



Virtual Workshop

On

Enhanced Oil Recovery

(Theme: “EOR Enablers -Technology & Policy Framework to leverage EOR Potential in India”)

Date: December 11, 2020

A virtual workshop on ‘Enhanced Oil Recovery (EOR)’ with the theme “EOR Enablers - Technology & Policy Framework to leverage EOR Potential in India” was organized by Federation of Indian Petroleum Industry (“FIPI”) on 11th December 2020. Earlier, FIPI organised a workshop on “EOR” in 2017 and prepared a way forward document for DGH further which the Union Cabinet approved the EOR policy to incentivize the enhanced recovery methods for oil and gas.

The current workshop was organised to refresh the latest technology developments, academic researches and policy support required in the space of EOR.

Welcome Address



Dr. R.K Malhotra, Director General, FIPI welcomed all the panellists, speakers and participants at the workshop. In his welcome address, he said the following:

Government of India has been trying to reduce the import dependence by increasing the domestic oil & gas production. Government also have a vision to increase the gas share in the total energy mix. FIPI is helping the industries in resolution of issues and framing of policies and regulations which can help increasing the domestic production, facilitate investments in upstream and downstream sector. In this connection, FIPI had organized

a workshop in March 2017 on EOR and key takeaways from that workshop was presented and shared with the government. Based on this, EOR policy was formulated and subsequently approved in October 2018. The objective was to build a supportive ecosystem through academia collaborations to encourage the deployments of good technology. 5% increase in recovery can lead to 120 million metric tons of oil in 20 years and a 3% increase in gas recovery rate can give 52 BCM of gas in 30 years. FIPI has been deliberating on the tweaking required in EOR framework and based on the deliberation; the workshop has been planned. He further said that the issues flagged during the workshop will be recorded and key points will put in the form of key takeaways. This will be shared with government and DGH for necessary improvements required in the EOR policy.



Opening Remarks



In his opening remarks Shri Amar Nath, Joint Secretary (Exploration), MoP&NG mentioned that Enhanced Oil Recovery (EOR) is one of the most crucial elements of production. Oil and gas companies are facing the energy transition and investment in the upstream sector is going to be a challenging one. In India, the energy requirement is going to increase continuously. While energy consumption will increase, there will be new forms of energy in the energy basket. Upstream sector have two aspects. One of them is to find oil & gas through exploration and second is to see the commercial viability of the same. The investment decision is dependent on this. Extracting the resource is more of an engineering and technological aspect. In 2018, the policy was introduced to incentivize the companies. Financial incentives are only a part of the entire ecosystem and there are host of other things.

He also mentioned that in India 42 billion ton of oil equivalent is identified as prognostic resources and out of which only 25% was established. Recovery factor is 23%. Resources which are known must be extracted. Even if the recovery improved by 5% or 10%, the outcome will be monumental. This requires an ecosystem from the industry as well. Technology is available to improve the recovery from the matured field. EOR should not be a different thing. He desired that this workshop should bring out emerging innovative ideas which are actionable and implementable and need to be identified through a combined effort to take the EOR campaign forward. He referred the use of digital technology, nanotechnology etc. in EOR operation and desired FIPI to submit a report to the government for consideration.

Panel Session: Technology & Policy Framework to leverage EOR potential in India.

Mr. S Roychaudhury, Director, Strategy & Business Development, Antelopus Energy, moderated the panel session. He welcomed all the panelists, dignitaries and the participants of the event. At the beginning to set the context of the Panel discussion, Mr. Roychaudhury mentioned that the country is on a cross-road as long as EOR is concerned. He believed that India has plenty of oil, whether it is from the mature field or brownfield and the recovery factor must be improved. As there has been some shift in the energy basket, he wondered how to balance between these two activities. He felt that there will be some shift over the next 30 years from conventional oil to other forms of energy and the repercussion will be felt in College and universities as they have to change curriculum focusing on other forms of energy. Technology providers have a lead role to play in extracting the vast amount of oil in more efficient and environmental friendly ways. NOC and other Oil companies might not have adequate people to implement a large number of EOR projects as a good number of experts from the industry will be retiring, less younger people due to shift in curriculum and the number of projects on EOR concurrently will go up.



Recently in the PDPU Convocation, Hon'ble Prime Minister has mentioned to change the name of the University from PDPU to PDEU which is a change from Petroleum University to Energy University. This is a challenging situation for the country.

While introducing the Panelists, he mentioned that there will be three modules set for the discussion in the next two hours. The first module will be between Academics and Industry Panelists. The second will be with Technology Providers and the third will be with Policy Makers.

Against this background, he then requested the panel speakers to share their thought based on their experience under Indian scenario.

