Oil & Gas Authority

Enhanced Oil Recovery (EOR) Strategy

Contents

1. Foreword

The OGA has been set up to influence, promote and regulate the UK oil and gas industry and has been provided with a range of new powers to enable it to do so. The development of a series of strategies represents a key step in setting the strategic direction of how the OGA and industry will work to maximise economic recovery (MER) from the United Kingdom Continental Shelf (UKCS) and was one of the core recommendations of the Wood Maximising Recovery Review.

The MER UK Strategy underpins our work and came into force in March 2016. It describes how MER UK should operate in practice, setting out a legally binding central obligation to take the steps necessary to secure the maximum value of economically recoverable hydrocarbons.

It also sets out a range of supporting obligations as well as the required actions and behaviours of collaboration and cost reduction. In support of the MER UK Strategy the OGA is, in collaboration with industry and the MER UK Boards, developing this series of strategies.

The purpose of these strategies is to drive the direction of a new way of working across the oil and gas lifecycle. The strategies will also be followed by accompanying delivery programmes, providing further direction and detail on the implementation of each strategy.

2. Executive summary

Successful Enhanced Oil Recovery (EOR) can play a huge role in maximising economic recovery from the UKCS. EOR can significantly increase the volume of recovery, extend field life (by as much as 10 years), support job provision in the supply chain, help stimulate field redevelopments and defer decommissioning activities.

However, offshore EOR is currently largely unattractive economically due to being both capital intensive and requiring higher operating costs than conventional water flood.

The importance of encouraging industry uptake of EOR was outlined in the Wood Maximising Recovery Review and subsequently EOR is an integral theme of the MER UK Asset Stewardship Board.

As stated in its Corporate Plan, the OGA has committed to delivering a strategy to facilitate sanctioning, by 2021, of projects designed to deliver up to 250 million barrels of oil equivalent (mmboe) of additional reserves. This will be implementing polymer and low salinity water flood techniques as well as other EOR opportunities.

The aim of this strategy is to help deliver EOR projects in the UKCS and this strategy supports both the MER UK Strategy and the OGA Corporate Plan.

The current status and future potential of EOR in the UKCS is described in Section 3. The OGA's ambition of supporting the delivery of up to 250 mmboe through EOR, described in Section 4, includes:

- Working with operators and supply chain to support existing polymer EOR projects and ensuring readiness for future projects
- Demonstrating a proven offshore operation of low salinity EOR by 2021 and encouraging evaluations for all new projects
- Advancing the next tranche of EOR technologies and developing a framework for their economic implementation.

Section 5 describes the eight-step programme – endorsed by the MER UK Asset Stewardship Board – which will help aid the delivery of EOR projects, while Section 6 provides an overview of stakeholder engagement with regard to EOR.

3. Strategy context

3.1 Where are we now and what's the opportunity?

The UK Continental Shelf (UKCS) is one of the most mature offshore basins in the world. Achieving optimal recovery from the basin is demanding, but with the average UKCS recovery factor from oil fields projected to be approximately 46% at end of field life, there is still a significant prize to be gained by increasing recovery from existing oil fields.

EOR techniques are used to recover incremental oil beyond that which can be extracted from the more conventional depletion and water flood recovery mechanisms. The key focus of EOR is to improve the recovery from the pore scale (for example, using low salinity EOR or miscible gas) and/or improve the sweep (for example, using polymer EOR).

There are currently only two active EOR schemes in the UKCS: the hydrocarbon miscible gas injection scheme at Magnus and a pilot polymer EOR scheme at the Captain field. Additional projects are now either in execution, such as Clair Ridge (the world's first offshore low salinity EOR scheme), or are at pre-sanction stages of evaluation.

3.2 EOR opportunities (un-risked incremental oil potential)

The potential EOR prize was initially presented in the PILOT[1] EOR Work Group Report in April 2014 and also summarised in "Maximising Enhanced Oil Recovery Opportunities in the UKCS through Collaboration" (SPE 172017, 2014).

The principal barriers to implementing EOR projects are typically:

- Incomplete subsurface understanding (eg pore scale and sweep)
- Supply of secure, low-cost injectant, in particular for miscible gas EOR
- Cost of building EOR facilities or redevelopment of existing brownfield assets
- Concerns over EOR economics.

The potential to expand the number of EOR schemes in the UK has been assessed by the PILOT work group and an analysis conducted to:

- Systematically screen all UKCS fields for EOR potential
- Engage industry and look for synergies by geography/geology/EOR type and collaborative opportunities to progress EOR understanding, and
- Where possible, initiate EOR projects with operators and/or suppliers.

The OGA has consulted with a number of UKCS operators and concluded that there remains a significant EOR prize to be gained if further schemes could be implemented on existing and new fields. The estimate, validated by operators, was that the theoretical maximum (un-risked) total EOR potential of the UKCS is approximately 6,000 million stock tank barrels (mmstb) of oil, which assumes that the optimal EOR project will be carried out on each field where it is applicable.

