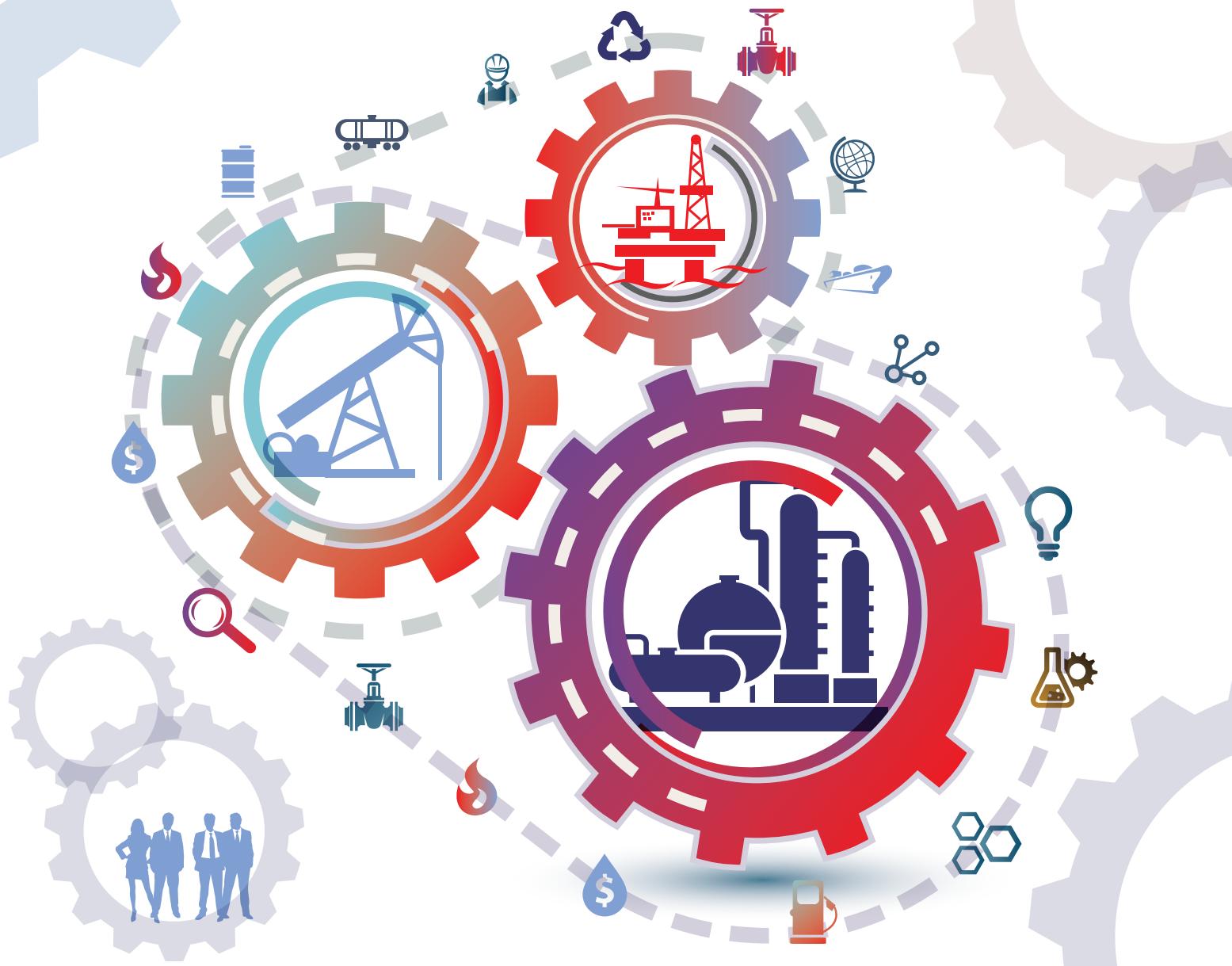


EOR Whitepaper

“How to Advance EOR Collaboration in the Gulf?”



Contents

- 02** Gulf Intelligence: How to Advance EOR Collaboration in the Gulf?
- 06** ***"To Make EOR Economically Viable, We Need to Focus on Four Areas: Talent Development, Technology Partnership and Investment"***
By Qasem Al Kayoumi, Technical Center Manager & Member of Upstream Leadership Team, ADNOC
- 08** ***"What are the Key Challenges & Opportunities to Advancing EOR Collaboration in the Gulf"*** – International Debate
- 10** WORKSHOP Stream 1
What are the Top 3 Steps to Advance EOR Partnerships in the Gulf?
1. Create a joint Industry and Academia regional Center of Excellence to share EOR knowledge across the GCC and standardize where applicable
 2. Establish the Gulf as a rewarding place to invest in R&D and collaboration
 3. Gulf EOR Conference Focused on Addressing Strategic & Business Topics
- 14** WORKSHOP Stream 2
What are the Top 3 Steps to Deepen EOR R&D & Innovation in the Gulf?
1. Establish a Top-Down Approach
 2. Develop a GCC EOR Technology Roadmap
 3. Create a Project Platform Between Industry & Academia

Advancing EOR Collaboration in the Gulf

Over 40 senior level stakeholders from across the region's Energy Industry, Academia & Government gathered on November 12th 2017 in Abu Dhabi to explore and capture top recommendations on how to advance EOR collaboration in the Gulf. The region presents a plethora of opportunities for more collaborative EOR partnerships. With investment into technologies and solutions for the process expanding, the EOR Workshop identified the successes & challenges thus far in the region as well as best practices globally, and through interactive discussion, recommendations were made by the stakeholders at the table. A master list was captured, followed by a vote on the top five proposals within each Stream. The top three recommendations were then shortlisted from each discussion to form those presented in this Whitepaper.



