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The Effect of Stroke Length and SPM Variations on Production Rate and Economic Profitability of AH-052 Well

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ABSTRACT

AH-052 well, which uses a Sucker Rod Pump (SRP), began to experience a decline in productivity over time. The performance of the AH-052 oil well in South Sumatra, which uses a Sucker Rod Pump (SRP) as an artificial lift system. This well has a depth of 289.87 meters with a perforation interval of 236.52–238.05 meters. Before optimization, this well produced 264 BFPD with a 97% water cut and a pump efficiency of only 72.28%. Through variations in the SRP pump system parameters, the available equipment specifications were 1 1/4-inch and 1 1/8-inch rods, rod number 109, a 2-inch plunger, a stroke length (SL) of 140 inches, and a pump speed (n) of 5 spm. The parameters used successfully increased pump efficiency significantly to 91.12% and production rate to 381.2 BFPD. Economic feasibility analysis based on the Production Sharing Model Contract Cost Recovery contract model showed very positive results. This project generated a Net Present Value (NPV) of MU$202.08, an Internal Rate of Return (IRR) of 1153%, a Payback Time (PBT) of 0.086 years, and a Profitability Index (PI) of 22.56. Based on these indicators, this optimization project is considered highly financially viable and provides substantial benefits.

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INTRODUCTION

Initially, oil wells can produce through natural flow mechanisms, which occur when the reservoir formation pressure exceeds the hydrostatic pressure in the wellbore. However, over time, a predictable decline in reservoir pressure leads to reduced production rates or, in some cases, a complete cessation of flow. This phenomenon is caused by the depletion of reservoir energy, which renders the reservoir unable to drive fluids from the formation to the surface. Consequently, to sustain production levels in accordance with the well's potential, the implementation of artificial lift methods becomes imperative.

Common artificial lift techniques employed within the oil and gas industry include sucker rod pumps (SRP), hydraulic pumping units (HPU), electric submersible pumps (ESP), progressive cavity pumps (PCP), Gas Lift, and Plunger Elevators. The selection of a specific artificial lift system must take into account reservoir characteristics, wellbore conditions, surface constraints, and other operational variables (Amanda et al., 2019).

Among these methods, the Sucker Rod Pump is widely used to lift oil from the wellbore to the surface (Widiyanto & Syahrial 2022). Over extended operational periods, the productivity of an SRP system may undergo degradation. Such performance declines necessitate a rigorous evaluation to determine the mechanical and volumetric efficiencies of the currently installed pumping unit (Indriani et al., 2025).

Well AH-052 currently utilizes an SRP system as its primary artificial lift method. As of April 1, 2024, the well recorded a gross production rate of 264 BFPD with a 97% water cut (WC), yielding a net oil production of 8 BOPD. To optimize Well AH-052's output, comprehensive reservoir and production data are required, particularly through diagnostic procedures such as sonolog testing. Given the critical role of sonolog surveys in evaluating pump performance, this data is vital for technical redesign. Furthermore, an economic analysis of these well service activities is fundamental to assessing the feasibility and viability of the investment opportunity.

METHODOLOGY

Well AH-052 is an oil production well situated in South Sumatra, utilizing a SRP system as its artificial lift mechanism. The analytical framework for this well incorporates an integrated dataset encompassing pump specifications, wellbore architecture, reservoir properties, and historical production data. Fundamental metrics, including static reservoir pressure (Ps), bottom-hole flowing pressure (Pwf), and oil production rate (Qo), are utilized to determine the Productivity Index (PI) and the inflow performance relationship (IPR), which are essential for evaluating well productivity and performance (Indriani et al., 2025).

The well is completed at a total depth of 289.87 meters (951.063 ft), with the active perforation interval located between 236.52 and 238.05 meters (776.02 – 781.04 ft). Currently, Well AH-052 exhibits a high water cut (WC) of 97% and a gross fluid production rate (Qprod) of 264 barrels of fluid per day (BFPD).

