Dissertation Report

ON

"Shale Gas in India: Issues and Challenges Ahead"

UNDER THE GUIDANCE OF

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DECLARATION

I, Harsh Mittal, student of MBA (Energy Trading) hereby declare that the project titled “Shale Gas in India: Issues and Challenges Ahead” which is submitted by me to Department of Oil and Gas, College of Management and Energy Studies, Dehradun, in partial fulfillment of requirement for the award of the degree of Master of Business Administration in Energy Trading, has not been previously formed the basis for the award of any degree, diploma or other similar title or recognition.

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Date 18th April, 2014

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BONAFIDE CERTIFICATE

This is to certify that Mr. Harsh Mittal, student of University of Petroleum and Energy Studies, Dehradun, pursuing MBA (Energy Trading), has successfully completed his dissertation project. As a part of his curriculum, the project report titled, "Shale Gas in India: Issues and Challenges Ahead" submitted by the student to the undersigned is an authentic record of his original work which he has carried out under my supervision and guidance. This study has not been submitted anywhere else for degree purpose.

I wish him all the best.

OBO!—
ABHIJIT SINGH
24/4/14

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It is due to the fruitful discussions with above mentioned guides which has enabled me in finalizing the shape and complete this project in due time.

Last but not the least; I would like to thank my parents for their kind support which helped me a lot in completing the project

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ABSTRACT

This report named "Shale Gas in India: Issues and Challenges Ahead" mainly deals with the legal issues that the shale gas development companies would face in case the Ministry of Petroleum & Natural Gas, GoI finalizes and does allow the investors to invest and unveil the various potentials of the cleaner energy source. There already exist some issues in Production Sharing Contract (PSC), the prevailing contractual framework for the companies to carry out the E&P activities in India, like companies currently being parties to the PSC cannot produce shale gas even though they have a potential opportunity to do so. The study also talks about various other problems than the water management issues, like infrastructure's role in the successful shale play development, life-cycle GHG emission control, and other legal hurdles.

Keywords: Shale Gas Policy, Issues and Challenges

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DEFINITIONS

1. AIR QUALITY- A measure of the amount of pollutants emitted into the atmosphere and the dispersion potential of an area to dilute those pollutants.

2. AQUIFER- A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

3. COAL BED METHANE/NATURAL GAS (CBM/CBNG)- A clean-burning natural gas found deep inside and around coal seams. The gas has an affinity to coal and is held in place by pressure from groundwater. Drilling a wellbore into the coal seam(s) produces CBNG, pumping out large volumes of groundwater to reduce the hydrostatic pressure, allowing the gas to dissociate from the coal and flow to the surface.

4. COMPLETION-The activities and methods to prepare a well for production and following drilling includes installation of equipment for production from a gas well.

5. DIRECTIONAL DRILLING- The technique of drilling at an angle from a surface location to reach a target formation not located directly underneath the well pad.

6. DRILL RIG- The mast draws works, and attendant surface equipment of a drilling or work-over unit.

7. EMISSION- Air pollution discharge into the atmosphere, usually specified by mass per unit time.

8. EXPLORATION- The process of identifying a potential subsurface geologic target formation and the active drilling of a borehole designed to assess the natural gas or oil.

9. FRACTURING FLUIDS- A mixture of water and additives used to hydraulically induce cracks in the target formation.

10. GROUND WATER- Subsurface water that is in the zone of saturation; source of water for well's seepage, and springs. The top surface of the groundwater is the "water table."

11. HORIZONTAL DRILLING- A drilling procedure in which the wellbore is drilled vertically to a kickoff depth above the target formation and then angled through a wide 90 degree arc such that the producing portion of the well extends horizontally through the target formation.

12. HYDRAULIC FRACTURING- Injecting fracturing fluids into the target formation at a force exceeding the parting pressure of the rock thus inducing a network of fractures through which oil or natural gas can flow to the wellbore.

13. INJECTION WELL- A well used to inject fluids into an underground formation either for enhanced recovery or disposal.

14. NORM (Naturally Occurring Radioactive Material) - Low-level, radioactive material that naturally exists in native materials

15. SHALE GAS- Natural gas produced from low permeability shale formations

16. TIGHT GAS- Natural gas trapped in a hard rock, sandstone or limestone formation that is relatively impermeable.

18. WATER QUALITY- The chemical, physical and biological characteristics of water with respect to its suitability for a particular use.

19. WORKOVER- To perform one or more remedial operations on a producing or injection-well to increase production. Deepening, plugging back, pulling, and resetting the liner are examples of work over operations.

1. INTRODUCTION

Since the fossil fuels are discovered (especially coal and crude oil), the world relies on a huge energy supply to power everything from communication to transportation, to health delivery systems and security. And ever since, the energy market has grown volatile. But lately the world has faced two major energy problems and has forecasted for a longer term; the climate change and, the peak oil.

Now-a-days, news about the depleting oilfields is on the rise as compared to the news about new discoveries of the oil/gas blocks, which is creating a sense of urgency to device 'an alternative' in the industry. Oil majors are moving farther into the sea to dig deeper in their quest for the fossil fuels. Increasing costs of fossil fuel is the imperative of the increasing expenditures of the operations in newer unknown geographical locations which now seems to be the norm for the E&P industry. Considering such a bleak outlook for the future, one can say that natural gas (NG) can ease the demand pressure, at least for some decades. During the last decade we have observed the NG price peak, as its demand rose significantly with the technological development in many industries to use the NG as their primary fuel/ feedstock. This created the interest of many countries and companies in development of 'unconventional' NG resources, especially the shale gas (SG).

Since the millennium year, SG has become one of the major sources of NG in the United States. This has led to spread of interest to potential SG reserves in the rest of the world too. In 2000 SG provided negligible share of U.S. total NG production but by 2010 it was over one-fifth and the EIA[1] predicted that by 2035, almost half of the US' NG supply will come from SG.

Some analysts' speculations mark that SG has the potential to greatly increase the global energy supply base. Apart from the supply security, SG is also seen to restructure the global energy geopolitics. A study by the Baker Institute[2] concluded that "increased SG production in the North American continent could help prevent traditional NG exporters like Russia and Persian Gulf countries from dictating higher prices for the gas they export to European and Asian countries."

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[1] EIA, U.S. federal government's energy agency, Energy Information Administration
[2] Baker Institute of Public Policy at Rice University

The Obama administration, a staunch believer of "better health for all," believes that increased Shale gas development (SGD) will help reduce greenhouse gas (GHG) emissions (based on the evidences by a report in 2012, US CO_2 emissions dropped to a 20-year low). They also anticipate that public health will benefit from SG replacing coal burning. But a review by the DoECC[3] in 2013 noted that most studies of the subject have estimated that life-cycle GHG emissions from SG are similar to those of conventional NG, and are much less than those from coal, usually about half the GHG emissions of coal. There was this noted exception in a 2011 study by Howarth[4], which found that SG GHG emissions were as much as those of coal.

Although not established as a hypothesis, but some recent studies also pointed to high rates of decline of some SG wells in US as an indication that SG production can eventually be lower than is currently projected. But shale-gas discoveries are also opening up new substantial reserves of "shale oil".

Talking of the technology which made this phenomenon an actuality, one of the two important technologies used for exploration of shale gas—Hydraulic fracturing[5]—involves pumping fluid at very high pressures in a well which causes cracking in the rock formations along the fault lines occurring naturally. Fracturing is in practice since last three to four decades, depending on the oil fields. But now, 'slick-water hydraulic fracturing' which uses primarily water with a few additives to catalyze the process, is used. Modern fracturing technology is the result of technological advancements in the field of industrial chemistry and the E&P activities. Another technology which is essential to the Shale Gas development (SGD) is the horizontal drilling. Both the technologies are explained in detail in the chapter discussing the technology of the SGD.

