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Selection & Optimization of Artificial Lift Using Delphi, TOPSIS, and SAW Methods for Natural Flow Oil Wells at HAS Field

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ABSTRACT

The HAS field started producing oil and gas in 2004 until 2018, production wells in HAS experienced a decrease in oil production from 45,000 bopd to 6,190 bopd and an increase in water production from 0 bwpd to 20,463 bwpd. The decline in production occurs due to increased water production. The decrease in production was caused by a decrease in reservoir pressure, causing a larger water cut. Therefore, it is necessary to optimize production wells by considering the things mentioned above.

The artificial lift selection method used is the Delphi method which has 21 screening parameters combined with the Topsis method; helps facilitate Decision-Making from various complex alternatives, by conducting comprehensive comparisons between each alternative and using the Simple Additive Weighting (SAW) method; known as the weighted addition method. The selection of the Artificial Lift in the HAS Field was carried out based on the reservoir parameters, production, well construction, and the economic factors of the artificial lift used. The artificial lift method that will be used in the HAS Field is the Electrical Submersible Pump (ESP). Based on the results of the selection of an artificial lift with a combined method of Delphi, Topsis, and SAW,

Efforts to increase production with an electric submersible pump (ESP) are carried out by optimizing the number of stages and setting the frequency to a value of 45 Hz. Further optimization is carried out by gradually changing the pump frequency up to a maximum of 60 Hz, without changing the pump type. From the results of the economic analysis in the HAS Field, it was found that the most economical scenario was to use an ESP pump with the highest NPV@10 % value than the other scenarios, namely 434.85 MUS$.

Keywords : Artificial Lift Conversion; Delphi; Topsis; SAW; Optimization

1. PRELIMINARY

The HAS field produces oil and gas through production wells in PAD-A and PAD-B. Several things behind the implementation of this research are the long-term plan for the HAS field, optimization of oil well production in the HAS field, and the efficiency of gas production to increase oil well production. The purpose of this study is to analyze oil wells in the HAS Field that have the potential to increase their production with Artificial Lift and obtain recommendations and the results of Artificial Lift designs for suitable and efficient well candidates.

Problems arise when oil production drops drastically followed by a significant increase in water cut during the period from 2012 to 2018. It can be seen in Figure 1 that oil production was 40,000 bopd in 2012 and decreased to 6,190 bopd in 2018. The main cause is a decrease reservoir pressure of natural flow oilwell, this can be indicated due to a decrease in the rate of liquid production.

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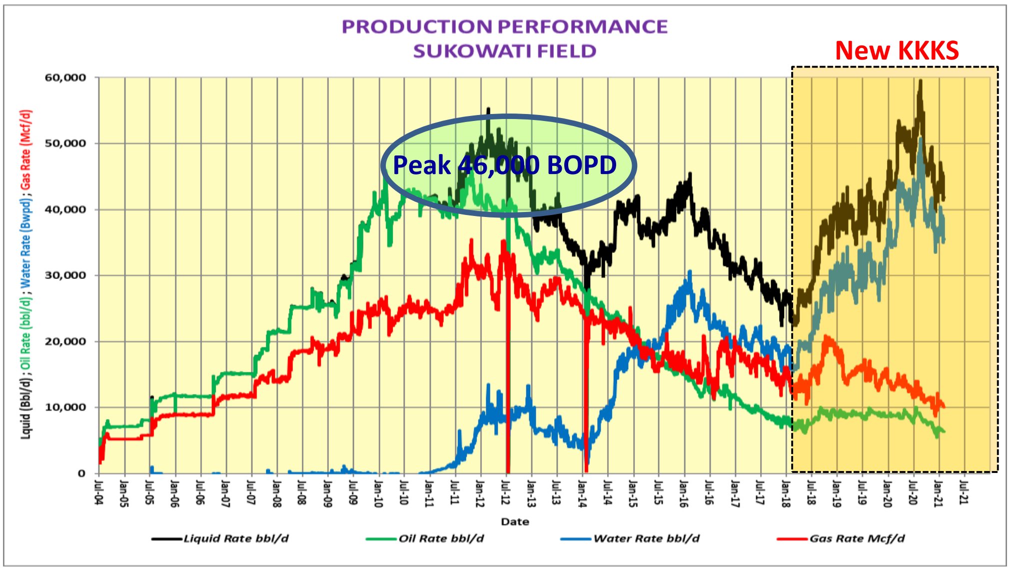

Image 1.HAS Field Production Performance

2. METHOD

The selection of the Artificial Lift in the HAS Field was carried out based on the reservoir parameters, production, well construction, and the economic factors of the artificial lift used, so that it could match the actual conditions of each well.