"Attributed to the growing number of oil reserves which exist in the Middle East, the GCC is expected to show the highest growth rate in the global enhanced oil recovery market"

30%-60%

Higher oil reservoir extraction through installed enhanced oil recovery technology.

GLOBAL ENHANCED OIL RECOVERY MARKET VALUE

2012
 2023

US\$38.1bn
US\$516.7bn

ACTIVE EOR TECHNIQUES ACROSS THE GCC

- ✓ Co₂ Injection
- ✓ Thermal Recovery
- ✓ Steam Injection
- ✓ Solar-Powered
- ✓ Miscible Gas Injection
- ✓ Chemical Recovery



Sources: Future Market Insights, Transparency Market Research and U.S. Department of Energy

The oil fields of the Gulf are some of the most mature in the world; ageing assets pose a significant challenge to the region's oil producers at a time when maximizing the life and output from wells and fields is of utmost importance. The combination of the low oil price and the region's challenging heavy oil wells requires a collaborative and innovative approach in order to maintain the high production levels needed to meet rising local demand while satisfying international supply.

Improving existing and developing new enhanced oil recovery (EOR) technologies will prove integral to determining the future success of hydrocarbon exploration and production throughout the GCC. Using EOR, 30 to 60%, or more, of the reservoir's original oil can be extracted, compared with 20 to 40% using primary and secondary recovery, according to the U.S. Department of Energy.

The EOR process is a lengthy one and urgency for implementation of solutions must be stressed amongst GCC producers. From lab tests to full field application, EOR operations can take between seven and ten years and there are often several redesigns and testing phases intended to ease the implementation process. As part of this process, pilot testing can take between two and four years. In addition, to see a visible impact on production, it can take another three to four years.

From lab tests to full field application, EOR operations can take between seven and ten years and there are often several redesigns and testing phases intended to ease the implementation process."

Research and Development for EOR technologies is also costly, and investment in the area has broadly reflected the oil price trend. EOR projects more than halved from the late 1980s to the mid-1990s when oil prices dropped and experts have warned there will be a decline in investment during this current downturn.

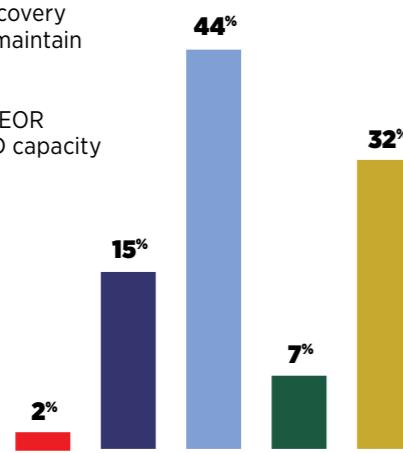
However, in the long-term, improving existing EOR systems and developing new innovative technologies will help discover further reserves, improve understanding of their complex nature, and enhance production and recovery rates, in turn establishing the Gulf as a leader in the EOR sector. By collaborating now, its nations have the opportunity to develop technologies and build a skilled workforce that will be of great benefit domestically and can be leveraged abroad. ■

"How to Advance EOR Collaboration in the Gulf?"

OCTOBER 2017

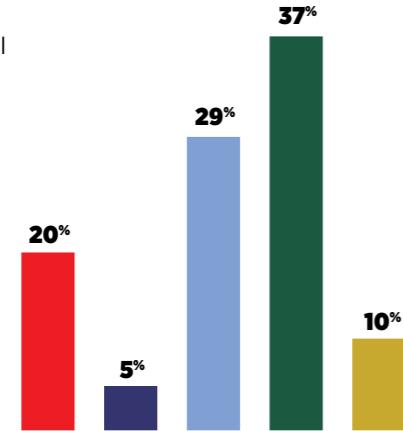
Which of the following is the strongest incentive for regional collaboration on developing EOR solutions?

- A. Off the shelf solutions not sufficient
- B. Common Reservoir architecture across the Arabian Peninsula
- C. Shared cost and risk of piloting new technology
- D. Need for tertiary recovery extraction rates to maintain Market Share
- E. Limited indigenous EOR Talent pool and R&D capacity

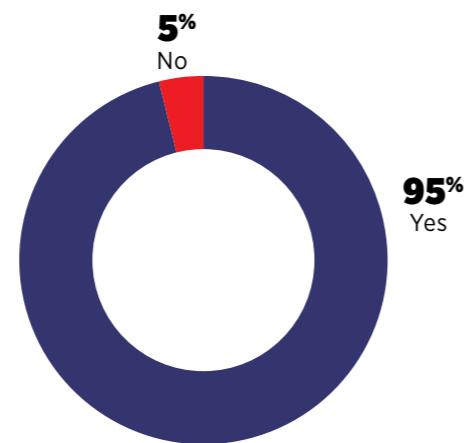


Which of the following EOR solutions should regional academia and industry prioritize for R&D?