In the free and open market of the United States, there are various industry based alliances and formal groups of companies which come together and work with a broader vision to benefit the society while achieving their individual purposes. For example, there is an alliance representing North America's leading independent NG exploration and production companies, ANGA[6], which works with government, customers, industry and all other stakeholders to promote the latent demand for the abundant NG resource for a greener and more secure energy future and to ensure its continued availability. Apart

[3] DoECC, United Kingdom Department of Energy and Climate Change
[4] Howarth and others of Cornell University
[5] Hydraulic Fracturing is also known as Fracking
[6] ANGA, America's NG Alliance

from ANGA, there is a forum named ACC[7] which represents the leading companies in the business of industrial chemistry. These are the companies which make modern life possible by their various chemical products which are generally not known to the end consumers like us. All the ACC members make a voluntary commitment to maintain the highest standards of work practices and a good health, safety and environment regime. Its members get to know about important business opportunities and information, including networking, economic and statistical publications. Smaller and medium-sized enterprises are also catered through a special forum as per their needs.

Looking at the policy background of various stakeholders in the US regarding SG, the various policies reveal that the industry players individually and as a community are going to rely on affordable and abundant NG as a source of energy and as a feedstock for their countless products. Because of the relatively lower price of NG, local manufacturers would have an advantage over foreign competitors that rely on a more expensive oil-based feedstock in their countries.

For US, growth in domestic NG production reduces prices and creates a more stable supply. It is estimated that U.S. shale deposits contain 100 years of NG supply. SG is a "game changer" in US and can significantly strengthen the local manufacturing, boost industry exports, create millions of new jobs, and improve the nation's energy security.

The process of extracting NG from shale plays includes hydraulic fracturing, during which fluids and solids are pumped into the well. This process poses a potential threat to the environment if not executed with care. Also, keen government watch is needed to protect the environment around. A comprehensive strategy for energy must increase the production of local energy supplies (supported by increased gas supplies) while implementing non-discriminated regulatory policies that protect our environment.

1.1 TECHNOLOGY

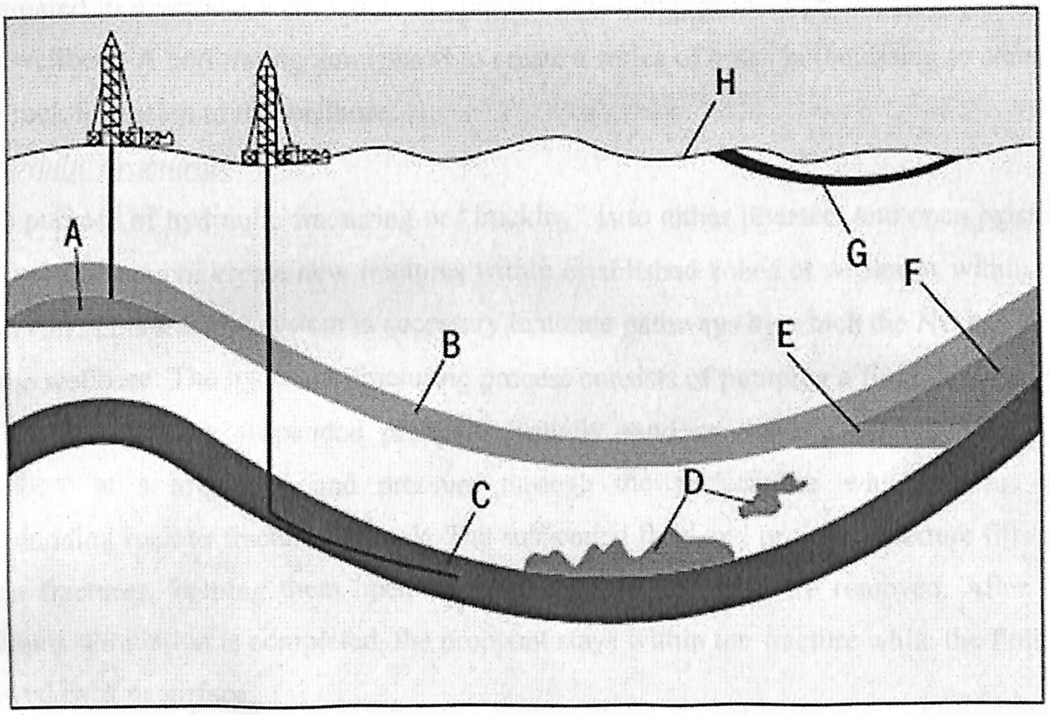
How is Shale Gas stored in Shale plays?

Shale rocks contain very fine grains of minerals separated by very small spaces called "pores". NG or oil molecules that have been created from the organic material in the rock are trapped within the numerous micro-pores or are attached to the organic material by a process called adsorption. The amount of pore space within the shale usually ranges

[7] ACC is American Chemistry Council

between 2-10% allowing a large volume of NG to be stored within the rock. The amount of NG that is stored within shale is variable depending on the amount of open pore space, amount of organic material present, reservoir pressure and thermal maturity of the rock. Thermal maturity is a measure of how much pressure and temperature the rock has been subjected to. It also measures whether oil or gas has been generated during the process. Core samples are often collected to allow laboratory tests to be taken that will measure the amount of organic material present as well as the thermal maturity.

Figure 1: Geology of SG and Conventional NG



A- Conventional non-associated gas
B- Seal
C- Gas-rich shale
D- Tight sand gas
E- Oil
F- Conventional associated gas
G- Coalbed methane
H- Land surface

Source: US Energy Information Administration (2011): www.eia.gov

What is the technology behind SG becoming feasible commercially?

Unlike conventional mineral formations containing NG deposits, shale has low permeability, which naturally limits the flow of gas or water. In shale plays, NG is held in these unconnected pores and natural fractures and thus requires some method of increasing the amount of reservoir in contact with the borehole. Hydraulic fracturing is the method commonly used to connect these pores and allow the gas to flow. Another process which has a main role in producing NG from shale deposits is horizontal drilling.

Horizontal Drilling

Horizontal drilling requires drilling a vertical well to a predetermined depth above the SG reservoir. The well is then drilled at an increasing angle until it meets the reservoir interval in a horizontal plane. Once horizontal, the well is drilled to a selected length, which could extend to as much as 2500m. This portion of the well, called the horizontal leg or lateral, allows significantly increased contact of the wellbore with the reservoir as compared to a vertical well. Upon completion of drilling, production casing is placed in the wellbore. A perforating gun is used to create a series of holes in the casing to connect the rock formation to the wellbore.

Hydraulic Fracturing

The purpose of hydraulic fracturing or "fracking" is to either intersect and open existing natural fractures or create new fractures within established zones of weakness within the reservoir. This fracture system is necessary to create pathways by which the NG can flow to the wellbore. The hydraulic fracturing process consists of pumping a fluid, either a gas or a liquid, with a suspended proppant (usually sand or ceramic beads), down the wellbore at a high rate and pressure through the perforations which causes the surrounding rock to fracture or crack. The suspended fluid and proppant mixture fills the open fractures, keeping them open after the fracture pressures are removed. After the fracture stimulation is completed, the proppant stays within the fracture while the fluid is flowed back to surface.

Multi-Stage Fracking

In most horizontal wells multiple fracturing operations are required in order to effectively stimulate the reservoir rock. This process is called "multi-stage fracturing" and consists of dividing the horizontal leg into sections which are then fractured independently. During this operation, each "stage" is isolated from the rest of the wellbore using various types of plugs or packers (seals). Upon completion of all fracture stages, the plugs or packers are removed and all stages of the wellbore are allowed to flow back to the surface.

What are the stages of SG exploration and development?

The commercial development of a SG project is actually the culmination of a process requiring several years of exploration, experimentation and data collection. These stages of exploration require significantly huge investment by the company with no assurance of success, means a substantially huge risk in itself. Each company has their own processes for development, but in general, SGD requires five stages of exploration and evaluation to reach commercial development. Each of these stages is designed to gather technical information that is then analyzed and used in the development of the next stage. All stages of development include stakeholder dialogue and consultation. Pace of development is largely dependent on resource complexity, technical success, local circumstances and market conditions.

Hydraulic fracturing (commonly referred to as "fracking") is often misused as an umbrella term to include all of the steps involved in SG production. These steps include road and well pad construction, drilling the well, casing, perforating, hydraulic fracturing, completion, production, abandonment, and reclamation. A summary of these stages and the types of activities that may take place are:

Stage 1: *Identification of the Gas Resource*

This stage includes processes like Land Acquisition, securing seismic and drilling location permits, land-use agreements along with initial geophysical and geochemical surveys in some regions.

