and particularly for the primary uses of residential and commercial heating.

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9. In their monograph on ***Robinson Township v Commonwealth of Pennsylvania: Examination and implications***, **J.C. Dernbach**, **J.R. May** and **K.T. Kristl** outline and analyse this decision rendered by the Pennsylvania Supreme Court. The Court invoked the Pennsylvania State Constitution which includes an "Environmental Rights Amendment," stating that: "The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and (a)esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people." (Article I, Section 27) Among other things the Court held that major parts of Pennsylvania's *Oil and Gas Law* (Act 13 of 2012) which was designed to facilitate the development of natural gas from Marcellus Shale to be unconstitutional on the basis of the above constitutional environmental right.

10. In their report titled ***Human Rights Assessment of Hydraulic Fracturing and Other Unconventional Gas Development in the United Kingdom***, **A. Grear *et al*** adopt a human rights approach in arguing that the UK Government has a clear and urgent duty to fully investigate the human rights implications of fracking before authorising any exploratory or extractive fracking operations in the UK. The report outlines both the substantive and procedural human rights obligations of the UK government. On the strength of this argument it recommends a moratorium on the conduct of fracking operations until such a time as a full, industry-independent, publicly funded Human Rights Impact Assessment has been properly undertaken and placed in the public domain

11. In his chapter titled ***Sustainable development and proposed shale gas extraction in South Africa: prospects and challenges***, **J. Glazewski** outlines and assesses proposed fracking activities in South Africa against the backdrop of the environmental right in South Africa's Constitution which among other things exhorts the right to measures that "…secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."

12. Although **J. Glazewski** and **L. Plit**'s article titled ***Towards the Application of the Precautionary Principle in South African Law*** is written specifically against the backdrop of proposed fracking in South Africa, the underlying argument is of universal application. The authors outline the history and purpose of the precautionary approach and describe how it has been applied in other jurisdictions including Canada, Australia and the European Union and argue that the precautionary principle should be applied in South Africa in the context of fracking. It suggests that a similar argument is valid in other jurisdictions where fracking is being considered.

Terms and Definitions

The term hydraulic fracturing or "fracking", is shorthand for what is commonly referred to as falling into the category of "unconventional gas extraction". Hydraulic fracturing' requires the injection of fluids into geological formations to create and expand fissures, allowing the enclosed gas to be released and flow out of the formation into the well bore.

The industry typically distinguishes between "unconventional" as opposed to "conventional "oil and gas" extraction. The term "conventional" refers to the situation where gas is trapped in reservoirs in which buoyant forces keep hydrocarbons in place below a sealing cap-rock. The combination of good permeability and high gas content typically permits natural gas (and oil) to flow readily into wellbores through conventional methods that do not require artificial stimulation. Conventional sources are typically sandstone, siltstone and carbonate (limestone) reservoirs. In contrast, releasing natural gas from "unconventional" formations and bearing rocks requires typically a system of natural and/or artificial fractures.

Shale gas, along with "tight gas" and "coalbed methane", is an example of unconventional natural gas. The term "unconventional" does not refer to the characteristics or composition of the gas itself, which are the same as "conventional" natural gas, but to the porosity, permeability, fluid trapping mechanism, or other characteristics of the reservoir or bearing rock formation from which the gas is extracted. These differ from conventional sandstone and carbonate reservoirs and these characteristics result in the need to alter the geological features of the reservoir or bearing rock formation using artificial stimulation techniques such as hydraulic fracturing in order to extract the gas. Oil could potentially also be extracted from unconventional reservoirs such as oil shales using hydraulic fracturing techniques. However, there is at present no indication of a significant increase in shale oil production in Europe or the US.

Websites

Fracfocus: https://fracfocus.org/data-download

According to Wikipaedia FracFocus is a Chemical Disclosure Registry and a joint venture of the *Ground Water Protection Council* and the *Interstate Oil and Gas Compact Commission* to produce a web site for drilling companies to voluntarily, self-report and register the chemicals they use in hydraulic fracturing. The web site accesses an extensive database of chemicals self-reported by well number and location. It also has an educational mission to better inform the public about hydro-fracturing and groundwater protection. However it has been criticised by among others the Forbes Group. See for example:

http://www.forbes.com/sites/davidblackmon/2013/04/25/harvards-fracfocus-study-grades-an-f/