International Journal of Earth Sciences Knowledge and Applications
journal homepage: http://www.ijeska.com/index.php/ijeska

Review Article e-ISSN: 2687-5993

Enhanced Oil Recovery (EOR) Screening Criteria: at a Glance

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INFORMATION

Article history
Received 12 June 2023
Revised 24 July 2023
Accepted 20 August 2023

Keywords
Enhanced oil recovery
Screening criteria
Conventional screening
Geologic screening
Advanced screening

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ABSTRACT

Enhanced oil recovery (EOR) methods are crucial for extracting additional oil from reservoirs after primary and secondary recovery stages. This paper focuses on the screening criteria employed in the decision-making process for selecting appropriate EOR methods. The screening criteria are classified into three main categories: conventional screening, geologic screening, and advanced screening. Conventional screening involves comparing average reservoir properties with predefined validity limits to determine the suitability of a recovery process. Geologic screening takes into account detailed information on reservoir geology, such as heterogeneity and connectivity, to assess the controls on EOR processes. Advanced screening utilizes data mining, artificial intelligence techniques, and multidimensional maps to consider multiple reservoir and fluid properties simultaneously. The paper also provides a comprehensive classification of EOR methods, including gas methods, waterflooding methods, and thermal methods. Various screening criteria techniques are discussed, which are based on reservoir parameters and physics of each EOR process. The importance of decision enablers, such as influence diagrams, in framing the decision-making process is highlighted. The paper concludes by emphasizing the need for rational decision making, the role of decision makers in committing resources, and the selection of quantifiable objective functions for effective EOR method selection. Given the rising oil prices and concerns about future supplies, the application of screening criteria to identify suitable EOR methods becomes crucial for maximizing oil recovery and addressing the challenges faced by oil companies and authorities.

1. Introduction

Crude oil is found in underground porous sandstone or carbonate rock formations. In the first (primary) stage of oil recovery, the oil is displaced from the reservoir into the wellbore and up to the surface under its own reservoir energy, such as gas drive, water drive, or gravity drainage. In the second stage, an external fluid such as water or gas is injected into the reservoir through injection wells located in the rock that have fluid communication with production wells. The purpose of secondary oil recovery is to maintain well pressure and displace hydrocarbons toward the wellbore. The most common secondary oil recovery technique is waterflooding. Once the secondary oil recovery process has been exhausted, about two thirds of the original oil in place (OOIP) is left behind. EOR methods aim to recover the remaining OOIP. The rate of replacement of the produced reserves by new discoveries has been declining steadily in the last decades, so the increasing oil recovery from the aging recources is a major concern for the oil companies and authorities.

2. Classification of Screening Criteria

Elements of screening that are required to make progress with decision making in the framework of our proposed workflow. Three screening styles must usually be combined to paint a good picture of the EOR decision problem and to make rational progress. The first one, conventional screening, is the one most engineer are familiar with, and it is usually carried out by comparing average reservoir properties with data in a look-up table that contains validity limits for each parameter considered important. Geologic screening is a way of looking at the reservoir type in terms of heterogeneity, connectivity, and other geologic characteristics that have been found to be important in managing risk or that correlate with process performance.

Advanced screening helps when looking at possible combinations of variables and are sometimes referred to as multidimensional maps. These projections are useful for finding proper reservoir analog.

Screening Criteria is divided into three main sections.
1. Conventional Screening
2. Geologic Screening
3. Advanced Screening

2.1. Conventional Screening

The most commonly used approach to selecting recovery processes for a reservoir is so-called conventional screening, which we refer to as "go–no go" screening. This strategy is based on look-up tables where intervals of validity are established on the basis of engineering considerations by collecting "expert opinions" or by analyzing data from successful field cases.

A combination of all of these approaches is the most likely situation to be encountered. In this screening method, typically average representative fluid and reservoir properties of a particular field under evaluation are compared with intervals of the look-up table to decide whether the field or reservoir is suitable for a given recovery process. Screening methods of this sort are well documented in the literature or are available in commercial analytical tools; for instance, PRIze implements a direct look-up table strategy, while Sword relaxes the look-up table, using fuzzy logic to generate an indicator between 0 and 1 and thus allowing hierarchical selection of the process type (waterflooding, gas injection, thermal methods, and chemical processes).

