Research Report

Environmental Commission

Limiting the negative effects of fracking on the environment

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Forum	Environment Commission
Issue:	Limiting the negative effects of fracking on the environment
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Introduction

Natural gas and oil have been a secure, abundant and economical source of energy on a global level since the industrial revolution. Nowadays, both resources are essential for the functioning of the economy in every state. We cannot live without these resources, as they are required for transport, production and living in our society. Every country is dependent on these natural resources.

In the past, efforts of the oil and gas industry across the planet were mainly focused on the exploration and development of natural gas reserves of a conventional type. More recently, since the beginning of the 21st century, these conventional resources have been starting to run dry. This, coupled with the augmented usage of these resources, has led to the rise of energy prices. As a result, the industry has started to focus on the development of unconventional gas resources instead. The natural gas and oil from these new sources are not distinguishable from conventional natural gas and oil. However, the development of these unconventional gas resources is more expensive and requires the use of special technologies designed to facilitate the production of the aforementioned resources. Fracking is one of the main technologies developed for cost-effective production of gas and extraction of oil from new oil wells.

Recently, this technique has generated a lot of controversy due to the negative impact it has on the environment. Nevertheless, large industrial operators are preparing to exploit new oil and gas fields in the United States of America (USA), Canada and the rest of the world.

Definition of Key Terms

Hydraulic fracturing

Hydraulic fracturing, commonly referred to as 'fracking', is the targeted fracturing of little permeable geological formations by means of injecting a highly pressurized fracturing fluid into the rock in order to create a micro-crack and, by doing so, fracturing the rock. This fracturing can be performed near the surface or deeper into the soil. Where a conventional well would have produced small quantities or even nothing at all, this technique allows the extraction of oil or gas in dense substrates.

Fracking fluid

Fracking fluid is the liquid used for hydraulic fracturing. It exists of water (90%), sand (about 9,5%) and chemicals (about 0,5%). When the pressure of the fluid at the desired depth exceeds the pressure created by the weight of rocks located above, one or more fractures are created. Continuous injections of fluid allow the widening of fractures, possibly for several hundred meters, when fluid intake is maintained. The management of the fracking fluid, and thereby the fracking procedure as a whole, is at this moment far from being fully controllable.

Shale gas

Shale gas is methane produced from the decomposition of organic matter (algae and plankton). It is found in a sedimentary rock type called shale, which consists of plates stacked on top of each other, therefore having a very low permeability. The gas is located in the interstices between these impermeable plates. This formation of layers inhibits the usage of normal pumping techniques. It is therefore necessary to break the rock of the different layer in order to remove all the disseminated and scattered methane.

Shale oil

Shale oil is petroleum contained in the same manner in the shale as shale gas and extracted, such as gas, by hydraulic fracturing. Shale oil and shale gas are intended for the same uses as conventionally extracted oil and gas.

Fracking wastewater

As stated before, water is the main element of hydraulic fracturing and a lot of water is pumped into the well. Because of this, a lot of water is released during the fracking

process, thereby mixing itself with the other elements in the oil well and creating two different waste products: *flowback* water and *produced* water. Flowback water comes from the original fracking fluid mixed together with the chemicals from the oil well. Over a small period of time some of the water flows, through a pumping system, back to the surface where it can be treated in different ways to dissolve the negative effects of the chemicals. Produced water is a mix of the water originally present in the shale layer, original minerals and hydrocarbons and the chemicals used during hydraulic fracking.

Environment

All elements (biotic or abiotic) that surround an individual or species, some of which contribute directly to meet their needs.

Groundwater

Groundwater is any water beneath the surface, in the saturation zone (aquifer) and in direct contact with the ground or underground.