Stage 2: *Early Evaluation Drilling*

Seismic surveys to map the extent of gas bearing formation(s) and geological features; such as faults or discontinuities that may impact the potential reservoir; initial vertical drilling to evaluate SG resource properties; commonly core samples are collected.

Stage 3: *Pilot Project Drilling*

Drilling of initial horizontal well(s) to determine reservoir properties and optimize completion techniques (includes some level of multi-stage fracturing); continued drilling of vertical wells in additional regions of SG potential; initial production tests.

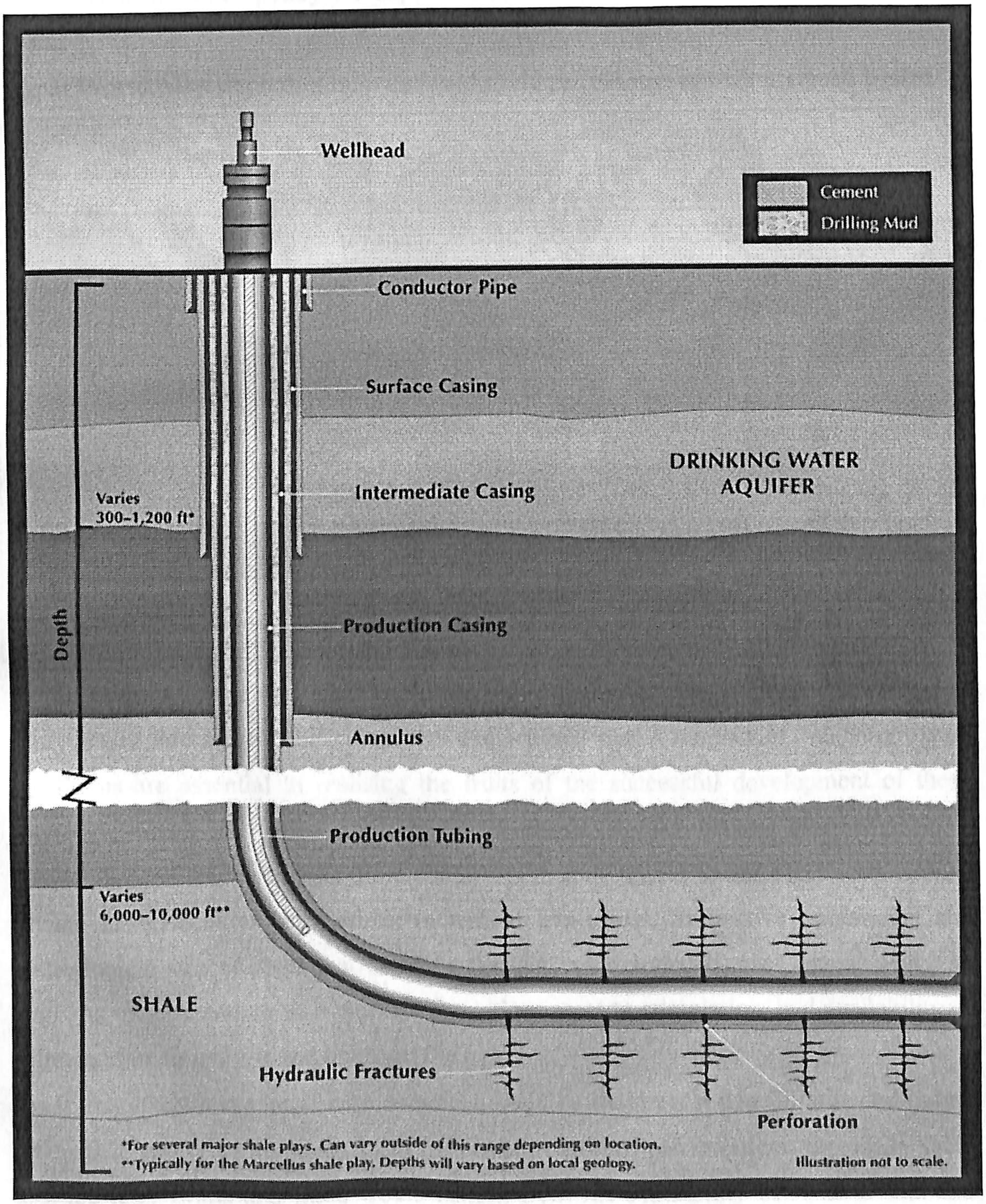
Stage 4: *Pilot Production Testing*

Drilling of multiple horizontal wells from a single pad as part of a full size pilot project; Optimization of completion techniques including drilling and multi-stage fracking with micro-seismic; Pilot production testing; Planning and acquisition of pipeline right of ways for field development

Stage 5: Commercial Development

Commercial decision to proceed for development of the block and to take government approvals for construction of gas plants, pipelines and drilling.

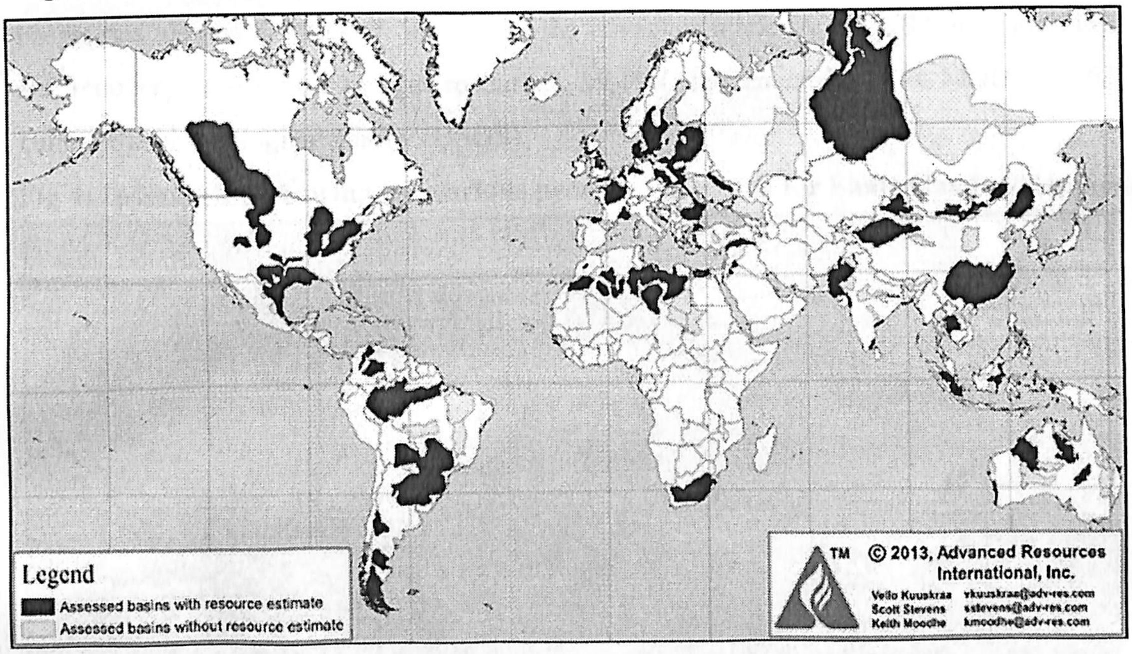
Fig 2: Illustration of developed well for shale gas extraction



1.2 SHALE GAS POTENTIAL

The study to find out the SG prospects globally was conducted by the EIA in April 2011. The Report assessed 48 SG basins in 32 countries. India is one of the countries covered in this Report along with Canada, Mexico, China, Australia Libya, Brazil etc. The initial estimate of technically recoverable SG resource in these countries is 5,760 Trillion Cubic Feet (TCF), and that in USA is 862 TCF, which adds up to 6,622 TCF globally, according to the draft policy for exploration and exploitation of Shale Oil and Gas in India.

