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AUTOMATED PRE-SCREENING METHOD FOR PRODUCTION ENHANCEMENT USING ELECTRICAL SUBMERSIBLE PUMP IN MALAYSIA'S OFFSHORE BROWN FIELDS

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Abstract— With over 80% of Malaysia's fields using gas lifts, tackling late-life challenges is crucial for maintaining oil production. Issues like gas lift gas shortages, aging infrastructure, and rising water cuts limit efficient oil recovery, prompting the search for alternative lift technologies. Replacing gas lift systems is complex, making it essential to streamline candidate identification. This study proposes an automated pre-screening approach to quickly evaluate candidates, reducing the time and effort needed to process numerous wells. The system, tested with data from Fields B, D, and S, prescreens strings to identify opportunities for detailed analysis. By digitizing this process, automation narrows down potential candidates for electrical submersible pump (ESP) design, economic assessment, and other enhancements, saving time and broadening candidate selection. This method extends to acid stimulation, gas lift optimization, and water shut-off candidates, revolutionizing the process and improving decision-making for production enhancement activities.

I. Introduction

For over a century, gas lift technology has been extensively used in Malaysia's offshore oil fields. Currently, more than 80% of the wells in Malaysia are gas-lifted [1]. However, these fields are now facing late-life challenges, including increased water production due to premature water breakthroughs in new wells and the late-life effects in older wells. High water cut wells, those with more than 90% water content, are a significant issue, leading to a shortage of gas lift gas, increased solid production, and high operating expenditures for aging facilities. The rising demand for fossil fuels pressures oil companies to boost production rapidly, necessitating the identification and maturation of candidate wells within a short timeframe. According to one of the researchers, evaluating over 300 wells and identifying 50 viable candidates with complete technical justifications within six months seemed impossible [2] and engineers need more time and manpower to identify several suitable economical candidates from hundreds of strings including active and idle strings.

However, advancements in technology, data digitalization, and visualization have made meeting these requirements feasible. This is in line with Malaysia's initiative towards IR4.0 which to progress towards automation, data exchange, cloud computing, internet of things (IoT) and artificial intelligence, incorporating data digitalization and automation that enhances processes and accelerates progress in the oil and gas industry. This study is intended to minimise the time required to perform the analysis and shortlist the strings for candidate maturation using automation and digitalization where the identified candidate will be classified into a basket of opportunities for production enhancement activities. This paper will explore the entire process of candidate identification through data digitalization and visualization, demonstrating how these tools facilitate efficient and effective decision-making.

II. Methodology

A. Data Gathering, Mining and Data Hygiene for Digitalization

In the candidate screening process, various dynamic and static data were analysed. Dynamic data, including production, well testing, sand production, and historical pressure data, determined well potential and were consolidated into Excel for visualization. Static data, such as digitalized well schematics, well deviation surveys, and reservoir PVT data, were categorized into well parameters [3]. All formatted data were converted into Excel sheets to facilitate data digitalization and automation. All static and dynamic data were gathered, sorted, and validated for quality. This ensures an accurate representation of current conditions, preventing misconceptions during automation. Once sorted and verified, the data undergoes an integrated automation process to classify the strings into established opportunity categories.

B. Opportunities Category

Opportunity categories are based on parameters such as water cuts, well integrity issues, gas lift issues, facility limitations, and short-term boosts [3]. These categories help identify and address issues for each string. The data-driven overview relies on well tested data, well schematic diagrams, intervention history, and surface facility data. High water cut strings (WC>80%) and those with integrity issues or surface limitations are classified accordingly [4]. Figure 1 shows these categories.

High Water Production	Gas Lift Issues	Facilities Limitation	Integrity Issues
• Water cut of the strings > 80% • Water production rate > 1000bopd (high producer strings) **	• High gas oil ratio strings • Gas robbing issue • Over injection issue • Multipointing & shallow injection	• No Gas Lift line / Gas Lift choke • Seperator limitation • Gas lift comperasor limitation • Gas lift gas shortage	• Sand production/ deposition • Organic deposition • Inorganic deposition • Tubing Leak • Fish left in the hole