In the artificial lifting screening method, the initial step taken is to collect reservoir data, production, wellbore profiles, and surface equipment in the HAS Field, then the next steps taken are:

- determine the parameters for artificial lift screening using the Delphi method,
- evaluate each artificial lift using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method,
- evaluate each each artificial lift using the Simple Additive Weighting (SAW) method,
- selecting an artificial lift based on the results of a combination of 3 screening methods,
- carry out design and optimization scenarios for selected artificial lifts,
- perform economic calculations and analysis.

3. DISCUSSION

Delphi method

The DELPHI method, also known as the expert investigation method, combines the opinions, experiences, and knowledge of experts regarding the determination of the factors or parameters that affect the Artificial lift selection process. Based on the literature, there are 21 parameters and weighting limits/assessments that apply to the selection of Artificial Lift, which are obtained from the analysis using the DELPHI method, as shown in Table 1.

After knowing the parameters and weighting values in the artificial lift screening, the next step is the scoring process for each parameter, based on the existing criteria in the literature, as shown in Table 2. The scoring is based on the level of conformity between the input values and the criteria from literature, with a range score:

- Score 5: Input value fall within the range of criteria from the literature
- Score 4, 3, 2: Input value close to the criteria range from the literature
- Score 1: Input value is not fall within the range of criteria from the literature

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Table 1. Delphi Method Screening Parameters

SCREENING ARTIFICIAL LIFT				
No	**Parameter**		**Unit**	**Weighting Factor***
1	**Well Geometry**	Depth	ft	8
2		Well Deviation	Degree	5
3		Dog Leg Severity	Degree/100 ft	8
4		Casing Diameter	Inch	8
5		Dual Completion	Yes = 1, No = 0	5
6	**Production Characteristics**	Liquid Production	BPD	5
7		Gas Liquid Ratio	SCF/STB	5
8		Watercut	%	5
9		Bottom Hole Pressure	Psi	8
10		Bottom Hole Temperature	^{0}F	8
11		Oil Gravity	^{0}API	5
12		H_2S Content	%	10
13		CO_2 Content	% Mole	5
14		Wax Content	%	5
15		Sand Problem	Yes = 1, No = 0	5
16		Scale Problem	Yes = 1, No = 0	5
17		Paraffin Problem	Yes = 1, No = 0	5
18		Corrosive Fluid	Yes = 1, No = 0	5
19		Intermittent Flow	Yes = 1, No = 0	5
20	**Drive Mechanism**	Water Drive	Yes = 1, No = 0	8
21		Depletion or Gas Cap Drive	Yes = 1, No = 0	8

Table 2. Scoring parameters

SCREENING ARTIFICIAL LIFT														
No	**Parameter**		**Unit**	**Weighting Factor***	**Scoring**									
					ESP					**GAS LIFT**				
					5	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**
1	**Well Geometry**	Depth	ft	8	0-7600	7600-8000	8001-8300	8301-15000	>15000	0-7600	7600-8000	8001-8300	8301-15000	>15000
2		Well Deviation	Degree	5	0-50	50-55	55.1-60	60.1-65	>65	0-50	50-55	55.1-60	60.1-65	>65
3		Dog Leg Severity	Degree/100 ft	8	<2	2.1-3	3.1-4.9	5-7	>7	<2	2.1-3	3.1-4.9	5-7	>7
4		Casing Diameter	Inch	8	>3.5					>3.5				
5		Dual Completion	Yes = 1, No = 0	5	1				0	1				0
6	**Production Characteristics**	Liquid Production	BPD	5	>2000	1999.9-1500	1499.9-1250	1249.9-1000	<1000	>2000	1999.9-1500	1499.9-1250	1249.9-1000	<1000
7		Gas Liquid Ratio	SCF/STB	5	<100	100.1-1000	1001-2000	2001-3000	>3000	>1000	1000-800	800-600	600-400	<400
8		Watercut	%	5	0-100					<10	10.1-12	12.1-15	15.1-20	>20
9		Bottom Hole Pressure	Psi	8	<3000	3001-3500	3501-4000	4001-4500	>4500	<1250	1250-1000	1000-500	500-200	<200
10		Bottom Hole Temperature	^{0}F	8	<200	200.1-225	225.1-235	235.1-250	>250	<200	200.1-2355	235.1-245	245.1-250	>250
11		Oil Gravity	^{0}API	5	<42	42-35	30.1-35	30-20	<20	<42	42-35	30.1-35	30-20	<20
12		H_2S Content	%	10	0	0.1-3	3.1-5	5.1-10	>10	0	0.1-3	3.1-5	5.1-10	>10
13		CO_2 Content	% Mole	5	<30	30 - 34.9	35-39.9	40-45	>45	<35	35-39.9	40-45	45.1-50	>50
14		Wax Content	%	5	0-1	1.1-5	5-9.9	10-15	>15	0-1	1.1-9.9	10-15	15.1-20	>20
15		Sand Problem	Yes = 1, No = 0	5	1				0	1				0
16		Scale Problem	Yes = 1, No = 0	5	1				0	1				0
17		Paraffin Problem	Yes = 1, No = 0	5	1				0	1				0
18		Corrosive Fluid	Yes = 1, No = 0	5	1				0	1				0
19		Intermittent Flow	Yes = 1, No = 0	5	1				0	1				0
20	**Drive Mechanism**	Water Drive	Yes = 1, No = 0	8	1				0	0				1
21		Depletion or Gas Cap Drive	Yes = 1, No = 0	8	0				1	1				0

