A Substantial Study on Environmental Legal Framework for Exploration and Exploitation of Unconventional Hydrocarbon Resources (UHR) Around the Globe

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Abstract: The necessity for the hydrocarbon is rising day-by-day as a result of globalisation. Large number of international companies are opened their firms in the developing countries because of the man power capacity and wider market in it. It results in the development of newer infrastructure such as roadways, buildings, electrical lines and so on. For this, a large amount of energy is needed and is provided by conventional hydrocarbons in the form of oil and gas. We are extracting conventional reservoirs since the beginning of hydrocarbon energy era as it is cheap and safe. But the rate of production is declining. To overcome this Unconventional Hydrocarbon Resources such as Shale Oil, Shale gas, Oil Sands, Tight Oil, Gas hydrates and Coal Bed Methane has to be tapped in a larger scale to meet out the hydrocarbon demand and maintain stability in the world's oil market. But this UHR extraction is expensive and it results in environmental pollution. There is no standard procedure and framework is followed worldwide as on date for UHR production. This paper discuss about the need of environmental legislation framework for the exploration and exploitation of UHR in large-scale.

IndexTerms: Assessment, Environment, Exploration, Exploitation, Fracking, Risk assessment, Water,

1. INTRODUCTION

UHR gains its attention for the last decade as the conventional reservoirs are approaching its declining stage [10]. UHR is the source of oil & gas which require more advanced techniques such as horizontal drilling and hydraulic fracturing which are not in common practice as that of conventional reservoirs [8].

2. EXTRACTION

Hydraulic Fracturing Hydraulic fracturing is the most commonly adopted process in the extraction of UHR. It is the process of sending high pressurized fluid to fracture the tightly packed rock. The fluid is composed of 90% of water, 8% of sand and 2 % of chemicals which varies from formation to formation based on the geologic texture of the rock.The process of hydraulic fracturing is summarized as follows:

1. A well is drilled vertically upto the kick-off point and from there it is drilled upto few thousand feet till the oil & gas is expected to be present.
2. Now, the fracking fluid which is a mixture of water, sand & chemicals are sent at high pressure to create fissures in the rock.
3. Through the man-made fissures the oil & gas comes along with the injected chemicals to the surface.
4. The oil & gas is separated and is sent for market. The waste water is sent for treatment.

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2.1 Problems associated with Hydraulic Fracturing

In general, 10-40% of the injected volume of the fracturing fluid returns along with the produced oil & gas. The flowback fluid not only contains fracturing fluid but it also consists of various substances suspended in the formation and contains Fluorine, Chlorine, Bromium, Iodine, Strontium, Barium, Radioactive materials and various organic & inorganic substances[1]; [2]. When it is not processed properly, it will drastically affect the ecology and environment of the region. For these reasons it is banned in some European countries namely France, Germany, Bulgaria and Ireland with certain limitations and completely banned in certain part of USA, the states of New York & Maryland and in Australia, the State of Victoria.

3. NEED OF FRAMEWORK REGULATION

Before going for the production operation of UHR, a standard procedure is documented for the consumption capacity of freshwater for fracturing operation and its contamination with the nearby aquifers, waste water treatment and its disposal. A standardised framework is couched by comparing the national & international scenario of the existing technologies deployed, environmental legislation and risk associated with it. The exact range of risk whilst the operation is carried out is measured by taken into account of the climate, geology, water-bearing formations and bionomics of the area.To frac a well, we need a minimum of 36 million litres of water approximately, out of which 40% will comes initially along with the formation fluids once the production commences. The flowback water which we injected not only carries the chemicals which we sent, it also carries the dissolvable chemicals in the formation. This has to be processed effectively and efficiently in order to nullify the contamination of household & irrigation water supply. If not, it will drastically adverse both the biotic and abiotic community of the region.

3.1.1 Schematic Plan

To regulate and rationalize the UHR exploitation activities, a schematic plan is articulated by considering & comparing the existing environment & legal framework globally.Various physical, chemical, ecological, geological and economic factors were taken into account with the help of Geographical Information System (GIS), Global Positioning System (GPS), United States Geological Survey (USGS), Synthetic Aperture Radar (SAR), International Energy Agency (IEA), Google Earth and other local governmental database [9].Based on the existing data at the regional level and depending on the information from the international agencies, each UHR site is characterized to 20 criterion accordingly. Criterion 1-9 indicates the natural physical environment; Criterion 10-13 shows ecosystem and Criterion 14-20 symbolises human environment and are as follows:

1. Temperature – Biochemical processes are slower in lower temperature which increases time of recovery whereas the higher temperature results in operational challenges.
2. Rainfall – High rainfall leads to natural disaster such as landslides, floods, soil erosion which makes the operation riskier.
3. Hachure – Sudden hachure changes heighten the chance of landslip and degradation of land.
4. Wind – Continuous and high-speed winds cause more spreading of atmospheric pollutants such as particulate matter and which contaminates the populated community.
5. Ground water depth – When the ground water table depth is high, any micro seismic activity may be intentional or accidental which leads to the contamination by hazardous chemicals.
6. Wetlands – The propinquity to streams, rivers, lakes, ponds & estuaries increases the probability of contamination by intentional or accidental spill.
7. Water resources – The presence of water resources in the vicinity of the UHR operation affects the hydraulic fracturing process.
8. Land quality – When the quality of the land is high, say agricultural or any other occupational land, which has the greater risk of environmental pollution and degradation due to accidental spill
9. Hydrologic system – If there is any hindrance in the actual flow path of the water leads to the erosion and flooding which eventually increase the risk of accidents during the UHR operation.
10. Ecoregion – Depending upon the type of ecoregion where we do our operation shows the sensitivity & vulnerability of the ecosystem exposed to.
11. Homo sapiens diversity – Human beings is the highest of all the creatures in the earth, any changes to this community as a result of UHR operation will be more dangerous to the ecosystem and environment.
12. Mountain ecosystem – This ecosystem is more prone to the destruction by human activity, as they demolish the mountain wealth for speed up of UHR operation where nobody questions them.
13. Endangered ecosystem – Nearness to protected ecosystem such as National parks, Biosphere reserves, Sanctuaries or species in the verge of extinction such as Sea turtles, Gorillas, Saola have high risk of decease and environmental damage.
14. Infrastructure – A newly developed infrastructure such as pavement and roads increases the probability of accidents and totally destructs the local environment. viz., Deforestation, Landslides.
15. Services – When a new UHR project is started in a region, huge man power is to be deployed. To cater their needs basic amenities such as electricity, food, gas, water and sewage has to be facilitated properly. It directly induces environmental effects and increase in the utilization of more natural resources.
16. Waste management – A newer method of integrated solid waste management scheme has to be established to handle the general and hazardous waste produced from UHR operation but limited to minimal generation of waste, thereby reducing the environmental risk.
17. Habitat hub – When an UHR project is commenced near a populated area it hinders the movement of people and goods, the competition for natural resources occurs because of the new immigrants and the inhabitant's economy gets reduced/altered.
18. Productive areas – If we set out an UHR project in the vicinity of an intense agricultural region, it leads to the protest from local community, degradation of resources and competition from local workers.
19. Territorial system – Before starting a UHR project in a new territory, it has to be structured for the mobility and livelihood of the local community. It is particularly needed in special considerations such as people of aboriginal territories and tribes.
20. Historical areas – Care must be taken while implementing an UHR project in historically valued places such as Forts, Monuments, Palaces and Places of archaeological importance as it will scathe the heritage value of it.

An UHR environment is selected randomly and the above 20 criterion is taken into account and a scale value is assigned ranging from 1 to 5, where 1 indicates lower environment risk and 5 indicates high risk.Out of the 20 criterion discussed, the most important criterion which directly impacts the human being and environment are considered and are Wetlands, Water resources, Endangered ecosystem, Habitat Hub, Productive areas and Historical areas. The risk is calculated with the distance ratio: 5 (< 500 m); 4 (500 – 1000 m); 3

(1000 – 3000 m); 2 (3000 – 5000 m) and 1 (>5000 m). Eventually, an analysis of UHR project was put through, which identifies the risk and environmental impacts associated in exploration and exploitation activities and its possible remedies. Mainly, the treatment of flowback water is considered and depending upon the quantity and quality of the treated water, it will be sent for further usage such as Irrigation, Household activities & Industrial purposes [3].

3.1.2 Steps to be considered

The above listed 20 criterion shows that environmental factor is a critical component in the exploitation of UHR. Based on various study, three components constitute the environmental risk of exploration and exploitation and are Environmental regulatory framework, Atmospheric conditions of the surrounding environment and Technology implemented.