Dr. Raj Mehta, University of Calgary, Canada:



Dr. Raj Mehta with his long global experience mainly in North America on EOR and representing Academics from Canada brought out the following salient points:

He mentioned that the University of Calgary has played a stellar role in EOR research and process for the industry which has been accepted by Indian oil and gas industry. Over the last 40 years, the university has collaborated with several global companies, especially in North America in improving EOR projects. In North American context, the issue is low oil price. Each EOR technology is reservoir specific, which is something that industry can't ignore. While talking about Indian reservoirs, he said that the Indian reservoirs are much mature and EOR needs to be implemented. Each Indian reservoir needs a specific EOR technology. In Indian perspective, there are challenges and opportunities in terms of implementing new technologies and to increase production based on the visions of Indian Prime Minister, Petroleum Minister and industry champions. Despite the differences in terms of motivation between the oil industry and academia, there needs to be a mutually beneficial and profitable relationship. This has been proven in North America where industry and the universities have established long term collaboration in research and development. Academia must excel in terms of relevancy and must be ready to work with the industry. Universities must invite industry speakers/instructors as a part of expert interaction. Involving students in industry-relevant research is important. University collaboration has helped Canadian oil reserves to move from 6 million barrels to about 200 billion barrels. Since the last 20-30 years, Canada has produced to close to 2 million barrels per day due to SAGD technology. Given the size of prize and variety of reservoir in India, something must be done quickly. The best way is to partner with external experts to build the required skillset. Companies must involve motivated/talented in-house people to ensure technology transfer and there must be a plan for the long term. External talent must be used to develop academic expertise within local universities that can eventually provide relevant academics, laboratories and excellent students. Role of Government will be key in terms of funding and setting up laboratories. Role of government is also required in providing a stable regulatory requirement. Strategic funding for industry and academy can help in the development of in-house technology.



Dr. Samarth D Patwardhan, Professor, MIT-WPU, Pune:

Dr. Patwardhan representing Academia from an Indian Petroleum University shared his points on the role of Academia in India.



He stated that 20 years ago, in India, there were just two universities that offered a Petroleum Engineering course. Now, the number stands around 40-45. Students becoming experts in EOR is kind of tall order to expect from a four-year course because they have to be trained in all aspects of petroleum engineering. In most universities theoretical knowledge is imparted to students properly, however, they lack the experimental perspective, due to a lack of requisite facilities. Getting industry support is critical for the universities in India, to be able to train the manpower needed to work on EOR projects. In the US, companies like Chevron, Anadarko sponsors laboratories in Universities like Texas A&M University (Drilling and Completions Lab, Petrophysics Lab, CO2 EOR Lab), University of Wyoming (Instrument support for expanding CO2 EOR), New Mexico Institute of Mining and Technology (Enabling better CO2 floods), and NTNU, Norway (for research on CCUS processes). Such million dollar sponsorship from the companies enables students and faculty members to have a cohesive environment for working on a particular project by collaborating with the industry and providing advisory services to the industry by working shoulder to shoulder with them. In India, from a capability building perspective, there is a need to build a similar model of joint industry partnership. A select group of companies can come together by forming a consortium and then they can identify a particular university to fund a specific lab or assist with Masters or PhD work (companies in both U.S. and Europe are involved in such activities). Companies can identify few key faculty members and have a dialogue with like-minded companies or technology providers for funding the faculty, from a capability development standpoint.

Further, similar to government initiatives in Canada (Canada Excellence Research Chair and Canada Research Chair program), in the U.S. (DOE funded projects), government in India can also support universities through research funding programs. In short, following suggestions could be provided to the policymakers in India:

1. Industry helps develop dedicated labs (with required funding) at institutes with capability (not just government institutes) to take science further.
2. Industry gets involved in training the next generation workforce by providing field exposure, sharing resources like core samples, oil samples and samples of chemicals injected downhole.
3. Government establishes chairs at institutes, leading to continuous support.
4. Government should have a long-term vision of creating more IRS-like labs in India, and take the necessary efforts (trainings, funding) in those directions.
5. Facilitate and Enable Joint Industry Partnerships (JIP) between industry (group of companies) and universities for research, as well as capability building.

Dr. P Chandrasekaran, Director (Exploration & Development), Oil India Limited:



Dr. Chandrasekaran, Director (E&D) from OIL, the oldest E&P Company in India presented the EOR work done by the company in early days and also now proactively making a number of collaborative efforts/projects with US University.

He mentioned that Oil India is the first company to make an oil discovery in Asia and the first company to do a seismic survey in this part of the world. Oil India implemented the first gas injection-based EOR in 1965 which was continued up to 1996. Oil India implemented its first polymer injection type EOR in 1975 which was continued up to 1991. Oil India has done all forms of EOR, however, due to a breakthrough, these processes were stopped later. Oil quality in the upper Assam shelf is good with excellent viscosity. Low salinity water injection (LSWI) started in 1966 the mainstay of OIL's EOR process and that is continued till date. Company is continuously producing 3.2 million tons of oil year after year because of multiple factors out of which lower salinity water injection is the mainstay. 30% of OIL's in-place oil volume is subjected due to Lower salinity water injection. 23 % is the global recovery factor while this basin saw a recovery of 31%. Microbial Enhanced Oil Recovery (MEOR) was also tried by OIL and it wasn't sustainable. Digboi fields also saw the implementation of steam injection in 1980-90s. Oil India was the first company in India to implement cyclic steam stimulation for EOR. Oil India is trying to adopt all methodologies and technology to increase oil production and to improve the oil recovery factor. Oil India will continue to use LSWI as the mainstay of EOR process and it caters to 30-40% of total EOR volume. The industry has bought certain compulsions and there is need to have a complete R&D ecosystem. Amount of work association in USA or Canada or in other parts of the world has not evolved. Oil India has gone ahead for working in association with the University of Houston, Heriot-Watt University for Co₂ injection. National Oil Companies (NOCs) don't wait for EOR policy to be in place and the NOCs take all possible methods to maximize oil production. After studying through all the fields, Oil India will be using three major EOR methods namely Carbonated water injection, CO₂ injection and polymer flooding. In the last 10 years, Chemical injection has seen a lot of development.

