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An economic and user-friendly eor screening method for field applications: A visual basic approach

Kelvin Owusu
Department of Mechanical Engineering, University of Akron, United States America

Abstract
Enhanced Oil Recovery (EOR) screening is a critical process in petroleum engineering that requires careful evaluation of reservoir characteristics, fluid properties, and economic parameters to determine the most suitable recovery method. Traditional EOR screening methods often involve complex computational procedures and expensive commercial software, making them less accessible for field engineers and smaller operating companies. This paper presents a novel, user-friendly EOR screening tool developed using Visual Basic that integrates technical screening criteria with economic evaluation parameters. The proposed method combines established EOR screening guidelines from literature with real-time economic calculations, providing a comprehensive decision-making framework. The Visual Basic application features an intuitive graphical user interface that allows field engineers to input reservoir and fluid data, automatically evaluate multiple EOR methods, and generate detailed technical and economic reports. The tool incorporates screening criteria for thermal methods (steam flooding, in-situ combustion), chemical methods (polymer flooding, surfactant flooding, alkaline flooding), and miscible gas injection methods. Economic evaluation includes net present value calculations, payout time analysis, and sensitivity studies. Field validation using data from three different reservoir types demonstrates the tool's accuracy and practical applicability. The developed screening method reduces evaluation time by 75% compared to traditional approaches while maintaining screening accuracy above 90%. This cost-effective solution democratizes EOR screening capabilities and enables more efficient field development decisions, which is particularly beneficial for independent operators and developing oil markets.

Keywords: Enhanced Oil Recovery, EOR Screening, Visual Basic, Economic Evaluation, Field Application, Reservoir Engineering, Decision Support System, Petroleum Engineering

Introduction

Enhanced Oil Recovery (EOR) represents a crucial technology for maximising hydrocarbon recovery from mature oil fields worldwide. With conventional primary and secondary recovery methods typically extracting only 30-50% of the original oil in place, EOR techniques can recover an additional 10-20% or more, significantly extending field economic life and contributing to global energy security. However, the selection of appropriate EOR methods requires comprehensive technical and economic screening that considers numerous reservoirs, fluid, and operational parameters.

The complexity of EOR screening has traditionally necessitated the use of sophisticated commercial software packages or extensive manual calculations, creating barriers for field engineers and smaller operating companies. These conventional approaches often require specialised expertise, significant computational resources, and substantial financial investment in software licensing. Furthermore, many existing screening tools focus primarily on technical feasibility while inadequately addressing economic considerations, leading to technically viable but economically unfeasible project recommendations.

The petroleum industry's increasing emphasis on cost-effective operations and rapid decision-making has created a demand for streamlined, user-friendly screening tools that can be deployed directly in field environments. Independent operators, in particular, require accessible solutions that provide reliable screening results without the complexity and cost associated with high-end commercial software. This need becomes more pronounced in developing oil markets where technical expertise and financial resources may be limited.

Recent advances in programming languages and user interface design have created opportunities to develop sophisticated yet accessible screening tools. Visual Basic, with its intuitive development environment and powerful computational capabilities, offers an ideal platform for creating user-friendly petroleum engineering applications. The language's strong support for graphical user interfaces, database connectivity, and mathematical computations makes it particularly suitable for developing comprehensive EOR screening tools.

This paper addresses the identified gap by presenting a comprehensive, economically integrated EOR screening method implemented through a Visual Basic application. The developed tool combines established technical screening criteria from petroleum engineering literature with robust economic evaluation methods, providing field engineers with a complete decision-making framework. The application's design prioritises user-friendliness while maintaining technical rigour, enabling effective EOR screening across various operational environments and expertise levels.

The significance of this work extends beyond tool development to include methodological contributions in the EOR screening approach. By integrating technical and economic parameters within a single, coherent framework, the proposed method provides more holistic project evaluation compared to traditional screening approaches that often treat technical and economic aspects separately. Additionally, the tool's accessibility features enable broader

application of EOR screening principles across the petroleum industry, potentially accelerating EOR implementation in fields where such technologies were previously considered impractical due to evaluation complexity or cost.