Well and pump data

Comprehensive monitoring of Well AH-052 has yielded an extensive dataset of operational parameters essential for evaluating the performance of the SRP system. Table 1 delineates the specific well production parameters that serve as the foundational data for optimizing the currently operating SRP unit. Furthermore, in addition to production metrics, technical specifications for the pump and wellbore equipment are pivotal for strategic optimization and redesign of the SRP system. The detailed specifications for the pump and associated equipment utilized in Well AH-052 are systematically presented in Table 2.

Table 1. Production data of well AH-052

Parameter	Result	Unit
Total Production Rate	264	BFPD
Bottom Hole Pressure	107,652	Psi
Static Pressure	183,296	Psi
Fluid Gradient	1,43	psi/meter
Oil Production Rate	8	BOPD
Water Production Rate	256	BWPD
Water Cut	97	%
Specific Gravity Oil	0,85	-

Table 1. Production data of well AH-052, (continued).

Parameter	Result	Unit
Specific Gravity of Water	1,01	-
SGmix	1,01	-

Table 2. Pump data of well AH-052

Parameter	Result	Unit
Pump Type	Conventional	
Pump Unit	C-640-305-120	
Peak Torque Rating	640	ln/lb
Polished Rod Rating	305	Ib
Stroke Length	120	Inch
Diameter Casing	7	Inch
Diameter Tubing 2 7/8 (OD)	2,875	Inch
Diameter Tubing 2 7/8 (ID)	2,441	Inch
Diameter Plunger	2,25	Inch
Berat Rod 1	2,9	lb/ft
Berat Rod 7/8	2,22	lb/ft
Luas Area Rod 1	0,785	Inch²
Luas Area Rod 7/8	0,601	Inch²
Stroke Length	120	Inch
Pumping Speed	5	SPM
Service Factor	1	
Crank Pitman Rasio	0,33	
Modulus of Elasticity	30000000	
Displacement Pompa	351,78	BFPD

RESULT AND DISCUSSION

Performance evaluation dictates that the volumetric efficiency of a pumping unit is considered optimal when it falls within the range of 70% to 80% (Brown, 1980). Should the calculated efficiency fall below this established benchmark, subsequent optimization protocols must be implemented. These corrective measures typically involve modifying the plunger diameter, increasing the Strokes Per Minute (*SPM*), and adjusting the pump's stroke length. While achieving a volumetric efficiency exceeding 80% signifies favorable well performance, the system may still be subject to further enhancement. Continual optimization can be pursued to maximize production potential, contingent upon the technical discretion and recommendations of the presiding petroleum engineers.

Evaluation of AH-052 well well production capacity

The determination of the well's productivity begins by calculating the static reservoir pressure (*Ps*) and the bottom-hole flowing pressure (*Pwf*) from fluid level measurements. By utilizing the mid-perforation depth relative to the static fluid level (*SFL*) and the dynamic fluid level (*DFL*), multiplied by the gradient fluid (*GF*) of 0.435, the Ps and Pwf are identified as 183.296 psi and 107.652 psi, respectively.

These pressure values are critical for establishing the Productivity Index (PI), which is calculated at 3.49 BFPD/psi for Well AH-052. Consequently, this index allows estimation of the maximum production potential (Q_{max}), yielding a theoretical capacity of 435.22 BFPD. These parameters collectively provide a comprehensive baseline for evaluating the inflow performance and optimizing the subsequent artificial lift redesign.

Installed pump performance

The mechanical evaluation of the SRP installation begins with a detailed assessment of the rod string and subsurface components. By determining the tubing and plunger areas and rod string percentages for the 1" and 7/8" sections, the total rod weight in the air (Wra) is calculated to be 1,934.96 lb. This data, when integrated with acceleration and impulse factors of 0.0426 and 1.0426, respectively, allows precise determination of the Peak Polished Rod Load (PPRL) at 3,132.05 lb and the Minimum Polished Rod Load (MPRL) at 1,604.42 lb.

Furthermore, the analysis assesses structural integrity through stress calculations, where the maximum stress (σ_{max}) of 3,989.87 psi remains safely below the allowable stress (σ_a) of 29,899.67 psi. Dimensional adjustments, including plunger overtravel (*ep*) and the combined elastic stretch of the rods and tubing (0.9223 inch), are utilized to determine the effective plunger stroke (*Sp*) of 119.12 inches.