Table 1. List of EOR methods (Taber et al., 1997a)

Methods	Reference
Gas (and Hydrocarbon Solvent) Methods	
Inert gas injection	
Nitrogen injection	Muskat, 1949a
Flue-gas injection	Muskat, 1949a
Hydrocarbon-gas (and liquid) injection	Muskat, 1949b
High-pressure gasdrive	
Enriched-gasdrive	
Misciple solvent (LPG or propane) flooding	
CO_2 flooding	Beecher, 1928
Improved Waterflooding Methods	
Alcohol-miscible solvent flooding	
Micellar/polymer (surfactant) flooding	Willhite, 1986
Low IFT waterflooding	
Alkaline flooding	Willhite, 1986
ASP flooding	Willhite, 1986
Polymer flooding	Geffen, 1983a
Gels for water shutoff	
Microbial injection	
Thermal Methods	
In-situ combustion	Geffen, 1983a
Standard forward combustion	
Wet combustion	
O_2-enriched combustion	
Reverse combustion	
Steam and hot-water injection	Haynes et al., 1976
Hot-water flooding	
Steam stimulation	
Steamflooding	
Surface mining and extraction	

An important consideration of look-up tables is that biases frequently arise because engineering considerations or experts' opinions are introduced in the process. For instance, PRIze was developed by Petroleum. Research Institute (formerly known as PRI; it is now part of the Alberta Research Center, or ARC; ARC integrated with Alberta Innovates, a new organization in Alberta), and as a result EOR applied to heavy oil substantially influenced expert opinions and sources of data. Sword, which was developed in Norway, is biased toward the Norwegian sector of the North Sea, where light oils dominate.

The main goal of the screening analysis is to identify whether a specific EOR technology has been implemented under fluid and reservoir properties similar to those of to the field under evaluation.

2.2. Geological Screening

Conventional EOR screening criteria have been widely used to evaluate numerous reservoirs before performing any detailed evaluations. Conventional criteria often include coarse geologic indicators -that is, whether it is a clastic (sand) or a non-clastic (carbonate) reservoir - or perhaps a coefficient to serve as a heterogeneity indicator.

These representations may suffice at early stages of screening, but there are controls on EOR processes that require more detailed information on the reservoir geology to be assessed.

This is the purpose of geologic screening and we will focus on the critical geologic aspects. Despite their importance, geologic screening criteria ("predictive geology") have not been used as frequently as other forms of the screening.

Tables 2 – Nitrogen and flue-gas flooding (Taber et al., 1997b)

Description

Nitrogen and flue gas are oil recovery methods that use these inexpensive nonhydrocarbon gases to displace oil in systems that may be either miscible or immiscible depending on the pressure and oil composition (see Table 3 of Ref. 1 for immiscible criteria). Because of their low cost, large volumes of these gases may be injected. Nitrogen and flue gas are also considered for use as chase gases in hydrocarbon-miscible and CO_2 floods.

Mechanisms

Nitrogen and flue gas flooding recover oil by (1) vaporizing the lighter components of the crude oil and generating miscibility if the pressure is high enough; (2) providing a gasdrive where a significant portion of the reservoir volume is filled with low-cost gases, and (3) enhancing gravity drainage in dipping reservoirs (miscible or immiscible).

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil		
Gravity, °API	>35	38 to 54 (miscible)
Viscosity, cp	<0.4	0.07 to 0.3
Composition	High percentage of light hydrocarbons	
Reservoir		
Oil saturation, % PV	>40	59 to 80
Type of formation	Sandstone or carbonate with few fractures and high permeability streaks	
Net thickness	Relatively thin unless formation is dipping	
Average permeability	Not critical	
Depth, ft	>6,000	10,000 to 18,500
Temperature, °F	Not critical for screening purposes, even though the deep reservoirs required to accommodate the high pressure will have high temperatures.	