After drilling and scoring for each parameterthen an assessment can be made for the wells in the HAS field, as shown in Table 3

.

Table 3. Parameter Assessment in Artificial Lift Screening (HAS-12)

No	Parameter		Unit	Value	Score		Weighting Factor*
					ESP	GL	
1	Well Geometry	Depth	ft	**6727**	5	5	8
2		Well Deviation	Degree	**19,58**	5	5	5
3		Dog Leg Severity	Degree/100 ft	**0,29**	5	5	8
4		Casing Diameter	Inch	**7**	5	5	8
5		Dual Completion	Yes = 1, No = 0	**0**	5	5	5
6	Production Characteristics	Liquid Production	BPD	**1756,9**	5	1	5
7		Gas Liquid Ratio	SCF/STB	**311,9**	4	5	5
8		Watercut	%	**80,658**	5	1	5
9		Bottom Hole Pressure	Psi	**2493,9**	5	1	8
10		Bottom Hole Temperature	^{0}F	**242**	1	1	8
11		Oil Gravity	^{0}API	**39,1**	4	4	5
12		H_2S Content	%	**2,2**	4	4	10
13		CO_2 Content	% Mole	**36**	2	4	5
14		Wax Content	%	**0**	5	5	5
15		Sand Problem	Yes = 1, No = 0	**0**	5	5	5
16		Scale Problem	Yes = 1, No = 0	**0**	5	5	5
17		Paraffin Problem	Yes = 1, No = 0	**0**	5	5	5
18		Corrosive Fluid	Yes = 1, No = 0	**0**	5	5	5
19		Intermittent Flow	Yes = 1, No = 0	**0**	5	5	5
20	Drive Mechanism	Water Drive	Yes = 1, No = 0	**1**	5	1	8
21		Depletion or Gas Cap Dri	Yes = 1, No = 0	**0**	5	5	8

After assessing each parameter for the wells in the HAS field, the next step is to conduct an assessment using the Topsis method and the Simple Additive Weighting (SAW) method.

TOPSIS method

Topsis is a method for multi-criteria decision analysis (Hwang and Yoon, 1981), which is an attempt to help facilitate Decision-Making from various complex alternatives, by making comprehensive comparisons between each alternative.

This method is carried out by evaluating 21 parameters as was done in the Delphi method. After assessing each parameter, the next step is to add up the scores for each parameter. Then calculate the Distance (Di) for the positive solution and the negative solution as shown in Table 4. Then calculate the Relative Closeness (Ci) value for each artificial lift. If the relative close (Ci) value is close to 1, then artificial lift is the optimal artificial lift solution/method to be used.

Distance (Di) positive formula:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(y_i^+ - y_{ij}\right)^2};$$

Distance (Di) negative formula:

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_i^-\right)^2}$$

Relative Proximity Formula (Ci):

$$C_i = \frac{D_i^-}{D_i^- + D_i^+}$$

Table 4. Tabulation of Di+ and Di- Value Calculation Results (HAS-12)

PARAMETER	SCORE			NORMALIZATION		Pij		Ej	dj	Wj	Vij			A +	A -	(A+ - Vij)^2		(A- - Vij)^2	
	ESP	GL	SUM	ESP	GL	ESP	GL				ESP	GL	SUM			ESP	GL	ESP	GL
1	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
3	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
4	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
5	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
6	5	1	6	0,98	0,20	0,833	0,167	0,650	0,350	0,157	0,153	0,031	0,184	0,153	0,031	0,000	0,015	0,015	0,000
7	4	5	9	0,62	0,78	0,444	0,556	0,991	0,009	0,004	0,002	0,003	0,006	0,003	0,002	0,000	0,000	0,000	0,000
8	5	1	6	0,98	0,20	0,833	0,167	0,650	0,350	0,157	0,153	0,031	0,184	0,153	0,031	0,000	0,015	0,015	0,000
9	5	1	6	0,98	0,20	0,833	0,167	0,650	0,350	0,157	0,153	0,031	0,184	0,153	0,031	0,000	0,015	0,015	0,000
10	1	1	2	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
11	4	4	8	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
12	4	4	8	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
13	2	4	6	0,45	0,89	0,333	0,667	0,918	0,082	0,037	0,016	0,033	0,049	0,033	0,016	0,000	0,000	0,000	0,000
14	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
15	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
16	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
17	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
18	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
19	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
20	5	1	6	0,98	0,20	0,833	0,167	0,650	0,350	0,157	0,153	0,031	0,184	0,153	0,031	0,000	0,015	0,015	0,000
21	5	5	10	0,71	0,71	0,500	0,500	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Based on the values of Di+ and Di– in each of the parameters shown in Table 4, the calculation of the Relative Value (Ci) for each artificial lift is carried out, the next step is to calculate the value of relative closeness (Ci). Artificial Lift with a relative proximity value close to 1 is the optimal artificial lift solution/method.