These mechanical variables are essential to calculate the peak torque and counterbalance requirements for operational stability. Ultimately, the pump displacement (*PD*) is computed at 351.42 BFPD based on the effective stroke and plunger area. Comparing this theoretical capacity to the actual production rate yields a volumetric efficiency (E_v) of 72.28%. This baseline efficiency indicates that, while the system is functional, there is significant potential to optimize fluid recovery and overall pumping performance.

Optimizing the AH-052 well pump by changing other pump parameters

The optimization process involved re-engineering the Sucker Rod Pump (*SRP*) configuration, using a refined rod string design with 1 ¼-inch and 1 ⅛-inch diameters (Rod No. 109). By reducing the plunger size to inches while simultaneously increasing the stroke length (*SL*) to inches at a constant speed of SPM, the system's volumetric efficiency (E_v) improved significantly to 92%.

Subsequent nodal analysis performed via PIPESIM software validated these adjustments, demonstrating a substantial increase in the production rate to 381.2 BFPD, as illustrated in Figure 1. This technical reconfiguration effectively balances mechanical loads with fluid displacement, ensuring the redesigned system operates at peak performance while maximizing the well's recovery potential.

Analysis of the results of the redesign of the sucker rod pump for well AH-052

The optimization results demonstrate that Well AH-052 achieved a remarkable volumetric efficiency of 91.12%, a significant improvement over the baseline of 72.28%. This technical refinement ensures that the actual production rate (Q_{prod}) remains above 80% of the well's maximum theoretical capacity while stabilizing the initial flow parameters to maintain reservoir integrity. By maximizing the displacement efficiency through the redesigned Sucker Rod Pump (*SRP*) configuration, the system effectively bridges the gap between mechanical potential and fluid recovery. Consequently, the transition from 72.28% to over 91% efficiency underscores the success of the optimization strategy, confirming that the adjusted operational parameters provide a superior balance between pump performance and sustainable production output for Well AH-052.

Table 3. Initial Parameter Data and Pump Optimization

Parameter	Initial Data	Optimization Data
Tubbing	2 7/8 inch	2 7/8 inch
Rod	1 1/8	1
Plunger	2 inch	2 ¼ inch
Stroke Length	120 inch	140 inch
Pumping Speed	5 SPM	5 SPM

Economic analysis

The economic viability of the AH-052 well optimization is evaluated using key performance indicators within the Production Sharing Contract (*PSC*) Cost Recovery framework, specifically Net Present Value (*NPV*), Internal Rate of Return (*IRR*), Payback Time (*PBT*), and Profitability Index (*PI*). The capital expenditure for the well service and Sucker Rod Pump (*SRP*) reconfiguration is estimated at US$ 9,375.

Revenue projections are derived from an incremental oil gain of 11.43 BOPD, calculated under the assumption of a US$ 90 per barrel oil price and a 10% annual decline rate over a two-year monitoring period. Commencing in April 2024, the financial analysis incorporates a 10% annual discount rate (Rate of Return) to determine the present value of future cash flows.

This comprehensive tabulation of the NPV accounts for the fiscal dynamics of the Indonesian petroleum industry, ensuring that the investment reflects both operational costs and the time value of money. The following calculations provide a quantitative basis for assessing whether the production enhancements translate into a robust and sustainable investment opportunity. Based on the financial