For the existing producing fields, the un-risked incremental oil potential of EOR for oil fields in the UKCS has been estimated to be:

Miscible hydrocarbon flood	5,400 mmstb
Miscible CO_2 injection	5,700 mmstb
Surfactant/polymerchemical EOR	4,800 mmstb
Polymer (on its own)	2,100 mmstb
Low salinity water flood	2,000 mmstb

Note: the EOR potential figures shown above amounting to ~20,000 mmstb are not additive as different EOR techniques can be considered as viable options for the same reservoir. When the optimal EOR project would be carried out on each field this unrisked figure equates to ~6,000 mmstb.

[1]Cross Industry / regulator work group comprising DECC, BP, CNR, EnQuest, Fairfield Energy, Nexen, Talisman and TAQA. PILOT has been superseded by the MER UK Forum. Implementing EOR is performed by industry but is a key activity in the OGA Corporate Plan. Responsibility to deliver tangible and quantifiable results falls upon the Asset Stewardship MER UK Board.

3.3 EOR opportunities (risked)

The PILOT EOR work group's view was that the economic (or risked) EOR potential is between 10% to 20% of the maximum (un-risked) amount so in the range 600 to 1,200 mmboe. This represents a significant resource potential.

For instance, the economic (achievable) EOR potential for the top 20 fields alone equated to 500 mmboe, which is comparable in size to the top 20 new projects that had their Field Development Plans (FDPs) approved over the six-year period from 1998 to 2013.

Whilst there are a number of EOR techniques available, three have been prioritised based on their prize and a view on their suitability and applicability in the UK offshore environment. These are:

- Chemical EOR (polymer and surfactant)
- Low salinity water flooding and
- Miscible gas injection (either hydrocarbon or CO_2).

3.4 Industry context – impact of oil price and activity levels

The PILOT EOR work helped to define potential EOR projects and enabled operators to evaluate various EOR technologies for their respective fields; subsequently the Wood Review proposed a way forward for EOR.

However, since both these reports were published, the oil price has declined significantly and this currently impacts EOR economics making the task of maximising economic recovery through EOR even more challenging.

There are five EOR projects that have Field Development Plans (FDPs) in place:

- Magnus hydrocarbon miscible gas EOR – in operation
- Captain polymer EOR pilot and field-wide implementation – in front end design phase
- Schiehallion/Loyal Quad 204 polymer ready scheme – in construction (pre-investment in tanks and pumps has been approved, ordering of polymer and deployment into the reservoir is still subject to partner sanction)
- Clair Ridge (to implement world's first offshore low salinity EOR scheme) – in construction
- Mariner polymer pilot scheme – in construction (pre-investment in tanks, pumps and infrastructure has been approved).

It is believed that polymer EOR presents the greatest opportunity for medium-term success in the UKCS and a number of heavy oil fields could have their recovery factor increased through polymer EOR.

A number of other low salinity water flood and chemical EOR (polymer and surfactant) experimental and simulation studies have been completed which have helped determine the potential prize of these chemical EOR technologies.

Miscible hydrocarbon gas EOR (similar to that being deployed at Magnus) continues to be evaluated where spare gas is available. However there is limited hydrocarbon gas available in the UKCS and the current low oil price may reduce the possibility of maximising the full potential prize of this proven EOR technology for the time being.

Miscible CO_2 EOR is a future opportunity that could use CO_2 which becomes available from Carbon Capture and Storage (CCS) projects. A 2015 study by the Energy Research Partnership[2] reviewed the interaction of CCS on CO_2 EOR and made a number of recommendations. In addition to oil price, low cost of carbon, a lack of CO_2 supply and the ageing facilities of the UKCS will be key factors influencing whether CO_2 EOR economics will be viable.

There are other EOR technologies/synergies being developed on the back of lessons learned over the past decade when high oil prices led to a stimulus in EOR research and development among governments, oil companies and universities.

With its potentially high recoveries, the application of thermal EOR (steam flooding) could be of interest for the more heavy oil reservoirs of the UKCS. However, this technique is energy intensive and potentially many years away from fruition.

Current low oil prices have resulted in the OGA developing an EOR Strategy focused primarily on existing UK EOR projects and those future projects that will benefit from low-cost EOR technologies such as polymer EOR and low salinity EOR whilst screening new projects obligations at Field Development Plan (FDP) review stage.

[2]The Energy Research Partnership has been designed to give strategic direction to UK energy innovation, seeking to influence the development of new technologies and enabling timely, focused investments to be made.

