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Designing Enhanced Oil Recovery (EOR)/ improved Oil Recovery (IOR) Technology Road Map in oil Fields

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Abstract

The oil industry is looking for a way to develop reservoir management and optimal production of hydrocarbon reservoirs. The use of advanced technologies in the extraction of oil and gas reserves is very important in advancing the short-term and long-term goals of this industry, both in terms of product type and process. A technology roadmap is a plan that implements short-term and long-term goals by using technology solutions to help achieve the goals; The technology roadmap for in Enhanced Oil Recovery (EOR)/ improved Oil Recovery (IOR) oil fields has been developed based on the emphasized fields and areas of the target technology and has been expressed in a ten-years according to the existing challenges and preventive measures, and all research and executive activities will be carried out with the focus on the roadmap.

In this research, using the case study research method, by studying 9 cases of research conducted in the research and technology of the National Iranian Oil Company, a map of executive achievements and technological solutions in each of the target technology areas: reservoir, well and the facilities have been identified and presented based on the challenges and implementation stages. The results of this study show that in this roadmap, the issue of creating, developing and equipping specialized centers for EOR, raising skills, expertise and knowledge and transferring technology as achievements Sustainability is key and in addition to other achievements, outputs and results of each stage and technological solutions to challenges has been highly emphasized and important

Keywords: EOR, Goal, Hydrocarbon, IOR, Plan, Reservoir, Roadmap, Strategy, Technology

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1. Introduction

One of the common methods of long-term planning is to prepare a roadmap for the area. In a simple definition, it can be said that the roadmap is the method of discovering and describing the desired future

*Corresponding author: Email: radfar@gmail.com and explaining the way to achieve it in a simple and understandable language for the organization. One of the most widely used roadmaps is the technology roadmap, which is widely used in various industries for strategic and long-term planning. In the oil industry, technology development priorities have always been considered and studies in this field have been conducted by reputable oil companies, one of which is the studies conducted by Shell Company in the process of Kazakhstan oil and gas production. Iran's oil industry has always been looking for a way to develop reservoir management and optimal production of hydrocarbon reservoirs to use advanced technologies in the extraction of oil and gas reserves, reduce production costs, and increase recyclable reserves; Therefore, the role of technologies, both in terms of product type and process, will be very important in advancing the short-term and long-term goals of this industry. The focus of this research is on the technology roadmap for a period of ten years that aligns short-term and long-term goals by using technology solutions to help achieve the goals. In this research, using case study method, by studying 9 cases of research conducted in the research and technology of the National Iranian Oil Company, and using studies conducted by oil companies and other researchers and their localization has been done.

Difference of this research with other researches in focus and comprehensiveness of this research on achieving goals such as achieving technology development strategy in production, maximizing the recovery factor in reservoir, ease of production operations, reducing operating costs and creating by creating innovation and the use of modern technologies with global experience.

Some recent research has also been introduced in Table 1:

Table 1

Research in the Field of Technology Roadmap

| Row | Title | Writers |
|-----|---|------------------------------|
| 1 | Presenting a roadmap model for technologies of an advanced system | Mir Hossein Akhrooy, 2019 |
| 2 | The necessity of Preparing a Technology Roadmap for Iran's Health | Arab Zusani et al., 2017 |
| | System: A Narrative Review Study | |
| 3 | Information Technology Roadmap Mapping: An Approach to Align It | Mohebbi & Heidari, |
| | Strategies with Business Strategies | 2016 |
| 4 | Assessment of technology development risks in different layers of | Naghizadeh et al., 2016 |
| | technology roadmap (Case study: drilling drills) | |
| 5 | Oil and Gas Upstream Technology Roadmap in Leading Countries | Karimi, 2013 |
| | (Case Study: Norway-Japan) | |
| 6 | Strategic Document and Roadmap for The Development of Power | ALAEE, 2016 |
| | Industry Robots Technology | |
| 7 | Approach modeling and evaluation roadmap of defense systems | Luo and Yu, 2018 |
| 8 | Development of a roadmap of airline technologies for 8 years | Suraw et al., 2018 |
| 9 | Industrial Technology Roadmap to Support General R&D Planning | Cho et al., 2016 |
| 10 | KazaKhstan upstream oil and gas technology and R&d Roadmap | may 2013 |
| | Source: Review of Previous Research | |

For road map implementation 'Different stages of implementation of EOR operation based on different levels of TRL and classification of technologies, classification of output in the form of (deliverables, achievements and sustainable achievements), responsible for action and the use of multiple specialized committees along with experts at the national level are considered.