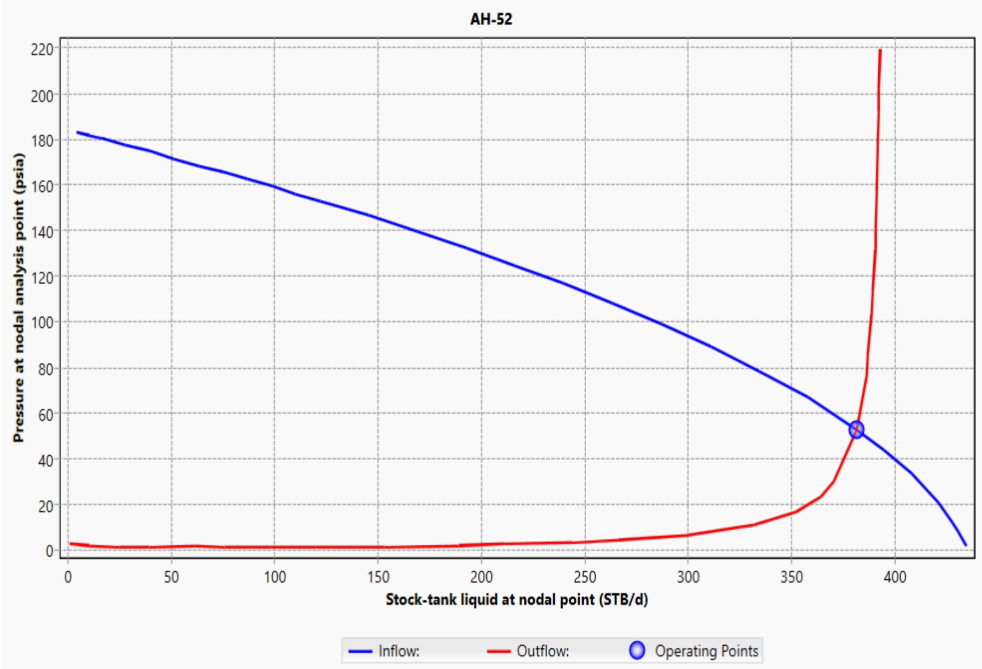

Figure 1. Nodal curve analysis after AH-052 well

Table 4. Economic calculation results

Parameter	Unit	Result
Production		
- Oil Production	bopd	11,43
Price		
- Oil Price	USD/bbls	90
- Condensed Price	USD/bbls	90
Cost Production		
- Oil Cost Production	USD/bbls	20
- Condense Cost Production	USD/bbls	20
GROSS REVENUE	MUS$	751
- Oil Gross Revenue	MUS$	751
FTP	MUS$	38
Gross Revenue - FTP	MUS$	713
EXPENDITURE	MUS$	177
- Investment Cost	MUS$	9
- Investment Capital Cost	MUS$	9
- Investment Non-Capital Cost	MUS$	0
- Abandonment & Site Restoration	MUS$	1
- Operating Cost	MUS$	167
- Depreciation	MUS$	10
Cost Recovery	MUS$	173
EQUITY TO BE SPLIT	MUS$	541
Government Take	MUS$	347
Contractor Take	MUS$	231
NPV	MUS$	202,08
ROR	%	1153
POT	Years	0,086
Net Profit	MUS$	227
Net Profit Margin	%	128,05
PI		22,56

