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Shale Gas Development: Their Gain, Our Pain and the Cost

Lanre Aladeitan[1] & Chisom Nwosu[2]

[1] Lecturer, Department of Public and International Law, Faculty of Law, University of Abuja, Gwagwalada, Nigeria

[2] Law Graduate, Faculty of Law, University of Abuja, Gwagwalada, Nigeria

Correspondence: Chisom Nwosu, c/o Suite B43, Shakir Plaza, Garki Area 11, Abuja, Nigeria. Tel: 234-813-371-9098. E-mail: chsmnwosu@yahoo.com

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Abstract

With an estimated reserve of 187 trillion cubic feet of gas and a policy thrust of domestic gas utilisation and participation as a key player in the international gas market, Nigeria in the last two and half decades has invested significantly in the development of its gas sector thus positioning itself as a potential gas producing country. To this effect, a lot of capital resources were committed to building the necessary infrastructural backbone for the country's gas development. In some cases, these projects are financed by loans with strict repayment terms contingent on the off-take of gas production. It is against this background, that the development of gas from unconventional sources such as the shale basin becomes a subject of concern and the focus of this paper in order to assess its economic implication and cost to erstwhile importing countries and hitherto exporting countries.

Keywords: Shale gas, natural gas, hydraulic fracturing, unconventional oil and gas resources, global energy industry, Nigerian liquefied gas project

1. Introduction

Unconventional gas and oil resources have become a huge topic of discourse in the global energy industry with focus on their potentials and implications for nations and global players in the field. However, none has caused more intellectual debate and analysis than the controversial shale resources.

Interest in these resources covers a lot of fields as its development could have profound implications (positive or negative) depending on the side of divide one finds himself/herself and the weight of the consequences. The recurring questions have nevertheless centred on the effect of shale gas on the global energy industry in terms of economic, geopolitical, environmental and legal considerations.

2. Shale Gas

Shale gas is natural gas trapped in shale formations. These are sedimentary rocks which contain clay, quartz and other minerals. According to the U.S. Geological Survey (USGS), the shales have been known to be source rocks (of both natural gas and oil deposits) but have only recently attained importance as reservoir rocks. (Note 1) This recent development has led to extensive research to learn more about their nature and evolution as reservoir rocks for determination of the resource potential and to make publicly available, important information on the different shale rock formations.

By category, shale gas belongs to the unconventional gas resources such as coal-bed methane, gas from tight sandstones ('tight gas') and methane hydrates (Note 2) which exist in a different form from conventional resources, thereby requiring a different mode of extraction.

According to the World Energy Council (WEC):

> […] shale gas is always found proximal to conventional reservoirs. In fact source rock exists in many settings where no conventional reservoir rock is available for permeation of natural gas. This is why the shale gas resource is expected to be plentiful…source rock can be found in other parts of the world, even in those without significant conventional gas reservoirs. The depth of shale gas varies. In most cases it is shallower than conventional gas reservoirs, but in some cases, it could be as deep as or deeper than conventional reservoirs. (Note 3)

From the observation of the WEC, it seems that shale gas resources are vastly distributed and that regions and countries with no previous expectations of sizeable domestic gas reservoirs such as China (which is estimated to have the world's largest reserves of shale gas) now have an opportunity to exploit resources within their territory to meet their domestic energy needs. This obviously has consequences for all global energy players as will be discussed subsequently.

As unconventional gas resources which more often than not are exploited from deeper well depths, the costs of accessibility and production are rather expensive and difficult compared to conventional resources. For instance, some of the best shale gas basins like the Eagle Ford and Haynesville have deeper well depths of 10 000-13 000 feet. (Note 4) This is also the case with most shale gas reservoirs outside the US such as those in Sichuan province of China which is approximately 6600-19 700 ft below ground. (Note 5) Empirically, exploiting shale gas at such depth pose technical challenges (High Pressure/High Temperature and high fracturing pressure requirement) as well as steep production cost. (Note 6) Hence, the question, on why there is a global race towards the development of shale gas resource?