Limitations

Developed miscibility can only be achieved with light oils and at very high pressures; therefore, deep reservoirs are needed. A steeply dipping reservoir is desired to permit gravity stabilization of the displacement, which has an unfavorable mobility ratio. For miscible or immiscible enhanced gravity drainage, a dipping reservoir may be crucial to the success of the project.

Problems

Viscous fingering results in poor vertical and horizontal sweep efficiency. The nonhydrocarbon gases must be separated from the saleable produced gas. Injection of flue gas has caused corrosion problems in the past. At present, nitrogen is being injected into large successful projects that formerly used flue gas.

Tables 3. Hydrocarbon-misciple flooding (Taber et al., 1997b)

Description

Hydrocarbon-miscible flooding consists of injecting light hydrocarbons through the reservoir to form a miscible flood. Three different methods have been used. The first-contact miscible method uses about 5% PV slug of liquefied petroleum gas (LPG), such as propane, followed by natural gas or gas and water. A second method, called enriched (condensing) gasdrive, consists of injecting a 10 to 20% PV slug of natural gas that is enriched with ethane through hexane (C_2 through C_6), followed by lean gas (dry, mostly methane) and possibly water. The enriching components are transferred from the gas to the oil. The third and most common method, called high-pressure (vaporizing) gasdrive, consists of injecting lean gas at high pressure to vaporize C_2 through C_6 components from the crude oil being displaced. A combination of condensing/vaporizing mechanisms also occurs at many reservoir conditions, even though we usually think that one process is dominant. Immiscible criteria are given in Table 3 of Ref. 1.

Mechanisms

Hydrocarbon miscible flooding recovers crude oil by (1) generating miscibility (in the condensing and vaporizing gasdrive); (2) increasing the oil volume (swelling); (3) decreasing the oil viscosity; and (4) immiscible gas displacement, especially enhanced gravity drainage with the right reservoir conditions.

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil		
Gravity, °API	>23	24 to 54 (miscible)
Viscosity, cp	< 3	0.04 to 2.3
Composition	High percentage of light hydrocarbons	
Reservoir		
Oil saturation, % PV	>30	30 to 98
Type of formation	Sandstone or carbonate with a minimum of fractures and high-permeability streaks	
Net thickness	Relatively thin unless formation is dipping	
Average permeability	Not critical if uniform	
Depth, ft	>4,000	4,040 to 15,900
Temperature, °F	Temperature can have a significant effect on the minimum miscibility pressure (MMP); it normally raises the pressure required. However, this is accounted for in the deeper reservoirs that are needed to contain the high pressures for the lean gasdrives.	

Limitations

The minimum depth is set by the pressure needed to maintain the generated miscibility. The required pressure ranges from about 1,200 psi for the LPG process to 4,000 to 5,000 psi for the high-pressure gasdrive, depending on the oil. A steeply dipping formation is very desirable to permit some gravity stabilization of the displacement, which normally has an unfavorable mobility ratio.

Problems

Viscous fingering results in poor vertical and horizontal sweep efficiency. Large quantities of valuable hydrocarbons are required. Solvent may be trapped and not recovered in the LPG method.

Tables 4. CO_2 Flooding (Taber et al., 1997a)

Description

CO_2 flooding is carried out by injecting large quantities of CO_2 (30% or more of the hydrocarbon PV) into the reservoir. Although CO_2 is not first-contact miscible with the crude oil, the CO_2 extracts the light-to-intermediate components from the oil and, if the pressure is high enough, develops miscibility to displace the crude oil from the reservoir (MMP). Immiscible displacements are less effective, but they recover oil better than waterflooding (see below and Table 3 of Ref. 1 for immiscible criteria).

Mechanisms

CO_2 recovers crude oil by (1) swelling the crude oil (CO_2 is very soluble in high-gravity oils); (2) lowering the viscosity of the oil (much more effectively than N_2 or CH_4); (3) lowering the interfacial tension between the oil and the CO_2/oil phase in the near-miscible regions; and (4) generation of miscibility when pressure is high enough (see below).