Fig 3: World Map depicting international shale gas resources with assessed basins

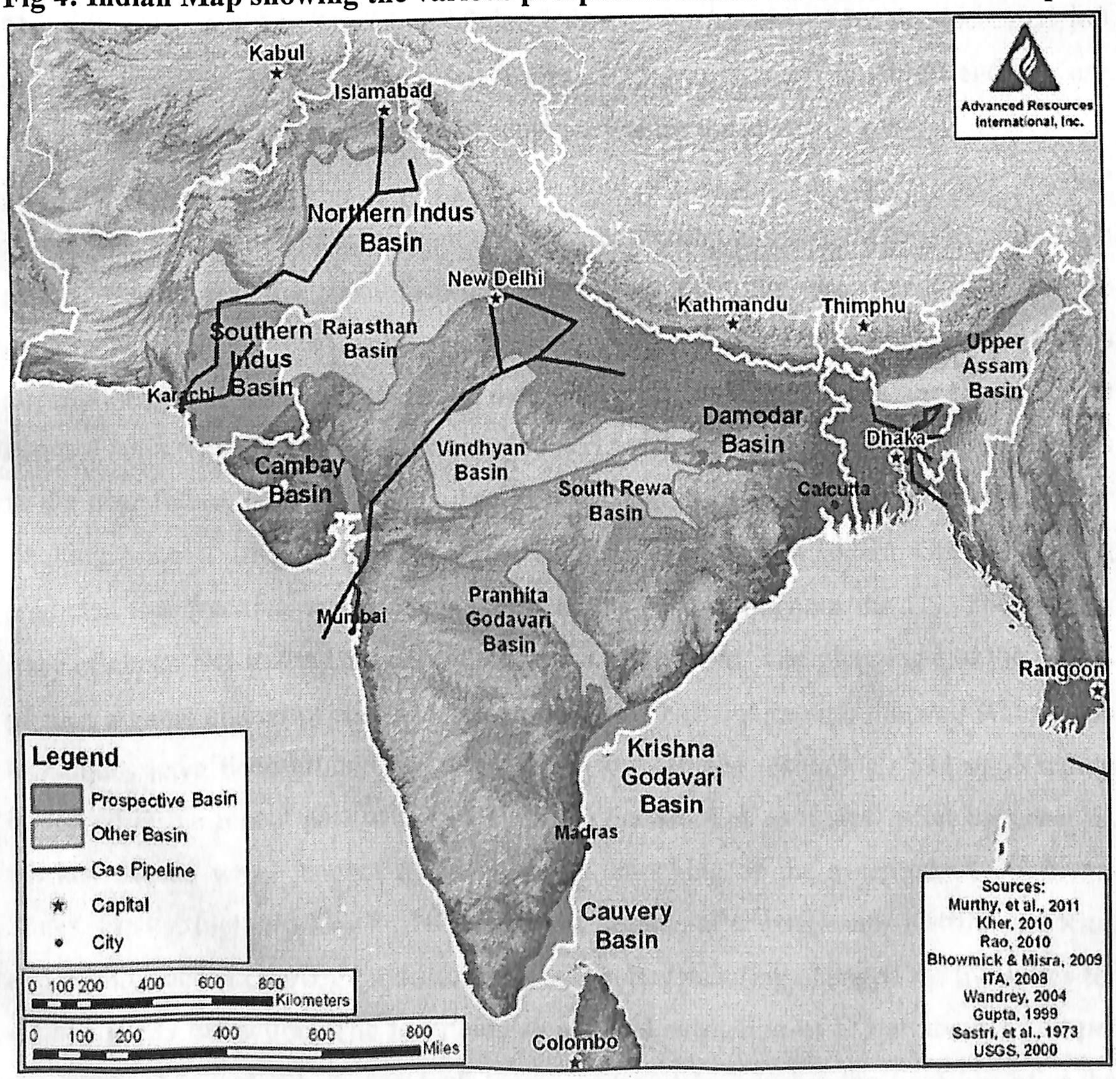


North American shale resources have been unlocked by the respective governments and other stakeholders like E&P companies and realised that a number of "above-ground" conditions are essential in realising the fruits of the successful development of these resources, which is a must learn lesson for the developing nations like India. North American experience suggests these conditions include access to shale gas resources on private lands, economically attractive natural gas prices, innovative operational and technological step changes that combine fracking with extended-reach lateral wells, an evolving under-standing of how shale formations react to stimulation, and availability of infrastructure to process and transport the gas.

Emerging investments into North American shale basins suggest that Chinese and Indian interests in exploring the potential of their unconventional gas resources, especially shale gas, are real. China and India would benefit from the availability of reliable data and processing capability. Additionally, both countries have yet to fully formulate policy frameworks concerning regulatory and physical infrastructure, pricing mechanisms, and environmental and resource management as well as issues associated with societal challenges that may accompany a large-scale development of their unconventional gas resources.

For the study, Indian map was divided into 26 sedimentary basins. And it was assessed that India has 290 TCF of total reserves with 63 TCF of technically recoverable resources in 4 out of those 26 basins. The study also indicates an additional potential for shale oil in Indian basins. So, process of identification of potential shale oil/gas resources in 11 other basins has also been initiated. In view of the advances made by the USA in exploration and recovery of shale oil and gas resources, MoPNG has entered into an MOU with the United States Geological survey (USGS).

Fig 4: Indian Map showing the various prospective basins for Shale Gas Development



1.3 ADVANTAGES OF SHALE GAS

Fracking has increased US NG reserves to three times over the last decade, and the Energy Information Administration (EIA) expects this trend to continue. It now predicts that the US will have enough gas to satisfy domestic demand for a century and that the US will soon have a surplus sufficient to begin exporting gas to Asia. Fracking has already allowed them to replace 10% of the coal that was traditionally used to generate electricity with cleaner burning NG, and EIA predicts that trend to continue for many years. The International Energy Agency predicts that the US will become the world's largest gas producer by 2017. Among various advantages of SGD in any country rich in SG reserves we include the following categories:

1.3.1 Economic Advantages

The several economic advantages of the SGD can be accounted by the increased job creation, lesser production cost of the manufacturing industries (which do and can use NG as their feedstock), lower prices of commodities for the customers, etc.

With the economic viability of SG projects, price of NG becomes competitive to other liquid fuels and coal. This significant reduction in the cost of energy through reduced gas prices encourages the manufacturing activity supporting the new jobs in the manufacturing industry as well as the jobs related to SGD. For example, fracking has already produced large numbers of new jobs and major increases in prosperity in Pennsylvania, and Ohio has the potential to add many thousands of fracking-related jobs in the near future. New York is poised to participate in the economic boom created by fracking once it lifts its temporary embargo on fracking. President Obama as well predicted that fracking will produce 600,000 new jobs throughout the US. The success story of cheap NG in the US was not written word to word. The planning and the causes of such a game changing phenomenon go back to 1990's. Although the well stimulation techniques have been around for nearly 50 years, but the technology has significantly improved in the recent past of not older than a decade. Let us review what happened in the last decade which caused the spur in the unlocking of the potential of SG in the States. Firstly, higher prices for NG in the last decade, after hurricanes Katrina and Rita, and the advances in horizontal drilling and hydraulic fracturing changed the dynamics for economic SG extraction. The technologies allowed extraction of SG at about $7.00 per thousand cubic feet, which was well below prices of NG during the time just after the hurricanes. With new economic viability, NG producers responded by drilling more and more wells, setting off a "shale gas rush". As the learning curve effects came into picture, the cost to extract SG fell, including return on capital, making even more supply available at lower costs. In economists' terms, the supply curve shifted to the right, resulting in lower prices and greater availability. Since the mid-2000s, US-proved NG reserves also rose by one-third. During this same time, average NG prices fell from $7.33 per thousand cubic feet in 2005 to $3.65 per thousand cubic feet in 2009. In 2010, a recovery of gas-consuming industries and prices occurred. Average daily consumption rose to 66.0 BCF and prices strengthened to $4.14 per thousand cubic feet. Figure below illustrates how this new technology's entrance into the market pushed prices lower and expanded supply.