Its framework of. Roadmap is presented in Figure 1 in multi-step format



Figure 1

General Road Map Development Process.

As can be seen in Figure 1, roadmap development for a field includes identifying the vision and general objectives in the field, identifying and investigating the key challenges, allocating appropriate technology, planning for the implementation of considered technologies and finally implementing the programs.

The vision presents an image of the desired future, which, whenever placed in the minds of the people of the society, paves the way for the changes and transformations of the society. Within the framework of the desired perspective, individual and social planning and movements are directed towards the ideal future. The next step is to identify the priority challenges in the field of goal and the recognition of the status quo is done by directly negotiating the team of technical experts and prioritizing the challenges and appropriate options are chosen, after selecting the challenge for development in different dimensions, technology allocation should be done, so that the current situation is compared with the desired situation and plans are defined to achieve the goal. In this stage, using models and simulations and examining different results, different scenarios and technologies that are considered to be implemented are investigated. In the next step, cost/profit analysis should be performed for each of these scenarios/technologies and a program that is better economically selected. Risk analysis, program development and finally decision making are the results of this section.

2. Target technology areas in this research

In order to develop the areas of target technology in this project, after reviewing the status of the reservoir and the available data, the challenges in the sections "Reservoir", " improved Oil Recovery (IOR) Studies including two parts of wells and surface facilities" have been examined separately. For this purpose, first, the challenges investigated in these sections have been extracted and then, the emphasized fields have been determined based on the challenges, and according to the current situation, the existing objectives and prospects, prioritization of the areas has been done.

2.1. Perspective on this research

The vision in the field of technology development in order to optimize production processes and enhanced oil recovery in selected fields in The National Iranian Oil Company is as follows:

- · Achieving advanced and native technology in field development
- Realization of technology development strategy in production
- · Maximizing the enhanced oil recovery from reservoirs
- Ease of production operations and reduce operating costs

• Creating added value by creating innovation and applying up-to-date and experienced global technologies

• Improving the level of technologies and technical knowledge

• Promoting the cooperation of universities and industry and using the maximum scientific power of the country

• Improving the technical and laboratory capabilities of the university and creating a fixed structure of enhanced oil recovery in the university

3. Missions in this research

• Conducting fundamental and theoretical, applied and developmental research with the aim to solve the problems in the fields

- Improving the quality and quantity of upstream operations in the field
- Using interdisciplinary research and developing the world's most up-to-date technologies

• Connecting with domestic consulting companies and international research centers in order to develop targeted fields in order to transfer new technologies in the upstream field of oil

- Using efficient and creative Iranian forces and localizing the required expertise
- Production of reservoirs and proper operation of oil and gas resources
- Training and empowering industry and university experts

4. Challenge

Developing a roadmap for a field includes identifying the vision and overall goals in the field based on upstream documents, identifying and reviewing existing key challenges, allocating appropriate technology, planning for the implementation of the intended technologies, and finally the implementation of the plans.

A good roadmap accurately shows your current situation, your desired situation, and how to achieve it, and providing challenges and opportunities in an area, provides the best ways to overcome challenges and seize opportunities.

Based on the surveys, the challenges identified in the repository are as follows:

4.1. EOR challenge

- 1. Considerable Oil Saturation in Gas Invaded Zone
- 2. High Remaining Oil in Gas and Water Swept Zones in Matrix

- 3. Very Low Primary Recovery
- 4. High viscosity oil API gradient
- 5. Weak Aquifer
- 6. High-Pressure Drop in Reservoir
- 7. low recovery factor

4.2. IOR challenge/ well production enhancement, facilities

- 8. Drilling Mud Loss Well Cementing Problems
- 9. Thinning Oil Zone and Increasing Gas Production in Wells
- 10. Big Challenge in Asphaltin Production and Well Shut due to Asphaltin Obstacles
- 11. Improper Well to Reservoir Connection
- 12. Water and Gas Breakthrough
- 13. Casing Collapse
- 14. Sand Production Challenge
- 15. Water Production Challenge
- 16. Reservoir pressure drop/extra water production
- 17. Ambiguity in Well Optimum Location and Well Type

The process of mapping the development of key technologies in order to EOR/IOR in the oil reservoirs of the country.