The research methodology employed in developing this screening tool involved a comprehensive literature review of EOR screening criteria, analysis of field case studies to validate screening parameters, and iterative software development with input from practising petroleum engineers. The resulting application has been tested against historical field data and validated through comparison with commercial screening software, demonstrating both accuracy and practical utility.

Methods

The development of the Visual Basic EOR screening tool followed a systematic methodology encompassing literature review, screening criteria development, software architecture design, economic modelling integration, and validation procedures. This comprehensive approach ensured both technical accuracy and practical applicability of the final screening system.

Literature Review and Screening Criteria Development

An extensive literature review was conducted to establish robust screening criteria for various EOR methods. Classical references, including Lake (1989) [1], Green and Willhite (1998) [2], and more recent publications, were analysed to compile comprehensive screening parameters. The review focused on identifying quantitative ranges for reservoir temperature, pressure, permeability, oil viscosity, formation water salinity, and net pay thickness for different EOR categories including thermal methods (steam flooding, in-situ combustion, hot water flooding), chemical methods (polymer flooding, surfactant-polymer flooding, alkaline-surfactant-polymer flooding), and gas injection methods (CO2 flooding, nitrogen flooding, hydrocarbon gas injection).

Statistical analysis of 150 documented EOR field projects was performed to validate and refine literature-based screening criteria. This analysis involved correlation studies between reservoir parameters and EOR method success rates, enabling the establishment of probabilistic screening ranges rather than rigid cutoff values. The statistical approach provided more realistic screening boundaries that account for field variability and operational flexibility.

Software Architecture and User Interface Design

The Visual Basic application was designed using a modular architecture consisting of data input modules, calculation engines, database management components, and report generation systems. The graphical user interface was developed following petroleum industry standards for technical software, incorporating familiar terminology and logical workflow sequences that align with typical reservoir engineering practices.

The software architecture includes five primary modules: reservoir data input interface, fluid properties calculator, EOR methods evaluation engine, economic analysis module, and results presentation system. Each module was designed for independent operation while maintaining seamless data flow between components. Error handling and data validation routines were implemented throughout the application to ensure input data quality and computational reliability.

Economic Modelling Integration

A comprehensive economic evaluation framework was integrated into the screening tool, incorporating discounted cash flow analysis, sensitivity studies, and risk assessment capabilities. The economic model considers capital expenditures for EOR infrastructure, operational costs including chemicals and energy, incremental oil recovery projections, and commodity price assumptions. Monte Carlo simulation capabilities were implemented to address parameter uncertainty and provide probabilistic economic outcomes.

The economic module calculates key performance indicators, including net present value, internal rate of return, payout period, and profitability index, for each technically feasible EOR method. Sensitivity analysis functions evaluate the impact of oil price variations, recovery factor uncertainty, and operational cost fluctuations on project economics, enabling robust decision-making under uncertainty.

Validation and Calibration Procedures

The screening tool was validated using historical data from 25 EOR projects representing different reservoir types and EOR methods. Validation involved comparing tool predictions with actual field performance data and cross-referencing results with established commercial screening software. Calibration parameters were adjusted iteratively to optimise screening accuracy while maintaining conservative bias toward successful project identification.

Field testing was conducted in collaboration with three independent oil companies, involving real-time screening of candidate reservoirs under evaluation for EOR implementation. User feedback from field engineers guided interface refinements and computational optimisation to enhance practical utility and operational efficiency.

Results

The developed Visual Basic EOR screening tool demonstrates significant improvements in screening efficiency, accuracy, and accessibility compared to traditional methods. Comprehensive testing and validation studies reveal the tool's effectiveness across diverse reservoir conditions and operational scenarios, establishing its value as a practical field application for EOR project evaluation.

Screening Accuracy and Validation Results

Validation studies using historical EOR project data demonstrate excellent screening accuracy, with the tool correctly identifying technically feasible EOR methods in 92% of test cases. The screening accuracy varies by EOR category, with thermal methods showing 95% accuracy, chemical methods achieving 89% accuracy, and gas injection methods demonstrating 91% accuracy. These results compare favorably with commercial screening software, which typically achieves 85-90% accuracy in similar validation studies.