- A. Solar Thermal
- B. Natural Gas Thermal
- C. CO₂
- D. Chemical
- E. None of the Above

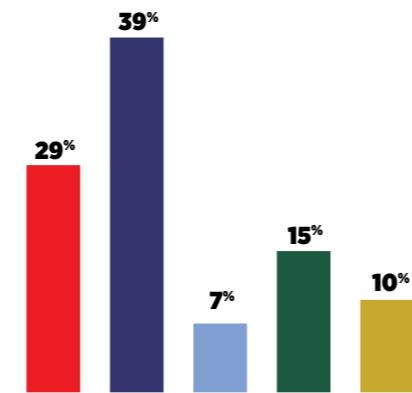


Should Gulf States cooperate on developing bespoke regional EOR solutions?



Which of the following is the strongest deterrent to regional EOR collaboration?

- A. NOCs in some countries do not yet consider EOR a top priority
- B. Confidentiality of Data
- C. Crude oil and reservoir qualities differ between countries
- D. Sharing solutions leads to higher risk of compromising intellectual property
- E. None of the above



Participants

- A Malik Jaffar, Regional Director, PETRONAS Subsidiaries, Middle East, PETRONAS
 Alex Al Shakarchi, Vice President , Middle East, Africa & Asia-Pacific, CH2M
 Ali Vezvaei, President & CEO, Bilfinger Middle East
 Amna Al-Qenae, Petroleum Engineer, Kuwait Oil Company
 Anton Leemhuis, Director Production Optimization TNO - Netherlands Organization for Applied Scientific Research
 Arafat Saleh Al Yafei, Vice President Subsurface & Data Management, ADNOC Offshore, Abu Dhabi National Oil Company
 Ayesha Al Marzouqi, Manager, Enhanced Oil Recovery Department, Abu Dhabi National Oil Company
 Chen Kah Seong, Vice President, Centre of Excellence, Development & Production, Upstream Business, PETRONAS
 David Worrall, International Energy Consultant
 Dawoud Kamal, Team Leader Enhance Oil Recovery, Reservoir Management Group, Kuwait Oil Company
 Dr. Ali M. Al Sumaiti, Assistant Professor, Department of Petroleum Engineering, The Petroleum Institute - A Part of Khalifa University of Science and Technology
 Dr. Carole Nakle, Chief Executive Officer, Crystol Energy
 Dr. Gregor Brodt, Head Technology Scouting & Innovation, BASF SE
 Dr. Hussein Hoteit, Associate Professor, Ali I. Al-Naimi Petroleum Engineering Research Center, King Abdullah University of Science and Technology
 Dr. Klaus Langemann, Director Global Technology & Innovation, Wintershall Holding GmbH
 Dr. Mohammed Al Kobaisi, Associate Professor, The Petroleum Institute - A Part of Khalifa University of Science and Technology
 Dr. Mohammed Haroun, Associate Professor, Department of Petroleum Engineering, The Petroleum Institute - A Part of Khalifa University of Science and Technology
 Dr. Naim Jabari, CEO & Founder, Xross Technology
 Dr. Nasir Haji Darman, Senior General Manager, Group Research and Technology, Project Delivery & Technology Division, PETRONAS
 Dr.Peter Rodgers, Acting SVP Research & Development, Associate Vice President (Research Engagement), Professor Department of Mechanical Engineering, The Petroleum Institute - A Part of Khalifa University of Science and Technology
 Qasem M. Al Kayoumi, Technical Center Manager & Member of Upstream Leadership Team, Abu Dhabi National Oil Company
 Rob van der Stel, Director, Verocy
 Tahani Al Rashidi TL Field Development West Kuwait, Kuwait Oil Company
 Wan Anas Masyudi W Abdullah Sani, Head, Technology Investment, Research and Technology, Project Delivery & Technology Division, PETRONAS

SUPPORTED BY:





FOREWORD

BY QASEM AL KAYOUMI

Technical Center Manager & Member of Upstream Leadership Team, Abu Dhabi National Oil Company

The EIA has forecast that 30% additional energy will be required by 2040 - that's around 30 million barrels per day (b/d) or three Aramco's - not a small amount. Yes, there is U.S. shale and there are electric cars that will also reduce demand for fuel, but I don't believe the contribution of these two factors will be sufficient to meet global energy demand.

Most of current supply is coming from conventional reservoirs which are declining, and some of them very fast so we need to do something to sustain and improve recovery. Hence, the importance of Enhanced Oil Recovery (EOR) and Improved Oil Recovery (IOR).

Globally, primary and secondary recovery rates are currently around 30% to 35%. We are lucky here in Abu Dhabi that the number is around 50% thanks to favorable water and flat conditions and rock and fluid interaction. But that leaves 50% of our resources underground as untapped, and we should not leave it as such.

EOR is not a cheap business. However, we have seen examples where what we thought would be very expensive, was in fact realized economically, like with unconventional and fracturing technology. We can achieve what we want from EOR economically and we have no other option actually with current global prices and the competition we have from other renewable energy.