3. Shale Gas: A Diversification and Supply Security Necessity

Expectedly, self sufficiency, energy security and the desire to diversify options for the supply of natural gas are readily available answers. Against this background and the trail blazing experience of the development and exploitation of shale gas in the United States, other countries, for example China have been motivated to begin exploitation of their domestic shale reservoirs. The incentive to drill and produce shale gas in China was described by a Chief Executive Officer of a company operating in China as follows: "China now realizes it has incredible opportunity to find another major fuel source other than coal." (Note 7) It follows therefore that for China, as with most other countries, the aim is diversification in energy sources in order to ensure energy security. This position can be said to be equally true for the European Union countries which have been at the mercies of Russia, Algeria (Note 8) and the Persian Gulf countries for most of their natural gas supply. In fact, the case for diversification and security of supply became imperative with the experience in 2009 of a pricing and payment dispute between Kyiv in Ukraine and Moscow in Russia. As a result of the dispute Russia turned off its gas supply for nearly two weeks thus disrupting gas supply to European Countries. This act was noted by all gas importing nations in Europe as a direct threat, (Note 9) therefore the development of shale gas became a welcome 'revolution' in hopes that shale gas quantities in Europe will help reduce reliance on Russian gas.

Similarly, the California energy crisis of 2000-01 led to shortfalls in supplies and in some cases shortages over an extended period because of dwindling domestic conventional gas resources. This resulted in higher prices, with the US appearing destined to become more dependent on imports of Liquefied Natural Gas (LNG). (Note 10) About the same time, extensive research into the possibilities of extracting gas from unconventional sources bore fruits at the Barnett shale basin in Texas when Mitchell Energy and Development (now part of Devon Energy) (Note 11) and other independent US companies paired horizontal drilling with high-volume hydraulic fracturing ('fracking') to liberate gas from fissures in the soft black rock layer a mile or more underground. (Note 12) Interestingly, this was carried out at a lower cost than originally anticipated thus enabling a turnaround in the fortunes of the US. It is therefore not surprising that the US, (Note 13) other countries, oil majors and energy stakeholders are buying in, into the idea of 'shale gas' development despite the not so competitive costs and viability.

4. Technology Advancement and Development of Shale Gas

The deployment of the combined technology of through the combination of horizontal drilling and hydraulic fracturing technologies has advanced the development of shale gas resources. The technological procedure operates by sinking a well to a depth just above a known shale deposit and then gradually deviating until the drill bit is running horizontally through the shale bed. (Note 14) Next, the horizontal bore is perforated in a number of locations and artificial fracturing induced through the process of hydraulic fracturing or "fracking". This is achieved by the high-pressure injection of water with some chemicals and sand used to keep the fracture open (called a proppant) into the well to induce artificial fracturing to release the hydrocarbons and cause free flow of the resource into the well. An advantage of the spread of the hydraulic fracturing process is that more accurate resource data becomes available. (Note 15) The hydraulic fracturing process is shown in the diagram below.

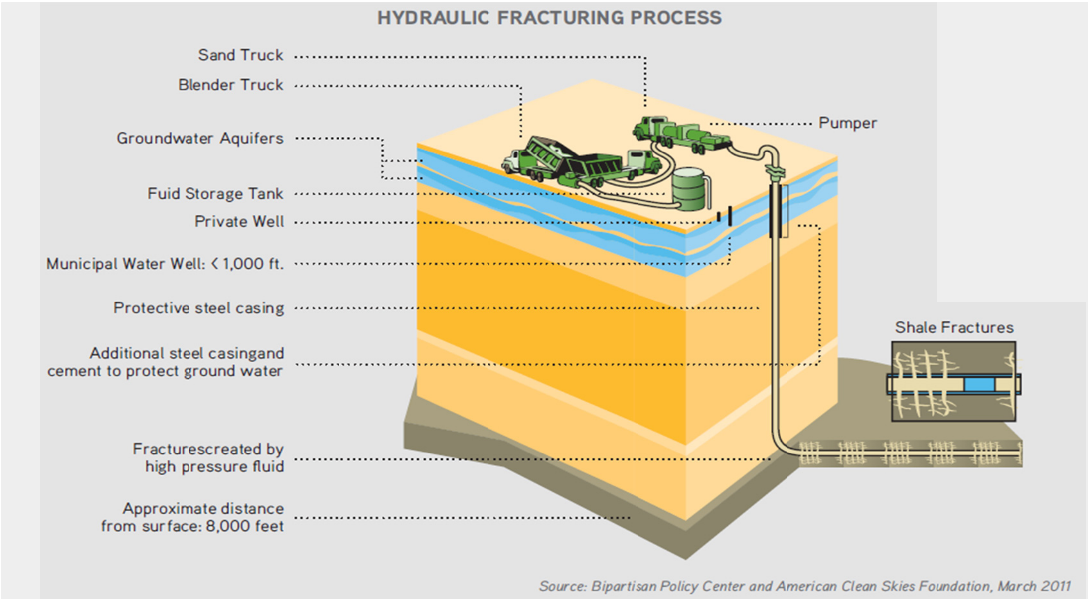

Figure 1. Bipartisan policy center and American clean skies foundation: Hydraulic fracturing process, March 2011

