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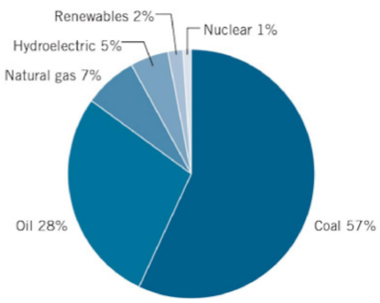
Shale Oil & Gas, Gas Hydrates: Opportunities and Challenges in India.

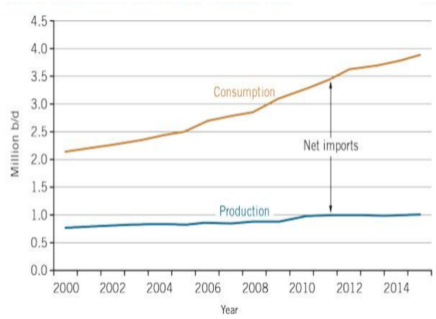
Abstract

With continuous increase in demand for energy, the trend world throughout has been to supplement conventional oil and gas production with alternative/ unconventional energy fuel sector. Shale gas trapped within deep shale rock formations is one such source of unconventional energy and will be a valuable addition to the basket of fuel mix. Like any other energy resource, shale oil & gas have its own environmental concerns. These are mainly associated with use of large quantity of water for hydro fracking, protection of water aquifers, disposal of produced water after hydro-fracturing, impact on communities, biodiversity and ecosystems. There are also issues concerning pollution due to air, noise etc. In a similar fashion, Gas hydrate is a material very much tied to its environment— it requires very specific conditions to form and remain stable. Pressure, temperature, and availability of sufficient quantities of water and CH4 are the primary factors controlling gas hydrate formation and stability, although geochemistry and the type of sediment also play a part. These unconventional sources can bring a big change over to global energy needs. This paper discusses the entire foreplay and mechanism which are facilitated to meet he need of cleaner energy.

Introduction

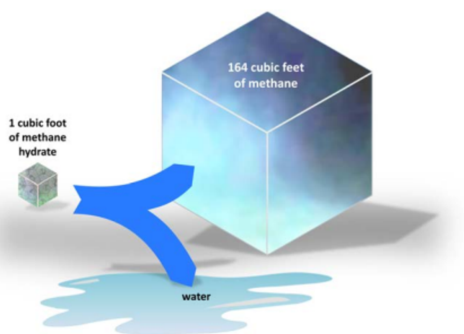
Depletion of fossil fuels that meet ~80% of global energy requirement and the growing demand of carbon emission-free energy necessitate looking for an alternate source of energy for sustainable development of energy-starving countries like India. India is the third largest consumer of energy in the world after China and USA (Source: BP Statistical Review, 2016), but it is not endowed with abundant energy resources. High reliance on imported energy imperils fiscal stability given volatile energy prices, and also impinges adversely on energy security. Meeting the energy needs of achieving 8%-9% economic growth as also meeting the energy requirements of the population at affordable prices, therefore, presents a major challenge. It calls for a sustained effort at increasing energy efficiency to contain the growth in demand for energy while increasing domestic production as much as possible, to keep import dependence at a reasonable level. The scope for containing the growth of demand for energy depends upon our ability to reduce the energy intensity of GDP taking account of both the need for energy as an input into production, and in direct final consumption in lighting/heating/cooling and transport. Energy intensity has special relevance in petroleum sector, as our import dependence is likely to rise from 73% in 2011-12 to more than 80% by the end of the 12th Plan (2016-17). This is accentuated by the fact that the use of petroleum products in several areas cannot be substituted by other fuels. Enhancing fuel efficiency of vehicles is vital for India, especially in Heavy Duty Vehicles (HDVs). As India maintains its rate of economic growth, primary energy consumption is unlikely to abate. In the year 2015, the growth in the primary energy consumption in India over the previous year was 5.2 %, whereas China, US, Russia and Japan registered growth rates of 1.2%, -1.9%, -3.3%, and -1.2%, respectively. In petroleum, India registered nearly 11% growth rate in 2015, a historic high. It is expected that as has been the trend world over, the share of gas is likely to rise given increased availability and trade of gas and its environment friendly nature. As per International Energy Agency (IEA), if the industry abides by the ‘golden rules’ proposed by it, the share of gas in the global energy mix could rise from the present levels of 23% to 25% in 2035 overtaking coal (24%), to become the second largest primary energy source after oil (27%). This has even prompted IEA to suggest in a publication in 2012 that the world is entering a golden age of gas. The share of unconventional gas in natural gas could rise from 14% in 2010 to 32% by 2035. Consequently, the emergence of unconventional sources of gas, particularly shale gas, holds special relevance for India. Policy Planners are committed to evolving a conducive policy for harnessing modern technology in tapping this source of energy to augment domestic energy supply.