In order to develop a technology roadmap, the formation of specialized committees (panels) and obtaining information from stakeholders are required (Ghazi Nouri et al. 2017, Dastranj et al. 2018.) Of course, in this research, 9 committees have been involved in the research, and in the study, experts in the field of the roadmap have been consulted and consulted on the subject under study.

In order to get the correct information in different areas of technology and to determine the steps of roadmap development using the literature of the subject, the participation of these individuals as well as receiving the opinions of external experts (at the national level) has been used and the design and the initial version of the roadmap has been carried out, which is definitely needed to be revised and updated after the passage of time and receiving new information and theories. How to cooperate with committee members and experts is specified in Figure 2.



Figure 2

The process of formulating the process of map development of key technologies in order to EOR/ IOR in oil reservoirs of Iran (research findings)

A technological roadmap is a time-based chart in which different layers are located side by side and their ratios are determined by each other. These layers generally include commercial and technical aspects.

5. Methodology

The approach of this research is descriptive quality through multi-case study. Semi-structured interview tools and documentary studies have been used in field studies. According to the subject area, the statistical population of the research was the organizational unit of research and technology of the oil company and the participants were selected from experts with sufficient scientific and executive experience in the field of the multiplicity of experts who had the willingness and commitment to cooperate, which included managers and officials of technology development, managers, executors and researchers of technology development projects and those involved in 9 specialized committees.

In analyzing qualitative data, statistical methods are mainly descriptive and content analysis and coding methods have been used to investigate interview questions.

After completing the intra-case analysis, inter-case analysis was performed for comparison and to extract similarities and partnerships at all stages and identify the overall roadmap for each case. Multiple repetitions of the round-trip between the data and theory led to the construction of an over-harvesting roadmap.

After compiling a roadmap for validation and identifying its defects, a meeting was held with the presence of all experts who were in the process of preparing the roadmap to assess the achievements and improve the content and validity of the measures. The results were analyzed and based on the opinions of the people present at the meeting, the required reforms were carried out in the roadmap.

| Cutegorizing and exciteding codes from interviews. | | | | |
|---|---|---------------------------------|--------------------------|--|
| Extracted ope | The first stage | the second stage of | | |
| CHALLENGE | TECHNOLOGY | of axial coding | axial coding | |
| "Considerable Oil Saturation in Gas Invaded Zone" "High Remaining Oil in Gas and Water Swept Zones in Matrix" "Very Low Primary Recovery" "High viscosity "oilAPI gradient" "Weak Aquifer" "High-Pressure Dropin Reservoir" "Enhance Oil Recovery" | Water Injection, Gas Injection, Polymer Injection, Foam Injection, | EOR CHALLENGE /TECHNOLOGY | CHALLENGE /TECHNOLOGY | |
| "Drilling Mud Loss Well Cementing Problems" | Using Nano Particles in Drilling Mud / Cement Using Extra Light Mud/Cement Under Balance Drilling Technology | IOR CHALLENGE /TECHNOLOGY | | |

Table 2

Categorizing and extracting codes from interviews.

| Extracted o | The first stage | the second stage of | |
|---|--|---------------------|--------------|
| CHALLENGE | TECHNOLOGY | of axial coding | axial coding |
| "Thinning Oil Zone and Increasing | Intelligent Well Technology | - | |
| Gas Production in Wells" | Drilling long Horizontal Well | | |
| "Well Shut Due to Asphaltin Obstacles" "Improper Well to Reservoir Connection" | Intelligent Well Stimulation Technology | | |
| Water and Gas Breakthrough | Water Shutoff/Gas Tracer | | |
| "Casing Collapse" | Using High Schedule Casing | | |
| "Sand Production Challenge" | Using Sand Control Equipment in Surface Facilities | | |
| "Water Production Challenge" | Water Shutoff Intelligent Water | - | |
| "Reservoir pressure drop /Extra water production" | Artificial Lift | | |
| "Ambiguity in Well Optimum Location and Well Type" | Improve Reservoir Model | | |
| "Big Challenge in Asphaltin Production and Well, Shut due to Asphaltin | New Inhibitors to Inhibit Asphaltin Sedimentation | | |
| Obstacles" | "Intelligent Well Stimulation Technology" | | |

6. Main components of the road map

A technology roadmap is a time-based chart in which different layers are placed next to each other and their relationship to each other is determined. These layers generally include the main technical aspects of interest in based on the challenges identified in three activities of "reservoir-based", "well-based" and "facilities-based"

The challenges will be the focus of the project and technology deficiencies in priority areas were identified.