5. Estimated Shale Gas Reserve

Considering the relative novelty of shale gas development, the resource is yet to be quantified on a national level for most countries. Estimates available are widely varied (Note 16) with more recent studies proving conservative, i.e., far less than earlier enthusiastic reports. In 2011, for instance, an evaluation of shale gas resources in 14 regions consisting of 32 countries without including significant reservoirs in the Middle East, Russia, Indonesia, and other countries of the world reveals that the estimates of shale gas resources were more conservative (Note 17) than those reported in 2010, mainly due to the differences in the methodology adopted by the data publishers. (Note 18) The report estimates that the total risked technically recoverable gas amounts to 6622 Trillion cubic feet (Tcf). (Note 19) Figure 2 is the outcome of the report by region.

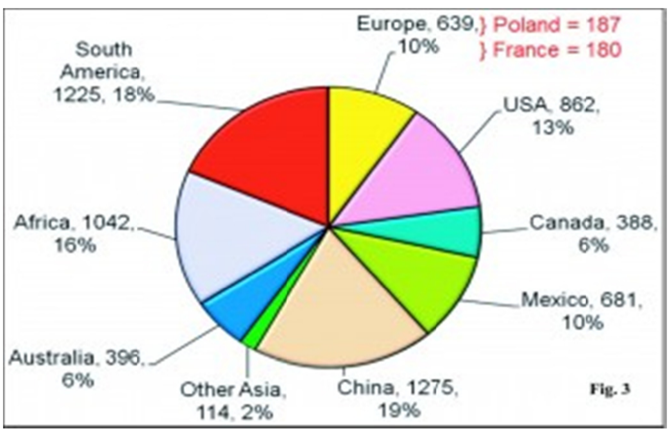

Figure 2. U.S. energy information administration, world shale gas resources: An initial assessment, U.S. department of energy, Washington DC 20585, February 17, 2011

Although there are possibilities of these estimates changing as new information, additional experience, and advances in technology become available. However, for now, eighty nine percent (89%) of the 6622 Tcf technically recoverable shale gas are in 12 countries, i.e. China 1275 Tcf, USA 862 Tcf, Argentina 774 Tcf, Mexico 681 Tcf, South Africa 485 Tcf, Australia 396 Tcf, Canada 388 Tcf, Libya 290 Tcf, Algeria 230 Tcf, Brazil 226 Tcf, Poland 187 Tcf and France 180 Tcf. (Note 20)

6. Economics of Shale Gas

The technical challenges associated with the development of shale gas makes it difficult to operate at reasonable cost. (Note 21) To this effect, Arthur Berman, a geological consultant who specializes in sub-surface petroleum geology, during the meeting of the Association for the Study of Peak Oil and Gas (ASPO) in Washington DC in October, 2010 observed that:

> Shale plays are marginally commercial at best… The plays have consistently contracted to a core area that represents 10-20% of the resource that was initially claimed. The manufacturing model has failed. (Note 22)

Consequently, the economics and profitability of developing and producing shale gas is determined by accessibility, environmental regulations compliance cost, geology and the proximity to natural gas infrastructure of individual shale basins. Production costs therefore differ according to the location and country. Access to relevant technologies and infrastructure also has profound effect on production costs. Isolated shale basins require higher costs due to lack of infrastructure. (Note 23) In the same vein, countries with more stringent regulations like the US through its agency, the Environmental Protection Agency (EPA) which requires drillers to adhere to more environmentally friendly practices certainly drives up production costs. (Note 24) Production costs are even higher in situations where there are needs for water reclamation and chemical clean up because of the massive input of water and the attendant hazards involved in “fracking” operations. (Note 25) Notwithstanding this profitability determinant, the large scale acquisition of stock in shale gas resources by reputable international oil companies (IOCs) (Note 26) seems to point to a belief in the long-term economics of shale gas. These acquisitions, which obviously will require further investments over a period of several years, demonstrate the value that the oil industry places on the future of shale gas. (Note 27)