Table 5. Calculation results of Di and Ci values (HAS-12)

Artificial Lift	Di +	Di-	Relative Closeness	Rank
ESP	0.031	0.273	0.90	1
GL	0.273	0.031	0.10	2

From the results of the calculation of the Ci value, it can be seen that the optimal artificial lift for the HAS-12 Well based on 21 screening parameters using the TOPSIS method is ESP for rank 1 and Gas Lift for rank 2.

Simple Additive Weighting (SAW) Method

The next step is to validate the results of the TOPSIS screening method by comparing the results of the TOPSIS screening method using the results of the artificial lift screening with the Simple Additive Weighting (SAW) method.

The SAW method is often known as the weighted addition method. The basic concept of the SAW (Simple Additive Weighting) method is to find the total weight of each parameter. This method is done by determining the value (score) for each parameter and then multiplying the parameter score by the weighting factor for that parameter. The artificial lift with the highest total score is the optimal artificial lift to apply. The SAW method is a scoring combination method assigned to the parameter with the expected effect on each possible alternative. This is the most frequently used method because it is relatively simple. (Rodriguez. et al, 2018).

If the results between the selection using the Topsis method are the same as the SAW method, it can be seen that the results of the selection based on these 21 parameters can be used/applied to the HAS-12 well.

In this SAW method, the calculation for the value of each parameter is carried out by multiplying the score parameter by the weighting factor of the parameter, an example of the calculation for the depth parameter is as follows,

- Parameter 1 (Depth - ESP)
  Aj ESP : Weighting Factor x ESP Score
  Aj ESP : 8 x 3
  Aj ESP : 24
- Parameter 1 (Depth – Gas Lift)
  Aj GL : Weighting Factor x GL Score
  Aj GL : 8 x 3
  Aj GL : 24

After that, do the sum of 21 parameters for each artificial lift, as shown in Table 6.

Table 6. Calculation Results using the SAW Method (HAS-12)

PARAMETER	Weighting Factor*	SCORE		Aj	
		ESP	GL	ESP	GL
1	8	5	5	40	40
2	5	5	5	25	25
3	8	5	5	40	40
4	8	5	5	40	40
5	5	5	5	25	25
6	5	5	1	25	5
7	5	4	5	20	25
8	5	5	1	25	5
9	8	5	1	40	8
10	8	1	1	8	8
11	5	4	4	20	20
12	10	4	4	40	40
13	5	2	4	10	20
14	5	5	5	25	25
15	5	5	5	25	25
16	5	5	5	25	25
17	5	5	5	25	25
18	5	5	5	25	25
19	5	5	5	25	25
20	8	5	1	40	8
21	8	5	5	40	40
TOTAL				**588**	**499**

The artificial lift with the highest total score is the optimal artificial lift to be applied to the HAS-12 well. From the results of screening using the Simple Additive Weighting (SAW) method, it can be seen that the optimal artificial lift for use in the HAS-12 Well is ESP for the first rank and Gas Lift for the second rank, as shown in Table 7.

Table 7. Total Value of SAW Method for HAS-12 . Well

Artificial Lift	Total Score	Rank
ESP	588	**1**
GL	499	**2**

By using a combination of the Delphi, Topsis, and Simple Additive Weighting (SAW) methods, the results of screening for 22 wells in the HAS Field are shown in Table 8.