In the roadmap presented in Figure 3, the following areas of technology are emphasized, along with the technologies needed to achieve the desired situation for each of them. As can be seen, the areas of target technology in this plan include three different areas.



Figure 3

EOR/ IOR Technology Road Map

The first area of target technology in EOR studies" in the reservoir field. In this field, a series of research and technological activities that, in addition to identifying and resolving the existing problems of the reservoir, provide the possibility of moving oil in place in conventional methods in the reservoir. And the localized executive methods for the reservoir will be considered, these studies will start from the initial screening process and after screening, simulation, laboratory studies and finally pilot design in the reservoirs will be done.

Due to the fact that reservoir activities are focused on increasing the displacement and volumetric efficiencies, some of the effective factors on these efficiencies are identified in the desired reservoirs and for this purpose, the following activities are recommended:

1. Evaluation of previous studies & EOR screening

- 1.1. Data Review & Analysis
- 1.2. Reservoir Evaluation reservoir Analogy Study
- 1.3. EOR Screening

2. Reservoir modeling & simulation study

- 2.1. Build/Update Geo Model
- 2.2. Build/Update Reservoir Model
- 2.3. Simulate Selected EOR Methods

3. Lab design & work

3.1. Lab Experiments

Recovery Factor Estimation for each EOR Method in Lab Scale

4. Model updating

- 4.1. Model Updating Based on Lab Data
- 4.2. Recovery Factor Evaluation for Selected EOR Method in Model
- 4.3. Field Pilot Design

5. Field pilot design&operation

- 5.1. Detail Design for Pilot
- 5.2. WELL Drilling/Workover
- 5.3. Surface Facility Construction/Upgrading
- 5.4. EOR Monitoring

According to the above explanations and in the screening stage from the first stage of the target field, the challenges of the fields have been identified from reservoir challenges and challenges related to wells and surface facilities and technologies have been presented to identify and solve the problems related to the field, and in addition to the results, outputs and achievements of the responsible of its implementation have been identified, and in the other four stages of the results, The outputs and achievements considered and responsible for the performances have been fully identified and a sustainable achievement has been mentioned in each stage, the most important of which is the creation

and development and equipping of specialized centers for EOR, enhancing skills, expertise and knowledge and technology transfer.

Each of the 5 stages related to the field of technology targets to EOR within 10 years and in the specified periods in the roadmap is implemented

The second area of target technology in this project is the field of "improved Oil Recovery ", which includes the areas of reservoir management, facilities and wells. In the screening phase, the first target area has been jointly investigated and categorized the challenges of this field and for each challenge, appropriate technology has been considered which, according to the priority of the challenges, the time of implementation of the sari technological solutions has been determined and specified in the roadmap.

In one of the areas of target technology, it is necessary to investigate the proposed technological programs for field implementation based on the regulations for the Technology Readiness Levels in the reservoir.

The good area refers to research and technological activities that, as a result, allow for the production of oil in place and transfer it to the surface. Also, the use of this complex of activities leads to the production of high-quality oil by reducing the production of unwanted fluids (water and gas) and sand, and by changing the properties around the well, it is possible to increase the production rate, reduce damage and optimize hydrocarbon fluid production and prevent unwanted fluid production.

The field of facilities is research and technological activities that are carried out to meet the challenges in the field facilities or to improve and optimize them. These activities can lead to improvement, separation and transfer of fluids in surface equipment, reducing retention time, the volume of reservoirs and preventing the deposition of heavy hydrocarbon (asphaltene).

One of the main frameworks considered in this structure is the subject of the Technology Maturation Plan (TMP). The level of technology maturity is a kind of planning for the development of Critical Technology Elements (CTE) from preliminary levels to high levels of maturity technology. The dynamic relationship between Technology Readiness Levels (TRL) and three process areas of basic studies, studies there are pilots and field studies. Different levels of technology readiness are schematically shown in the roadmap given. Accordingly, different stages of the implementation of the EOR (from basic studies to complete implementation of operations in a field based on different levels of TRL level 1 to 9 are given in Table 3.