General Overview

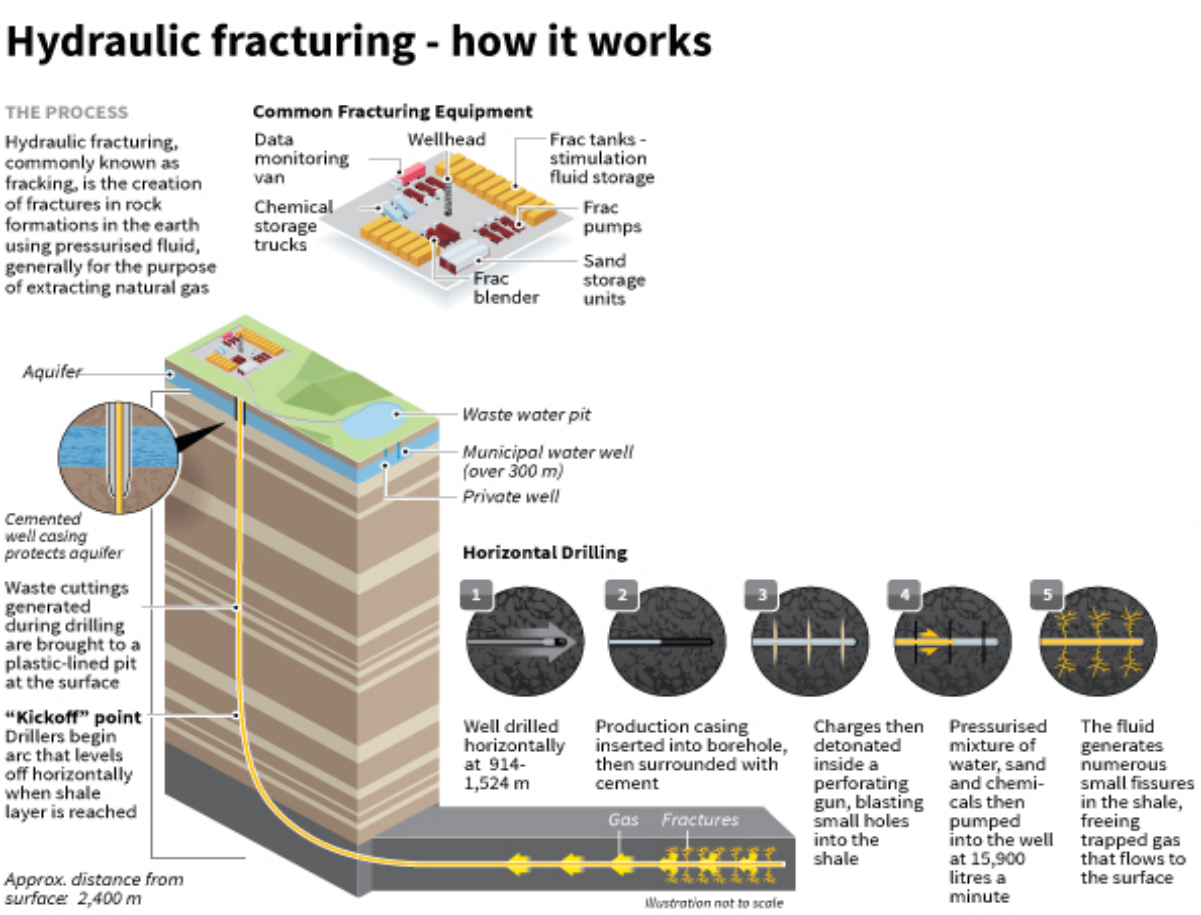
The process of fracking

The hydraulic fracturing technique consists of injecting fracturing fluid (a mixture composed of water, sand and chemical additives) under high pressure (about 300 bar at 2500m depth) into the shale layer in order to fracture the rock. Then, a mixture of gas or oil and part of the injected water and additives rises to the surface.

Hydraulic fracturing is often associated with the horizontal drilling technique of directing a pipe towards the axis of the bedrock at a 1 to 3 km depth. An interlocking cemented steel casing allows the complete isolation of the well and prevents leakage of oil or fracturing fluid injected at depth. Prior to hydraulic fracturing, a series of small diameter holes (less than 12 mm) is drilled along the horizontal casing by detonation of small explosive charges. These holes allow the contact between the fracturing fluid under high pressure and the rock when it is fractured and propped open with sand and chemical additives. The cracks in the rock are only a few millimetres wide, but can reach a depth of ten meters or more into the drilled layer.