Figure 1: Example of categories identified

Once opportunities are categorized for each string, those with high water production, gas lift issues, and integrity problems are prioritized. Candidates are then evaluated for technical potential using automated tools based on the Hagedorn and Brown correlation as in Equation (2) for vertical lift performance and the Vogel method as in Equation (1) for inflow performance [5]. During screening, numerous parameters are considered, including remaining reserve, well status, current absolute open flow, well angle, dogleg severity, current water cut, gas volume fraction, oil gain, and potential drawdown. These parameters are critical for defining well potential and the feasibility of operations, helping to identify first-level candidates for the maturation process.

$$\frac{q_o}{q_{o_{max}}} = 1 - 0.2\frac{P_{wf}}{\bar{P}} - 0.8\left(\frac{P_{wf}}{\bar{P}}\right)^2 \quad (1)$$

$$H_L = \frac{H_L}{\psi} \times \psi \quad (2)$$

where:

q_o= Inflow Rate (bbl/d)

$q_{o_{max}}$ = Inflow rate when zero potential, (bbl/d)
P_{wf} = Flowing bottomhole pressure
$\bar{P}$ = Average reservoir pressure (psi)
H_L = Liquid holdup factor, fraction
ψ = Secondary correlation factor, dimensionless

Table 1 shows the range that has been set for all strings to exclude the outliers by automating the process.

Table 1: Parameters with a range of selections as a potential candidate

Parameters	Range
Remaining Reserve (MMSTB)	> 0.1 MMSTB
Well Status	Active & Effective Idle
Current Liquid Rate (bbl)	< 4000 bbl
Well Angle (°)	< 80°
Dogleg Severity (°/1000ft)	< 7°/1000ft
Current Water cut (%)	< 90%
Potential Drawdown (psi)	< 800 psi
Potential Oil Gain (bopd)	> 50 bopd
Gas Volume Fraction (v/v)	< 90%

C. Master Database

In this study, a well-structured database was crucial for identifying candidates for the maturation process. The database includes all essential parameters, starting with critical parameters, then essential parameters, and finally optional parameters. Critical parameters are the minimum requirements for predicting well potential and operational feasibility. Essential parameters complement the critical ones in the analysis, while optional parameters help narrow down candidate options. Table 2 shows the parameter categorization.

Table 2: Classification of data types for respective parameters

No.	Types of Parameters	Data Type
1	Critical Parameters	Well Status: Remaining Reserve (MMSTB), Water Cut ((%)), GVF (v/v), Current AOF (STB/D), Pump Set depth (ft), Oil Gain (bopd)
2	Essential Parameters	Existing tubing size: Sand Count Range (pptb), Gross Production liquid (blpd), Oil production

		rate (bopd), Gas oil ratio (scf/bbl), Drawdown at design rate (blpd)
3	Optional Parameters	Current artificial lift, DLS Max to RIH, Maxwell deviation, Well integrity issues, Flow Assurance Issues

A master database is essential for data management and serves as a reference for data architecture. Ensuring data quality before integration or transformation is crucial. Transforming data into a user-friendly visualization dashboard enhances confidence in analysis and conclusions. Digitalization automates database updates and dashboard refreshes, maintains reliability and eliminates setbacks related to accessibility and new data integration.

D. Data Analysis

Data analytics transforms raw data into an accessible format for analysis, enhancing decision-making. Using various tools and technologies, it solves problems and provides insights for performance improvement. Big data analytics goes further by identifying trends and patterns within massive datasets. This complex process involves six steps as shown in Figure 2.

Data gathering collects data from various sources and formats, like PDF, Word, Excel, or PowerPoint. This data is consolidated into a single destination for easier processing. Data cleaning removes errors and inconsistencies, ensuring accuracy. Data sorting organizes the data for efficient analysis. Finally, data visualization presents findings interactively, enhancing user understanding [6].

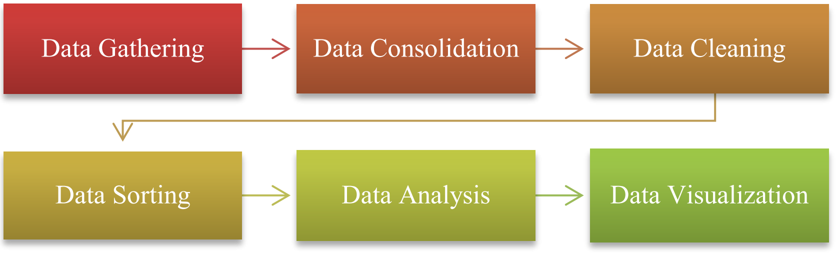

Figure 2: Workflow of data analysis and visualization

E. Data Analysis

As the nation embraces machine learning, AI, automation and digital transformation are crucial in the oil and gas industry. With billions of datasets captured in real-time, automation prevents errors, increases production, and reduces safety risks, evolving rapidly to support the global digital revolution [2].