4. LEGISLATION OF ENVIRONMENTAL FRAMEWORK

Different types of environmental ordinance is followed for the exploitation of hydrocarbons around the world. But there is no defined set of rules & regulations for the exploitation of UHR. “Article 41 of Argentina national constitution states the right to a healthy, balanced environment, suitable for human development and so that productive activities satisfy present needs without compromising those of future generations”. In other countries, the national and intra-national law enacts mainly on the protection of water from pollutants. The larger UHR extracting country say USA emphasize mainly on the protection of water from pollutants. The Environmental Protection Agency (EPA) has regulations which include discharge of wastewater from exploration, drilling, production, well treatment and well completion activities. It prevent the discharge of pollutants in produced water to the fresh water resources [4].

4.1.1 Assessment of Environmental site

The 20 criterion discussed earlier has to be matched with a new UHR project location. Based upon the type of risk and distance ratio the nature of the environment is linearized. With the help of remote sensing and hyperspectral imaging techniques the data regarding the Landform, Type Of Soil, Type Of Vegetation, Nearness To Water Body, Land Utilization (e.g., Agriculture, Animal Husbandry And Massive Vegetation), Infrastructure (e.g., Buildings, Pathways & Electric lines), Populated centres, Areas of special attention (e.g., Biosphere, Tribal lands, Historical places) and Terrestrial structure. It also permits the study area for mapping of geographic region, river boundaries, municipality, and waste yards and so on. It will be highly useful during the field visit for selection of site. With the existing and available information about the region and environmental legislation paves the way for safer exploitation of UHR with technological advancements [5].

4.1.2 Analysis of applicable technologies

Technological advancements plays a vital role in the development of UHR, by rationalizing the maximum recovery with minimal operation costs without compromising the health, safety & environmental aspects of both human beings & ecology. Water is the vital source in all the stages of UHR production say drilling, completion and fracking [4]. The presence of aquifer, depth of the water table, oil-water contact zone and effluent treatment plan have direct relationship with the environmental management. During completion, the well has to be sealed-off and cemented with a permeability <0.1mD, if not it results in the communication between hydrocarbon and the local environment.Availability of freshwater is the key factor in the UHR production. Drilling and fracking consume huge capacity of water, approximately 1.8 million m3/well [7]. The utilization of water level may be seen large but is nearly half in comparison with 3.6 million m3/well for EOR & 3.9 million m3 for a combined cogeneration power plant.Hardly, the quantity of water utilized in fracking is 1-2% of the total water consumption in that region. But if the region is water scarce, any sort of water extraction leads to public attention. To overcome this, recycling of produced water obtained during drilling and mixing it with high salinity water say sea water and other water which is non-potable & unused for agricultural purpose and is effective and economical in larger scale hydraulic fracturing operations. Advanced technology has to be deployed for the water scarce region [5]. Technology plays a key factor in all the stages of drilling and production of UHR. Identification of risk bearing problems associated with each stage is mandatory, so that it can be minimized with advanced technologies or it can be given to the service providers in the form of non-risk bearing technical service contracts by the operators.

5. RESULTS AND DISCUSSIONS

Environmental risk assessment is a useful tool at basin and sub-basin level. It can be performed with basic data taken from regional, geographical, ecological, socioeconomical bodies and can be equilibrated with data obtained from remote sensing and field visit to the basin.The result of the analysis of the regions with UHR shows mostly the environmental factors (Criterion 1-9) are at risk. Along with the regulations, technological complexity and management system, the areas with low & high environmental risk are identified. This intromits identification, implementation and development of UHR with minimal environmental risk, thereby accomplishing the sustainability of the project.The UHR activity has various impacts associated with it viz., usage of groundwater, flowback water treatment and disposal. It shows that more research & development work is needed in establishing a safe & secure UHR operation.Internationally, USA has the most legislation & regulation for the UHR operation. They mainly emphasize on the disposal of flowback water.The flowback water is discharged into the sinkholes. The sinkholes are the natural depressions found in the earth formed by the collapse of caverns. The following are the conditions required for flowback water to be discharged in sinkholes and are as follows:

1. Characteristics and isopach map of sinkhole formation and its seal geometry, the seismic profile and depth the aquifer level in order to protect the aquifers which present above the sinkhole.

2. During the drilling of sinkhole, the cementation, corrosion profile and hermeticity tests were conducted in order to minimize the accidents that results in contamination of aquifers.
3. Characteristics and nature of the flowback water, the expected flowrate and pressure, the physio-chemical analysis of flowback water such as hydrogen ion concentration, conductivity, density, salinity, presence of hydrocarbon. Analysis of water compatibility between the flowback water and the formation water based on sulphate ion (SO4 2-) and Carbon-tri-oxide (CO3 2-) ion.

It is hereby evident that an environmental legal framework is mandatory for the exploration and exploitation of UHR by compliance with local governing bodies.

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