4. EOR ambition and implementation

4.1 OGA EOR ambition

The OGA's ambition with regard to EOR can be described as follows:

- **Drive** economic development of 250 mmboe incremental reserves primarily through polymer EOR over the next decade. Work with operators and the supply chain to support existing projects to ensure readiness for future projects and to drive risk reduction via technical and economic improvement
- **Demonstrate** a proven offshore operation of low salinity EOR by 2021 and progress further opportunities by encouraging evaluations for all new projects
- **Advance** the next tranche of EOR technologies and develop a framework for their economic implementation.

In order to create the right conditions to meet this ambition, the following areas are crucial to advance polymer EOR:

- **Cost reduction** – the creation of a competitive, robust supply chain is required to improve polymer EOR economics and reduce risk
- **Collaboration** – where possible, share learnings to build EOR knowledge and competency in the UKCS and reduce barriers to EOR development at both producing and future fields
- **Sustainability** – identify opportunities for standardisation of EOR-related technologies such as industry standards for testing base polymer.

4.2 Implementation programme

The OGA will be the custodian of this strategy and any updates. A member of the MER UK Asset Stewardship Board has been appointed to be the industry lead for this focus area.

In line with other OGA issued strategies, a delivery programme will be published which will be reviewed and may be updated as appropriate by the MER UK Asset Stewardship Board with any significant changes requiring discussion and endorsement by the board.

Whilst EOR in the UKCS will largely be led by industry, the EOR delivery programme supporting this strategy will also detail how the OGA will ensure MER obligations continue to be met.

5. Implementation and accountabilities

5.1 Eight-step programme

Whilst the OGA can help stimulate the implementation of EOR, industry will be required to make the necessary investments and deliver the additional reserves. The EOR ambition has a number of risks for which an eight-step programme has been developed to aid the delivery of EOR projects, as follows:

Programme 1
Existing EOR projects

To mitigate the risk that current polymer and low salinity EOR projects fail to be progressed in line with their FDPs:

- Support the Captain polymer field-wide EOR implementation redevelopment
- Support the implementation of Schiehallion/Loyal Quad 204 polymer scheme
- Support Clair Ridge to implement the world's first offshore low salinity EOR scheme
- Support the Mariner polymer pilot programme

Programme 2
MER for future EOR projects

To mitigate the risk that EOR opportunities are not identified early enough in field life cycle:

- Enforce early EOR screening for regulatory approval in draft FDPs
- Encourage operators to progress high-graded EOR resource opportunities
- Create a pipeline of opportunities to underpin business cases, track and communicate progress
- Plan and conduct specific OGA studies to evaluate future EOR opportunities

Programme 3
Workgroups and industry partnerships

To mitigate the risk that EOR technology lessons are not shared:

- Proactively drive operator collaboration and partnerships via EOR workgroups – recognising the need for companies to protect their intellectual property
- Actively support industry partnerships and collaboration
- Using publically available information, create and manage an OGA EOR library for EOR technologies
- Engage in EOR Joint Industry Projects (JIPs)

Programme 4
Technology development and deployment

To mitigate the risk that EOR technologies are not developed or deployed:

- Encourage technology providers and operators to develop and deploy low-cost EOR
- Drive operators to optimise polymer EOR technology
- Drive operators to develop further and trial low salinity EOR technology
- Actively support emerging technology Joint Industry Projects (JIPs) engaging global knowhow

Programme 5
Creating value – improving economics

To mitigate the risk that marginal EOR project economics stifle investment:

- Develop an improved economic understanding to facilitate informed discussions
- Develop a compelling business case for EOR technology; generic and specific cases
- Facilitate a competitive polymer supply chain and drive down costs

Programme 6
Advance next EOR and support CO_2 storage

To mitigate the risk that, while prioritising polymer and low salinity EOR, other EOR technologies are missed:

- Advance the next tranche of EOR, such as miscible gas/CO_2 injection and develop a framework for economic implementation
- Support miscible gas EOR opportunities in specific fields
- Develop a CO_2 EOR strategy and five-year plan
- For CO_2 storage, continue to provide technical and regulatory support to the CCS agenda

Programme 7
Knowledge management

To mitigate the risks associated with poor EOR awareness and knowledge transfer:

- Create and manage an OGA EOR library for EOR technologies
- Actively support international EOR conferences
- Actively co-operate with other governments and their technology centres

Programme 8
Communication and stakeholder plans

Responsibility to deliver tangible and quantifiable results falls upon the MER UK Asset Stewardship Board, including senior industry leadership engagement on EOR. To mitigate the risk that lack of senior industry leadership buy-in to the deployment of EOR technology limits investment in EOR projects:

- Develop a clear stakeholder plan
- Develop and lead a powerful promotional campaign for EOR