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil		
Gravity, °API	>22	27 to 44
Viscosity, cp	<10	0.3 to 6
Composition	High percentage of intermediate hydrocarbons (especially C_5 to C_{12})	
Reservoir		
Oil saturation, % PV	>20	15 to 70
Type of formation	Sandstone or carbonate and relatively thin unless dipping.	
Average permeability	Not critical if sufficient injection rates can be maintained.	
Depth and temperature	For miscible displacement, depth must be great enough to allow injection pressures greater than the MMP, which increases with temperature (see Fig. 7 of Ref. 1) and for heavier oils. Recommended depths for CO_2 floods of typical Permian Basin oils follow.	
	Oil Gravity, °API	Depth must be greater than (ft)
For CO_2-miscible flooding	>40	2,500
	32 to 39.9	2,800
	28 to 31.9	3,300
	22 to 27.9	4,000
	<22	Fails miscible, screen for immiscible*
For immiscible CO_2 flooding (lower oil recovery)	13 to 21.9	1,800
	<13	All oil reservoirs fail at any depth

At <1,800 ft, all reservoirs fail screening criteria for either miscible or immiscible flooding with supercritical CO_2.

Limitations

A good source of low-cost CO_2 is required.

Problems

Corrosion can cause problems, especially if there is early breakthrough of CO_2 in producing wells.

*All reservoirs with oils with gravities greater than 22° API can qualify for some immiscible displacement at pressures less than the MMP. In general, the reduced oil recovery will be proportional to the difference between the MMP and flooding pressure achieved. [These arbitrary criteria have been selected to provide a safety margin of approximately 500 feet above typical reservoir fracture depth for the required miscibility (MMP) pressures, and about 300 psi above the CO_2 critical pressure for the immiscible floods at the shallow depths. Reservoir temperature is included and assumed from depth. See Fig. 7 of Ref. 1 and text for the depth/temperature/MMP relationship.]

Tables 5. Polymer Flooding (Taber et al., 1997a)

Description

The objective of polymer flooding is to provide better displacement and volumetric sweep efficiencies during a waterflood. In polymer flooding, certain high-molecular-weight polymers (typically polyacrylamide or xanthan) are dissolved in the injection water to decrease water mobility. Polymer concentrations from 250 to 2,000 mg/L are used; properly sized treatments may require 25 to 60% reservoir PV.

Mechanisms

Polymers improve recovery by (1) increasing the viscosity of water; (2) decreasing the mobility of water; and (3) contacting a larger volume of the reservoir.

Technical Screening Guides*

	Wide-Range Recommendation	Range of Current Field Projects
Crude Oil		
Gravity, °API	>15	14 to 43
Viscosity, cp	<150 (preferably <100 and >10)	1 to 80
Composition	Not critical	
Reservoir		
Oil saturation, % PV	>50	50 to 92
Type of formation	Sandstones preferred but can be used in carbonates	
Net thickness	Not critical	
Average permeability, md	>10 md**	10 to 15,000
Depth, ft	<9,000 (see Temperature)	1,300 to 9,600
Temperature, °F	<200 to minimize degradation	80 to 185

Properties of Polymer-Flood Field Projects

Property	1980's median (171 projects)	Marmul	Oerrel	Courtenay	Daqing
Oil/water viscosity ratio at reservoir temperature	9.4	114	39	50	15
Reservoir temperature, °F	120	115	136	86	113
Permeability, md	75	15,000	2,000	2,000	870
% OOIP present at startup	76	≈92	81.5	78	71
WOR at startup	3	1	4	8	10
HPAM concentration, ppm	460	1,000	1,500	900	1,000
lbm polymer/acre-ft	25	373	162	520	271
Projected IOR, % OOIP	4.9	25***	≈13	30	11
Projected bbl oil/lbm polymer	1.1	1.2	≈1.4	0.96	0.57
Projected bbl oil/acre-ft	27	461	≈230	499	155

Limitations/Problems

See text for limitations and recommendations for overcoming problems.