Another important factor that strengthens shale resource development viability is the presence of shale liquids which are either oil found in shale, such as in the Bakken, or liquids found in association with shale gas. The presences of shale liquid have a multiplier effect on the economics of shale gas. This has therefore made shale gas more profitable than traditional dry gas reservoirs. (Note 28) Hence, the prospect of shale liquids has been a major driver for shale exploration now in the US compared to what it was as at 2010. (Note 29) For instance, shale basins like the western portion of the Marcellus, Utica and Eagle Ford, represent ‘wet’ shale gas deposits that contain significant amounts of molecules larger than methane, such as ethane, propane and butane. (Note 30) It is pertinent to remark here that natural gas liquids, the “wet” part of wet gas, are priced in relationship to the price of oil (which is much more expensive than gas, at least in the US as opposed to Europe where the high cost of gas makes for a lower oil-gas price differential) thus making shale liquid an important part of the resource (Note 31) and thereby enhancing its economics.

7. Natural Gas Pricing Dimension

The development of shale gas has had a significant impact on the dynamics and pricing of natural gas. The coming on stream of gas from shale basins holds the potential of easily creating a glut in the natural gas market and thus causing shale gas to “become a game changer in the global energy mix”. In recent time, the Henry Hub reference price of gas has been forced to less than $3 per million British thermal units (mBtu) from about $7 mBtu just a year earlier. (Note 32) This decline in prices is inimical to the interests of existing and traditional gas companies, their investors and host countries. The effect of price decline to traditional gas countries can be best described as a pain while on the other hand it be aptly referred to as a gain to the natural gas industry of countries such as the US, who are now seeking to export fuel in order to secure new markets to bolster its potential revenues. (Note 33)

In fact, a study by the Baker Institute of Public Policy at Rice University concluded that increased shale gas production in the US and Canada could help prevent Russia and the Persian Gulf countries from dictating higher prices for the gas they export to European countries. (Note 34) It is submitted that with more gas supply source and availability, it only follows logically that there would be a drop in spot market prices which may necessitate the need to modify subsisting long-term gas supply contracts.

8. Gains and Pains

From European dependency on Russian gas which has seen rocky days to the dependency on foreign oil faced by countries like the US and China, (Note 35) who are thus affected by exporting countries facing political instability and crisis, shale gas is certainly a game changer with enormous economic and geopolitical implications for the global energy industry.

8.1 The United States

In the US, shale gas accounted for about 20% of the country's natural gas supply in 2010 from being just 1% of US natural gas production in 2000. The US government's EIA predicts that by 2035, shale gas will account for 46% of US natural gas production. (Note 36) The growth in production has led to the US producing more dry gas than Russia (Note 37) for 2 consecutive years from 2009 and has the potential to become a net gas exporter from being a net importer as shown in Figure 3.