III. Results and Discussion

With the help of data digitalization, automation and data visualization processes, it is expected to identify as many potential economic ESP candidates from Field D, Field B and Field S.

The automation process as shown in Figure 3 begins with data gathering, followed by data correction and standardization to create a consolidated database. This database is then used with automation commands to integrate internally developed tools for analysis. Output data is stored automatically in the master database, and another automation process visualizes this data. This approach reduced the candidate identification duration by approximately 70% (about 2 months), allowing more time for maturation. It narrowed the candidate list from 383 to 49 strings. Figure 4 illustrates the filtration process and parameters used

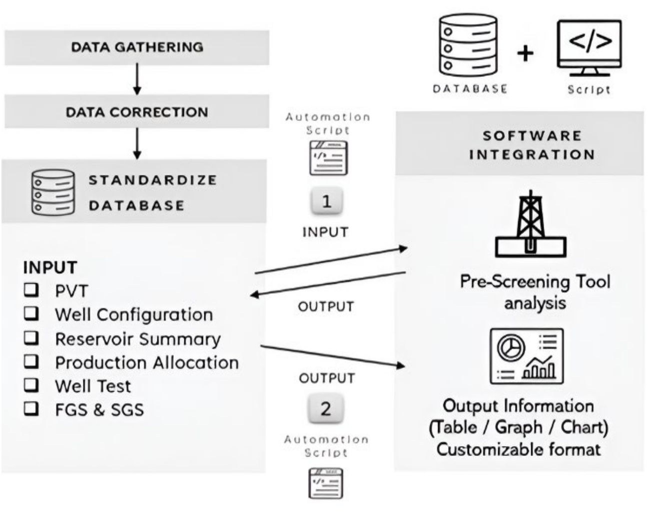

Figure 3: Process of automation and visualization of the data

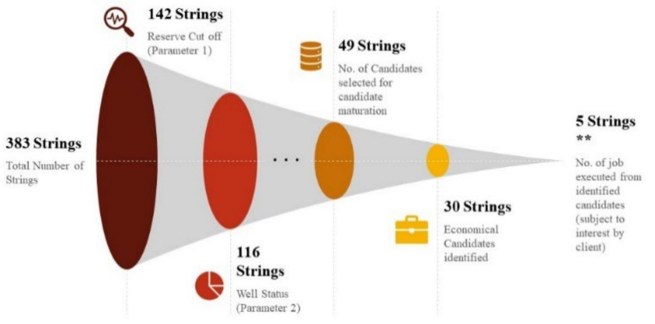

Figure 4: Candidate screening process through data automation

Figure 4 demonstrates the candidate identification process using data automation and digitalization. From the study been conducted for 6 months, it is it found out that automating the screening reduced the process time from 3 months to 1 month, allowing ample time for high-quality technical justification and meeting project deliverables. The standardized automation process minimized human errors, such as incorrect data input, and efficiently managed large data volumes. By incorporating parameters like reserve cut-off and well status, the automation ensured that candidates identified were fit for execution, offering three key benefits: error prevention, efficient data handling, and time savings. An analysis of three fields revealed that Field D had more economical candidates than Fields B and S, primarily due to its higher remaining reserves and simpler job execution. Additionally, Field D had a greater number of active strings, further increasing its candidate count. The final breakdown of the 30 economic candidates is detailed in Table 3.

Data automation and visualization overcame time constraints and ensured timely project delivery. The established opportunity categories facilitate the identification of additional opportunities and advanced technologies for wells with limitations. This process often reveals opportunities that might be overlooked by manual methods.

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Table 3: Breakdown of 30 economic candidate wells

Field	No. wells	No. Strings
Field D	14 Wells	28 Strings
Field B	12 Wells	21 Strings
Field S	4 Wells	5 Strings

IV. Conclusion

In summary, data management, visualization, and automation offer significant advantages over manual workflows, enhancing opportunity identification, best practices, and trend analysis. Digitalizing and automating historical data are as valuable as real-time data for business improvement. However, data quality is crucial; poor data can hinder progress. Ensuring accurate, consolidated data inputs is essential for achieving quality outcomes.

V. Acknowledgement

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