Fracking fluid consists mostly of water (about 90%) and sand (about 9,5%); the last part consists of chemicals such as acid, friction reducers, viscosity maintainers, corrosion inhibitors and clay stabilizers. The amount of chemicals compared to the other substances in the fluid may seem little in proportion. However, considering that it can take between 15 and 25 million litres of water to fracture a well, thereby injecting between 70 and 125 tons of chemicals into the oil well in the process, the impact of those chemicals on the environment can become significant. The water and some of the chemicals are used to fracture the layer of rocks and thereby allow a smoother flow of the hydrocarbons (oil and gas) to the oil well. The sand and other materials such as gels are placed between the different fractured shale plates once the fracturing process is stopped, to provide a continuous flow of shale gas and oil by keeping the created fracture open. The chemicals are added to the fluid to ameliorate the extraction progress, by means such as but not limited to: disinfecting the water, limiting the growth of bacteria, cleaning the bedrocks, limiting the friction of the different layers and pipes, preventing corrosion, controlling the positioning of the sand and limiting the fluid loss. At this moment there is a great lack of clarity on the chemicals being used for hydraulic fracturing. The composition and contents of each product or mixture is kept secret by producers and users. For example, in the USA the users are only obliged by law to reveal the names of the products they are using. The composition and contents of each chemical and mixture vary depending on the conditions to suit the rock type, working phase, depth, etc.

The injection of fracturing fluid can last several hours to several days. It is possible to repeat the fracturing process several times on a single well in order to activate a network of cracks when the production of the well decreases. This operation is called ‘multifracking’.



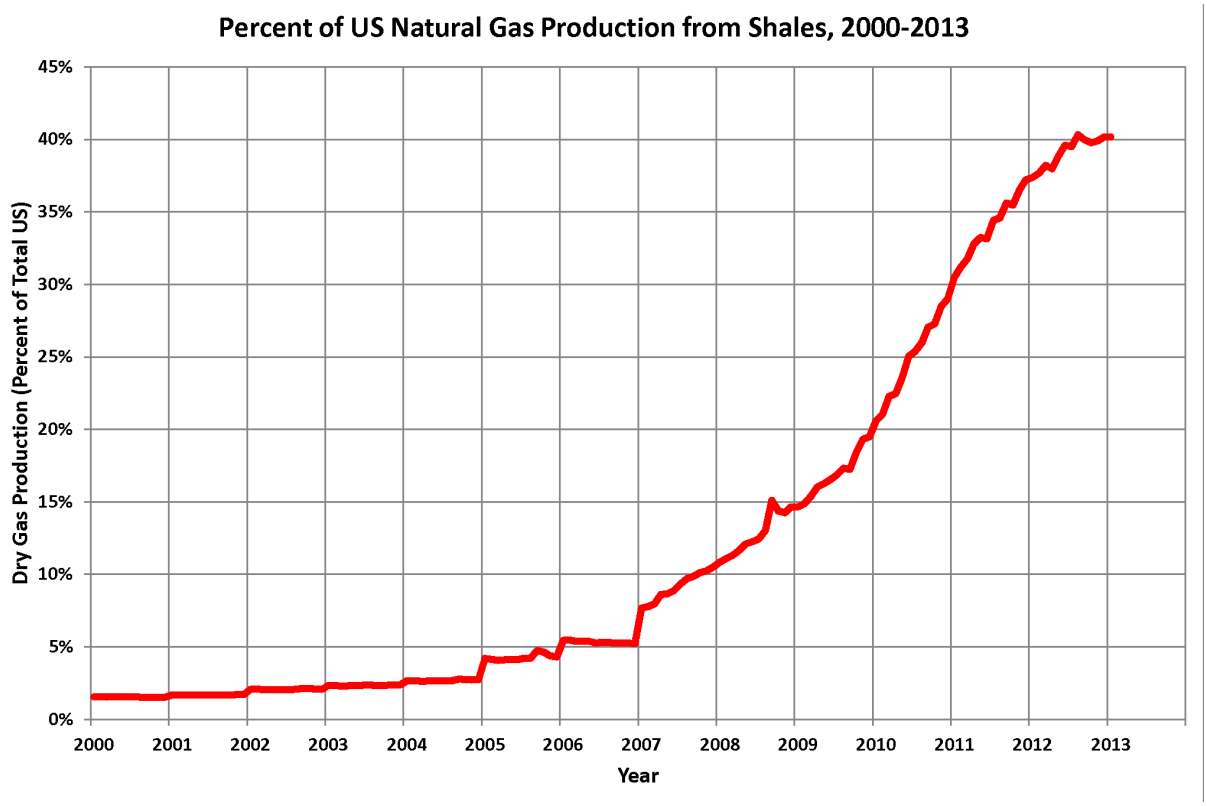
Hydraulic Fracturing
"Fracking Explained." *Marc to Market*. N.p., n.d. Web. 17 Aug. 2014. <http://www.marctomarket.com/2013/01/great-graphic-fracking-explained.html>.