Table 8. Results of Screening for Artificial Lift in HAS Field

	Sumur	Ql, BLPD	WC, %	LIFTING	KANDIDAT ARTIFICIAL LIFT	
					RANK 1	RANK 2
1	SKW-02	2270.16	76.65	Natural Flow	ESP	Gas Lift
2	SKW-03	3468.26	79.58	Natural Flow	ESP	Gas Lift
3	SKW-07	3502.37	81.73	Natural Flow	ESP	Gas Lift
4	SKW-10	1997.67	96.93	Natural Flow	ESP	Gas Lift
5	SKW-12	1756.85	80.66	Natural Flow	ESP	Gas Lift
6	SKW-14	91.72	35.14	Natural Flow	ESP	Gas Lift
7	SKW-15	235.70	61.08	Natural Flow	ESP	Gas Lift
8	SKW-16	235.76	93.85	Natural Flow	ESP	Gas Lift
9	SKW-17	2538.33	94.80	Natural Flow	ESP	Gas Lift
10	SKW-18	2060.48	95.92	Natural Flow	ESP	Gas Lift
11	SKW-19	1838.47	80.66	Natural Flow	ESP	Gas Lift
12	SKW-21	2249.93	53.55	Natural Flow	ESP	Gas Lift
13	SKW-23	1205.88	91.37	Natural Flow	ESP	Gas Lift
14	SKW-24	2467.05	91.41	Natural Flow	ESP	Gas Lift
15	SKW-27	2167.31	75.63	Natural Flow	ESP	Gas Lift
16	SKW-28	1964.59	41.35	Natural Flow	ESP	Gas Lift
17	SKW-29	219.75	91.71	Natural Flow	ESP	Gas Lift
18	SKW-30	866.30	1.97	Natural Flow	ESP	Gas Lift
19	SKW-32	4295.75	96.17	Natural Flow	ESP	Gas Lift
20	SKW-33	1678.68	94.95	Natural Flow	ESP	Gas Lift
21	SKW-35	3466.43	93.50	Natural Flow	ESP	Gas Lift
22	SKW-36	369.57	43.01	Natural Flow	ESP	Gas Lift

Artificial lift optimization

Determination of the electric submersible pump (ESP) optimization method that considers the economic limit value of the well for the installation of an artificial lift of 23 BOPD and a critical rate of 1000 – 1300 BLPD in the HAS field.

Optimizing with an electric submersible pump (ESP) is done by optimizing the number of stages and setting the frequency to a value of 45 Hz. Further optimization is carried out by gradually changing the pump frequency to a maximum of 60
Hz, without changing the pump type.

HAS-12

Production of HAS-12 started on August 5, 2009 until January 28, 2021, with the latest production flow rate, namely oil production rate (Qo) of 339.82 BOPD, water production rate (Qw) of 1417.08 BWPD, liquid production rate (Ql) is 1756.89 BLPD, gas production rate (Qg) is 0.55 MMSCFD and water cut is 80.66%. The HAS-12 will be optimized with an Electric Submersible Pump (ESP) when the oil flow rate reaches 23 BOPD. After the ESP optimization was carried out, the oil production rate (Qo) became 27.2 BOPD, and the inflow vs outflow graph after optimization is shown in Figure 2. Table 9. shows the optimization of HAS-02. Figure 3 shows the results of the basecase prediction until December 31, 2030. While Figure 4 is the result of the plot between Basecase vs ESP Optimization with Cumulative oil until December 31, 2030 is 1588.94 STB.

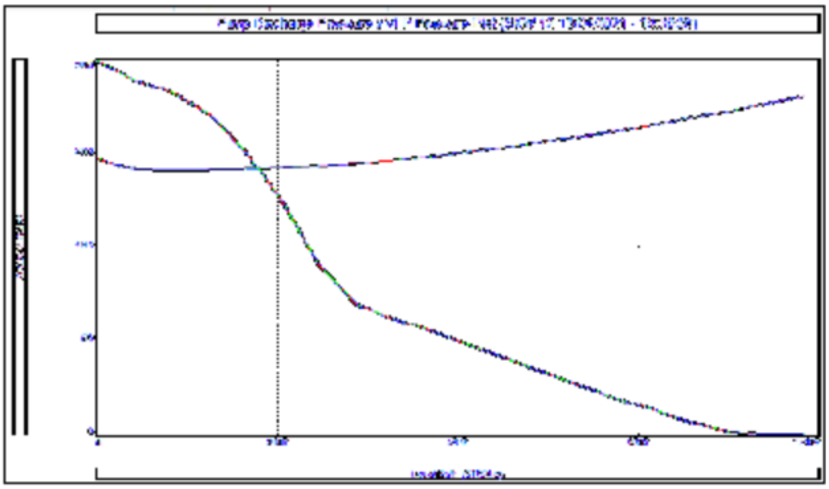

Figure 2. Inflow vs. Outflow After ESP Optimization in HAS-12

Table 9 HAS-12 . ESP Optimization Results

SUMUR	ESP		START SIMULATION	OPTIMATION 1	
	PUMP	STAGES	DATE	DATE	SPEED, HZ
SKW-12	CENTRILIFT K34	99	28/01/2021	28/12/2029	45