He also opined that each reservoir is unique and every reservoir needs a unique injection. Oil India is going ahead with top EOR techniques and is hopeful of increasing the current estimate of 40% to 50%. 1% increase in the recovery factor will improve oil production by about 3 years in the current production rate. With these methods, the life of the producing fields can be enhanced with an increase in production. There is a need for the academy to develop new innovations for the industry. Industry alone cannot do it all on its own and it's practically impossible. If industries start from core analysis, it will take about 20 years and it will need well-developed infrastructure for the same. The industry needs collaboration with academia for future innovations.



Mr. O N Gyani, Head IRS, Oil & Natural Gas Corporation Ltd:

Mr. Gyani presented the EOR journey of ONGC, the largest National Oil Company of India and its present programme on EOR for improving the recovery. He mentioned that ONGC started its EOR journey in 1985 with its polymer injection in Sanand field. Till 2018, 4 commercial EOR processes were implemented by ONGC. Apart from Polymer flood in Sanand, two commercial EORs namely In-situ combustion were implemented in the heavy oil fields of Balol and Santhal and one was miscible gas injection in Gandhar. By the end of the last century, ONGC had gained knowledge and expertise in a different type of EOR methods namely thermal, chemical and gas injection. During the process of implementation of these 4 EOR schemes, the company learned the art of commercial EOR implementation in the field.



He stated that any process designed for a particular outcome may not see the expected outcome always. There will be a need for mid-course corrections depending upon the field monitoring and surveillance. EOR is a complex process and it takes a long lead time of few years for implementation. Companies must know how to plan and design it given the higher cost and technological challenges involved. Any EOR process takes 5-7 years to come into the commercial stage. There is a need to shorten this time to see the economic value earlier.

Current EOR policy was introduced in 2018. Prior to the policy, ONGC had only four commercial EOR schemes. After ER policy, first initiative of ONGC was to implement all the final investment decisions on EOR in the field. Now, ONGC has 6 commercial EOR schemes. One pilot EOR program in Bechraji field that was approved by the ER committee have been implemented. Pilot results are encouraging.

Second action was to scan all fields in the kitty and raise the target volume under EOR. Out of around 211 fields operated by ONGC, some 26 fields and 53 reservoirs were selected by screening all the reservoirs, using the in-house software "EOR Ranker". Design of EOR process takes around 6 months to 1 year. Given the resource constraint on EOR designing, the company hired service provider and is currently planning about 15 pilot EOR projects. Currently, ONGC is targeting around 500 MMt of oil under EOR domain thro' pilot and commercial process which has increased from 100 MMt prior to ER policy.

ONGC is determined to use Carbon Capture and Storage (CCS) for its EOR projects. The company has tied up with one of the biggest refineries for the same. Doing this, the country can get rid of CO₂ and can also address environmental concerns.

Another important aspect to implement EOR on a larger scale is skill development. There has to be continuous interaction between the industry and academia. Currently, ONGC is



interacting with various universities in India and provide training. The company sponsored technical projects in fields of Nanotechnology and biotechnology. However, when it came to take up a no. of pilot design project, the company couldn't find indigenous service provider or an institute to catch up with the speed. It is the responsibility of the academia and industry and all the stakeholders to build capability within India. A roadmap for EOR needs to be developed with meticulous planning to develop in-house capacity to deal with the challenges pertaining to EOR.

Mr. Amitabh Pandey, Senior Advisor - EOR, Cairn Oil & Gas, Vedanta Ltd:



Mr. Pandey from Cairn Vedanta , the company which has undertaken one of the largest Polymers in EOR programme, brought out his experience from operational, policy and collaboration point of view.