As a result of fracking, gas now costs less than one-third of the price of oil in the US. The gas boom and its beneficial economic effects will be felt far beyond U.S. borders. Gas is far more expensive in Europe and Asia than it is in North America. The increase in the gas supply attributable to fracking in the US has already changed the conditions in the global gas market in ways that have put downward pressure on gas prices in Europe and Asia. The effects of fracking in the US will increase as the US and Canada begins to export gas. Fracking in other countries has far more potential to reduce the price of gas in Europe and Asia.

1.3.2 Environmental

NG plays a greater role in helping reduce air pollution in communities across the country. The environmental advantages can be seen in various sectors depending upon the scale and way of use of the natural gas. We can broadly categorize the sectors in two namely, manufacturing and transportation. For the ease of the study the manufacturing sector consists of heavy industries, medium and small scale industries and power generation plants (fossil fuel fired).

Manufacturing

When used to generate electricity, NG burns cleaner than other fuels, with fewer pollutants and no heavy metals (ex- mercury). In the controlled NG market of India, power sector has been notified as the primary sector, to be allotted the NG on a preferential basis than other sectors. So policy-wise support to the power sector is seen as an advantage to the power companies to switch to the cleaner and greener fuel i.e. NG. The country has seen some of the private players of the power generation sector, taking a bold initiative to convert their coal fired power plants to gas fired ones. Though some of those projects have seen a setback while implementation, but as the technology is becoming more prevalent in the west, the generators have a positive sentiment for a shift in the technology thereby cutting their direct and indirect costs. This reduced cost of electricity production can also be transferred to the end consumers, may it be domestic or commercial. Domestic power consumption will not be

Transportation

Greater adoption of this cleaner transportation alternative can significantly improve air quality in communities across the country. An NGV[8] emits an average of three quarters of the carbon dioxide emitted by a vehicle that runs on traditional gasoline or diesel. And, NG is the only fuel alternative that can power heavy-duty trucks and buses, among the busiest vehicles on the road. By focusing on existing large public fleet of various modes and the growing share of public fleet, India can ease its dependence on foreign energy supplies, dramatically reduce emissions and create clean energy jobs here at home. By embracing NGVs, Indians can take a very practical step to help clean the air in their communities as,

- NGVs run 25 per cent cleaner than vehicles powered by traditional gasoline or diesel.
- NGVs also reduce smog-producing pollutants by up to 95 per cent.
- Converting one waste truck from diesel to NG is the pollution-reduction equivalent of removing as many as 325 cars from the road.

The economic appeal of NGVs is attractive, too. Based on the study done by ANL[9] in 2012 on the data record maintained by the And, as NGVs enter into wider use, many fleet managers are finding that they have far lower operating and maintenance costs, generating significant vehicle life-cycle savings. Similarly, businesses and cities alike have found that NGVs pay for themselves in fuel savings. Many NGV fleets report a 15 to 28 per cent savings compared to diesel fleets. A study by the CNGVC[10] found that "the

8 NGV, Natural Gas Vehicles
9 ANL, Argonne National Laboratory, U.S. DOE
10 CNGVC, California Natural Gas Vehicle Coalition

relative average annual cost difference of owning, maintaining and operating comparably equipped vehicles was found to be small over the range of expected fuel prices, vehicle technology costs and vehicle fuel economy."

1.3.3 Energy Security

As per the MoPNG[11] of India, Indian energy imports have crossed the figure of 80 percentage of the total annual consumption in the recent past which means there exists a huge energy supply and demand gap. This gap leads to higher fuel prices, high inflation and a high current account deficit. It also exerts an upward pressure on the amount of subsidies to be sanctioned for the petroleum products in the country (including LPG, PNG and CNG) and hence the under-recovery of the oil marketing companies goes higher and higher.

One of the primary reasons behind this phenomenon is the limited supply of domestic crude oil and NG which forces the energy hungry economy to rely on imported energy commodities. But once the potential of the indigenous shale gas/oil plays are unlocked, there can be a significant addition to the domestic crude oil and NG supplies providing the most awaited energy security for the world's third fastest growing economy.

1.4 ENVIRONMENTAL IMPACTS OF SHALE GAS

Environmental impacts associated with SGD occur at the global and local levels. These include impacts to climate change, local air quality, water availability, water quality, seismicity, and local communities. The following are the identified impacts on the environment as found in the studies that have been done on the SGD in the US.

1.4.1 Life-Cycle Ghg Emissions

NG is considered to be a low-carbon fuel, as its combustion produces significantly less carbon dioxide emissions than coal and petroleum-based fuels. The following chart lists Environmental Protections Agency (EPA) emission rates:

[11] MoPNG, Ministry of Petroleum and Natural Gas

Emission Rates for Coal and Natural Gas

	Coal	Natural Gas
Carbon Dioxide (lbs/MWh)	2249	1135
Sulfur Dioxide (lbs/MWh)	13	0.1
Nitrogen Oxides (lbs/MWh)	6	1.7

However, to understand the implications for climate change, one must look the greenhouse gas (GHG) emissions from combustion in a vehicle or power plant and also those from production activities. For NG, the primary concern is leakage and venting throughout the supply chain, as methane (CH_4) which is its primary constituent and is a potent GHG.

One key activity that can produce significant CH_4 emissions is SG well completions. When flow-back water is removed from the well prior to the beginning of gas production, NG can be vented to the atmosphere over the course of several days. Evidently, in 2011, the EPA doubled its estimates of CH_4 leakage for the U.S. NG industry, partly because of the inclusion of emissions from SG production for the first time.

In practice, NG operators often take steps to limit these emissions. One such initiative is the EPA's NG STAR program in the USA, an industry and government partnership to reduce CH_4 emissions, has been reporting significant, approximately half, emission reductions through the use of flaring and reduced emissions completions (RECs), which allow them to capture gas that otherwise would have been vented to the atmosphere (Burnham et al. 2012). However, the estimates of savings lack transparency, as they are highly aggregated to protect confidential business information. Another area of uncertainty when estimating the impacts of these emissions is projecting future well productivity, which is an important factor in life-cycle calculations. Because SG production is so new, these projections range widely, and if wells are less productive than the industry projects, then the emissions impacts of well completions will be of greater importance.

Several studies have been released that have estimated the life-cycle GHG emissions of shale gas; however, results have varied due to differences in methodology and data assumptions (Howarth et al. 2011, Skone et al. 2011, Jiang et al. 2011, Burnham et al. 2012). Argonne researchers estimated a base case leakage rate for large-scale SG of 2.0% over the entire life cycle and 1.2% for production activities (Burnham et al. 2012). The

EPA does not explicitly examine SG leakage, rather examines the entire NG industry; however, previous EPA estimates for NG leakage prior to large-scale SG production were 1.4% for the life cycle and 0.4% for the production phase (EPA 2011a, Kirchgessner et al. 1997). While the estimated leakage rate has increased significantly from previous estimates for various activities associated with production, those for other stages such as transmission and distribution have declined due to replacement of older pipelines, thereby reducing the overall impact. On the other hand, Cornell researchers estimated a base case leakage rate for SG of 5.8% for the life cycle; however, they do not account for technologies that capture vented CH_4 and include several data points that likely overestimate emissions, such as using Russian pipeline information in place of U.S. data (Howarth et al. 2011).

Using current leakage estimates for large-scale production, NG CH_4 emissions account for approximately 15% of the total life-cycle GHG emissions on a 100-year time scale and the relative benefits of NG depend on how it is ultimately used. For example, most studies show that NG power plants can provide approximately 30–50% reduction in GHG emissions, depending on the plant's efficiency, as compared to a typical coal plant (Skone et al. 2011, Jiang et al. 2011, Burnham et al. 2012). For light-duty vehicles, use of compressed NG may provide nearly a 10% reduction in GHG emissions as compared to gasoline (Burnham et al. 2012). However, for heavy-duty natural-gas vehicles using spark-ignited engines, such as a transit bus, there may be no GHG benefit as compared to diesel vehicles, because of the efficiency advantage of compression-ignition engines run on diesel.