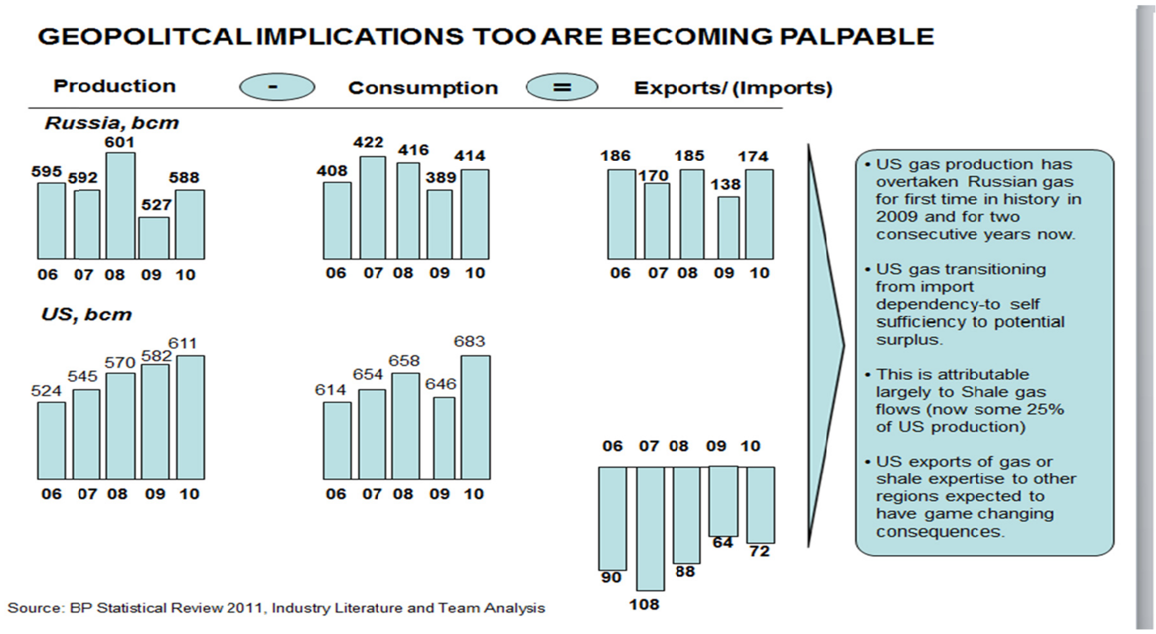

Figure 3. Geopolitical implications of the growth in Shale Gas production with focus on the US and Russia (Note 38)

Shale gas therefore has several positive implications for the US economy including cutting oil imports (Note 39) and having the ability to, as stated by President Barack Obama, "support more than 600 000 new jobs in natural gas alone." (Note 40) It will also reduce significantly, the US dependence on foreign oil and its attendant political challenges resulting from political instability of exporting nations. Consequently, the emergence of domestic shale gas supplies will foster greater energy security in the US. However, in addition to the foregoing, the increased production of natural gas has led to the decline in coal utilization since 2010. This change which can be primarily attributed to the cheaper price of natural gas has had some positive environment effect on the country's energy-related CO_2 emissions in early 2012. (Note 41)

8.2 China

With the increase in demand for energy in recent years by China resulting from large scale economic growth, (Note 42) shale gas development came as a much desired solution to cater for the country's energy needs. China's shale gas reserves have been estimated at 1275 trillion cubic feet by the US Energy Information Administration, (Note 43) making the country the world's largest shale gas resource holder. With estimated potentially recoverable reserves of 25.1 trillion cubic metres, energy security might well be within China's reach in reasonable time as this estimate is equal to the energy required to meet China's energy needs for the next 200 years. (Note 44) Furthermore, shale gas as a cleaner source of energy (with less CO_2 and sulphur emissions), will substantially reduce China's reliance on coal, thus paving the way to a cleaner energy future for the country which is currently regarded as the world's number one greenhouse gas (GHG) producer. (Note 45)

8.3 Europe

As far as Europe's economy is concerned, shale gas is more than just a commodity, it is a liberating tool to destroy the monopoly that Russia enjoys and has exploited to exert political influence on natural gas importing countries as well as its excessive spot prices for gas. For example, in 2009, Russia cut off gas shipments via Ukraine for nearly two weeks amid a price and payment dispute. This singular act sent more than 15 European countries scrambling to find alternative sources of energy. (Note 46) The emergence of shale gas development is therefore a gain to Europe by ensuring a reasonable level of supply diversification and thereby reducing dependence on Russian gas. (Note 47) It must nevertheless be mentioned that due to the low estimate and small percentage of shale resources in Europe as reported by the initial assessment of the US Department of Energy in 2011, which put Europe's share of global shale resource base at 10%, (Note 48) it thus appears that Europe will still be left at the mercies of Russia and the Middle Eastern countries for gas for heating transfer and petrochemicals. (Note 49)

Apart from the issue of estimates, the situation in Europe is peculiar as there is no convergence of views regarding shale development. For instance, the United Kingdom considers shale gas exploration as necessary to ease its growing dependency on imports which could rise from \$8.5bn presently to more than \$11bn by 2015 because of dwindling supplies from the North Sea, a gap which Norway struggles to fill. The reason is not farfetched because natural gas is Britain's biggest electricity fuel, providing 40% of Britain's fuel and a decline in its reservoirs means it cannot meet up with demand hence the result to imports from Norway and Qatar. (Note 50) It is for this reason also that Britain's Institute of Directors hold the opinion that shale gas development can offset the effects of growing dependency on importation and that by halting an increase in imports, shale gas production will help to reduce prices too. (Note 51) On the other hand, France has banned hydro-fracking, while Poland has issued 101 exploration permits to 25 companies and Hungary has refused to explore their shale basin for fear of water contamination. (Note 52) Regardless of the divergence of views and situation in Europe, the US led shale gas 'revolution' has impacted considerably on the price of gas in a global context which also have spill-over effects in Europe where Liquefied Natural Gas (LNG) price has also reduced.