He shared his thought with the idea that Technology and Policy support will be the key drivers to take EOR implementation to next level in India. EOR implementation consumes a lot of time and it took 10 years for Cairn for implementing polymer flooding in Mangala field. It took close to 15 years to reach the current stage. The process started with EOR screening studies right after the discovery of the Mangala field. Cairn involved multiples agencies and multiple universities and took external support for modelling to estimate the EOR potential. EOR team visited multiple fields to learn and understand the experience of EOR from different operators. Polymer flooding pilot was done in 2011 and by 2014-15, full-scale EOR was implemented. Pilot and associated development studies were done between 2014 and 2018 to formulate a quicker development plan. The entire process faced a lot of challenges. There is need to unlearn something that was already learned in school days. One example is that generally tertiary recovery process is considered as the most efficient process and hence it was applied early stage of the field's life. It is important to plan early and to have a flexible development so that EOR implementation can be accommodated at the later stage of field's life. Companies must have an in-house champion who can drive the effort and can maintain the momentum within the company. Companies must engage in long term partnerships with experts and universities research. Every research doesn't get solved in labs and some research must be done in the field as well. Field process must have good surveillance ad must take mid-course correction as in when needed. Division of work is important, things which will be done internally and things that require external help must be defined clearly. It is important to have the support of management for the implementation of EOR. Oil price volatility will be the key challenge. Govt policies can support EOR. EOR is cost-intensive and carries higher risk & uncertainties. There is a need for better risk management. Availability of chemicals is a challenge. It requires a domestic set up for chemicals and the logistics involved with it. The biggest challenge is availability of manpower for EOR. Skilled and experienced manpower is not enough to manage such a large number of EOR projects that cairn is planning. Training and retraining of the EOR crew are important.



Other supports needed are technology, cheaper chemicals, modular capacities, improved modelling. There is a need for collaboration between the industry, Service Company and academia. There is a need to have multi-prong activity for reducing EOR implementation time. A supportive policy for EOR can give a win-win situation for the government and the operator. The government must make an investment to help local academia to develop research activities at par with the global universities. Joint ventures can help to reduce risk and can bring out the external technology needed for the implementation of EOR.

Mr. Sidhartha Sur, EOR Expert, Director, AskEOR Tech Hydrocarbon Pvt. Ltd.:

Mr. Sur, the EOR expert in the country brought out the importance of EOR, the role of Universities and operations in a different mind sector, He mentioned that majority of Indian oil fields are mature and they need rejuvenation. Efforts from the government to enhance EOR activities in the nation are a welcome step. Based on the association with universities, it is evident that universities are passionate about learning EOR. However, there is a need for tweaking the existing course. To bring about a change in the national perspective, the young brain needs to be targeted. Knowledge



transfer is the need of the hour for the budding petroleum engineers or for the fresh recruits in oil companies. It is more essential if recruits are from various disciplines other than petroleum engineering. Lack of laboratory facilities hinders students from getting visualization. Faculty needs to go to the industry and work alongside in actual field projects to have the right mix of Theory, Laboratory and Field practices. Similarly, industry experts should visit universities and impart their practical knowledge to their students. Developing ideas and concepts with EOR process in the present system shouldn't be an issue. Indian talents need to be closely associated with globally renowned universities/institutions for driving out the fear of the unknown of taking the processes from laboratory to field. Companies and Universities should be careful when copying global techniques for Indian fields. Our fields are limited in size and resources and do not match the global standard. Geological and reservoir settings are different too and two reservoirs are never the same. In the present scenario, companies cannot think conventional and companies need to change their approach in a smarter way and design the technique that is cost-effective and suit their needs. Companies need not get captive to their own experience & capabilities. The biased approach can lead to a missed opportunity or gain negative. While translating a lab study to field, involves the most crucial phase of engineering, procurement and construction. There are sometimes gold plated design (indicating lack of experience of designer), Time & Cost overruns that are detrimental to economics and even to reservoir dynamics for successful EOR application. Sometimes, there is so much delay that the field never sees the application of an EOR and it languishes.

CO2 miscible as mentioned is a true tertiary recovery process after successful waterflood. To ensure success, objectives of the EOR must be aligned across the entire organization and it



must not be just limited to achieving physical targets. Experience of working in Colombia was all about reducing the lead time from concept to reality in a multicultural joint venture environment. This led to the earlier realization of oil, resulting in value addition to all the stakeholders ie. Partners, Government and Community.

Going forward from this point it is required to enhance the skill set of young minds in Universities and Industry. Passionate EOR leadership should be in the forefront in EOR journey. To see more of EOR, companies need more champions and continuity of knowledge in the organization. Data analytics and big data will play a big role in days to come. Creation of an ecosystem similar to that of Colombian business model involving partnership with technically and financially robust companies will be a game-changer and will benefit everyone.

Mr. R. K Srivatsava, Director (Exploration), Oil & Natural Gas Corporation Ltd:



Mr. Srivastava stated that there is no denial that EOR is the remedy process that is needed to improve the yield from mature fields which are in the declining phase. EOR is established across the globe for improved recovery of oil. EOR contributes to 2 million barrel of global oil supply, which is 2%. Based upon a few industry studies, EOR will contribute 4-6 million barrels per day which will be 4% of global oil supply. Among the 375 EOR projects globally and in 80% of EOR projects in North America, have been through government support. On the technology front, it comes to per barrel of oil produced and the cost attached to it. They are capital intensive and they have a long payback period. It takes around 10 years for an EOR project to go through the stages of pilot, initial testing, design and execution. The demand for low carbon footprint will challenge the current scenario and this means that that time available for producing oil is getting reduced and this issue will challenge the future EOR projects. Materials used for EOR process and injectants of chemical EOR will increase the cost per barrel by USD 10-20. Industry-academia collaboration will be required to bring down the cost by developing advanced chemicals and other tools required for EOR. All these processes also requires Govt support and it will be the key to the success of EOR.