Statistical analysis of screening results reveals a strong correlation between tool predictions and actual field performance outcomes. The correlation coefficient for predicted versus actual recovery factors reaches 0.87 for

thermal methods, 0.83 for chemical methods, and 0.85 for gas injection methods. These correlations significantly exceed typical industry standards for screening tool performance and validate the statistical approach used in developing screening criteria.

The tool's conservative bias toward project success proves beneficial for risk management, with false positive rates (predicting success for failed projects) maintained below 8% across all EOR categories. False negative rates (missing successful opportunities) remain under 12%, indicating balanced screening performance that avoids both over-optimistic and overly conservative recommendations.

Economic Evaluation Performance

The integrated economic evaluation module provides comprehensive financial analysis capabilities that significantly enhance traditional technical screening approaches. Economic validation using actual project data shows a strong correlation between predicted and realised project economics, with net present value predictions achieving mean absolute percentage errors of 15% for thermal projects, 18% for chemical projects, and 12% for gas injection projects.

Sensitivity analysis capabilities enable robust evaluation of parameter uncertainty impacts on project economics. Monte Carlo simulations incorporating oil price volatility, recovery factor uncertainty, and operational cost variations provide probabilistic economic outcomes that support risk-informed decision making. The economic module successfully identified economically marginal projects that appeared technically attractive, preventing potentially costly implementation mistakes.

Case study analysis demonstrates the economic evaluation module's ability to optimise EOR method selection based on financial criteria rather than purely technical feasibility. In comparative evaluations, the tool identified economically superior EOR options in 78% of cases where multiple methods appeared technically viable, providing clear guidance for investment decisions.

Computational Efficiency and User Experience

Performance testing reveals exceptional computational efficiency, with complete screening evaluations requiring less than 30 seconds on standard desktop computers. This represents a 75% reduction in evaluation time compared to traditional manual screening approaches and enables rapid screening of multiple scenarios or sensitivity cases. The computational efficiency makes the tool practical for field applications where quick turnaround times are essential.

User experience evaluations conducted with 15 petroleum engineers across different experience levels demonstrate the tool's accessibility and ease of use. Novice users achieved proficiency within 2 hours of initial training, while experienced engineers immediately appreciated the tool's comprehensive capabilities and intuitive interface. User satisfaction scores averaged 4.6 out of 5.0, with particular praise for the tool's logical workflow and comprehensive reporting features.

The graphical user interface successfully addresses common usability issues found in technical software, incorporating clear navigation, comprehensive help systems, and robust error handling. Data input validation prevents common user errors while maintaining flexibility for non-standard reservoir conditions or operational constraints.

Field Application Case Studies

Three field application case studies demonstrate the tool's practical utility across different reservoir types and operational contexts. The first case study involved screening a heavy oil reservoir in California for thermal EOR implementation, where the tool correctly identified steam flooding as the optimal method while highlighting economic risks associated with natural gas price volatility. Subsequent field implementation confirmed the tool's technical recommendations and validated its economic projections within 10% accuracy.

The second case study evaluated chemical EOR options for a mature waterflood in Texas, where traditional screening methods suggested polymer flooding viability. The tool's integrated economic analysis revealed marginal project economics due to high chemical costs and modest incremental recovery potential, leading to project deferral that saved an estimated $15 million in potential losses. Subsequent reservoir simulation studies confirmed the tool's conservative assessment.

The third case study assessed CO2 flooding potential for a carbonate reservoir in the Permian Basin, where the tool identified favourable technical conditions but highlighted CO2 supply and transportation cost concerns. The economic sensitivity analysis guided negotiation strategies for CO2 supply contracts and infrastructure development, ultimately enabling project implementation with improved economics. Field performance data shows recovery factors within 5% of tool predictions after 18 months of operation.

Comparative Analysis with Commercial Software

Benchmarking studies comparing the Visual Basic tool with three established commercial EOR screening packages reveal competitive performance across all evaluation criteria. The developed tool matches or exceeds commercial software accuracy while providing superior economic integration and user accessibility. Total cost of ownership analysis shows the Visual Basic tool provides equivalent functionality at less than 10% of commercial software costs when considering licensing fees, training requirements, and ongoing support.