Recent development of shale gas

The large-scale exploitation of shale gas (and to a lesser extent the exploitation of shale oil) began in the 2000s when the price of oil was established over a permanently high threshold in relation to the stagnation of the production of oil and gas and conventional growth in global energy consumption. These prices, as well as advances in extraction techniques, were used to finance the huge investments needed to enable the production of many wells in the USA. This country has played a pioneering role in the operation of this new resource: shale gas became a significant proportion of its energy consumption as of 2012.

Thanks to shale gas, the United States rose from 4th to 6th place in the ranking of net importers of natural gas in 2012 and in the future could, according to some forecasts, become a net energy exporter. In 2013 reserves in the world were estimated at 207 billion m3 of shale gas (32% of total natural gas reserves) and 345 billion barrels of shale oil (10% of total oil reserves). Reserves of shale gas are located in all continents, but China, Argentina, Algeria and the United States are in this order the largest holders. From 2010 to 2012, the increase in the production of shale gas in the United States and Canada has

resulted in downward pressure on gas prices, which reduced the ability of Russia to dictate high prices for the natural gas it exports to Europe. The effects of the dramatically increasing of shale gas exploitation on international energy markets have been significant, especially in Europe. Because the USA became less dependent of coal, as they extracted shale gas instead, the price of coal coming from the USA decreased considerably and the export from the US to Europe multiplied by a factor of 3, compared to 2003. This also reduced the economic attractiveness of renewable energy and even the usage of natural gas.



Percent of US Natural Gas Production from Shales 2000-2013
"Shale Gas in the United States." *Wikipedia*. Wikimedia Foundation, 08 July 2014. Web. 17 Aug. 2014. <http://en.wikipedia.org/wiki/Shale_gas_in_the_United_States>.

Environmental impact of hydraulic fracturing

Pollution and groundwater contamination ascribed to hydraulic fracturing in the United States has alarmed the general public. Opponents of fracking have voiced their concerns about several types of negative impacts caused by the exploitation of hydraulic fracturing.

Impacts on the site

The large quantities of water collected on the surface can, if they are not properly treated before being discharged into the environment, cause pollution and lead to health problems. Significant volumes of water may be contaminated by the injected

chemicals, but also by the dissolved salts in the process such as heavy metals, sulphates, carbonates and potential radionuclides, especially radon and uranium, which are all naturally present in the geological layers. The water used for hydraulic fracturing is usually then stored in surface impoundments before being transported by tankers or injected back into the ground. Part of the upwelling is treated on site and then re-injected in the soil

For example, in Pennsylvania (US), more than 6000 oil wells operating shale gas are active. They produce a large amount of wastewater discharged into the Monongahela River, which feeds more than 800,000 people, mainly in the city of Pittsburgh. This wastewater rates a radioactivity level that is up to 200 times the allowable limits for drinking water. Slightly lower radioactivity levels were observed in the Delaware River, which feeds more than 15 million people in the Philadelphia area.

Finally, the exploitation of shale gas is accused of damaging the landscape. The network of local pipelines must, over time, adapt to the changing pattern of the operating field. The landscape must be rearranged, roads and tracks for access to the different fracturing sites must be build, a network of pipes has to be installed; all of these measures have a significant impact on the local and regional environment. The exploitation of shale gas by means of hydraulic fracturing will have a significant impact on the landscape.