Mr. Omer Gurpinar, EOR Technical Director, Schlumberger:



Mr. Omer, the global expert with more than 40 years of experience shared his thoughts which are captured in the following:

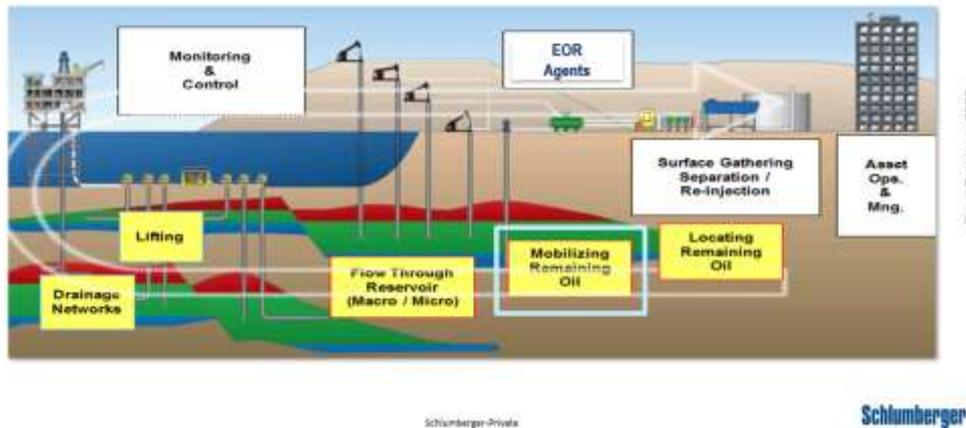


He mentioned that EOR deals with “recovery challenges” and ideally that needs to be dealt with starting from day one. Unfortunately, due to the traditional teachings, which is proven to be wrong, our industry does not do much for “recovery challenges” until decline starts and that leads to failing EOR projects. As I keep saying “getting ready for IOR/EOR” is as important as the project itself, if we had started getting ready much earlier in life of a field, not only we will estimate when EOR has to be initiated but also be ready. Other than a few projects, mostly offshore, early preparation never happened. Basically, drillers lead the development while reservoir engineers mostly silent until the decline starts, and then panic starts. We always have to drop old behaviors and try optimizing production and recovery simultaneously. When EOR projects implemented late, they usually fail, because field is not prepared for the next recovery operation. When you don’t know where the remaining oil is (that is usually the case in all mature fields) no EOR can help! Unsuccessful EOR projects leads to wrong conclusions like “EOR is too expensive” which usually leads to operators try avoiding EOR projects all together. It is not the technology nor the capabilities but old-way-of doing things is making EOR projects fail, we all must change. *I can expand on the concept of “getting ready for EOR has to start from day one” is a deeper / focused gathering.*

New EOR projects can be done significantly better than historic references. Real collaboration between technology providers and operators with a new approach to EOR could start the new era for EOR. Technology developments can help in doing a project in a better way. There is no shortage of technology, but they are underutilized. This hinders their progress from technology to product. Doing EOR in the old way should be changed and we need to find a faster new way. Pilot projects consume around 5 years and companies can’t wait for 5 years when production is declining. The opinion of service providers matters in the implementation of EOR. There is a need for the new approach and historical ways must not be followed. Traditionally most focus for EOR was about “how to mobilize the remaining oil” and that was a discussion between reservoir engineers and the EOR Labs. However if we think carefully recovering one extra barrel of oil reservoir; is a combined product of number of key enablers working together is a preset synchronization. In this new era we are proposing all these elements, as shown in the cartoon below, has to be incorporated into the project design. Missing one would severely reduce the success of EOR projects.

Our View on EOR – A new approach.

“Incremental Barrel of Oil” is a “complex function” of sum of key enablers



In mature fields, any EOR attempt has to start with in locating the remaining oil. Long years of waterflooding in mature fields, if not managed properly, would create a very challenging reservoir conditions for EOR to be successful. The first challenge starts with “locating the remaining oil”. For many does not sound like an EOR activity but w/o that every field Pilot will end up with false positive or negative outcomes. Another element to mention is the right reservoir characterization for the selected EOR scheme. Based on our project experience EOR-grade™ reservoir characterization is very much lacking globally. Again, that is not usually considered an EOR topic but w/o that no EOR project could be successful.