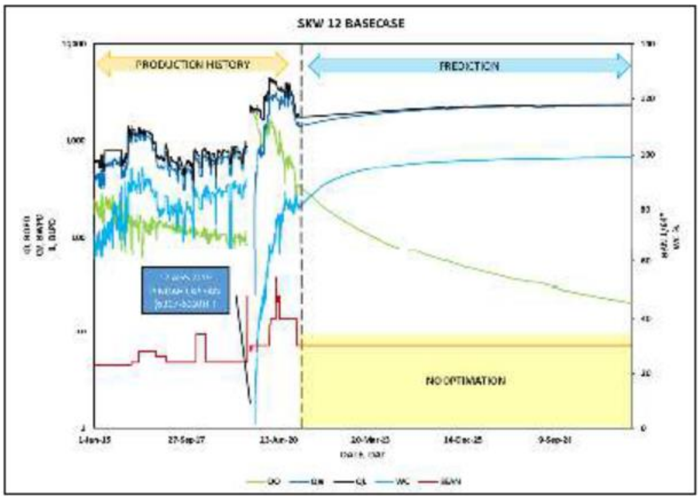

Figure 3. HAS-12 Well Basecase Prediction

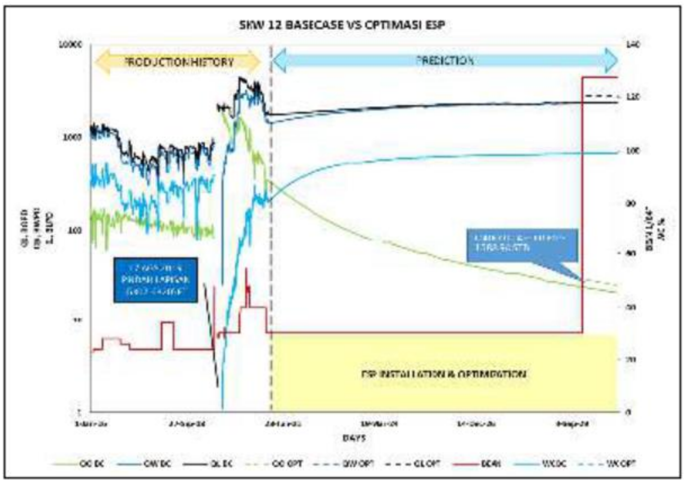

Figure 4. Basecase vs Well Optimization in HAS-12

HAS-18

HAS-18 started production on February 19, 2012 until January 28, 2021 (cut off date) with the production rate at the cut off date for oil (Qo) is 75 BOPD, water rate (Qw) is 1763.56 BWPD, liquid rate (Ql) is 1838.56 BLPD, and the gas rate (Qg) is 0.21 MMSCFD. The HAS-18 will be optimized with an Electric Submersible Pump (ESP) when the oil flow rate reaches 23 BOPD. After the ESP optimization was carried out, the oil production rate (Qo) became 29.4 BOPD, and the graph of inflow vs outflow after optimization was shown in Figure 5. Table 10 shows the optimization of HAS-18. Figure 6 shows the results of the basecase prediction until December 31, 2030. While Figure 7 is the result of the plot between Basecase vs ESP Optimization with Cummulative oil up to December 31, 2030 of 202.68 STB.

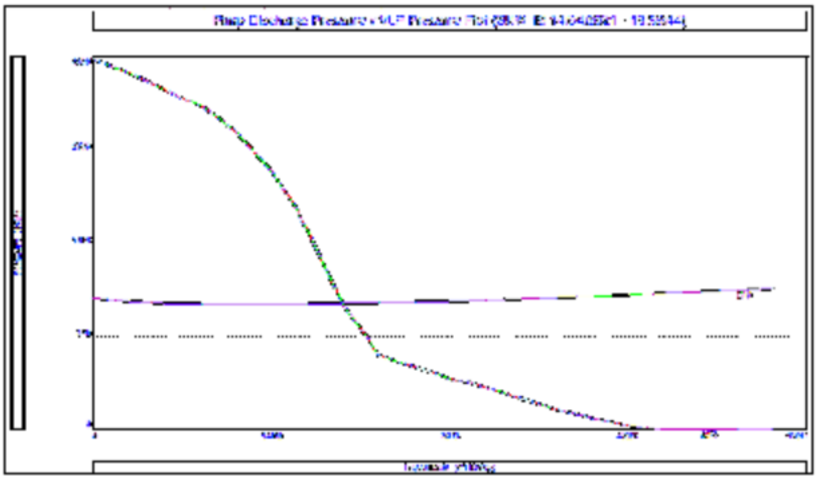

Figure 5.Inflow vs Outflow After ESP Optimization in HAS-18

Table 10. HAS-18 . ESP Optimization Results

SUMUR	ESP		START SIMULATION	OPTIMATION 1		OPTIMATION 2	
	PUMP	STAGES	DATE	DATE	SPEED, HZ	DATE	SPEED, HZ
SKW-18	CENTRILIFT P17	103	28/01/2021	19/06/2024	52	31/10/2024	60