To make EOR economically viable, we need to focus on four areas: talent development, technology, partnership and investment.

ADNOC is developing its talent by collaborating with renowned universities such as Norway's Berk University where Emirati ADNOC PhD students are working hand in hand with leading researchers in various hi-tech technologies. At London's Imperial College, our PhD students are working on rock physics and at Heriot-Watt University, they are developing techniques in carbonated water and low salt water injection. These are just small examples of how we create or we develop our talent. We are very proud in ADNOC that we have a mix of IOC partners from around the world who have helped us bring technology and knowhow and developed our talent.

On technology, we are working to develop formulas

where chemicals can have an impact on the very aggressive condition of high temperatures and high solutions that will help to improve efficiencies. I'm also proud to say that we have just finished establishing a subsurface center of excellence in ADNOC HQ that will house the latest technology in field development in EOR and modelling and visualization. This center will be able to house 4 subject matter experts from geophysics and reservoir engineering and all the way to digital oil fields.

Around 10% to 15% of our oil now is actually recovered by EOR, mainly by miscible gas injection. We have the CO2 Al Riyadha project - a unique project in ADNOC – and I believe we are just at the start with CO2 field injection and have many other phases to come.

We are also proud to say that we have one of the latest technologies when it comes to extended reach drilling and MRC wells. In one example offshore, we have four artificial islands and our plan is that these will cover the giant Upper Zakum field with hundreds of MRC wells drilled from these four centers. We have proven the concept of horizontalization and simulation of tight reservoirs, and we now have areas in Upper Zakum where we thought we would never be able to produce and where the rock is producing around 5,000 b/d.

We are also planning to test polymer injection, so all in all, we have an EOR roadmap in ADNOC where we are systematically implementing all these techniques in our reservoirs from the laboratory, to piloting, and then to the full scale projects.

As far as partnership is concerned, we work with IOCs, service companies, academia such as Khalifa University and Rice and Penn State University. We also have cross country GCC collaboration such as our plans for a joint industry project focusing on EOR.

Last but not least is investment which is crucial to sustain our business and the only way is to have smart investment where we can optimize resources as much as possible.

I would like to thank Gulf Intelligence for arranging this EOR workshop and I hope that the sessions will help us to better interact and share knowledge and come up with some recommendations. ■





Leadership Panel Session

"Advancing EOR Collaboration in the Gulf – What are the Key Challenges & Opportunities?"



PANELISTS:

- Qasem Al Kayoumi, Technical Center Manager & Member of Upstream Leadership Team, Abu Dhabi National Oil Company
- Chen Kah Seong, Vice President, Centre of Excellence, Development & Production, Upstream Business, PETRONAS
- David Worrall, International Energy Consultant

MODERATOR:

Sean Evers, Managing Partner, Gulf Intelligence

David Worrall: In my view, investment and collaboration in EOR will happen naturally. If some players in the region are already working on solutions to enable recovery rates to get to for example 60%, then others have no choice but to follow suit. Bespoke solutions will be needed, yes, because every reservoir is different but the general technology for EOR is already being developed and solutions are out there. There's a lot of brain power around the world being applied to work on these, and collaboration will come in when specific solutions need to be selected.

Sean Evers: Mr. Seong – how has Petronas tackled this subject in Malaysia and is there wider collaboration in the region other than just within your own company?

Chen Kah Seong: There is a very strong business process within Petronas which

is split into four parts. Number 1 is the universities; number 2 is research; number 3 is the Centre of Excellence and number 4 are the people managing the asset. The corporate structure many years ago set a target that we would hit x million barrels of reserves addition through EOR, and that has remained as the consistent business strategy. We have towed that line while also tracking and managing costs through the business funding the research. Of course, over time you need to prioritise your research, your assets or other things depending on the state of the oil price, but the overall strategy continues. We also have a business champion for EOR within Petronas.

Sean Evers: There are many incentives for collaboration on developing EOR solutions. One is that EOR is expensive and off-the-shelf solutions are perhaps not all sufficient.

Another is that the Arabian Peninsula has a common reservoir architecture and it also makes sense to share the cost and risk of piloting new technologies. Maintaining long term market share by achieving tertiary recovery extraction rates through EOR is also seen by some as critical. Cooperation would also make sense as there is limited indigenous EOR talent pools and R&D capacity within each country. 44% of this room of industry participants seem to be of the opinion that sharing cost and risk would be the strongest incentive for the GCC to cooperate. Qasem – your opinion on that?

Qasem Al Kayoumi: All are important really. Investing in our business longevity and continuity is very important – sustaining market share – to me, that is one of the main reasons. Sharing risk is also an incentive yes, but I would not really put as much emphasis on cost. We do have a lot



of similarities in our reservoirs – which are mostly carbonate – so we can learn a lot from each other there too.

David Worrall: To me, the biggest challenge is that often the people making the investment decisions who are part of the approval process, are not the technical experts, so they don't fundamentally understand what's happening and are therefore more wary. Often, investments upfront will bear fruit 20 years later, so it's an incredibly difficult decision to make.