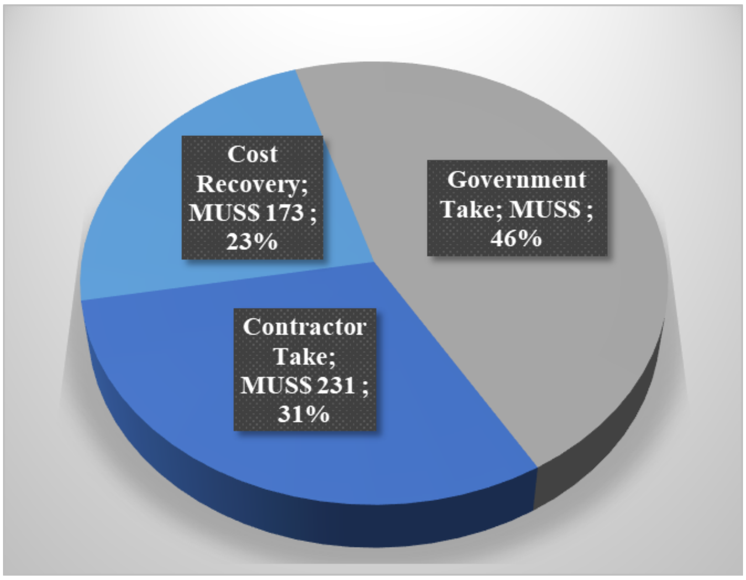

Figure 2. Skema production sharing contract cost recovery

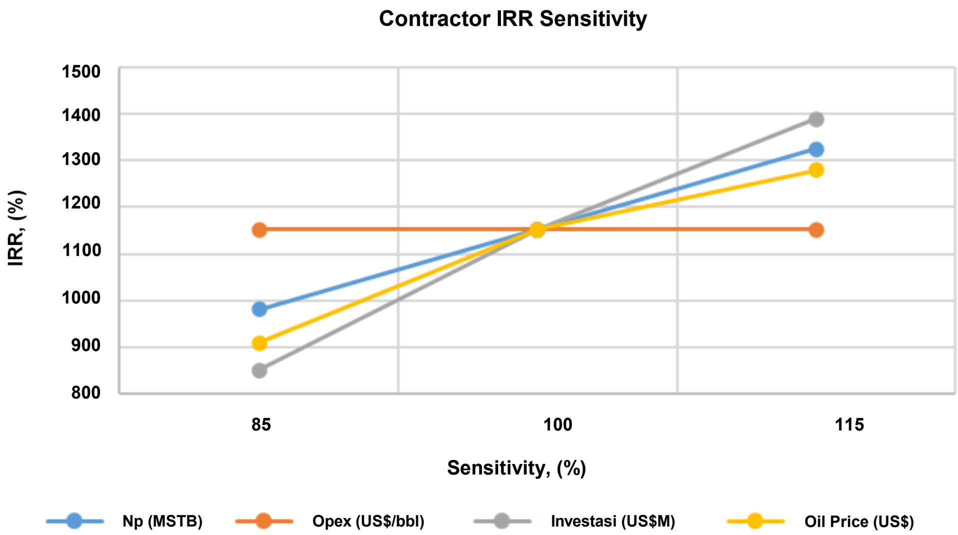

Figure 3. Contractor IRR sensitivity analysis

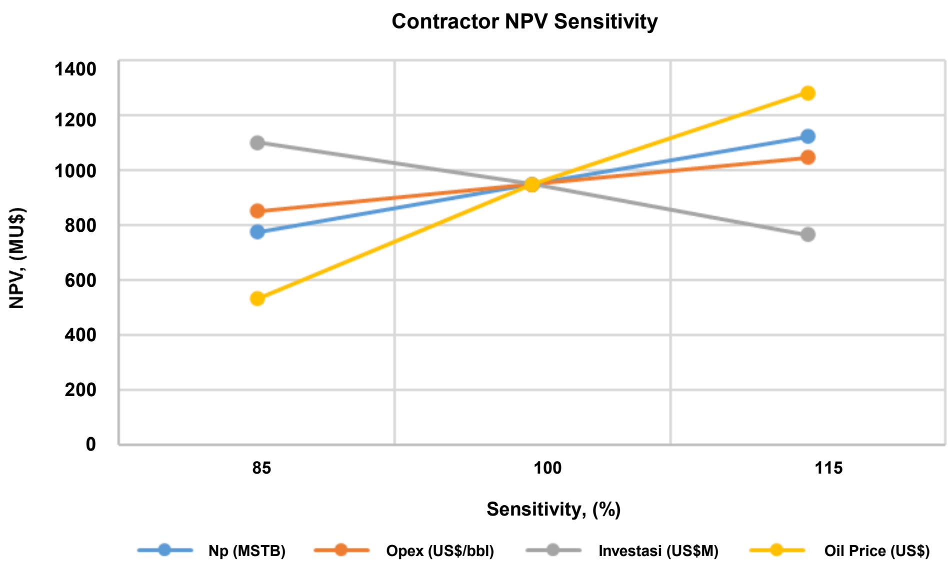

Figure 4. Contractor NPV Sensitivity Analysis

data presented in Table IV, the optimization of Well AH-052 yields a net present value (NPV) of MUS$ 202.08. The internal rate of return (IRR) is calculated at an exceptional 1153%, far exceeding the minimum attractive rate of return, thereby confirming the project's robust feasibility. Furthermore, the pay out time (POT) is remarkably brief at 0.086 years, or less than one month, indicating that the initial capital expenditure is recovered almost immediately, effectively minimizing investment risk.