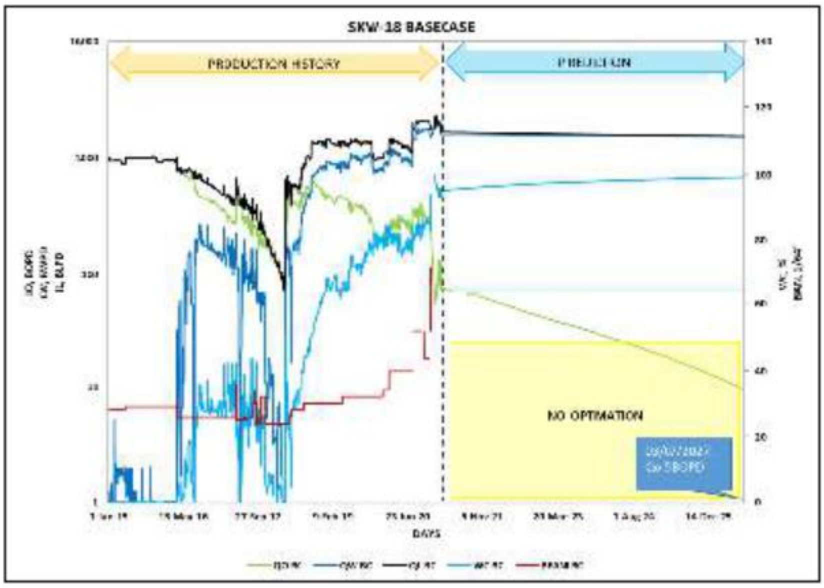

Figure 6.HAS-18 Well Basecase Prediction

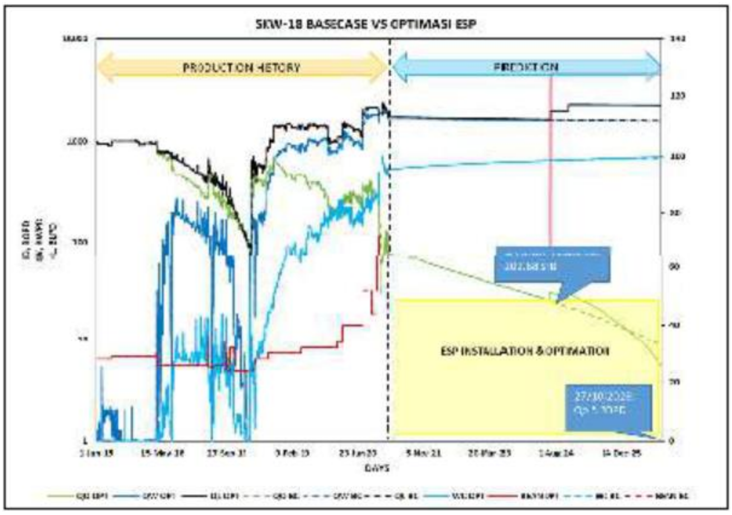

Figure 7.Basecase vs Well Optimization in HAS-18

Economic Analysis Scenario

Optimization of production carried out in the HAS Field is carried out with 2 (two) types of Artificial Lift, namely Electrical Submersible Pump (ESP) and Gas lift. Optimization with Gas Lift is carried out by 2 (two) types of gas injection, namely clean gas obtained from gas purchases at Gasuma or obtained from H2S & CO2 Removal and raw gas obtained directly from bore gas which is injected into the well using gas. lift.

Based on the optimization efforts carried out using two types of artificial lifts, namely ESP and gas lift, in the economic analysis of the HAS field, 5 (five) scenarios of economic calculation results from optimization and 1 (one) calculation of production base case are used, with the details of the scenarios as follows:

1. Basecase

Basecase is the economic calculation of the HAS Field without optimization on the existing lifting conditions.

2. Scenario I (ESP Lease)

Scenario I is the economic calculation of the HAS Field with the existing lifting converted into ESP which is rented from the vendor.

3. Scenario II (Gas Lift + Clean Gas From Gasuma)

Scenario II is an economical calculation with the existing lifting which is converted into a gas lift by gas injection using clean gas purchased from Gasuma.

4. Scenario III (Gas Lift + Clean Gas From H2S & CO2 Removal)

Scenario III is an economic calculation with the existing lifting which is converted into a gas lift by gas injection using clean gas from clean wells in the HAS Field with H2S & CO2 Removal.