Considering most fields are over their primes and arresting decline and hopefully increasing recovery are the overall mission for all, we see a need for RAPID EOR project development. Because time is against us; longer we wait more “in-place” reserves will be lost. With that urgency, we have been working on development of systems / processes / technologies so that operators could go from concept to field in less than a year. One of the enabler of our vision is “smart” field Pilots; field trials must not take more than 3 months. Need to focus on monitoring and control systems for long term success. In Schlumberger’s EOR-reboot plan of 2008, it was found that operators don’t know when and what they are doing the EOR. We have reviewed all EOR projects from the public records, they were about 4,000we then understood a few facts, (a) EOR projects and oil prices is not as closely tied as people believes; (b) most of the EOR experience is coming from early 80s; and (c) companies start EOR project very late, the traditional way.

Lastly, we all know EOR is not new but for some reason every time we talk about it we treat the topic as if EOR was invented just recently. Surely EOR physics in pore scale is well understood, for most of the basics schemes, but designing and implementing EOR projects have many new enablers which will make the next projects significantly more successful. Due to all of these our industry continuously lacks qualified talent to take projects to the next level. From our end, because we believe IOR/EOR is going to be the largest activity in the

remaining life of the oil industry, we have putting substantial effort to create a X-domain EOR understanding. After developing training courses and developing in-house EOR processes material, finally we changed our approach and utilizing “digital” means we developed “EOR Decision Systems”. Those systems could guide the project teams to select suitable EOR schemes or designing EOR Pilot or developing monitoring-control procedures. Our entire EOR project experience and domain knowledge are imbedded into the digital brain of the new EOR enablers. We fully believe in order to change behavior we have to make EOR accessible to everybody so that caring for EOR (recovery considerations) is a concern of all and starts early. We all need to adjust with the change of time.

Mr. Flavien Gathier, Sr. Director EOR Engineering, SNF Group France:



Mr. Flavien from SNF elaborated the activity and role of SNF as a polymer manufacturer and their presence in India. He told that Oil & gas companies are currently moving from pilot EOR projects to large multi-wells projects and full field application. Injecting polymer for EOR process can reduce the carbon print emission curve bell by up to 6 times. Acceleration in recovery can help in avoiding water and energy consumption in the fields. Polymer flooding is a proven technology and is adopted in projects worldwide. It has reduced the time frame and carbon footprint. Injecting extra chemicals would increase OPEX cost. Companies have to consider their economics. After analyzing the various ongoing chemical injection EOR projects, cost per extra barrel of oil is in the range of 3-\$6, which is still lower in terms of economic scale for the companies while oil is closing towards USD 50 mark. Technology is playing a major role for chemical injection projects. Chemical injection requires a large quantity of chemicals. Therefore it is essential to have a local supply capability to optimize the project costs and supply chain. SNF Group has built a plant in the Western coast of India especially for all the ongoing and upcoming EOR projects in India. Considering the local opportunities in India and the ongoing business, SNF Group has developed a big team in India to manage all the EOR operations and maintenance, even in the remote area of the country.

Dr. Pramod Patil, Lead Consultant and Founder of Rock Oil Consulting:

Dr. Patil from Rock Oil Consulting brought out the following salient points and focused on collaboration, innovation, and knowledge transfer.

His main points were that EOR projects are not slow always and some countries have taken quick decisions to implement EOR. The objective of Rock Oil Consulting is to move technology from the lab to the field and achieve upscaling. Collaboration between the university and the industry has to be strong. In North America, companies spend time with





universities through collaboration. Collaboration is a must and it is critical for the success of the EOR projects. Rock Oil has established collaboration with UT Austin, Louisiana State University, and the University of Tulsa where the US government-funded the projects to have innovation initiatives. As a company, Rock Oil is looking to establish something similar in India as a part of Atmanirbhar Bharat for enhancing its footprint in India. Having a full-fledged laboratory facility is a must to have for taking the technology from the lab to the field. More time spent in a lab will give an understanding, but there is a limitation in that too. Moving it to the field early is critical. With peak oil expected in 2030, companies have got around 10 years to focus on EOR given the current situation. A quicker execution and expertise can be achieved by collaborating with the technology providers or universities. Knowledge transfer is the key. Cross-training between the industry people and technology providers/universities is essential. Having an in-house consultation will be the key to achieve success in EOR projects. Experience matters as things are complex in the EOR process. Tender qualification criteria stand as a bottleneck for smaller players to participate in EOR projects in India. Operators can give a chance to smaller players where they might get an innovative solution. Making smaller and marginal field operators aware of the EOR process is needed. Getting too smart industry-academia collaboration is critical. The growth of talent has to be managed. Data Science will have a big role in terms of technology adoption. Industries can leverage the experience from the North American industry in terms of technology and innovation. CO₂ EOR from Permian Basin, Thermal EOR from Canadian industry, Nanoparticle enhanced chemical solutions for high temperature and high saline foam, IFT, and wettability alteration are some of the key innovations developed in North America. Reducing the timeline for EOR implementation from pilot to commercial-stage needs out of box thinking. I have the following thoughts and suggestion to be taken forward to policymakers:

1. Enhanced recovery is critical for energy security for India, how this can be supported by creating in-country value by supporting academic institutes build international standard facility and expertise – Funding mechanism for such initiative from government and industry
2. How policymakers can support small scale industries to enter the EOR market by offering innovative and proprietary services – tenders are typically designed for established companies and bigger brands, tender requirements need to be conducive for small players, support for companies bringing international level expertise needs to be judged from the expertise of key members of the company not just by the finance of the company
3. Creating a consortium or joint industry program led by FIPI or DGH to bring academic institutes and industries together for 2-3 days workshop – presentation from the industry with current challenges and successes on day-1, day-2 would be focused on research presentation from the institutes (Indian institutes as well as international institutes). Day-3 is where case studies would be conducted by discussing current challenges in EOR in the Indian context and have people generate ideas as a group (attendees will be divided into groups). This workshop/forum needs to be conducted



every year (government/industry to fund). Rock-Oil can provide some small funding for such initiatives.

4. How EOR pilot study can be supported by the government using tax incentives, stamped as a research program? The success of the pilot needs to be viewed through technical success and less on economical success. Generate pilot field cases for marginal fields with a cost-effective way of implementing field trials using modular skids and set-up.
5. Finally, data analytics is going to play a big role in IOR/EOR going forward. Create avenues or project initiatives where data analytics tools can be tested on existing projects. Develop industry-academia collaboration in India for these initiatives. Dicelytics Ltd. is our Pune based company where we are developing physics assisted AI and ML models for subsurface analysis. These advanced models are futuristic and will improve efficiency and allow us to make real-time decisions for recovery management in the field. Our vision is to create software that can be efficiently used in teaching at the universities for IOR/EOR concepts, physics, and data analytics. We are planning to offer our software free of cost to the universities to encourage and bridge the knowledge gap for students.

Discussion:

After panellists shared their thoughts on EOR, the moderator Mr. Roychaudhury opened the floor for discussion.

Mr. Sidhartha Sur brought out the facts that the subject of EOR is poorly understood in academia and in industry in the current moment. All have to cope-up with the fear of unknown. Concept of EOR has to change. Currently, companies are not attempting EOR in the fields. Companies may fail in their process, but they have to learn and repeat it. Executing single pilot is not the conventional way of executing EOR. Chemical EOR developed in the laboratory can be tested while drilling. A well under drilling is like a laboratory. Challenges faced in implementing EOR may not be faced in a laboratory at the earlier stage. Companies have to tackle such unforeseen situations. Companies have to join hands with the technology leaders as partners and not competitors to implement things quickly.

Mr. O.N. Gyani mentioned that workflow in the EOR is much beyond the subsurface. If EOR has to be successful, the whole value chain must be optimized. Production system, process system and disposal system has to be optimized. Environmental aspects must be considered during the implementation. EOR is not an event, but it is the culture of the company. The whole system has to be geared up. There must be enough support from the management, technology support and collaboration. Workflow has to be optimized for successful implementation of EOR. Fear of the unknown has to be overcome.

Mr. R.K Srivatsava stated that ONGC collaborated on technical aspects with the University of Calgary and The University of Texas Austin for EOR process. Going for pilot EOR projects must be left to the operator. Some policy tweaking might be required in this. The current policy

gives 3 years for the pilot project. Pilot projects can be implemented from drilling. However, there would a question on how the barrel of oil produced will be attributed to the process. How fiscal incentive will be given in such cases. Lab studies will help in understanding the quantum of numbers in such cases. In Ad valorem, the lower the oil price, the incentives go against it. It has to be another way. Most EOR projects in the globe are government-funded and come with the tax credit. From environmental point of view, Carbon dioxide injection will be net viable. Carbon dioxide injection will also increase the production from 0.2 mbpd to 2 mbpd. US have a tax credit incentive of USD 35/ ton of CO₂. Such incentives can make CO₂ injection viable. Pilot is capital intensive and takes longer time; therefore this can be considered for Incentivization. This can bring EOR viable in the long run.

Dr. Laxma Reddy, Additional Director General (Exploration), Directorate General of Hydrocarbons:



Dr. Reddy from DGH presented the regulator's perspective which is captured in the following:

DGH has taken a larger role as a facilitator instead of being known to be a regulator. DGH would like to be known as the facilitator and as a part of ease of doing business; some key initiatives are taken which has been effectively working even during the pandemic times. DGH is concurrently working with the industry in elevating the business climate for all the stakeholders.

A host of initiatives and policy reforms have been taken by the government with an objective of increasing the exploration activities, attracting domestic and foreign investments in unexplored and unallocated areas of sedimentary basins to enhance the production of oil and gas. The initiatives encompass solutions involving streamlining of the operations, relaxation of timelines, and minimization of impact on production activities while adhering to regulations, approvals and simplification of procedures and processes.