Climate change

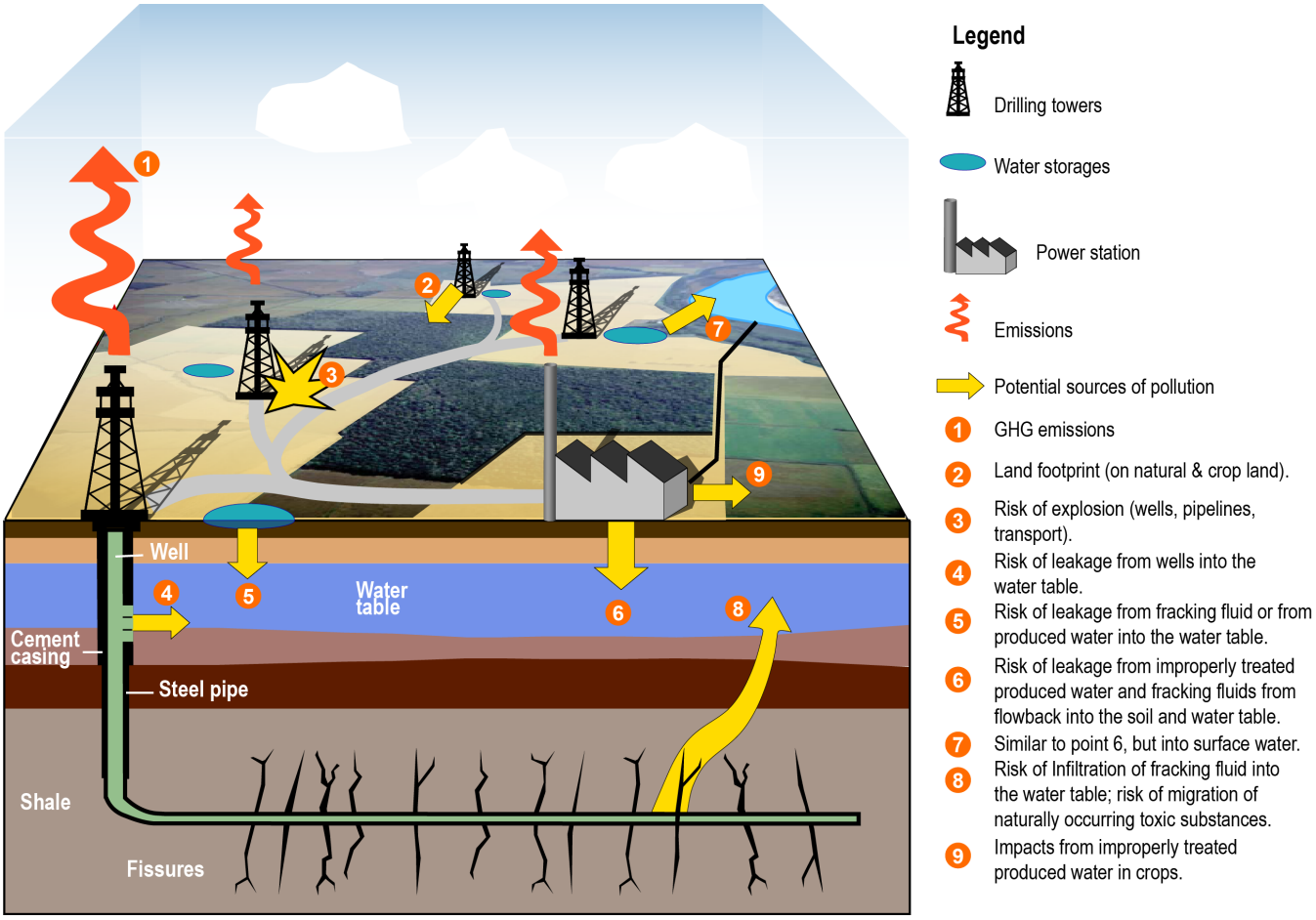
Fracking has a significant impact on the greenhouse effect. Normally gas is a cleaner source of energy than coal, but with this technique of fracturing a lot more greenhouse gasses are emitted into the environment due the unconventional way in which gas is extracted. A recent analysis by the National Academy of Sciences of the USA of a number of fracking sites in south-western Pennsylvania has found that the methane released into the atmosphere are 100 to 1,000 times the rate that the United States Environmental Protection Agency (USEPA) estimated beforehand.