1.4.2 Local Air Pollution

Shale gas production activities can produce significant amounts of air pollution that could impact local air quality in areas of concentrated development. In addition to GHGs, fugitive emissions of NG can release volatile organic compounds (VOCs) and hazardous air pollutants (HAPs), such as benzene. Nitrogen oxides (NOx) are another pollutant of concern, as drilling, hydraulic fracturing, and compression equipment—typically powered by large internal combustion engines—produce these emissions.

Several state emission inventories have shown that oil and NG operations are significant sources of local air pollution (e.g., the 2008 Colorado emission inventory showed that they accounted for 48% of VOCs, 18% of NOx, and 15% of benzene) and that SG operations may lead to increased levels of ozone and HAPs near these areas (Wells 2012). However, uncertainty about the impacts of these emissions exists, as air quality is highly dependent on local conditions. For example, in some areas VOC emissions will not be the primary driver of ozone formation; therefore, detailed modelling is required to understand the impact of emissions on local air quality. In addition, while elevated levels of benzene emissions have been found near production sites, concentrations have been below health-based screening levels, and with little data on how these HAP emissions impact human health, further examination is needed (Alvarez 2012).

Another local air pollutant of growing concern is crystalline silica dust, which can be generated from the sand proppant. Silica dust can be generated in the mining and transporting of sand to the well site and in the process of moving and mixing sand into the hydraulic fracturing fluid on the well pad. Crystalline silica dust within the respire-able size range (<4 microns) is considered a HAP and a carcinogen. In addition to an increased risk of lung cancer, exposure to crystalline silica can lead to a chronic, inflammatory lung disease called silicosis (Wisconsin Department of Natural Resources 2011). A recent field study of 11 different hydraulic fracturing sites in five different states by researchers at the National Institute for Occupational Safety and Health (NIOSH) found levels of crystalline silica that exceeded NIOSH recommended exposure limits (REL) in 79% of the samples and far exceeded the REL by a factor of 10 or more in 31% of the samples. The researchers concluded that existing safeguards may not be sufficiently protective of worker health and that additional safeguards should be put in place (Esswein et al. 2012).

1.4.3 ***Water Consumption***

Although water is used in several stages of the SG life cycle, the majority of water is typically consumed during the production stage. This is primarily due to the large volumes of water (2.3–5.5 million gallons) required to hydraulically fracture a well (Clark et al. 2011). Water in amounts of 190,000–310,000 gallons is also used to drill and cement a SG well during construction (Clark et al. 2011). After fracturing a well, anywhere from 5% to 20% of the original volume of the fluid will return to the surface within the first 10 days as flowback water. An additional volume of water, equivalent to anywhere from 10% to almost 300% of the injected volume, will return to the surface as produced water over the life of the well (Mantell, 2010). It should be noted that there is no clear distinction between so-called flowback water and produced water, with the terms typically being defined by operators based upon the timing, flow rate, or sometimes composition of the water produced. The rate at which water returns to the surface is highly dependent upon the geology of the formation. For example, we can consider two of the some oldest and most producing shale plays of the US, in the Marcellus play, operators recycle 95% of the flowback, whereas in the Barnett and Fayetteville plays, operators typically recycle 20% of the flowback. Water management and reuse are local issues and often depend upon the quality and quantity of water and the availability and affordability of management options. Over a 30-year life cycle, assuming a typical well is hydraulically fractured three times during that time period (EPA 2010), construction and production of SG typically consumes between 7,090,000 and 16,810,000 gallons of water per well.

Once the gas is produced, it is processed, transported and distributed, and ultimately used. Water consumption occurs in each of these stages as well, with the most significant non-production consumption potentially occurring during end use. Although NG can be combusted directly with no additional water consumption, if the end use of the gas is a vehicle tank, it might be compressed via an electric compressor. The electricity for compression is associated with water consumption of 0.6–0.8 gallon per gasoline gallon equivalent (GGE), according to King and Webber (2011), making the total consumption for the vehicle life cycle 1.0–2.5 gal/GGE depending upon location and the extent that flowback water is recycled. For comparison, vehicle life cycle water consumption associated with the use of conventional NG is between 0.9 and 1.1 gal/GGE, gasoline is between 2.6 and 6.6 gal/GGE, and corn ethanol is between 26 and 359 gal/GGE.

1.4.4 Water Quality

Concerns over water quality focus on potential drinking water contamination by methane or fluids from hydraulic fracturing activities. The possible pathways for this contamination include underground leakage from the wellbore to drinking water aquifers and improper disposal or accidental leakage of hydraulic fracturing fluids to surface water bodies. Owing to the depth of most shale plays, it is unlikely that a credible pathway (independent of the wellbore) exists for fluids to flow from the fractures within the shale through thousands of feet of overlaying rock into a drinking water aquifer. However, shallower shale deposits may be vulnerable to this direct connection, as is suggested by EPA's ongoing groundwater investigation in Pavillion, Wyoming, where as little as 400 feet separated gas deposits from drinking water resources.

For deep formations, contamination may occur due to defects in the wellbore. When the annulus between the well casing and surrounding geology is not adequately sealed during well installation, methane can migrate from the shale resource up the outside of the wellbore to shallow aquifers where it could dissolve in the drinking water. Another possible pathway for contamination is a defect in the casing at a shallow depth, allowing gas to flow from inside the wellbore to the aquifer. Faulty well construction appears to have caused one of the largest documented instances of water contamination, which occurred in Bradford County, Pennsylvania, after wells had been drilled but before any hydraulic fracturing took place (PADEP 2011). In addition to faulty well construction, Osborn et al. (2011) suggest that uncased, abandoned wells may also provide pathways for methane migration to occur. The most obvious, and perhaps most easily prevented, pathway for contamination is intentional dumping or accidental spilling of flowback water on the surface. A common cause of accidental spillage is overflows from retention ponds during major rain events.

Contaminants in flowback water from the mineral formation, such as NORM, or from additives to the hydraulic fracturing fluid can be a health concern when present in significant concentrations. EPA's investigation into possible groundwater contamination at Dimock, Pennsylvania, was launched out of concern over such toxic substances. While there are no Federal drinking water standard limits for methane, it is nevertheless a hazard in water because at sufficient concentrations it can volatilize and collect in houses, which can lead to suffocation or serve as a fuel for fire and explosions.

1.4.5 Induced Seismicity

Disposal of flow-back water from hydraulic fracturing depends upon the availability of suitable injection wells. For example, the limited availability of suitable geology in Pennsylvania has led to hauling flow-back water to Ohio for injection. The increased injection activity has been linked to seismic events or earthquakes, according to the Ohio Department of Natural Resources (ODNR 2012). Additional studies have indicated that injection activities in Arkansas have been linked to nearby earthquakes (Horton 2012). Injection activities have been halted in associated wells in Arkansas and Ohio.

According to ODNR, a properly located injection well will not cause earthquakes. A number of factors must be present to induce seismic events at a disposal site. In order for earthquakes to occur, a fault must exist nearby and be in a near-failure state of stress. The injection well must have a path of communication to the fault, and the fluid flow rate in the well must be at a sufficient quantity and pressure for a long enough time to cause failure along the fault or system of faults. A recent National Research Council study concludes that the majority of disposal wells for hydraulic fracturing wastewater do not pose a hazard for induced seismicity. This report also concludes that the process of hydraulic fracturing itself does not pose a high risk for inducing felt seismic events (NRC 2012).

1.4.6 Community Impacts

Oil and gas development is an industrial process and as such is not immune to the types of local impacts that most industrial activities tend to share. The process requires heavy equipment, including hundreds to thousands of truck trips to deliver water and chemicals to perform the hydraulic fracturing process, and many more to remove the flowback water generated by the process. This intense traffic places enormous stress on local roads, which may not have been built to handle heavy truck traffic, and can lead to congestion, which can become a source of frustration for local citizens. The large equipment used to drill and hydraulically fracture a well can also be noisy and visually unattractive, especially when in close proximity to occupied residences. Furthermore, this activity can have a negative impact upon local property values, especially in residential areas, owing to a combination of real and perceived risks and impacts. However, some aspects of SGD differ from those of other industrial processes. Intense trucking near well pads often occurs over a brief period on rural roads. This traffic is heavy enough to cause significant road degradation, but unlike a road to a stationary industrial facility that will support traffic over a long period of time, these roads are subject to heavy traffic for only a brief period, making road upgrades a difficult decision for local or state governments.