The time schedule for economic scenarios, 1 (one) basic economic analysis scenario and 2 (two) optimization results economic analysis scenarios are shown in Table 11.

Table 11. HAS Field Optimization Scenario Timeline

NO.	SKENARIO	SKENARIO OPTIMASI LAPANGAN									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	BASECASE										
2	RENT ESP										
3	GAS LIFT CLEAN GAS FROM GASUMA										
4	GAS LIFT CLEAN GAS FROM H2S & CO2 REMOVAL										

Economic Calculation Results

The results of the field economic analysis for each scenario can be seen in Table 12. From the results of the economic analysis, it can be seen that the scenario that uses ESP is the scenario that has the highest oil production value with the lowest investment value, thus obtaining a higher NPV when compared to the scenario using gas. elevator.

From the 2 (two) economic analysis scenarios of the HAS Field, based on the obtained NPV value, it can be seen that Scenario I (ESP Lease) is the most optimal scenario when compared to the scenario using a gas lift.

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Table 12. Results of the HAS Field Economic Analysis

No.	Parameter		Satuan	Base Case	SKENARIO 1	SKENARIO 2	SKENARIC
					ESP	CLEAN GAS	
					RENT ESP	CLEAN GAS FROM GASUMA	CLEAN GA FROM H2S CO2 REMOVA
1	**Contractor Take**						
		Net Cash Flow	MUS$	14503.51	814.99	257.18	253.9
		(% Gross Revenue)	%	8.4%	8.8%	5.6%	6%
		IRR	%	-	-	33.09%	42.05
		NPV @10%	MUS$	10746.78	434.85	100.25	87.66
		POT	Year	0.00	0.00	3.89	4.06
		PI		-	-	90.51	3.04
2	**Government Take**						
		FTP + Equity	MUS$	99641.69	5541.51	2008.75	2046.3
		Tax	MUS$	9872.14	554.74	175.06	180.1
		Net DMO	MUS$	9211.46	498.20	244.87	244.8
		Net Cash Flow	MUS$	118725.29	6594.45	2428.68	2471.3
		(% Gross Revenue)	%	69.0%	70.9%	53.1%	54%
		NPV @10%	MUS$	86215.04	3543.07	1149.94	1168.2

In the economic analysis of the HAS Field, a sensitivity analysis was carried out on the existing economic indicators, namely NPV by considering changes in economic parameters, namely:

1. Operating Cost
2. Investment Value
3. Production Rate (Production)
4. The price of crude oil (Oil Price)

The graph of the results of the sensitivity analysis can be seen in Figure 8.

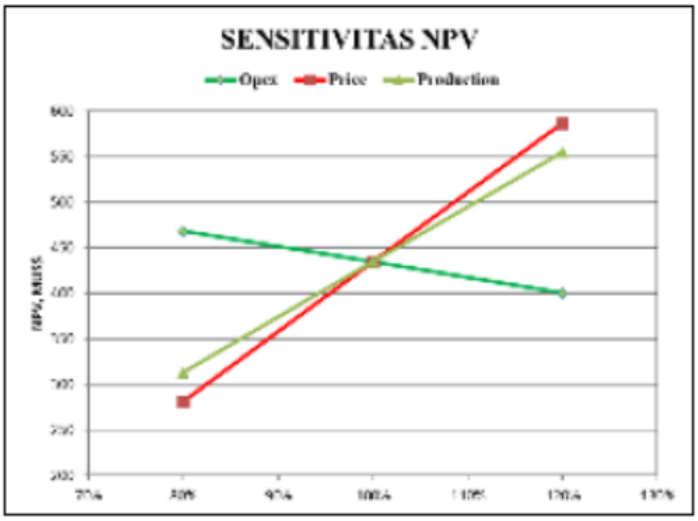

Figure 8. Scenario I NPV Sensitivity

4. CONCLUSION

Based on the results of the Artificial Lift Study Analysis in the HAS Field, it can be concluded that:

1. Based on the results of the artificial lift screening using the results of the integration of the Delphi method, the Topsis method and the Simple Additive Weighting (SAW) method, the artificial lift method that is suitable to be applied in the production of the HAS Field is the Electrical Submersible Pump (ESP) at first. place and Gas Lift in second place.
2. In calculating the economic analysis of Artificial Lift in the HAS Field using 6 (six) scenarios, namely:

- BASE CASE : BASE CASE
- SCENARIO I : ESP RENT
- SCENARIO II : GAS LIFT + CLEAN GAS FROM GASUMA
- SCENARIO III : GAS LIFT + GAS CLEANING FROM H2S & CO2 REMOVAL

3. Based on economic calculations, the most profitable scenario is using scenario I using ESP rent with the highest NPV@10 % value than the other scenarios, which is 434.85 MUS$.

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