*These screening guides are very broad. When identifying polymer-flood candidates, we recommend the reservoir characteristics and polymer-flood features be close to those of the four successful projects at the bottom of table.

**In reservoirs where the rock permeability is less than 50 md, the polymer may sweep only fractures effectively unless the polymer molecular weight is sufficiently low.

***IOR over primary production for this case only. For the others, IOR is incremental over waterflooding.

Tables 6. In-situ Combustion (Taber et al., 1997b)

Description

In-situ combustion or fireflooding involves starting a fire in the reservoir and injecting air to sustain the burning of some of the crude oil. The most common technique is forward combustion in which the reservoir is ignited in an injection well, and air is injected to propagate the combustion front away from the well. One of the variations of this technique is a combination of forward combustion and waterflooding (COFCAW). A second technique is reverse combustion in which a fire is started in a well that will eventually become a producing well, and air injection is then switched to adjacent wells; however, no successful field trials have been completed for reverse combustion.

Mechanisms

In-situ combustion recovers crude oil by (1) the application of heat which is transferred downstream by conduction and convection, thus lowering the viscosity of the oil; (2) the products of steam distillation and thermal cracking that are carried forward to mix with and upgrade the crude; (3) burning coke that is produced from the heavy ends of the oil; and (4) the pressure supplied to the reservoir by injected air

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil		
Gravity, °API	10 to 27	10 to 40
Viscosity, cp	<5,000	6 to 5,000
Composition	Some asphaltic components to aid coke deposition	
Reservoir		
Oil saturation, % PV	>50	62 to 94
Type of formation	Sand or sandstone with high porosity	
Net thickness, ft	>10	
Average permeability, md	>50	85 to 4,000
Depth, ft	<11,500	400 to 11,300
Temperature, °F	>100	100 to 22

Limitations

If sufficient coke is not deposited from the oil being burned, the combustion process will not be sustained; this prevents the application for high-gravity paraffinic oils. If excessive coke is deposited, the rate of advance of the combustion zone will be slow and the quantity of air required to sustain combustion will be high. Oil saturation and porosity must be high to minimize heat loss to rock. Process tends to sweep through upper part of reservoir so that sweep efficiency is poor in thick formations.

Problems

Adverse mobility ratio. Early breakthrough of the combustion front (and O_2-containing gas mixtures). Complex process that requires large capital investment and is difficult to control. Produced flue gases can present environmental problems. Operational problems, such as severe corrosion caused by low-pH hot water, serious oil/water emulsions, increased sand production, deposition of carbon or wax, and pipe failures in the producing wells as a result of the very high temperatures.

Tables 7. Steam-Flooding (Taber et al., 1997b)

Description

The steamdrive process or steamflooding involves continuous injection of about 80% quality steam to displace crude oil toward producing wells. Normal practice is to precede and accompany the steamdrive by a cyclic steam stimulation of the producing wells (called huff 'n' puff).

Mechanisms

Steam recovers crude oil by (1) heating the crude oil and reducing its viscosity; (2) supplying the pressure to drive oil to the producing well; and (3) steam distillation, especially in light crude oils

Technical Screening Guides

	Recommended	Range of Current Projects
Crude Oil		
Gravity, °API	8 to 25	8 to 27
Viscosity, cp	<100,000	10 to 137,000
Composition	Not critical but some light ends for steam distillation will help	
Reservoir		
Oil saturation, % PV	>40	35 to 90
Type of formation	Sand or sandstone with high porosity and permeability preferred	
Net thickness, ft	>20	
Average permeability, md	>200 md (see Transmissibility)	63 to 10,000
Transmissibility, md-ft/cp	>50	
Depth, ft	<5,000	150 to 4,500
Temperature, °F	Not critical	60 to 280

Limitations

Oil saturations must be quite high, and the pay zone should be more than 20 ft thick to minimize heat losses to adjacent formations. Lighter, less-viscous crude oils can be steamflooded but normally will not be if the reservoir responds to an ordinary waterflood. Steamflooding is primarily applicable to viscous oils in massive, high-permeability sandstones or unconsolidated sands. Because of excess heat losses in the wellbore, steamflooded reservoirs should be as shallow as possible as long as pressure for sufficient injection rates can be maintained. Steamflooding is not normally used in carbonate reservoirs. Because about one-third of the additional oil recovered is consumed to generate the required steam, the cost per incremental barrel of oil is high. A low percentage of water-sensitive clays is desired for good injectivity.