8.4 Nigeria

The discovery of shale gas as an alternative energy source and its use by US, a major importer of Nigeria's crude oil may in the long term have dire consequences for its export trade and in turn, its economy. (Note 53) This is borne out of the fact that Nigeria is heavily reliant on crude oil exports for about 80% of its revenue. Nigeria's export to the US went from over 1million barrels per day (bpd) in December 2009 to 325 000 bpd as at February 2012 (a loss of about 70% of the US market). (Note 54)

Following the decline in US import of Nigeria's crude oil, other major and prospective buyers of Nigeria's crude oil are diverting their attentions to shale gas development. At the same time there is increase in the number of African countries with significant oil finds. These developments cumulatively have dire consequences for Nigeria and her economy. (Note 55) Even India, which became Nigeria's major export trading partner after the decline in US import, has started mapping out its shale resources in a bid to reduce dependence on Nigeria's crude oil and plans to finish exploration rules by 2013. (Note 56) Similarly, other major importers of Nigeria's crude oil like China, the UK and even Japan (a prospective buyer) are tuning into the shale resource buzz. (Note 57)

Experts in the country's energy industry also view the production of shale gas across the globe as a threat to the growth of the Nigerian liquefied natural gas industry as this may lead to a drastic drop in LNG prices. (Note 58) Shale gas development is also likely to preclude investment in Nigeria's LNG industry not only due to drop in prices but also due to drop in demand as exemplified by the substantial decline in the Nigerian LNG exports to the US in 2011 and the cancellation of the gas supply agreement between Nigeria and the US with respect to the Brass LNG plant which is scheduled for construction in 2013. (Note 59)

8.5 Russia

Presumably, another country in the category of those that will experience the pain of decreased demand and less profit like Nigeria is Russia. It therefore becomes obvious that shale gas development may effectively destroy Russia's gas monopoly position in the EU. An indication of the implication of shale gas development on Russia can be gleaned from the recent financial report of Gazprom (the world's largest natural gas producer and exporter) which shows that profits had dropped by almost 25 percent. (Note 60) In the same vein, an IEA report in the summer of 2012 predicts that with the increase in unconventional gas exploration, Russia's share of international trade in natural gas will go from about 45% in 2010 to 35% in 2035 (Note 61) due to competitive international gas market development. There is nevertheless an illogical opinion expressed by a top Gazprom official that the low prices in the US would not last for long and that the expansion of the natural gas market will provide even more potential customers for Russia (which has enormous reserves) and in that regard concluded that Gazprom views shale gas as a gift to the industry. (Note 62) Definitely, it is only a question of time for the global energy industry to feel the impact of shale gas development.

9. Environmental Implications

The most visible environmental concern to the development of shale resources is contamination of ground water and water courses (Note 63) because of the possibilities of hydrocarbons or chemicals used in "fracking" flowing into aquifers that supply drinking water. (Note 64) Although, it has been contended that in most instances, the gas-bearing and water-bearing layers are widely separated by thousands of vertical feet, as well as by rock, with the gas being much deeper, (Note 65) and as such it is reasoned that hydraulic fracturing is unlikely to contaminate drinking water. Another likely effect of the process of fracturing for shale gas on water is the competing use and need of fresh water for other purposes such as farming because of the several thousands of gallons of water required in the process. However, the proponents of fracking have argued that the process is actually less water-intensive than many other types of energy production (Note 66) and therefore are confident that fracking will have no adverse effect on other uses of water. Whether this is right or wrong, the point must be made that any usage of water that will compete with human consumption is unacceptable.

Other environmental implications of shale gas development through hydraulic fracturing include seismic mishaps. The tendency for this to occur was made known by the British Geological Society (BGS) when they identified that any process that injects pressurised water into rocks at depths which could cause the rock to fracture could possibly produce earthquakes. Fracking in shale gas production clearly falls into this category and has been linked with small earthquakes in England, while underground disposal of fracking wastewater has been traced to tremors in Ohio and Texas in the United States. (Note 67)

10. Legal Issues

Certainly, the development of shale gas by its peculiar operation i.e. fracking and impact on the environment raises legal issues on the need for regulation. While the regulation for now may be on country by country basis, it may nevertheless be a global phenomenon if new findings suggest that the fears are worse than currently anticipated. On a more specific note, the US, has proposed the Fracturing Responsibility Awareness of Chemicals Act in 2009 to regulate production and operations of shale gas. The Act which is dubbed as the FRAC Act is a legislative proposal in the United States Congress to define hydraulic fracturing as a federally regulated activity under the Safe Drinking Water Act. The proposed act which would require the energy industry to disclose the chemical additives used in the hydraulic fracturing fluid was opposed by the gas industry. (Note 68) Unfortunately, as of March 2012, Congress had not yet passed the FRAC Act bills. France and Hungary on the other hand approached the issue of shale gas through a moratorium (Note 69) to halt all shale gas activities within their jurisdiction. Certainly, shale gas development like every other natural resource requires some form of regulation to safeguard the environment and provide a basis for contractual obligations that will arise from its production and supply. While this may be contemplated from a local or national perspective, having a broad based international legal instrument which recommends common international best practices and proffer likely solutions to some of the legal issues raised here and others that may evolve in the future may not in itself be out of place.