2. REVIEW OF LITERATURE

The very first country that comes to mind when thinking about a successful venture into the shale gas development is the United States of America. US have seen a huge investment in the development of the technology, many studies to learn about the geography of the shale gas. **Pierce (2013)** in one of his publications describes how **fracking will improve** the performance of the **US Economy and the US Environment.** The paper presented all the plus points of the Fracking. The paper explains with evidences from history, how the gas boom can significantly be beneficial to geopolitical conditions. For instance, India can import natural gas from the newly emerging gas exporters like US and Canada reducing its heavy reliance on Iranian natural gas exports. There are many conditions that need to be complied with/followed before reaping the sweet fruits of anticipation. But the author in the paper claims, "With the help of excellent reports from the US Department of Energy and the International Energy Agency, I am confident that we can satisfy those conditions."

A study was done at European Policy Studies (EPS) regarding the **hype created by the SGD** in various countries around the globe **and its potential effects on the European gas markets**. Based on data in a report of IEA[12] on shale gas and some scenario analysis performed by the Joint Research Centre, Teusch (2012) finds out that SG will not fundamentally change the EU's dependence on foreign gas supplies. This is supported by first argument of the researchers that the amount of natural gas resources unlocked by the SGD is undoubtedly immense but it is anyways not sufficient in completing the local gas market of Europe. Secondly, in the short term, the local gas market is required to start-up the SGD in areas where the political will is not a hindrance for SG extraction. And lastly, the contribution of the SG exploitation is not as much as it is hyped without mentioning the well-functioning local gas market to secure the Europe's gas supply.

Teusch also points out a cultural difference between the US and the European countries, that the practice of exemptions from environmental obligations in the US to keep economic advantages at priority cannot be replicated in Europe. SGD **in Europe** will not go ahead **until it is proven to be viable,** both **environmentally and economically.**

[12] IEA, International Energy Agency

Another interesting read is about an intense debate on risks versus benefits of unconventional fossil fuel exploration. According to **Dreyer and Stang (2013)** the environmental impact of SG is controversial. In spite of numerous benefits of SGD that the whole world chants about, there are risks/issues with the handling of chemicals while Fracking, chemical leaks into water aquifers underground, the potential seismic disturbances in drilling areas, etc.

Apart from this debate, the paper also discusses about the market infrastructure of the SG. According to the authors the SG boom should be viewed in conjunction with the evolution of international trade of gas (through LNG). Dreyer and Stang explained how the global gas prices will tend toward convergence in future due to greater market interconnectedness and increasing gas supplies from a number of countries. So the price of gas will be higher for the US, and will be lower for Asia and the EU in future as the markets mature. Not only that, but prices will also be subsequently delinked from oil due to the failure of the traditional model of oil-indexed gas pricing.

Dreyer and Stang also put up a beautiful argument to make a statement; "**natural gas is the fall-back energy source for EU.**" Post Fukushima Daiichi nuclear disaster in Japan, EU has witnessed the trend of increasing share of coal in its total energy mix; which lead to the increased carbon emissions to alarming levels. Now EU is keen to limit carbon emissions and at the same time trying hard to reduce its reliance on nuclear power. So in such a situation, EU is left on the mercy of unconventional energy sources. Due to the rising costs and inconsistency in the supply of renewables, EU will have to embrace the path of increased domestic gas production and usage. And it is feasible also, because EU's rising dependency on imported gas along with the above mentioned issues, could lead to lesser opposition to domestic SGD once the reasonably acceptable technology and regulations that respond to environmental concerns are in place"

To know about the connectedness of the natural gas markets, **Pashelinsky and Rothwell,** through their analysis on the subject, argue that the global markets for NG are not integrated. They studied the NG price trends in the number one importer of LNG globally, and found that there exists a huge gap between the gas prices in Japan and the gas prices at the major western trading hubs in US & Europe. They could not identify a single factor working against this divergence to force the prices at some equilibrium throughout the globe. Although further research is pending to determine the level of this disintegration; but it is apparent that there is huge scope of investment in LNG infrastructure (liquefaction and regasification capacity) development.

If we look from business perspective at the LNG industry, there exists this trend of **skewedness of prices** in various gas markets over the world which presents **opportunities for arbitrage profit generation.** In addition to that, sudden price spikes can also be expected to occur more frequently if the gap between NG supply and demand continues to remain wide, fetching more dollars to investors' pockets.

While enquiring about the reasons/responsible factors for the underdevelopment of the LNG market infrastructure, one can arrive at two of the most likely answers; market players and policy makers. In market players' defense, they might become uncomfortable with closing arbitrage windows as a result of **decreasing volatility of NG prices**; or the fact that LNG facilities are highly capital intensive and require continued streams of profits to recover the mammoth investments only, leave alone the gains out of the projects. On the regulation side, policy makers who have to take a call on the do's and don'ts for the new entrants have to consider safety or other issues which can be directly or indirectly responsible for the apparent under-development of the LNG sector.

Searching about some points in support of why India should at all think about unlocking their unconventional gas resources, the study by Nakano and group (2012) came handy. The study examines various challenges and potential of SG in Asia. As China and India are considered to be amongst the fastest growing economies, their growth provides a strong demand for various resources and energy. The study cites the forecast of global energy consumption between now and 2035, which is expected to grow by 50 per cent. This is an important consideration as India and China account for a little more than 50 per cent of this global growth. So subsequently the mere scale of energy consumption of these economies is bound to affect the global energy supply and demand. Needless to mention, the effect on price levels of various energy commodities in the global market-including NG-thereafter is inevitable.

In wake of a series of potential benefits (discussed in later chapters) to these rapidly developing economies like India and China, increased exploitation of unconventional oil & gas resources, especially SG, warrants close observations because of a host of potential economic and energy security benefits successful development may bring for the two growing economies.

Contemplating about a simple question, "What led to the SG boom in the United States?" can help inform various stakeholders in countries that are planning to go ahead with the development of their own SG resources. **Wang and Krupnick** reviewed the economic, policy, and technology history of SGD in the United States. This paper is also a case study of the incentive, process, and impact of technology innovations and the role of government in promoting technology innovations in the energy industry. The review lists government policy, private entrepreneurship, technology innovations, private land and mineral rights ownership, high NG prices in the 2000s, and a number of other factors all made important contributions to the SG boom.

3. OBJECTIVE OF THE STUDY

This study on the topic, SG *exploitation in India: Issues and Challenges Ahead*, primarily aims at "comparing policies for SG exploration and exploitation (regulatory framework and infrastructure related policies) of different nations with that of India."

The objective of this report is to investigate the challenges that lie ahead of development of unconventional gas, notably shale gas, in India. This report seeks to clarify the role SG could play as a potential source of energy in Indian energy market and also highlights issues as the environmental considerations, land acquisition or lack of infrastructure, etc. It also studies the factors contributing to the success of development of SG in USA and other countries to find out the policy gaps in India. It also covers resource estimates and the advancement of technologies for SG extraction.

This report considers the prospects for the indigenous production of SG within India. It evaluates the available evidence on unconventional gas resource size, extraction technology (past and possible future), resource access and market access. Specifically, it reviews effects of the rapid development of SG production in the United States of America. Further, it elaborates possible future scenarios for the potential impact of unconventional gas in our own energy sector.

4. RESEARCH METHODOLOGY

The research methodology adopted for this study is Doctrinal methodology.

The study is based upon the analysis of research papers, articles, industry reports and various discussions in relevant journals and other platforms related to the field of shale gas extraction and development. These sources are used to gather insights over the topic and to find out some significant issues and challenges for India in attempting the development of unconventional gas resources especially shale gas.

The study starts with some research papers which talk about all the major advantages of the shale gas for the developed countries venturing into shale gas projects. There have been a few countries from EU that have shown interest in the development of their unconventional gas reserves. So studies related to the future of shale gas development in European counties are also referred which bring powerful insights regarding the market scenario of natural gas before and after the shale gas extraction activities. These studies also helped in finding out the inherent factors that support/influence the general and economic feasibility of any shale play development.