Chen Kah Seong: I agree – you can find technology and you can do research but at the end of the day, the problem is that businesses are run by accountants who only look at bottom line numbers and at what is a fair and equitable return in every solution. In the case of Petronas, we rotate our roles which leads to a more open mindset to what is fair and creates more understanding between departments.

Sean Evers: What has been the strongest deterrent to regional EOR collaboration?

Is it that NOCs do not yet consider EOR a top priority; or is there concern on the confidentiality of data; or that crude oil and reservoir oil qualities differ too much between countries; or that sharing solutions leads to higher risk of compromising intellectual property? 39% of this room seem to think confidentiality of data is the strongest deterrent and 29% that NOCs do not yet consider it a top priority.

Qasem Al Kayoumi: I think the importance of EOR is still not yet perceived as vital for the continuation of our business. Yes, there is some element of confidentiality needed, but it's becoming less and less with time and I think we're more open than before. We all know that sharing information is a win-win and that we all benefit. We already have a vehicle to share information at the GCC level and these

kinds of workshops today for example, are another path to collaboration.

Sean Evers: Would anybody like to comment from the floor?

Delegate: The most important reason that is preventing developing EOR in the region is simply mindset - we are blessed with huge reservoirs that we've been producing for the last 40 to 70 years in mostly conventional fields where not much investment is required in new technologies. This mindset is changing, but the pace is still slow, and the reason is, as mentioned already, sometimes the corporate leadership does not have a background in reservoir engineering and the advanced requirements of EOR. At the same time, they are presented with proposals to approve large EOR investments which won't produce results for 10-20 years.

The solution I think is forums like these and better communication within organizations and also horizontally between countries and NOCs – to agree to push forward together the need to get EOR results sooner.

Sean Evers: David – are the IOCs in any way an obstruction to this progress in the sense that they are even more sensitive to the matter of proprietary technologies or data and so on?

David Worrall: I get the opportunity to work across the whole region in a variety of different organizations, and I have seen a lot of oilfields where EOR has just been left too late, and that's an important point. You can easily miss the boat so you need to be proactive and challenge this inertia that is built into the system.

The big hurdle is probably the gap in financial alignment between NOCs and IOCs as their investment timeframes and focus are very different. IOCs want returns in five years, they're on a contract, maybe the contract stands 20 years, so their financial focus is different. The NOCs are looking at the full lifetime of the field

to maximize the resource for the nation. Getting the objectives and strategy aligned is important.

Delegate: We are in the oil and gas business and its normal to expect projects to take 20 years to show results. But I think what is missing here is sufficient regulatory information – this is what is required to enhance investment in EOR. Regulations differ between one country and another, so they need to be updated and synchronized to encourage investment in EOR.

Sean Evers: Which EOR solution should regional academia and industry prioritize for R&D? solar thermal, natural gas thermal, CO₂ or chemical?

Chen Kah Seong: In the Middle East, a lot of EOR has been done, but the solutions must be specific to the reservoir. What is very clear is that this region has a lot of solar power, and this should be harnessed – whether for thermal EOR or chemical CO₂ EOR because they all use energy. Research is one part of the puzzle but I still go back to the overall business strategy for success and drive – to ensure that all things move as a single unit – from the talent development through to the business unit that spends the money. Everything must be in syncd.

Sean Evers: Qasem – is there any one of these that ADNOC is ready to cooperate on?

Qasem Al Kayoumi: We have some experience with CO₂ EOR and we would be more than happy to share that. We're already sharing with some GCC countries. The reason we have developed CO₂ injection is not only for recovery reasons, but also from an environmental point of view I think it's a good example to have. The challenge is how can we bring the cost down, and that's really what we want to discuss with different partners, whether regional or international.

David Worrall: For me when you look at nationally determined contributions for the Paris Climate Accord, the UAE commitment is impressive, but it's just never enough and it's never quick enough. Energy demand here is ramping up rapidly and most of that will be met from gas in the future, which means that there's a lot of CO₂ to be developed and it's got to go somewhere. There's only one place you can go, which is back up to the grid – so let's work out the best solutions and get on with it. ■



WORKSHOP – STREAM 1

What are the Top 3 Steps to Advance EOR Partnerships in the Gulf?

The global EOR market is expected to cross \$140bn by 2024 (Global Market Insights Inc.) and at a compound annual growth rate of 24%, it is tipped to be one of the fastest-growing segments within the global oil and gas market (Baker Hughes). GCC countries are expected to witness the most growth during this period. The majority of daily oil production in today's global market comes from mature or maturing fields, with primary and secondary recovery rates averaging 35%. Achieving tertiary recovery rate targets of 50% or above to meet future energy demand requires committed investment in EOR solutions and partnerships could be a strong enabler on this path.

Gulf States are developing a number of EOR

techniques such as CO₂ gas injection EOR and renewable solar-powered thermal EOR. Oman's Miraah project is a successful example of the latter and is expected to deliver the largest peak energy output of any solar plant in the world – saving 5.6 trillion BTUs of natural gas and providing a sustainable solution for EOR steam. How long until solar thermal EOR becomes a norm across the Gulf? Has this successful case study been shared with other Gulf States? Kuwait became the first country in the region to use its own chemical oil extraction earlier this year, rather than seeking chemicals from third parties. Has this been promoted as a solution across the Gulf? Exactly how should the EOR Value Chain be adapted to embrace new Gulf partnerships and projects?