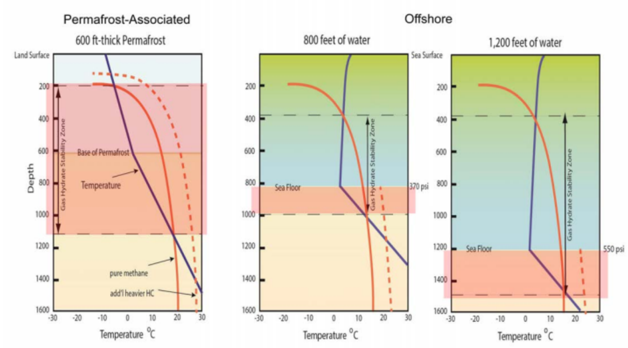

Renewables 2%
Nuclear 1%
Hydroelectric 5%
Natural gas 7%
Oil 28%
Coal 57%


Consumption
Net imports
Production
Million b/d
Year

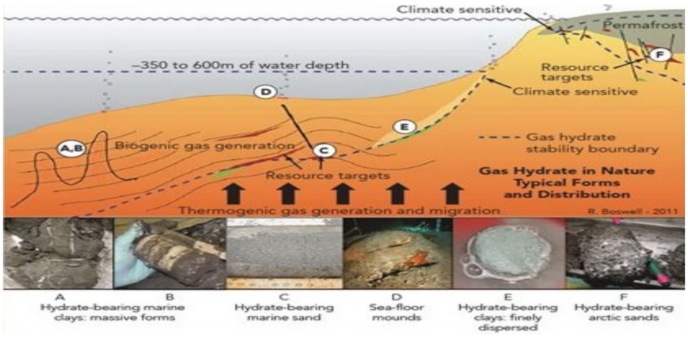
Gas Hydrates: Ice that Burns

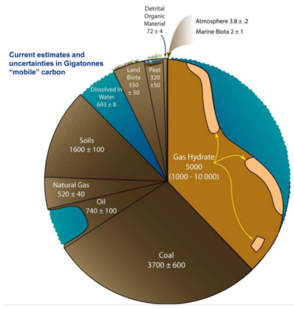
Natural gas hydrates are clathrates of natural gases (mainly methane), which are captured in water ice crystals wherever low temperature, high pressures and sediment organic concentrations are conducive to their formation. These clathrated compounds were discovered more than a century ago in the laboratory as a scientific curiosity. The academic and industrial efforts in the last three decades to investigate and explore naturally occurring gas hydrate have expanded and deepened our knowledge on the distribution and occurrence of gas hydrate in deep-sea sediments and permafrost regions. Natural gas hydrates are considered to be the vast sources of methane gas, which is entrapped in the hydrate crystals. Due to vast energy resource potential of gas hydrates, several countries like USA, Canada, Japan, India, China, Korea, Taiwan, Indonesia etc have launched national programs for gas hydrate exploratory research. The huge volume of gas trapped within global reserve of gas hydrates, though estimated to vary over several orders of magnitude, is envisaged as 1–120×1015 m3 according to a recent study, which is at least 10 times of total conventional natural gas accumulations. However, technically-recoverable global volume of gas would be ~3×1013 m3 gas. Even, this volume is also huge and only 15% recovery from this gigantic reserve can meet the global energy requirement for the next 200 years. If existing and new technologies can be applied economically to the development of methane hydrate as a source of natural gas, country like India could significantly decrease its reliance on foreign energy supplies. A number of countries that currently import much of their energy could become more self-sufficient.