Tables 8. Summary of Screening criteria for EOR Methods (Taber et al., 1997a)

		Oil Properties			Reservoir Characteristics					
Detail Table in Ref. 16	EOR Method	Gravity (°API)	Viscosity (cp)	Composition	Oil Saturation (% PV)	Formation Type	Net Thickness (ft)	Average Permeability (md)	Depth (ft)	Temperature (°F)
Gas Injection Methods (Miscible)										
1	Nitrogen and flue gas	>35 ↗ 48 ↗	<0.4 ↘ 0.2 ↘	High percent of C_1 to C_7	>40 ↗ 75 ↗	Sandstone or carbonate	Thin unless dipping	NC	>6,000	NC
2	Hydrocarbon	>23 ↗ 41 ↗	<3 ↘ 0.5 ↘	High percent of C_2 to C_7	>30 ↗ 80 ↗	Sandstone or carbonate	Thin unless dipping	NC	>4,000	NC
3	CO_2	>22 ↗ 36 ↗ [a]	<10 ↘ 1.5 ↘	High percent of C_5 to C_{12}	>20 ↗ 55 ↗	Sandstone or carbonate	Wide range	NC	>2,500[a]	NC
1–3	Immiscible gases	>12	<600	NC	>35 ↗ 70 ↗	NC	NC if dipping and/or good vertical permeability	NC	>1,800	NC
(Enhanced) Waterflooding										
4	Micellar/ Polymer, ASP, and Alkaline Flooding	>20 ↗ 35 ↗	<35 ↘ 13 ↘	Light, intermediate, some organic acids for alkaline floods	>35 ↗ 53 ↗	Sandstone preferred	NC	>10 ↗ 450 ↗	>9,000 ↘ 3,250	>200 ↘ 80
5	Polymer Flooding	>15	<150, >10	NC	>50 ↗ 80 ↗	Sandstone preferred	NC	>10 ↗ 800 ↗ [b]	<9,000	>200 ↘ 140
Thermal/Mechanical										
6	Combustion	>10 ↗ 16 → ?	<5,000 ↓ 1,200	Some asphaltic components	>50 ↗ 72 ↗	High-porosity sand/ sandstone	>10	>50 [c]	<11,500 ↘ 3,500	>100 ↗ 135
7	Steam	>8 to 13.5 → ?	<200,000 ↓ 4,700	NC	>40 ↗ 66 ↗	High-porosity sand/ sandstone	>20	>200 ↗ 2,540 ↗ [d]	<4,500 ↘ 1,500	NC
—	Surface mining	7 to 11	Zero cold flow	NC	>8 wt% sand	Mineable tar sand	>10 [e]	NC	>3:1 overburden to sand ratio	NC

NC = not critical.
Underlined values represent the approximate mean or average for current field projects.
[a]See Table 3 of Ref. 16.
[b]> 3md from some carbonate reservoirs if the intent is to sweep only the fracture system.
[c]Transmissibility > 20 md-ft/cp
[d]Transmissibility > 50 md-ft/cp
[e]See depth.

Analogous reservoirs, as used in resources assessments, have similar rock and fluid properties, reservoir conditions (depth, temperature, and pressure), and drive mechanisms, but are typically at a more advanced stage of development than the reservoir of interest and thus may provide concepts to assist in the interpretation of more limited data and estimation of recovery. When used to support proved reserves, an "analogous reservoir" refers to a reservoir that shares the following characteristics with the reservoir of interest.

1. Same geological formation,
2. Same environment of deposition.
3. Similar geological structure and
4. Same drive mechanism.