\$140bn

The level of investment that the global EOR market is expected to cross by 2024

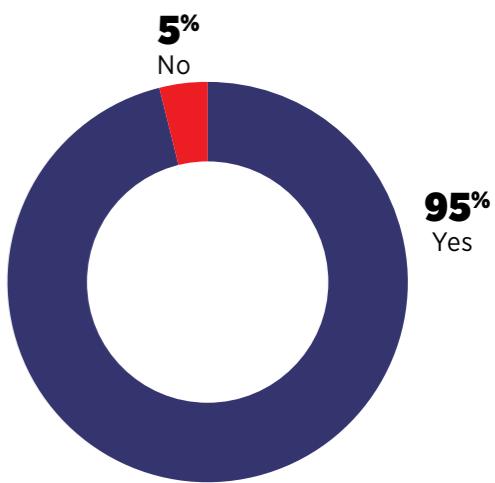


Kuwait became the first country in the region to use its own chemical oil extraction earlier this year, rather than seeking chemicals from third parties. Has this been promoted as a solution across the Gulf?"

Although some cooperation is already present amongst NOCs in the region, there is the opportunity for deepened, more structured partnerships which can provide targeted investments towards EOR and deepen collaborative advancements across the industry. Moving Gulf EOR players away from a legacy approach of working in silos and towards a collaborative synergy makes economic sense.

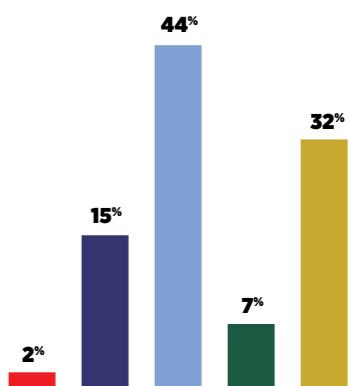
What are the next steps for developing these partnerships and establishing a region-wide framework that establishes the Gulf as a leader in EOR? Each GCC state has its own expertise and experiences – how can this be harnessed to create a world-leading EOR hub in the Gulf? Does the industry need to re-visit its approach to the life-cycle of its oil fields? How should energy resource management and EOR investments be addressed? ■

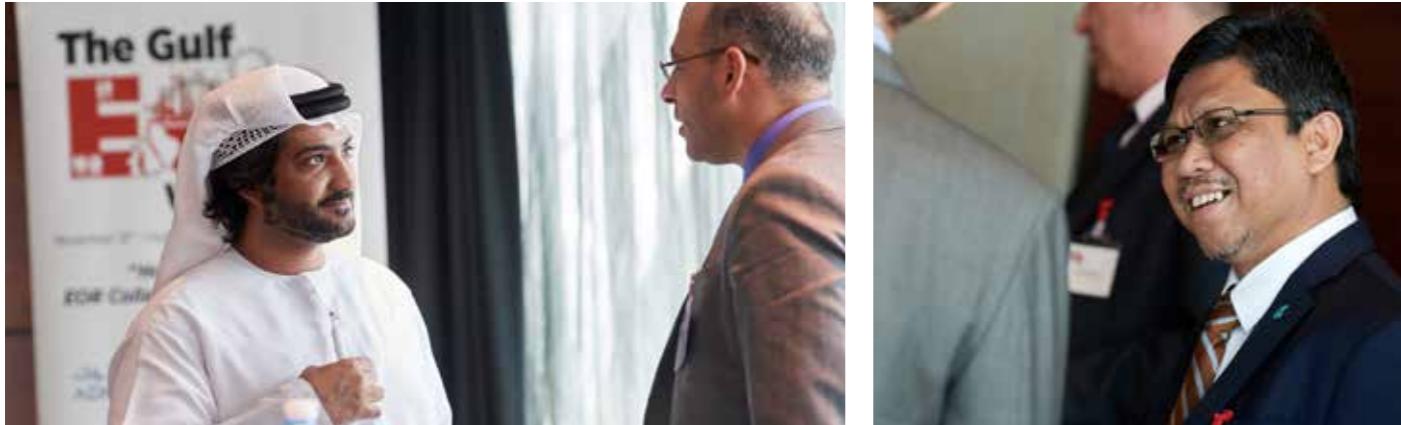
Should Gulf States cooperate on developing bespoke regional EOR solutions?



Which of the following is the strongest incentive for regional collaboration on developing EOR solutions?

- A. Off the shelf solutions not sufficient
- B. Common Reservoir architecture across the Arabian Peninsula
- C. Shared cost and risk of piloting new technology
- D. Need for tertiary recovery extraction rates to maintain Market Share
- E. Limited indigenous EOR Talent pool and R&D capacity





STREAM 1

Top Three Recommendations

1. Create a joint Industry and Academia regional Center of Excellence to share EOR knowledge across the GCC and standardize where applicable

Funding for such a Centre would be shared by

NOC shareholders such as ADNOC, PDO, KOC and Aramco. First steps would be to build a database and consortium to identify commonalities like reservoir conditions and use such data to update EOR screening. Many pilots are being done across the region and these should be categorized into tiers 1, 2, and 3 for example, to showcase quantifiable measurable mechanisms to be assessed – these need to be aligned. Once common reservoir challenges amongst countries have been identified, a portfolio of EOR concepts that will serve the region - for example, those which address heavy or light oil,

can be selected. How many partners would need to be in a project would also need to be determined. Resources and facilities already available in region should be used.