Based on the findings in these studies and several identified factors affecting shale gas development, a significant scenario generation for shale gas development in Asian countries (especially India and China) was done. In these scenarios, according to the close analysis of those factors, one can predict the preparedness of India for the shale gas projects.

5. ANALYSIS AND FINDINGS

In the analysis of the India faces many challenges in development of shale gas, related to infrastructure, environment, cultural acceptance, resource management, etc. All the points are further discussed in detail in this chapter.

5.1 CULTURAL ACCEPTANCE

Some of the largest SG deposits in India are located in states that do not have a recent history of oil and gas production like, Vindhyan basin, South-Rewa basin and Pranhita-Godavari basin. This leads to two potential challenges: public acceptance and regulatory sufficiency. The first challenge is that state agencies may not be well positioned to deal with rapid growth in oil and gas development. The experience of Pennsylvania from 2008 to 2012 can be a lesson to other states. State officials were caught somewhat off-guard by the boom in development in the Marcellus shale. In the process, they identified outdated laws regulating the disposal of produced water and well construction standards. Upon identification of deficiencies, improved regulations were developed, which are expected to significantly reduce risks to drinking water. Other states with shale resources have learned from Pennsylvania's experience and are beginning to review and modernize their regulations to ensure that they properly consider and minimize the risks associated with unconventional gas development.

Another challenge is that in areas without a recent history of oil and gas development, the public tends to be more sceptical of new development and the risks involved. This scepticism can manifest itself in public opposition to development that can be costly for operators to overcome. Additional, credible scientific research is needed to improve quantification of the actual versus perceived risks and to improve public trust. Adequate communication, coordination, and planning involving operators, regulators, and stakeholders prior to development can also be important to help address public concerns and ensure that best practices are being used to mitigate impacts and risks.

Another major challenge apart from the challenges of public acceptance is to tackle with the local political issues of the areas where the shale well pads have to be situated. According to the study by the EIA, the major shale basins are situated in the central and north-eastern part of the country. The local political issues in those part of the country are 'the parallel governments', terrorism, and other violent activities due to local cultural differences among the various classes and societies, etc.

5.2 INFRASTRUCTURAL CHALLENGES

One of the best ways of SGD in our country is the learning from the experiences of the global frontrunners of SGD like US, and other developed countries.

Talking about the United States, it already had an extensive network of pipelines to transport NG to market before SG became a major gas resource. Also important was the policy of open access to interstate NG pipelines (as well as NG storage facilities). Interstate NG pipelines previously sold pipeline transportation and NG as a bundled product, but the open-access policy limited interstate pipelines to offer transportation services only, on a non-discriminatory first come, first served basis. This open-access policy helped create a more competitive wholesale NG market. So India first needs to develop at least a minimum required scale of pipeline infrastructure so as to tap the economic advantages of the shale gas. Without the proper pipeline infrastructure in place, there can be many side-effects of SGD on India as a growing economy like economic loss, life-cycle GHG emissions, and other harmful impacts associated to it.

Looking at some of the recommendations of Governor Corbett's Marcellus Shale Advisory Commission 2011 report included the following:

- Effect the sharing of pipeline capacity and reduce surface disturbance and associated environmental impacts;
- Encourage the use of existing pipeline infrastructure and co-location with other rights-of-way;
- Achieve coordination and consistency of infrastructure planning and siting decisions by state, county and local governments;
- Provide sufficient authority and resources for appropriate government agencies to ensure that ecological and natural resource data are used in the review and siting of proposed pipelines, in order to avoid or minimize impacts to these resources.
- The Commonwealth should incentivize the development of intrastate NG pipelines to ensure the in---state use of Marcellus SG and to lower costs to consumers through the avoidance of interstate pipeline transmission costs.

Now looking at the recommendations above given by an advisory commission we can think of the basic requirements for the development of SG in India too. Currently India doesn't have proper pipeline infrastructure for the basic necessities like water and sewer, leave apart the pipeline-infrastructure for NG which is the unquestioned integral part of the successful commercially viable SGD project anywhere in the world.

5.3 RESOURCE MANAGEMENT

The management of humongous quantities of all the resources used in the SGD is quite a difficult job in itself considering the legal, commercial and execution related difficulties in different geographies and economies. For example if we consider in a country like India, where the legal proceedings and permissions take time to the tune of several weeks to several months, the process of acquiring the land for construction of road infrastructure from various factories to the well pads alone, would take several months. Now, such delays usually increase the costs of any capital intensive projects and in a project like this, the commercial viability of the SGD project itself can be in question and can have totally opposite end-results.

5.4 ENVIRONMENTAL CHALLENGES

In the past decade, the "shale revolution" has created millions of jobs in the U.S., enhanced their energy independence, and reduced U.S. GHG emissions by substituting NG for coal. Fracturing is controversial, however, because it presents a number of environmental risks. It may undercut the renewable energy industry, exacerbate air pollution and congestion, and use significant amounts of water. The most unique risk, which is the focus of this Article, is the potential contamination of groundwater. The fluid used in fracturing contains toxic chemicals. There is little evidence so far that subterranean fracturing can directly contaminate groundwater, and this risk may never materialize. But there are other ways in which fracturing might contaminate groundwater, including surface spills of fracturing fluid, improper handling of waste, and the migration of NG into water wells. Some of these risks are familiar from decades of conventional oil and gas production, while others are new.

In response, this Article proposes a strategy for regulating water contamination from fracturing. For issues that are already well understood, we would rely on best practices regulations. For issues that are unique to fracturing and are not yet well understood, we would rely on liability rules – and, specifically, a hybrid of negligence per se, res ipsa loquitur, and a regulatory compliance defense – to motivate industry to take precautions, develop risk-reducing innovations, and cooperate in the development of best practices regulations. To facilitate more accurate determinations of causation, we recommend information-forcing rules (e.g., requiring energy companies to test water quality before they begin fracturing). We also suggest other design features for the liability system, such as one-way fee shifting and provisions to ensure that defendants will not be judgment proof. To ensure that the regulatory regime draws on existing regulatory expertise and is both dynamic and tailored to local conditions, we recommend keeping the regulatory center of gravity in the states, instead of fashioning a new federal regime.

5.5 LEGAL FRAMEWORK

In the name of legal framework for SG exploration in India, there is only a SG policy that has been issued by the Ministry of Petroleum and NG, GOI, open for the industry players for feedback and the subsequent suggestions to improvise the policy so as a constructive framework can be put in place for the successful tapping of the potential of SG.

5.6 INTELLECTUAL PROPERTY RIGHTS

The industry has lately seen many cases battling over IPR issues for the newly developing technology in the shale gas extraction. For example many companies are trying to innovate and develop new biodegradable chemicals to be used for the purpose of Fracking, which are supposed to be non-hazardous for the water aquifers and can help resolve environmental issues/obligations in many countries which currently pose a challenge to the present shale gas industry. This issue can be proven a significant one as it will impact directly the cost of SG extraction.

6. CONCLUSION AND RECOMMENDATIONS

By this secondary study based on the comparison of the SGD policy of the United State and the world's biggest democracy and the third largest economy of the subcontinent of Asia, we can conclude the following things:

- Lack of pipeline infrastructure a major problem for India. In addition, the open access policy for pipeline infrastructure like the United States is an inherent need of the successful development of the shale gas resources.
- Lack of clean water resources is a serious concern in addition to the capital funding and technological advancements requirement for making the produced water available.
- On the basis of the fact, that each shale play has different geography and requires different kind of exploration and extraction process to take out the shale gas out and make it useful, the process of SGD in USA or any other developed country cannot be replicated everywhere because of various factors required for SGD in addition to the technology which is most likely to reach out everywhere.
- The legal and fiscal framework for SGD, should be framed keeping in mind the reasonable returns for the investors and the future effects of SGD on the environment.
- There are many factors, not only technical but others in supporting role, affecting directly or indirectly the process of SGD in USA (as discussed above in this study), which should be considered well before designing and implementing any policy to extract shale gas in India.
- A major outcome of this study is the scope of "factors analysis study" of the factors mentioned earlier for the development of shale gas in India.

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