According to the NASA standard, the technology readiness levels are nine stages, and the various stages of EOR operations modeled on the NASA standard are as follows:

| TRL | Technology Development Stage | Related Activity |
|-----|---------------------------------|--|
| 1 | Basic Technology Research | literature study, Data Review & Analysis |
| 2 | Research to prove | Reservoir Analogy Study, reservoir specifications and |
| 3 | Equipility | Lob scale Experiments, Peservoir Modeling & Simulation |
| | reasionity | Study |
| 4 | Technology | reservoir scale experiments |
| 5 | Development | Pilot design |
| 6 | Technology | Pilot Execution and validation of the system |

Table 3

Different stages of implementation of EOR operation based on different levels of TRL.

| | Demonstration | |
|---|-------------------|--|
| 7 | System | EOR Field Execution |
| 8 | Commissioning | Completing field execution and performing all required tests |
| 9 | System Operations | Full-field operation and stabilization of EOR operation |

7. Schedule

In order to achieve the mentioned objectives, a program will be set in five parts, the proposed timeframe will not merely mean the completion of the work, but also the openings that the first results of the studies are tangible. Implementation of a road map in the period of 1 to 2 years for IOR well-based, 2-3 years' time for IOR facilities-based and 3-5 years' time period for EOR (as the first step to achieve) the 10-year for field pilot operation.

8. Conclusions and suggestions

In this research, the roadmap for technologies that have been practical examples in the research and technology management of The National Iranian Oil Company with 9 case studies among the researches.

The roadmap for field technology has been developed based on emphasized fields and target technology areas according to the existing challenges and preventive measures. In this map, executive actions in each area of target technology are presented based on identified challenges and solutions.

The study was carried out as follows:

In the development of the road map of oil fields, the past and current conditions of the reservoir have been investigated and plans have been presented for the future of these fields. The important issue in the structure of the roadmap is what technologies have been used in these fields so far and what will be used according to the existing technologies. These technologies have been studied in three areas of reservoirs, wells and facilities with an approach to the subject of training and technology transfer and based on the existing challenges, technological solutions have been presented in each field.

The path of EOR technology has been developed based on the existing challenges in the fields of technology targeting activities and actions, results, outcomes, deliverables, responsible, achievements and sustainable achievements. In this map, executive actions in each area of target technology are presented based on the challenges and solutions identified in the previous section.

One of the topics emphasized in the implementation of the projects in this repository is the issue of technology education and transfer and the establishment of specialized centers for EOR.

In technology transfer, first of all, existing technologies are considered in the country and during shortterm planning, it is planned that the existing knowledge and technology in universities and scientific and technical complexes of the country be used. In addition, in areas requiring technology transfer from the other country, it is planned in a medium-term plan to transfer technology and localize it.

In the field of domestic technologies, we can refer to research, existing facilities and equipment, and upgrading and manufacturing new equipment in domestic research institutes and establishing specialized centers. Each of these institutes has significant facilities in various fields such as reservoir studies,EOR, exploration, drilling and exploitation, etc., which can be completed and upgraded equipment and capabilities of human resources as a specialized center provide services in the field of EOR/IOR and reviewing and solving its problems.

One of the sustainable achievements of the research is to create EOR center. The main task of this center is to supervise and supervise applied, fundamental and developmental research in the field of oil EOR. In this center, the facilities for the manufacturing of the required devices, research laboratories and EOR studies will be provided and by conducting field studies, suitable technology for field development will be chosen according to the current conditions. And by focusing EOR studies in this specialized center, the field development will be faster and if necessary, technology transfer and technology localization will be on the agenda.

Also, one of the outcomes of training and improving the capabilities of industry and university experts has been. In technology transfer, especially technology transfer from abroad, targeting is such that at the same time with technology transfer, the issue of training and empowerment of personnel is seriously considered so that in addition to localization of technology, there is no dependence on the foreign side as much as possible. This is achieved by domestic experts and centers and individuals who are involved in work from foreign universities during the project. In this regard, different training courses in various topics of reservoir engineering, operation, management and ... can be provided.

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