There are only one or two independent country Centres of Excellence for EOR being established in region so far and these are still in early stages of being created and revised. Need to create roadmap for Centre of Excellence at individual country level first before going to regional level. Suggestion that a virtual Centre could also be an option. i.e. doesn't have to be a physical space.

50% - 70%
Combinations of traditional EOR & IOR technologies has allowed high recovery factors internationally

4% - 8%
Oil Recovery Rates from Saudi Aramco's 2016 SmartWater flooding research program

2. Establish the Gulf as a rewarding place to invest in R&D and collaboration

Facilities & financial incentives to create win-wins and enable long-term investment for EOR. Need to look at innovating financing models for EOR and establishing new policies around investments. Innovation in technology needs to be matched with innovation in finance.

Ensure shareholders in NOCs and IOCs have an understanding of these and that facilities to raise financing are available. Currently there are not enough platforms to attract more R&D investment – it needs a better regulatory environment. Investors want the opportunity in context of a global portfolio. Top executive management at NOCs need to be more involved in strategic EOR planning.

230km
The length of the world's largest oil reservoir in the world (Arab D limestone in Ghawar, Saudi Arabia)

3. Gulf EOR Conference Focused on Addressing Strategic & Business Topics

An annual or biannual conference on EOR should be organized, along the lines of Arabal (aluminium sector) or the GPCA (chemicals sector) for example, at a platform where knowledge can be exchanged and where the business case for EOR could be assessed. EOR needs to become sustainable at \$40/barrel and this can be achieved if all parties and stakeholders can agree on such a target and meet regularly to set goals and sign NDAs if necessary to enable a frank and open discussion.



Other Recommendations From Stream 1

- ✓ Revise and align environmental regulations for industry CO2 emissions: collaborate with pollution generators such as the power industry and devise and encourage ways to dispose of their CO2 to where it is needed. Application of the circular economy thesis.
- ✓ Set up a system or process, mandated and supported by government, that links capability and research to asset management and production.
- ✓ Enhance communication between industry and government.
- ✓ Promote sharing of data and lessons learnt e.g. via an EOR Camp.
- ✓ Clarify and agree on investment policy for EOR within NOCs and in cooperation with stakeholders.
- ✓ Form a JV/consortium between GCC & International Universities with an NOC advisory board.
- ✓ Plan joint projects from the laboratory to pilot to share expertise, risks and losses – do not re-invent the wheel.
- ✓ NOCs should share EOR roadmaps – addressing specific strategic needs & challenges, including R&D and technology.
- ✓ Set up EOR Committee to meet on regular basis and share learning plans and best practices.
- ✓ Open innovation and Open Data – cooperation across the entire EOR value chain to overcome loss of data, information and know-how. Promote more transparency and willingness to share among stakeholders and across geographies – collaborative approach to cost competitiveness in EOR technology. ■



WORKSHOP – STREAM 2

What are the Top 3 Steps to Deepen collaborative EOR R&D & Innovation in the Gulf?

As the Gulf progresses with investment into Enhanced Oil Recovery (EOR) technologies, it is critical for the region to ensure a constant pool of talent develops to deepen regional research into EOR and support the range of applications being undertaken across oil fields. New discoveries of recoverable reserves are failing to match the pace set by the growing global demand for energy. This, in turn, increases the requirement for new technologies that can enhance recovery from both active fields and future discoveries.

Deepened cooperation between universities and the oil sector is still somewhat in its infancy. Recently, the University of Houston collaborated on a \$1.4 million project with Oil India Limited, to

demonstrate the use of carbon dioxide captured from nearby petrochemical plants to boost oil recovery in Assam, India. ADNOC have aligned with Bergen University to conduct applied research into EOR techniques that could extend the life of ADNOC's oil reservoirs. The NOC currently produces, principally through gas injection, 200,000bpd of crude (7% of total production). But even though some Gulf oil companies have research programs and funding is underway with international universities – they are currently not aligned amongst Gulf States.

Moving to new frontiers requires professionals, experts, and thought leaders to share EOR developmental efforts, industry experience and the latest research insights. In 2015, EOR accounted

1,000%
The increase of oil produced via CO₂ injection in the US between 1986 & 2012 according to Advanced Resources

200,000bpd
Crude produced by ADNOC through gas injection.

60-70%
BP's 2017 aim to boost recovery rates from oilfields in Abu Dhabi.

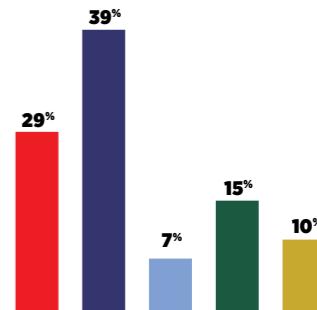
for around 11% of Petroleum Development Oman's daily production – this number is anticipated to rise to 33% by 2023 and is set to expand across the Gulf. Supporting regional talent & research, working with a broad spectrum of partners to address longer-term EOR challenges and supporting deeper innovative investment would be a huge benefit to the Gulf upstream oil sector. Increasing EOR efficiencies and abilities to support long term, sustainable profitable oil production is a priority for all Gulf States.