Groundwater contamination

The exploitation of shale gas is accused of polluting groundwater. Multiple wells are not cemented over their entire length; this mainly depends on the legislation of the country concerned. For example, Texas only requires cementing at the depth affected by ground water and ground connected to it, not beyond; accordingly, there may be a migration of the fluids involved in an undesired way. However, this problem is typical for all oil wells, thus not only for hydraulic fracturing.

Gas leaks in the oil well results in gas leaking to the groundwater-layer. In one case, a flame formed when a user opened the tap in the sink and approached it with a lighter. The U.S. administration has shown that in another case the leak was due to a defect in the cementing of the well, which had been sanctioned once investigated. In other cases, the leak of methane resulted in the degradation of natural organic material in the aquifer.

Normally, the chemicals used for the fracturing fluid do not rise up to the aquifer, the layer that contains the groundwater. These chemicals are usually injected between 1500 and 3000 m depth at the rock layer, far more deeply than the drinking and groundwater, which are flush with the ground surface (up to 500 m deep). Cracks in the hydraulic fracturing do not extend below 100 m distances, but note that the rock layers are sometimes naturally fractured and chemicals are not biodegradable.



Schematic representation of infrastructures and potential impacts
"Fracking Carries Significant Environmental Risks." *United Nations Radio*. UN, 17 July 2014. Web. 17 Aug. 2014. <http://www.unmultimedia.org/radio/english/2014/07/17/>.

Water consumption for fracking

The technique of hydraulic fracturing is based on a very large amount of wells drilled, each requiring large amounts of water, which can be problematic in areas where surface water is scarce. In 2014, the United Nations Educational, Scientific and Cultural Organization (UNESCO) reported that the rising demand for energy, i.e. shale gas, is a threat to freshwater supplies that are already under strain from climate change.

Increase of seismicity

The seismic risk of certain fractures has also been argued, especially after several earthquakes of low magnitude stimulated by a geothermal drilling in Switzerland and through the exploitation of shale gas in the United Kingdom. Crack propagation in fractured bedrock releases energy, but it would be an average equivalent to the fall of a book on a table. In both cases reported, the earthquake came due to a remobilization of a pre-existing fault. Geophysical reconnaissance basement avoids this risk.

Gas reserves worldwide

Stevens, Barry, PhD. "Shale Gas Is Not a Fracking Mess." N.p., n.d. Web. 17 Aug. 2014. <http%3A%2F%2Fwww.barryonenergy.com>.

Major Parties Involved and Their Views

United States of America (USA)

The United States has played a leading role in the innovation of this new resource and is therefore frequently mentioned in this report. A study by the Massachusetts Institute of Technology (MIT) estimates that natural gas will provide 40% of energy needs of the United States in the future, against 20% today, partly due to the country's abundant reserves of shale gas. According to the International Energy Agency (November 2012), the United States will become the largest producer of gas by 2015.The New York Times notes that under U.S. law, oil companies are free to export gas to Canada, Mexico and countries with which the United States has a free trade agreement. This does not include countries in Europe. Having said that, the Department of State can certainly allow the export of gas to other nations when these sales are considered of national interest.

However, the criticism against shale gas in the US is rising: a survey by the American Pew Research Centre Institute in September 2013 revealed that 49% of Americans are opposed to the extraction by fracturing, against 38% in March 2013.

One of the most criticized points is the exemption for this new industry from the Safe Drinking Water Act, made possible by the Energy Policy Act passed on 29 July 2005. This law exempts liquids used in the gas extraction process in hydraulic fracturing of any protection measures established by the Clean Air Act, the Clean Water Act and the Safe Drinking Water Act. By a legal vacuum, it frees companies from the obligation to publish a list of chemicals used in fracturing operations, therefore the negative impact of individual chemicals on the environment cannot be analysed, as they are kept secret from the government and other investigators.