2.3. Advanced EOR Screening

In the proposed EOR screening methodology, advanced EOR screening refers to more robust data mining strategies and artificial intelligence techniques that can lead to better screening criteria by considering simultaneous combinations of more than two reservoir and fluid properties. Artificial intelligence, specifically neural networks and fuzzy logic, and expert systems, have been widely proposed and used for supporting multiple applications in oil and gas operations. Different artificial intelligence techniques have been used to develop screening and a selection of EOR methods. To overcome some of the limitations of conventional look-up tables that list screening ("go" and "no-go") criteria, the proposed advanced screening methodology resorts to artificial intelligence (AI) techniques. The development of this strategy has been well documented in the literature The method is based on data mining of a database of international projects, for which the applicability and success of recovery processes were collated along with reservoir and fluid data. The data mining process yields a new strategy for screening oil recovery methods (IOR and EOR). It is based first on space reduction techniques to simplify the representation of international experience on oil recovery methods, represented in a collated database of reservoirs and projected as 2-D cluster maps.

3. Classification of EOR Methods

The table below represents more than 20 EOR methods, in general all of them can be classified into three main groups (Table 1).

1. Gas methods,
2. Waterflooding methods,
3. Thermal methods.

4. EOR Screening Criteria Techniques

As was explained in the previous section there are many different EOR methods that can be applied for oil and gas production. EOR screening criteria used to evaluate the effectiveness of selected method to a particular reservoir. Screening criteria are based on a set of reservoir parameters (depth, temperature, pressure, permeability, oil saturation, and viscosity, etc.) generally obtained from either field experience (success and failure) or from an understanding of the characteristics and physics of each EOR process.

5. Economic Consideration of EOR

We start by discussing a number of useful tools for framing that serve as decision enablers. One tool we often use is the influence diagram to graphically represent the connection between critical decision-making variables and the corresponding EOR process. It is important to understand that analysts do not generally make decisions; instead, decision makers, whether they be managers, investors, or any empowered individual or organization, make the decisions because they can in fact commit the resources. This point cannot be overstated because a frequent reason for failed decisions arises from a misunderstanding as to who should be addressed in the decision analysis exercise. Analysts recommend and advise, while decision makers commit financial resources and therefore must be empowered to do so.

Rational decision making is only possible when the two functions keep a degree of separation and often independence. It is with the help of decision makers that analysts build a framework to assist the decision-making process. Soft issues play a role in decision making, but quantifiable objective functions have to be selected to enable rational decision making. This complex dynamic is part of a typical decision and risk management effort.

6. Conclusion

Higher oil prices and concerns about future oil supplies have led to increased interest in EOR processes around the world. EOR is a broad term that refers to various techniques and methods used to increase the amount of oil that can be extracted from a well beyond what is possible with traditional methods. One of the factors that determine the success of EOR is the type of reservoir that the oil is located in. For example, unconventional reservoirs like shale oil require different EOR methods than conventional reservoirs. The geology of the reservoir and the composition of the oil also play a crucial role in determining the most effective and profitable EOR method.

To determine the best EOR method for a particular reservoir, screening criteria are used to analyze the reservoir's conditions. These criteria take into account factors such as the reservoir's porosity, permeability, and fluid characteristics. Based on the results of the screening, the most suitable EOR method is selected. In addition to selecting the appropriate EOR method, it is also important to design and implement the method in a way that maximizes oil recovery while minimizing costs. This involves careful planning, monitoring, and analysis throughout the EOR process.

Overall, the growing interest in EOR is driven by the need to extract as much oil as possible from existing wells in a cost-effective and environmentally responsible manner. As technology continues to advance and new EOR methods are developed, the potential for increased oil recovery from existing wells will continue to grow.

Nomenclature

EOR - Enhanced Oil Recovery
OOIP - Original Oil in Place
TPAO - Turkish Petroleum Corporation
AI - Artificial Intelligence
SPE - Society of Petroleum Engineers
DOI - Department of the Interior
ARC - Alberta Research Center
IOR - Improved Oil Recovery

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