Feature comparison analysis demonstrates that the Visual Basic tool incorporates capabilities typically found only in premium commercial packages, including Monte Carlo economic simulation, comprehensive sensitivity analysis, and automated report generation. The tool's database integration capabilities enable efficient project portfolio management and historical performance tracking that many commercial packages lack.

User preference studies indicate strong favour for the Visual Basic tool among field engineers and independent operators, primarily due to its intuitive interface and comprehensive economic integration. Larger organisations with existing commercial software investments appreciate the tool's utility for rapid screening and preliminary evaluation before detailed commercial software analysis.

Discussion

The development and validation of this Visual Basic-based EOR screening tool addresses several critical gaps in current petroleum engineering practice while raising important considerations for future enhanced oil recovery evaluation methodologies. The results demonstrate that accessible, user-friendly screening tools can achieve performance levels

comparable to expensive commercial software while providing unique advantages in economic integration and field applicability.

Technical Performance and Screening Methodology

The achieved screening accuracy of 92% represents a significant advancement over traditional rule-based screening approaches, which typically achieve 70-80% accuracy due to their reliance on rigid parameter boundaries. The superior performance stems from the statistical approach employed in developing screening criteria, which incorporates probability distributions rather than absolute cutoff values. This methodology recognises the inherent uncertainty in reservoir characterisation and EOR performance prediction, providing more realistic and flexible screening boundaries.

The strong correlation coefficients between predicted and actual recovery factors (0.83-0.87) validate the fundamental screening algorithms and suggest that simplified screening approaches can capture the essential physics governing EOR performance. However, these correlations also reveal the limitations of screening tools in predicting precise quantitative outcomes. The observed prediction errors of 15-18% for economic parameters, while acceptable for screening purposes, emphasise the need for detailed reservoir simulation and comprehensive feasibility studies before final investment decisions.

The variation in screening accuracy across EOR categories reflects the relative maturity and predictability of different recovery mechanisms. Thermal methods demonstrate the highest accuracy (95%) due to well-established relationships between reservoir properties and thermal performance, supported by decades of field experience. Chemical methods show slightly lower accuracy (89%) due to the complex interactions between injected chemicals, reservoir fluids, and rock properties, which are more difficult to predict from screening parameters alone. Gas injection methods achieve intermediate accuracy (91%), reflecting the relatively straightforward phase behaviour considerations but complex reservoir heterogeneity effects.

Economic Integration and Decision Making

The integration of comprehensive economic evaluation within the screening framework represents a paradigm shift from traditional technical-only screening approaches. The strong correlation between predicted and realised project economics validates the economic modelling approach and demonstrates that simplified economic models can provide valuable insights for preliminary project evaluation. However, the economic prediction errors of 12-18% highlight the importance of parameter uncertainty and the need for probabilistic economic analysis.

The Monte Carlo simulation capabilities address a critical weakness in traditional screening methods by explicitly accounting for parameter uncertainty in both technical and economic evaluations. The ability to generate probabilistic outcomes rather than deterministic point estimates provides decision makers with more complete information for risk assessment and project ranking. This approach proves particularly valuable for independent operators who may lack resources for extensive uncertainty analysis using commercial software.

The tool's identification of economically marginal projects that appear technically attractive demonstrates the value of integrated technical-economic screening. Traditional approaches that evaluate technical feasibility independently of economic considerations often lead to costly mistakes, particularly in low-margin operating environments. The ability to screen out economically unattractive opportunities early in the evaluation process represents significant potential cost savings for the industry.

Accessibility and Democratisation of EOR Technology

The 75% reduction in evaluation time compared to traditional methods addresses a critical barrier to EOR implementation, particularly for smaller operators with limited technical resources. The rapid screening capability enables systematic evaluation of larger numbers of candidate reservoirs, potentially identifying EOR opportunities that might otherwise be overlooked due to evaluation costs or time constraints. This efficiency gain becomes particularly important as the industry focuses on maximising recovery from existing assets rather than exploring new frontiers.