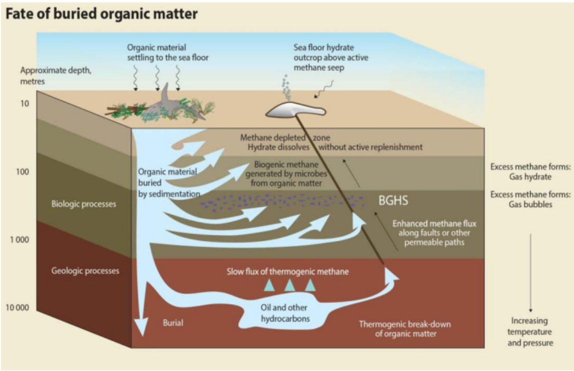




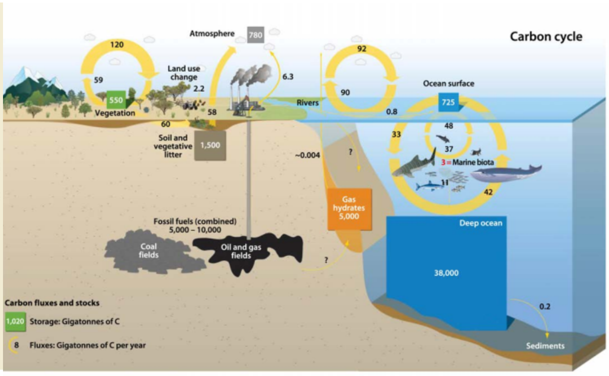
Methane hydrate is known to occur in both terrestrial (onshore) and marine (offshore) environments throughout the world. Terrestrial deposits have been found in polar regions, hosted in sediments within and beneath permafrost. Marine occurrences have been found mainly in sediments of the Earth's outer continental margins. These are the natural settings where methane and water are present, and where pressure and temperature conditions are suitable to form and sustain hydrate. The methane that is captured in methane hydrate may have been generated by biogenic or thermogenic processes. Biogenic methane is the common by-product of bacterial ingestion of organic matter. This is the.same process that produces methane in swamps, and it occurs continually within buried sediments all around the globe. Biogenic processes are capable of producing vast amounts of methane and are considered to be the dominant source of the methane trapped in hydrate accumulations in shallow seafloor sediments, as shown in the diagram below. Thermogenic methane is produced by the combined action of heat and pressure over long periods of time in deeply buried organic material. Over time and with deep burial, organic-rich source beds are literally pressure cooked, with the result being the production of large quantities of oil and natural gas. Along with the oil, the natural gas (largely methane, but also ethane, propane, and other gases) slowly migrates upward due to its relative buoyancy. Where sufficient quantities of gas reach the zone of hydrate stability, this gas is able to combine with water in the sediments to form methane hydrate, as shown below.







Methane creation in the environment. (Courtesy of W. Waite, USGS).

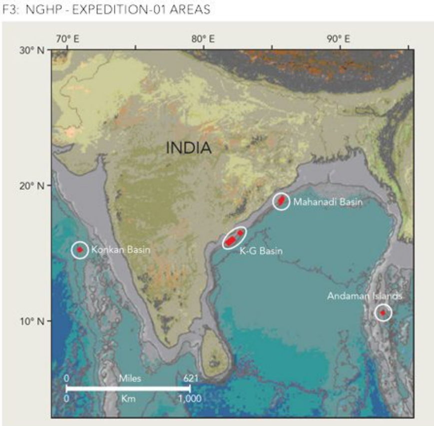


Global carbon cycle. (Courtesy of W. Waite, USGS).