New EOR technologies take time to complete – years, not months, so combining resources on R&D is an approach worth visiting. Does a lower oil price pose a challenge or incentive for more R&D collaboration? What is the best path to embrace a unified approach to business models and to joint research investment and funding and to also pooling talent across the Gulf? Ultimately, how can NOCs and universities create strategic partnerships and form a strong national research and innovation agenda. ■

“New EOR technologies take time to complete – years, not months, so combining resources on R&D is an approach worth visiting.”

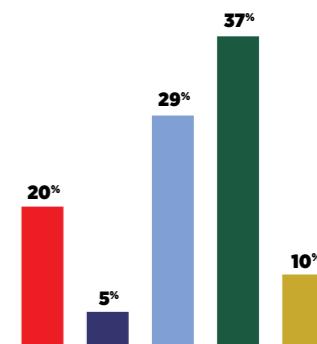
Which of the following is the strongest deterrent to regional EOR collaboration?

- A. NOCs in some countries do not yet consider EOR a top priority
- B. Confidentiality of Data
- C. Crude oil and reservoir qualities differ between countries
- D. Sharing solutions leads to higher risk of compromising intellectual property
- E. None of the above



Which of the following EOR solutions should regional academia and industry prioritize for R&D?

- A. Solar Thermal
- B. Natural Gas Thermal
- C. CO₂
- D. Chemical
- E. None of the Above





STREAM 2

Top Three Recommendations

1. Establish a Top-Down Approach

This is critical to R&D – align researchers, oil companies, service companies, NOCs and government, all towards a common goal and define common projects. Set up an institute to tender projects and establish which oil fields and players will take part. Universities can also plug into the projects identified and focus on what businesses can fund their projects.

Funding needs to be consistent and financial

barriers need to be improved. For example, in Malaysia, IOCs are asked to allocate 0.5% of their project budgets to research and they receive tax exemptions back from the government in return. In countries where there is no tax, parallel financial incentives can be devised.

The first step would be to establish a National Steering Committee to manage the Top Down approach and then move onto a GCC Steering Committee.

\$600mn
The agreement between Petroleum Development Oman & GlassPoint Solar to build a 1GWth solar field at Amal Oilfield, Oman.

40%
Percentage of EOR across the US that is conducted through thermal recovery.

2. Develop a GCC EOR Technology Roadmap

The urgent drive for EOR in the GCC is not there yet, with the exception of Oman. Solutions are needed – some already established solutions for EOR can be adopted in the GCC but reservoirs in the region are also unique in certain ways so the available solutions still need adapting.

A first step would be to establish what the top EOR challenges and needs are and then what would the

expected deliverables be for each project. Then, create a list of technologies to help with the solution. Some of these technologies may be ready, some may be partially developed and some may need new R&D. This should be established PER COUNTRY first and then on a GCC level where countries can partner on EOR technology and optimize resources – for example by selecting each country to focus on one technology.

\$2.3Bn
Value of PETRONAS investment into its EOR projects at the offshore Sarawak oilfield

3. Create a Project Platform Between Industry & Academia

Create a roadmap where all stakeholders can be involved and establish what challenges to focus on. Establish one structure or body where universities and industry can plug into and work on projects together. The most viable option would be to start in country eg ADNOC and Khalifa University are working out what's needed. Then link Centres of Excellence and a regional consortium and collaboration would come in second stage.



Other Recommendations From Stream 2

- ✓ View R&D as an investment and not as a cost centre – requires cultural change in mindset. Adopt flexible attitude to failure; accept that success rates may be 10% and focus on applying and exporting success cases. Continue with blue-sky R&D, not necessarily targeted to a specific need but which gives useful knowledge.
- ✓ Open EOR R&D more to private sector and SME engagement.
- ✓ Sharing and commercialization of IPs under a clear process.
- ✓ Establish business case and commercial incentive for international expertise to engage with NOCs in EOR R&D investment.
- ✓ Distinguish between different EOR solutions and focus on an area which is not yet applied very widely, even globally – establish a niche.
- ✓ Understand strength of each country to achieve more effective collaboration.
- ✓ Set up fund for a/next generation solutions; b/ short-term 3-5 year applications; c/ live collaboration between industry and academia.
- ✓ More attention on cooperative and applied research.
- ✓ Establish accountability and realistic KPIs.
- ✓ NOCs should set dedicated yearly budget for R&D.
- ✓ Establish co-led Centres of Excellence between industry and universities - can be consortia on a national or regional level.
- ✓ Access to more cross-country expertise.
- ✓ Appoint R&D 'Champion' at each NOC – to ensure corporate branch of NOCs gives required attention and understanding to R&D.
- ✓ Awareness of potential Crossover Technologies - "Toyota Principle".
- ✓ Open communication/share data between companies/research institutes/universities for regional collaboration.
- ✓ Establish roadmap for CO2-EOR in GCC countries.



Consultancy
Intelligence
Publishing