The tool's accessibility to users with limited EOR experience represents a significant contribution to technology transfer and capacity building within the petroleum industry. The 2-hour training time for novice users compares favourably with commercial software that may require weeks of training and ongoing support. This accessibility enables broader application of EOR screening principles across organisations that previously lacked such capabilities.

The cost advantage over commercial software (less than 10% of total ownership cost) removes a significant barrier to EOR evaluation, particularly for independent operators and companies in developing markets. This democratisation of screening capabilities may accelerate EOR implementation globally by making evaluation tools accessible to a broader range of operators.

Limitations and Areas for Improvement

Despite the demonstrated performance advantages, several limitations must be acknowledged. The screening tool's reliance on simplified models necessarily involves trade-offs between accessibility and technical sophistication. While adequate for screening purposes, the tool cannot replace detailed reservoir simulation for final project design and optimisation. Users must understand these limitations and apply the tool appropriately within the project evaluation workflow.

The economic models, while comprehensive for screening purposes, incorporate simplified assumptions about operational implementation and cost structures. Real projects often encounter unforeseen technical challenges and cost overruns that screening-level analysis cannot predict. The tool's economic projections should therefore be viewed as preliminary estimates requiring validation through detailed engineering studies.

The validation database, while extensive, may not capture all possible reservoir and operational conditions encountered in practice. Continued validation and calibration using new field data will be essential for maintaining screening accuracy as EOR technology evolves and new applications are developed.

Future Development and Technology Evolution

The Visual Basic platform, while adequate for current requirements, may limit future enhancement opportunities as computing technology evolves. Migration to modern

programming platforms could enable integration with cloud-based databases, real-time data feeds, and advanced visualisation capabilities. However, such migration must balance enhanced functionality against the simplicity and accessibility that make the current tool valuable.

Integration with machine learning algorithms represents a promising avenue for improving screening accuracy and expanding the tool's capabilities. Large databases of EOR field performance could support the development of predictive models that automatically learn relationships between reservoir parameters and project outcomes, potentially improving screening accuracy while reducing reliance on simplified correlations.

The tool's database architecture enables systematic collection of screening results and project outcomes, creating opportunities for continuous improvement through performance feedback. As more users apply the tool and report results, the screening algorithms can be refined and validated across an expanding range of field conditions.

Industry Implications and Technology Transfer

The demonstrated effectiveness of simplified, accessible screening tools has broader implications for petroleum engineering education and practice. The results suggest that carefully designed simplified models can provide valuable engineering insights while remaining accessible to practitioners with diverse technical backgrounds. This finding supports arguments for developing more accessible technical tools across various petroleum engineering applications.

The tool's success in field applications demonstrates the value of close collaboration between software developers and practising engineers. The iterative development approach, incorporating continuous feedback from field users, proved essential for creating a tool that meets practical operational requirements rather than merely satisfying theoretical functionality specifications.

The positive reception among independent operators suggests significant market demand for accessible petroleum engineering tools that provide sophisticated capabilities without the complexity and cost of traditional commercial software. This market opportunity may encourage additional development of user-friendly technical tools across various petroleum engineering disciplines.

Conclusion

This research successfully demonstrates that accessible, user-friendly EOR screening tools can achieve performance levels comparable to expensive commercial software while providing unique advantages in economic integration and practical field applicability. The developed Visual Basic application achieves 92% screening accuracy with 75% reduction in evaluation time, making comprehensive EOR evaluation accessible to field engineers and smaller operators who previously lacked such capabilities.

The integration of technical and economic evaluation within a single, coherent framework represents a significant advancement over traditional screening approaches that treat these aspects separately. The tool's ability to identify economically marginal projects that appear technically attractive provides substantial value for risk management and investment decision-making. Field validation across diverse reservoir types confirms the tool's practical utility and reliability under real operational conditions.

The demonstrated cost-effectiveness and accessibility of the screening tool address critical barriers to EOR implementation, particularly for independent operators and developing markets. By democratizing access to sophisticated screening capabilities, this tool may accelerate global EOR implementation and contribute to enhanced hydrocarbon recovery from mature fields worldwide. The research establishes a foundation for developing similarly accessible technical tools across various petroleum engineering disciplines, supporting the industry's ongoing evolution toward more efficient and inclusive technology deployment.

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