EOR strategy accountabilities

EOR implementation plans – single point accountable (SPA) and support role

EOR Role	Key EOR responsibility	EOR Strategy	Progress of implementing EOR Strategy	Plan 1: Existing EOR projects	Plan 2: MER for future EOR projects	Plan 3: Workgroups and industry partnerships	Plan 4: Technology development and deployment	Plan 5: Creating value-improving economics	Plan 6: Advance next EOR and support CO_2 storage	Plan 7: Knowledge management	Plan 8: Communication and stakeholder plans
OGA E&P EOR Manager	Develop EOR Strategy and interactions on economics/cost improvements	1	2					2			1
MER UK Asset Stewardship Board	Deliver tangible and quantifiable results, including senior leadership engagement on EOR	2	1	2	2	2					2
OGA Technology Director	Linkage of EOR Strategy to technology	2					1		2	2	
OGA Senior Economist	Linkage of EOR Strategy to economics							2	2		
OGA EOR Reservoir Specialist	Cross-field team EOR support, workgroups, JIPs, technology development and innovation, future miscible gas EOR, CO_2 EOR policy and knowledge capture	2	2	2	2	1	2	1	1	1	2
OGA Area Managers	Existing EOR projects and engaging operators early to promote readiness for future polymer EOR projects		2	1	1			2	2		2
OGA Facilities Engineers	Existing EOR facilities and readiness for future polymer EOR projects			2	2	2					

1 SPA 2 KEY SUPPORT

6. Communication and dialogue

6.1 Communication plan

An EOR communication plan will be developed. The key audiences for the EOR Strategy are:

- Operating companies – senior managers, development leads, operational engineers and research and development teams
- Oil & Gas UK
- CCS industry and the Carbon Capture & Storage Association (CCSA)
- Universities and EOR research and development organisations
- Supply chain in particular EOR chemical suppliers and EOR simulation vendors.
- Governments in particular HMT, BEIS and Scottish Enterprise
- MER UK Boards – Asset Stewardship, Regional Development & Infrastructure; Technology and Cost & Efficiency.

The key messages which the plan will be aiming to deliver to these audiences include:

- Successful EOR can significantly increase recovery, extend field life (by as much as 10 years), support job provision in the supply chain, help stimulate field redevelopments and defer decommissioning activities
- EOR has significant potential to increase hydrocarbon recovery in the UKCS
- Scale and deployment can help implement existing EOR technologies at significantly lower cost
- EOR is already being implemented in the UKCS
- EOR has marginal economics at lower oil prices so a longer-term vision is required
- EOR should be worked early in field life and implementation plans developed early
- Collaboration, including coordination of timing between developments, will reduce unitised costs of EOR and increase execution efficiencies.

6.2 Risks to achieving the strategy:

Some of the risks to achieving the EOR strategy include:

- Inability to achieve ‘the EOR ambition’ by not achieving sanction of 250 mmboe by early 2020s
- Inability to improve the recovery factor of heavy oil fields through polymer EOR
- Maximising economic recovery using EOR doesn’t get traction in a long-term low oil price environment
- Short-term risk-adverse views prevent long term resource progression through EOR
- Old negative ‘EOR myths’ still persist even though new EOR technologies are available
- Challenge of deploying EOR technology in the UK offshore environment when there are few offshore analogues globally
- CO_2 EOR development remains stagnant until large quantities of cheap CO_2 can be supplied to the UKCS.

7. Conclusion

The successful implementation and delivery of a basin-wide EOR Strategy presents a significant opportunity for the UKCS in terms of assisting to maximise the economic recovery of reserves. EOR can increase the volume of reserves recoverable and can help extend field life, stimulate field redevelopments and boost the supply chain through provision of jobs.

In summary this strategy is focused on:

- Driving economic development of 250 mmboe incremental reserves primarily through polymer EOR over the next decade
- Supporting existing EOR projects and ensuring readiness for future projects
- Demonstrating offshore operations of 3 different EOR techniques and progressing further opportunities by performing evaluations for all new developments.

The strategy will be delivered via an eight-step programme, which will require a step change in cost reduction, collaboration and sustainability.

The strategy will be developed into an accompanying delivery programme. This will focus on discrete deliverables, and will be used to manage and measure progress on delivery of the strategy and the positive impacts of the efforts.

8. Acknowledgements

This EOR Strategy has been compiled with the help, input and advice of many people and organisations. The OGA would like to acknowledge the following specific contributors:

The MER UK Asset Stewardship Board, comprising representation from the following organisations:

- BP
- Centrica
- Chevron
- Doosan Babcock
- EDF Energy
- Ineos
- Maersk Oil
- Nexen
- North Sea Midstream Partners
- Petrofac
- Ramboll
- Subsea UK
- Repsol Sinopec Resources UK
- Technip
- Wood Group

Supportive organisations, including:

The Polymer EOR work group

- BP
- Chevron
- Shell
- Statoil

Oil & Gas Authority