11. Conclusion

Although shale gas development raises critical legal and environmental challenges, yet its development seems set to take the global energy world in a revolutionary way. The effect of this gradual but sweeping revolution carries with it gains and pains. Gains are for those who traditionally were classified as importing countries and pains for the exporting countries in terms of loss of revenue. The pain will be even more grievous and severe for a country like Nigeria that depends largely on its oil and gas resources as the main stay of its economy. Russia also falls into this category and has in recent time received an unforeseen blow through the reduced reliance on her gas which has provided her with a well-established monopoly and even given her a veritable exploitative tool in terms of regional geopolitics in Europe. Against this backdrop, it is important that the erstwhile exporting countries see the gradual evolution of shale gas as an early warning threat which could become very destabilising once there is a massive output of shale gas in the not too distant future as projected. There is therefore no better time than now for Nigeria and other countries in this category to take steps to prepare for the proverbial 'rainy days' by embarking on an aggressive diversification of their economy to other sectors with foreign earning capabilities. It is equally advisable that these countries (Nigeria, Russia etc.) adopt an effective and sustainable longer term strategy like the sovereign wealth fund for the preservation of their economic fortune and future. More particularly, in the case of Nigeria, it is a wakeup call for the country to boldly and courageously stamps out corruption, embrace good governance, transparency, accountability and proper resource management as well as applying its earnings from oil and gas resources towards its national interest and development.

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Notes

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Note 7. YANG, supra note 5.

Note 8. Algeria was the second largest LNG importer in 2002, exporting mainly to European countries like France, Spain, Belgium and Turkey.

Note 9. FOCUS, supra note 2, at 29.

Note 10. Daniel Yergin, Global markets feel the force of North America's 'shale gale', WORLD ENERGY COUNCIL, WORLD ENERGY INSIGHT 2010 16(2010), http://www.worldenergy.org/documents/wec_combined.pdf

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Note 12. Id.

Note 13. YERGIN, supra note 10.

Note 14. FOCUS, supra note 2, at 12.

Note 15. Id.

Note 16. Such as the report compiled by the Advanced Resources International, Inc. (ARI) for the U.S. Department Of Energy's Energy Information Administration (EIA) in 2011

Note 17. MIAN, supra note 6.

Note 18. WORLD ENERGY COUNCIL, SURVEY OF ENERGY RESOURCES: SHALE GAS- WHAT'S NEW 3 (Jan. 2012), http://www.worldenergy.org/documents/shalegasupdatejan2012.pdf [hereinafter NEW]

Note 19. This means that part of reserves of gas (or oil) that may be recoverable using current recovery technology, without regard to cost.

Note 20. MIAN, supra note 6

Note 21. Id.

Note 22. J. DAVID HUGHES, THE ENERGY SUSTAINABILITY DILEMMA: POWERING THE FUTURE IN A FINITE WORLD 30 (May 2, 2012), http://www.eeb.cornell.edu/howarth/HUGHES%20Cornell%20Ithaca%20May%202%202012.pdf

Note 23. Such as Marathon operations in Poland, Total purchasing a portion of Chesapeake's shale operation in Ohio and the movement of energy giants like ConocoPhillips, Chevron and Halliburton into China's Sichuan basin to exploit its vast shale gas resources.

Note 24. NEW, supra note 18, at 6.

Note 25. Examples are China, which does not have the relevant pipelines and infrastructure for exploitation of shale gas above ground, and European countries which engage mostly in offshore operations and so do not have extensive onshore infrastructure

Note 26. FOCUS, supra note 2, at 16.

Note 27. Id.

Note 28. NEW, supra note 18, at 12

Note 29. Id., at 7

Note 30. Id. Butane is higher than oil because it is essentially a drop-in replacement for gasoline. Propane and ethane are at a discount to oil. Ethane is at about half the price of oil. But all have higher value than methane (the prominent constituent of natural gas).