These efforts are aimed at intensifying exploration, expediting production, to enhance domestic output and reduce import dependency. Policy initiatives have taken place in recent years in the area of category 2&3 basins, minimum work program, grant of area extending beyond the contract area, incentives for enhanced gas production from existing nomination fields, exploration and exploitation of unconventional hydrocarbons, enhanced recovery, improves recovery etc. EOR policy introduced in October 2018 is a key policy reform aimed at enhancing the recovery. Infusion of technology as a part of tertiary recovery methods is the key as the majority of India's production is coming from these mature fields over last 30-40 years. To realize the importance of technological intervention, the Government of India had notified the policy framework to promote enhanced recovery methods for oil and gas recovery. This policy is applicable to all policy regimes. Enhanced recovery committee has been constituted a part of this policy to look of the implementation of this policy in a

structured way. With the pilot phase, incremental recovery is envisaged around 11 million barrels to the tune of INR 1,900 crores. Through ASP, incremental production has been envisaged from pilot staged to 4 million barrels to the tune of INR 700 crores. Implementation of alkaline surfactant polymer (ASP) flooding has been a preferred method in the mature reservoir. Centre of Excellence, Guwahati and IIT Madras has been listed for the screening of EOR process. This will bolster the industry-academia relationship and will enhance the student's capability for future employment. The initiative is aimed to synthesize the technology partners and academia to conquer new horizons and reach a higher production level. DGH has been examining the various demands of the industry constantly. Speaking on the demand on extending the EOR policy for the life of commercial production, Dr. Reddy said that companies tend to sit idle when the policy is given for a longer period. Restricting the policy to a certain time frame will help in understanding how companies are performing. Speaking on the incentives for EOR production, he said that incentives are applicable only after three years of production and cannot be implemented from the beginning. Appropriate changes will be done once companies implement EOR and IOR policy and enhance production. DGH will facilitate the industry for widespread implementation of EOR policies in an economic way and profitable to all the stakeholders. The outcome of the discussions from this workshop will be taken to government and appropriate reforms can be brought in, in future.

Mr. Anurag Sharma, Director (Onshore) ONGC:

To reply to Moderator on a specific question on ONGC's EOR project implemented Mr. Sharma stated that currently, ONGC is running six (6) EOR projects and currently in process of adding four more projects in onland. Two (2) EOR projects were recently added. Fifteen (15) EOR projects are in pipeline. If EOR has to be implemented, companies have to take the challenges associated with EOR.



At the end of the panel discussion, Mr. S Roychaudhury said that one of the key elements to drive the growth of EOR in India is to have a group of passionate professionals. These professionals must have a space to grow and there must be enough excitement for the professionals to work on the subject and carry forward. Creating and nurturing of these professionals will be the hallmark for all the oil and gas operators operating in India.

Shri SCL Das, Director General, Directorate General of Hydrocarbons:



Shri S C L Das, DG, DGH in his Concluding Remarks mentioned the following:

He said that EOR is the need of the hour for India as the majority of current production comes from mature fields. There is a unique point where technology meets policy. The policy requires a high infusion of technology and technology requires appropriate policy. The meeting point between academia and industry doesn't happen regularly in the Indian ecosystem. We are in a situation where a symbiotic kind of partnership between the academia and industry will work with the support from overall fiscal and policy framework. When speaking about reducing carbon footprint, energy transitions, these relationships are vital. Relationship between academia and the industry should be strengthened and this will help in managing future things in a more sustainable manner. EOR is also about transforming the ecosystem, where increasingly the focus will be more on higher automation, efficient technology, cost reduction, lowering carbon footprint, aligning with the contemporary global and national issues. FIPI to compile the issues deliberated in the workshop and send it to DGH on the aspects of policy domain, fiscal domain, technology domain and system domain. DGH will take all these aspects and inputs to take this forward. Timeframes and the requirements of EOR must be unbundled and compressed in terms of making them parallel and reduce timeframe. Companies cannot keep doing pilot projects for years and keep waiting for the outcome. From the industry, the whole process needs to be more efficient and adaptive to these changes and induction of technology. In terms of accelerating the process, a committee is already working on. Contributions from the workshop will come handy for the committee and DGH will do its own advocacy in terms of supporting the best of the recommendations. DGH will set up a high-level mechanism and DGH will ask the committee to internalize some the recommendations and they should be quickly taken up to the government level. Today's efforts are certainly in the right direction and having a synergistic working in 2020. In 2021, the industry must have more interaction to see the results. It creates synergy and momentum in the entire ecosystem. Passionate professionals must come together and make it happen.

Shri T.K Sengupta, Director (Exploration & Production), FIPI delivered the vote of thanks. While thanking all the eminent Panelists, Moderator, delegates, organisations like OIL, SPG & APG for their support, Joint Secretary (Expln), MoPNG for opening remarks and DG, DGH for concluding remarks, he mentioned that the platform has been represented by dignitaries with huge knowledge bank on EOR and thus became a wonderful programme by virtue of rich content, knowledge sharing, interaction among panelists & moderator, brilliant new ideas generated and a positive and forward-looking guidance by both JS(Expln) & DG, DGH.





He assured DG, DGH & JS(Expl), MoPNG that FIPI will prepare a document on the discussion and a key takeaways which will be shared with DGH & MoPNG for their kind consideration.