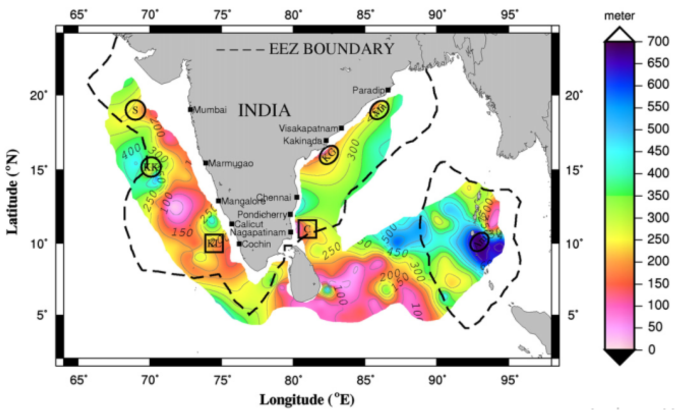
Gas Hydrate: Indian Scenario

India's Directorate General of Hydrocarbons launched the National Gas Hydrate Program (NGHP) in 1997 to coordinate activities related to exploration, appraisal, development, and extraction of natural gas from gas hydrates. The first NGHP expedition was carried out in 2006, with the US Geological Survey as the main technical collaborator. NGHP-1 drilled 39 wells in 21 locations, of which 16 were logged and 22 cored. The work established the presence of vast amounts of gas hydrates in India's continental shelf and river basins, most notably the Krishna-Godavari (KG) basin. India's Oil & Natural Gas Corp. Ltd. conducted a second expedition (NGHP-2) in 2015 with several technical collaborators. This project drilled 42 wells on 25 sites, and established the presence of producible gas hydrates in the deep offshore areas of the Indian Ocean and in sand reservoirs in the KG basin. A third expedition, NGHP-3, is scheduled to establish an efficient production plan but commercial gas-hydrate extraction technology remains in the research and development phase. India's exact gas hydrate reserves are unknown, but researchers with the National Geophysical Research Institute have estimated gas hydrates to be 1,500 times more abundant than the country's conventional gas reserves. With a 10% production rate, gas hydrates could meet India's energy needs for more than 100 years.

F3: NGHP - EXPEDITION-01 AREAS



Source: USGS, ICICI Securities



Shale Oil & Gas

Shale oil is an unconventional oil produced from oil shale rock fragments by pyrolysis, hydrogenation, or thermal dissolution. These processes convert the organic matter within the rock (kerogen) into synthetic oil and gas.The resulting oil can be used immediately as a fuel or upgraded to meet refinery feedstock specifications by adding hydrogen and removing impurities such as sulphur and nitrogen.The refined products can be used for the same purposes as those derived from crude oil. Shale gas is natural gas that is found trapped within shale formations. Because shales ordinarily have insufficient permeability to allow significant fluid flow to a wellbore, most shales are not commercial sources of natural gas. Shale gas is one of a number of unconventional sources of natural gas; others include coalbed methane, tight sandstones, and methane hydrates. Shale gas areas are often known as *resource plays*. The geological risk of not finding gas is low in resource plays, but the potential profits per successful well are usually also lower Shale has low matrix permeability, and so gas production in commercial quantities requires fractures to provide permeability. Shale gas has been produced for years from shales with natural fractures; the shale gas boom in recent years has been due to modern technology in hydraulic fracturing (fracking) to create extensive artificial fractures around well bores. Horizontal drilling is often used with shale gas wells, with lateral lengths up to 10,000 feet (3,000 m) within the shale, to create maximum borehole surface area in contact with the shale Shales that host economic quantities of gas have a number of common properties.They are rich in organic material (0.5% to 25%),and are usually mature petroleum source rocks in the thermogenic gas window, where high heat and pressure have converted petroleum to natural gas.They are sufficiently brittle and rigid enough to maintain open fractures. Some of the gas produced is held in natural fractures, some in pore spaces, and some is adsorbed onto the organic material. The gas in the fractures is produced immediately; the gas adsorbed onto organic material is released as the formation pressure is drawn down by the well.

In Situ Conversion Process

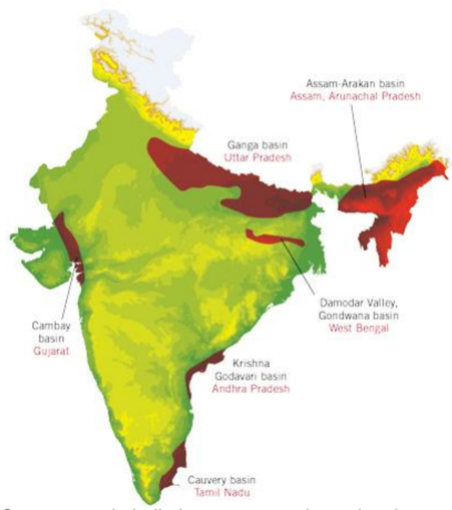
The in situ conversion process uses the oil shale reservoir itself as a giant retort. Conversion from kerogen to oil takes places over months, allowing the use of relatively low temperatures. Shell uses temperatures around 350°C, which is above the oil window maximum of 200°C, but still low enough to avoid significant product degradation. The in situ process produces a superior hydrocarbon mix, consisting of one-third propane and butane, with the balance a moderately low-sulfur 34°API mix of 10% naphtha, 40% kerosene, 40% diesel, and 10% heavy residual oil. By contrast, the conventional surface retort product is 20°API or below. The primary environmental problems of the in situ techniques are the ingress of water into the heated zone, and the escape of hydrocarbons and heavy metals into surrounding aquifers. Shell creates a freeze wall around the heated volume to prevent exchange of fluids between the reaction zone and external aquifers. The postproduction phase consists of repeatedly flushing the reaction zone with recirculated and reclaimed ground water.