China

Since the beginning of the 21st century, the Chinese government has been more and more interested in the exploitation of shale gas by means of hydraulic fracturing. In 2010, China became the largest consumer of energy and as such the country is extremely dependent of energy resources available in the long run. According to the International Energy Agency (IEA) projections indicate that by 2030 China will have to import 79% of its oil consumption. The solution for the energy trap that could place China in a situation of high external dependence, thereby drastically reducing its strategic flexibility, could be found in shale gas.

For China, the technological catch-up with the West happens in two complementary ways. The first is to enter the capital of Western oil companies specialized in unconventional hydrocarbons; the second is to break the monopoly of Chinese companies by opening the door to foreign companies technically capable of quickly beginning exploitation of shale gas.

The environmental impact of hydraulic fracturing and especially the extraordinary amounts of water needed for this technique poses many problems and questions in China, just like elsewhere.

This advancement into the unknown is closely accompanied by active cooperation with the United States, as US President Obama and the Chinese former President Hu Jintao have signed the US - China Shale Gas Resource Initiative in 2008. With this initiative, foreign partnerships are now present in a sector tightly controlled by the Chinese government in the past. Some big Western companies like Shell, Chevron, Exxon Mobil and British Petroleum are cooperating in Guizhou and Sichuan in so called 'Joint Ventures' with Chinese parties. China will certainly become a very big player in the field of hydraulic fracturing, as it has the highest shale gas reserves on earth, with 36.1 trillion cubic meters of shale gas compared to 24.4 trillion shale gas reserves in the USA, according to The Economist.

European Union (EU)

The development of shale gas in the EU may be called controversial. Some countries, such as the United Kingdom (UK), Denmark, Poland, and Romania, allow the development of hydraulic fracturing on their soil, but other states such as France and Bulgaria have banned any activity related to hydraulic fracturing. Germany has only banned hydraulic fracturing in water-rich areas of its territory.

According to the European Commission, a shale gas revolution similar to which has occurred in the United States is highly unlikely in the EU. However, the Commission also recognizes the need to develop any clean gas resource, conventional or unconventional, as it can reduce the dependence of the Union on imports of energy. According to the Commission, the production of shale gas could help the EU to respond to about 10% of its gas demand by 2035.

On January 22nd, 2014, the European Commission adopted a recommendation that leaves the way open for the exploitation of shale gas in Europe, as long as the operating parties meet the "common principles", including health and environmental standards.

Timeline of Events

Date	Description of event
1821	Natural gas is for the first time extracted from shale in the State of New York.
1972	US Congress passes the Clean Water Act (CWA)
1977	United States Department of Energy (DOE) successfully demonstrates hydraulic fracturing in shale
1986	DOE introduces for the first time the horizontal drilling technique for fracturing.
2000	Due to high conventional energy prices, unconventional energy sources by means of hydraulic fracturing become economically more attractive. Shale gas exploitation increases, becoming a significant part of US' energy production, all resulting in lower energy prices.
August 8, 2005	US President George W. Bush signs the Energy Policy Act of 2005
January 22nd, 2014	US President Barack Obama and Chinese President Hu Jintao sign the US-China Shale Gas Resource Initiative

UN involvement, Relevant Resolutions, Treaties and Events

Up to this moment, no resolution regarding 'fracking' or 'shale gas' has been adopted by the UN or any of its subsidiary bodies. This does not mean that the UN is not involved in this issue. So far, no compromise and no definite decisions have been made on the issue and therefore it is extremely important that the issue is discussed.

- Hydraulic fracturing for natural gas: A new threat to human rights, 19 September 2011 (**A/HRC/18/NGO/91**)

  Note: This is a written statement submitted by UNANIMA International, a non-governmental organization (NGO). In order to prevent any confusion, the presidency would like to point out that this statement has not been adopted by the UN General Assembly, nor by the Human Rights Council.

Evaluation of Previous Attempts to Resolve the Issue

The developments of fracking and the usage of this technique on a large scale are, as mentioned, very recent. At this moment, there are only a few countries in the world where hydraulic fracturing is used extensively and therefore this issue has not been much discussed on an international level yet.