Note 31. Id.

Note 32. Stanley Opara, Shale gas, threat to Nigeria's LNG industry- NAPE, PUNCH, (October 4, 2012), available at http://www.punchng.com/business/energy/shale-gas-threat-to-nigerias-lng-industry-nape/

Note 33. Marianne Lavelle, How Accurate is the 'Promised Land' Portrayal of the Shale Gas Boom? (Dec. 28, 2012), available at http://www.greatenergychallengeblog.com/2012/12/28/how-accurate-is-the-promised-land-portrayal-of-the-shale-gas-boom/

Note 34. Rice University, News and Media Relations (21 July 2011): Shale Gas and U. S. National Security

Note 35. FOCUS, supra note 2, at 29

Note 36. Ejiofor Alike, Fracking Revolution and the Foreboding Signs, THISDAY, January 14, 2013 at 12C

Note 37. The world's largest natural gas producer with the largest gas reserves.

Note 38. NEW, supra note 18, at 11.

Note 39. A goal it is already achieving as shown by the recent announcement that oil imports to the country have dropped by 25%, thereby lowering the country's dependence on oil from the Middle East. This also changes their public policy focus from the Middle East to China which is pumping in large investments in America in return for technological expertise for shale gas production.

Note 40. Kevin Begos, U.S. Natural Gas Boom Could Threaten Russia's Grip On European Market, HUFFPOST, (Sept. 30, 2012), available at http://www.huffingtonpost.com/2012/09/30/us-natural-gas-boom-russia_n_1926922.html

Note 41. Today in Energy, US energy-related CO2 emissions in early 2012 lowest since 1992 (August 1, 2012), available at http://www.eia.gov/todayinenergy/detail.cfm?id=7350

Note 42. WORLD ENERGY COUNCIL-KORN/FERRY INTERNATIONAL, 2007 GLOBAL ENERGY SURVEY 8(June 2007), http://www.worldenergy.org/documents/weckornferry_report2007.pdf [hereinafter INTL]

Note 43. MIAN, supra note 6.

Note 44. Ambrose Evans-Pritchard, China claims world's biggest shale gas reserves, THE TELEGRAPH, (Mar. 1, 2012), available at http://www.telegraph.co.uk/finance/china-business/9117072/China-claims-worlds -biggest-shale-gas-reserves.html

Note 45. YANG, supra note 5.

Note 46. BEGOS, supra note 39.

Note 47. JEROEN DE JOODE, ARJAN PLOMP AND ÖZGE ÖZDEMIR, A MODEL-BASED ANALYSIS OF THE IMPLICATIONS OF SHALE GAS DEVELOPMENTS FOR THE EUROPEAN GAS MARKET at 5, http://www.ecn.nl/docs/library/report/2012/m12023.pdf [hereinafter JOODE]

Note 48. MIAN, supra note 6.

Note 49. NEW, supra note 18, at 8

Note 50. OPARA, supra note 31

Note 51. Id.

Note 52. NEW, supra note 18, at 8

Note 53. ALIKE, supra note 35,at 12B

Note 54. Id.

Note 55. Id.

Note 56. Id., at 12C

Note 57. Id.

Note 58. OPARA, supra note 31.

Note 59. ALIKE, supra note 35. However, the Brass LNG responded by moving sales to the Far East.

Note 60. BEGOS, supra note 39.

Note 61. Finance Online, IEA: Russia is about to lose the leadership position in the global natural gas market, http://www.finance-ol.com/2012/06/iea-russia-is-about-to-lose-the-leadership-position-in-the-global-natural-gas-market/ (last visited December 30, 2012).

Note 62. BEGOS, supra note 39.

Note 63. Contamination of fresh water aquifers can occur through two avenues, that is, either by leakage of chemicals used in fracturing, i.e. liquid contaminants or through infiltration of aquifers by produced methane, i.e. a gaseous contaminant, albeit it gets dissolved in the water.

Note 64. YERGIN, supra note 10, at 17

Note 65. Id.

Note 66. Id., at 17-18

Note 67. YANG, supra note 5.

Note 68. Abrahm Lustgarten, "The FRAC Act under attack - Environment". Salon.com. Retrieved 2013-03-07 http://www.salon.com/env/feature/2009/07/14/gas/.

Note 69. A moratorium is a delay or suspension of an activity or a law. In a legal context, it may refer to the temporary suspension of a law to allow a legal challenge to be carried out.