India's shale oil and gas prospects

The Government of India has carried out studies through various national and international agencies for the identification of shale oil and gas resources in the country. Based on the data available from conventional oil/gas exploration in the country for the last so many years, the country holds promising reserves of Shale Gas & Oil resources and the following sedimentary basins are considered prospective from Shale oil and gas point of view:

- Cambay Basin
- Gondwana Basin
- KG Basin
- Cauvery Basin
- Indo-Gangetic Basin
- Assam & Assam-Arakan Basin

In January 2012, the United States Geological Survey estimated 6.1 tcf of technically recoverable shale gas in three basins, namely, Cambay, KG & Cauvery. Further, while in 2013, ONGC put the shale gas estimates to 187.5 tcf in five basins, namely, Cambay, KG, Cauvery, Ganga & Assam and Assam - Arakan, Central Mine Planning and Design Institute estimated 45 tcf of gas in six basins, namely, Jharia, Bokaro, North Karanpura, South Karanpura, Raniganj, and Sohagpur. Soon after these estimates, in October 2013, the Indian government approved the policy guidelines for the exploration and exploitation of shale gas and oil by various national oil companies under the nomination regime in their onland Petroleum Exploration License/Petroleum Mining lease areas. Accordingly, under Phase-I of assessment ONGC and Oil India Limited (OIL) have been allotted 50 and 6 blocks, respectively. In Phases II and III ONGC will carry out exploration in 75 and 50 blocks, respectively, while OIL will carry out exploration in 5 blocks each in Phase II and III. According to the Press Information Bureau, so far, ONGC has drilled 20 assessment wells for shale gas and oil. OIL has completed geological and geophysical studies and geochemical analysis in its identified areas besides completing Conventional Core in one well in Rajasthan.



Rank	Country	Technically recoverable Shale gas (trillion cubic feet)
1	China	1,115
2	Argentina	802
3	Algeria	707
4	U.S.A	623
5	Canada	573
6	Mexico	545
7	Australia	429
8	South Africa	390
9	Russia	285
10	Brazil	245
11	India	96
	World Total	**7576**

Major challenges in shale gas exploitation – Global Experience

Exploitation of shale gas poses bigger challenge than other sources of gas. They are different from conventional gas sources, also because being completely onland, shale gas exploitation leaves greater footprints. Even technologically, producing this source is very challenging. Due to the tightness of the reservoirs, these require hydraulic fracturing horizontally to cover a large part of the reservoir and sometimes require multi-stage fracturing and frequent stimulation. The typical flow rates of a shale gas well is very high in the first 1-2 years, and then tapers to a much slow rate extended over many years. This requires drilling of a large number of wells leading to greater interface with the communities, environment and effort.

Other Environmental Challenges for Unconventional Oil and Gas

Induced Seismicity: Geophysicists have long known about the potential for human activity, from petroleum extraction to water reservoir impoundments and fluid injection into the subsurface, to cause seismic activity. Changes in fluid volume and pore pressure through fluid injection can and have induced seismic events. Consequently, the three stages of the UOG life cycle that could potentially cause such events are: (1) during the disposal of UOG produced and flowback wastewater via deep injection wells. (2) long-term extraction of oil and gas; and, (3) large stage hydraulic fracturing.

Induced seismicity can also occur during other activities, such as enhanced geothermal recovery and carbon dioxide storage.

Control of Methane Leaks: Methane leakage during the production, distribution, and use of natural gas has the potential to undermine and possibly even reverse the GHG advantage that natural gas has over coal or oil.This is because CH4 is a potent GHG. CH4's lifetime in the atmosphere is much shorter than carbon dioxide (CO2), but CH4 traps more radiation than CO2. Te comparative impact of CH4 on climate change is over 20 times greater than CO2 over a 100-year period46 and about 86 times greater over a 20-year period.

Conclusion

The paper conjunctionally discusses the addendum need of utilizing UOG specially in country like India to meet the adequate requirement of energy with the latest trend of technology and mechanism along with the corresponding pros and cons throughout the energy pyramid.

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