The project generates a Net Profit of MUS$ 227 with a Net Profit Margin of 128.05%. This substantial margin, exceeding 100%, indicates that net gains significantly outweigh initial investment costs, reflecting extraordinary operational efficiency and low-cost well service execution. Such figures underscore the intervention's high profitability relative to the capital employed.

Finally, the profitability index (PI) is 22.56. Since this value is considerably greater than 1.0, the project is classified as highly attractive from a financial perspective, implying that every dollar invested generates a present value of $22.56. The detailed fiscal distribution under the production sharing contract (PSC) Cost Recovery scheme is further illustrated in Figure 2, providing a clear overview of the revenue sharing between the contractor and the state.

The sensitivity of the Contractor's Internal Rate of Return (IRR) in Figure 3 relative to fluctuations in key operational and economic variables. The data reveal that Capital Investment (Investasi) and Cumulative Production (Np) exert the most profound influence on project profitability, as evidenced by the steep gradients of their respective trajectories. Conversely, Operating Expenditure (Opex) shows a negligible impact, maintaining a nearly horizontal trend, while Oil Price variations show a moderate positive correlation with the IRR, albeit less volatile than investment costs.

Net Present Value (NPV) highlights the critical roles of Oil Price and Capital Investment as the primary drivers of project value. The steep slope of the Oil Price curve in Figure 4 suggests that the project's net valuation is highly sensitive to market volatility, while Investment costs show a significant negative relationship with NPV. In contrast, the impacts of Cumulative Production (Np) and operating expenditure (Opex) are relatively marginal, indicating that these factors have a lower marginal effect on the overall net present value than price and investment.

CONCLUSION

The redesign and optimization of the SRP system in Well AH-052 have yielded a substantial improvement in operational performance, with volumetric efficiency increasing from 72.28% to 91.12%. By utilizing available workshop inventory, specifically a tapered rod string of 1 ¼-inch and 1 ⅛-inch (Rod No. 109), a 2-inch plunger, a 140-inch stroke length, and a speed of 5 SPM, the gross production rate rose from 264 BFPD to 381.2 BFPD. Economic evaluation under the production sharing contract (PSC) Cost Recovery framework further validates this intervention, as evidenced by a net present value (NPV) of MUS$ 202.08, an exceptional internal rate of return (IRR) of 1153%, a rapid pay out time (POT) of 0.086 years, and a profitability index (PI) of 22.56. Collectively, these indicators confirm that the well intervention is not only technically feasible but also represents a highly attractive investment opportunity with minimal financial risk and superior capital efficiency.

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GLOSSARY OF TERMS AND SYMBOLS

Terms & Symbols	Definition	Unit
$Inch^2$	Plunger Area	Ap
$Inch^2$	Rod String Area	Ar
$Inch^2$	Area of Tubbing	At
	Barel fluid per day	BFPD
	Barel oil per day	BOPD
	Barrel water day	BWPD

lb	Counter Balance	Cb
ft	Dynamic fluid level	DFL
Inch	Plunger Overtravel	ep
Inch	Rod Stretch 1	er_1
Inch	Rod Stretch 2	er_2
Inch	Tubing Stretch 1	et_1
Inch	Tubing Stretch 2	et_2
%	Volumetric Efficiency of Pumps	Ev
	Feet	ft
US$	First Trache Petroleum	FTP
psi/ft	Fluid Gradient	GF
%	Internal Rate of Return	IRR
	Konstanta	K
ft	Rod Length 1	Lr1
ft	Rod Length 2	Lr2
lb	Minimum Polished Rod Load	MPRL
US$	Net Present Value	NPV
BFPD	Pump displacement	PD
	Profitability Index	PI
year	Payback Period	POT
lb	Peak Polished Rod Load	PPRL
	Static pressure	Ps
	Well flowing pressure	Pwf
	Maximum Flow Rate	Qmax
	Production Flow Rate	Qprod
ft	Static fluid level	SFL
Inch	Plunger Stroke	Sp
	Strokes per minute	SPM
	Sucker rod pump	SRP
%	Water Cut	WC
lb	Weight fluid	Wf
	Total Weight of Rod	Wr total
	Weight of Rod in Air	Wra
psi	Stress allowable	σa
psi	Stress maximum	σmax
psi	Stress minimum	σmin

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