Firstly, the environmental aspect: many countries are afraid of the possible consequences of hydraulic fracturing, given the many negative aspects of the technique policymakers have become aware of. Some countries, including the Republic of France, have decided to entirely ban this method; they choose to not take the risk of any negative impact on the environment. Not only in France, but also in the rest of Europe, the sensitivity of the subject is quite large; the EU has not banned the technique, but asks the national governments to act in consent with their current legislation and common principles, such as health and environment. Many governments have decided to prohibit fracking on a large scale, as the fracking-industry and economists on one side and the opponents on the other side heavily debate the consequences. Countries such as the UK allow hydraulic fracturing, although only on a small scale, in order to limit the potential consequences.

Until now, investigations have been mainly carried out by universities and environmental organizations and show that the negative effects are larger than previously thought by the government and the operating companies involved. The consequences are currently in some cases played down by some exploiting companies because they have an economic interest in being active in this field. The national government does also see the pros of fracking, as it can benefit immensely from this unconventional source of gas. Therefore, little solutions have been found so far. For example, in the USA, due to the Energy Policy Act of 2005, the chemicals used for fracking do not necessarily have to be published, be made available to the public, or even communicated to the US government.

At this moment, in both high fracking, as well as in low fracking-activity countries, there exists a total lack of coordination and a lack of an outline of the consequences of the process. As a result, companies are not always forced to take the best safety measures, as some of these measures could have a negative impact on their profit. Both regional and national governments thereby seem to be inadequate in controlling unconventional gas and oil wells, where that certainly should be the case.

Possible Solutions

This issue needs to be addressed from different perspectives in order to limit the negative consequences as much as possible. It is important to note that the negative consequences of the process should be limited, but the harmful effects of shale gas cannot be solved, since it is a fossil fuel, which is de facto harmful to the environment and is partly responsible for the current climate change.

A total avoidance of the impacts by means of an overall ban is effective in certain areas where national authorities are open to this possible solution, as the French Government is at this moment. However, it is unrealistic to demand this of the major global players in this field, as they are economically dependent of this energy source.

Different perspectives need to be addressed in order to solve this issue. Firstly, there is currently a great lack of transparency: processes remain trade secrets and are not shared with the public or the government. Potential hazards are therefore mostly not (directly) revealed and this hinders the achievement of clear results about possible risks. Especially in the field of scientific research on hydraulic fracturing concerning all stages of the fracking process, there remains a lot of uncertainty about the negative impacts.

The United States and Canada are the leading economies regarding the large-scale exploitation of shale gas and activity in developing such techniques and they are driven by the economic benefits that this technology gives. At this time, in these areas, because of the scale on which it is applied, much more research into the negative effects can be done than in for example Europe, where the process is done on a much smaller scale, resulting in results being less clear. This transparency can be achieved on a political level: governments have to be more effective in implementing legislations and setting out measures that should be taken by companies to prevent environmental accidents. The government should also take a greater interest in controlling all the security measures so unnecessary errors can be prevented. The commission should set a standard for a legal framework, in a possible form of a Code of Conduct, which requires businesses to actively counteract negative effects in the process and governments to have the means to control it respectively.

Lastly, the money earned from shale gas could also be a means to a long-term solution. Certain states no longer import energy in high quantities because of their shale gas exploitation. They would rather export their recourses, thereby earning enormous amounts of money. A portion of these profits should be invested in the development of cleaner technologies such as renewable energy sources. Fossil fuels are indeed unsustainable and will have to be replaced before they are exhausted. This is also the view of the

Intergovernmental Panel on Climate Change (IPCC), an advisory body in the field of environment to the UN. Shale gas may be a good temporary energy source that will lead to the amelioration of our sustainable energy resources. However, a long-term solution still has to be found.

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Appendices

I. http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf

II. http://unesdoc.unesco.org/images/0022/002257/225741E.pdf (page 31)

III. http://www.wef.org/uploadedFiles/Access_Water_Knowledge/Wastewater_Treatment/Fracking%20Factsheet%20Final(1).pdf

IV. http://savewestcoastnl.files.wordpress.com/2013/04/fracking-terminology-20143.pdf

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VI. http://www.csur.com/images/CSUG_publications/CSUG_HydraulicFrac_Brochure.pdf