RESEARCH ARTICLE

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Robust and Fit-for-Purpose Sand Control Technology to Produce Marginal Reserves in EKP

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ABSTRACT

East Kalimantan Petroleum (EKP) is an oil and gas exploration and production company which operates in East Kalimantan, Indonesia. Development of mature fields was aiming shallow unconsolidated sand-stone reservoirs which have high sand risk character. The proportion of shallow wells development compared to the main zone wells is tend to increase recently which has natural consequences of the increasing trend of sand-produced volume along with the hydrocarbon production. The sand grains abrasive physical property may cause consequences of a detrimental to the short-long-term productivity of oil and/or gas well. It can damage the hydrocarbon-contained surface facilities, and even causes a serious to catastrophic safety accident. The loss of containment leads might be followed by deadly disaster, such as fire and environment pollutions. The company currently produces these reservoirs type by applying the robust diesel-based chemical sand-consolidation (DB-SCON) technology for high stakes reservoirs and combined with the mechanical sand-screens application for the low stakes reservoirs. Along the field's production period, the trend of a shallow unconsolidated reservoir's average reserves is decreasing which lead to the declining trend of sand-control project economics. The company forms a project team under well intervention department to perform the research with the mission to find the new robust and fit-for-purpose sand-control technology application to produce the marginal reserves. The root causes analysis using current reality tree (CRT) reveals the three main factors of this economics declines trend: high chemical sand-consolidation investment cost, low-productivity and low-reliability of current mechanical sand-screen. The Analytical hierarchy process (AHP) defines the most robust and fit-for-purpose sand-control technology among the proposed alternatives: water-based chemical sand-consolidation (WB-SCON), high erosion resistance sand-screen (HERSS) and sand management (SM) technologies. As the result, the HERSS technology is chosen as the best solution among the alternatives. The field trials result compares HERSS performance to current robust DB-SCON. HERSS significantly reduces the investment cost by 68.0%, maintaining the reliability or success at 88.2% (DB-SCON recorded as 88.5%), maintaining the productivity at 2.5 MMscfd (gas production), accelerates the production two weeks earlier, and reduce the economic cut-off reserve limit from 0.1 down to 0.02 BCF. HERSS (made by zircon metal) technology is capable to significantly improve the performance of the mechanical sand-screen (Ceramic screen as current base-case). It increases the reliability from 64.7% to 88.5%, decrease the investment cost by 30.7%. The HERSS industrialization is planned in 2023 to replace current sand-control technology that potentially will generate significant economic improvement from the investment cost reduction with a total of $27.4 million.

Keywords: AHP, CRT, Fit-For-Purpose, HERSS, Screen, Sand-Control.

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I. Introduction

One of the biggest challenges of an oil and gas company is producing marginal reserves from the mature fields. This situation is commonly faced by majority of the companies which produces from its oil and gas fields that have entered the decline production phase. Today, EKP is dealing mostly with small-size reservoirs with very limited volume, spread over the fields and mainly located in the shallow zone. The shallow reservoir's rock strength is typically very weak and widely known as "unconsolidated sandstone formation" which very likely to produce sand during the production. The sand production is one of the major oil and gas industry problem because a single failure both on its sub-surface equipment and the surface production facilities may create a severe and serious safety accidents. Therefore, it is very important for the company to have robust sand-control technology to produce these typical of formations.

EKP, a company that operates limited and marginal reserves is continuously seeking for new potential sand-control technology application to guarantee the company's sustainability. This paper journal describes how EKP conducts the research to determine the most robust and fit-for-purpose sand-control technology applications in order to economically produce its marginal reserves. The study scope is limited to Field A (swamp area) which massively apply the sand-control technology application. However, the study result will be implemented for all field both in swamp and offshore area.

II. Business Issue

The main driver to select the economically proper sand-control technology implementation in EKP is the stake (reserve) behind a single treated-reservoir. The company's statistical data shows the continuous decreasing trend of this stake from the average of 1.07 BCF per reservoir before 2014 down to 0.34 BCF in the period 2021-2022. The company has demonstrated excellent adaptability to these conditions. The sand-control technology changes have driven the shifting of well completion types along the time to fit the economics.

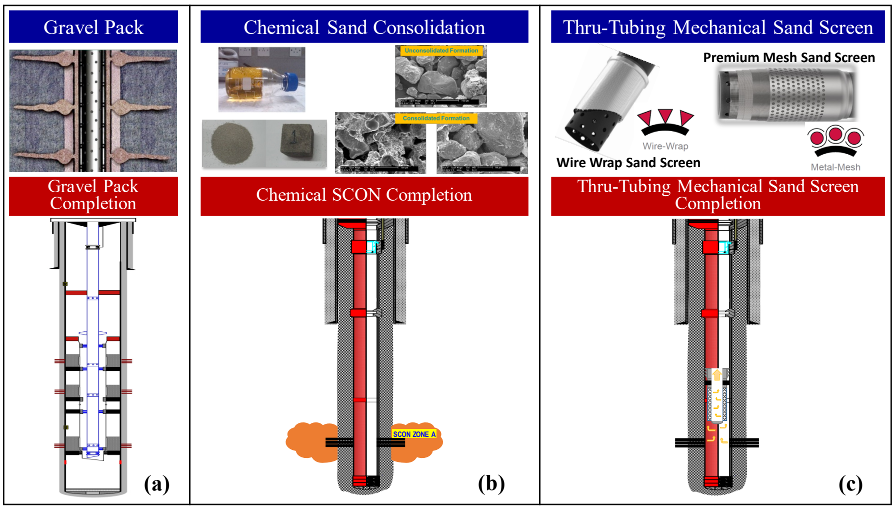

Fig. 1. Sand-control technology and completion types shifts to fit economics: (a) Gravel pack completion; (b) Tubing-less completion with Chemical SCON; (c) Tubing-less completion with Mechanical Sand Screen.

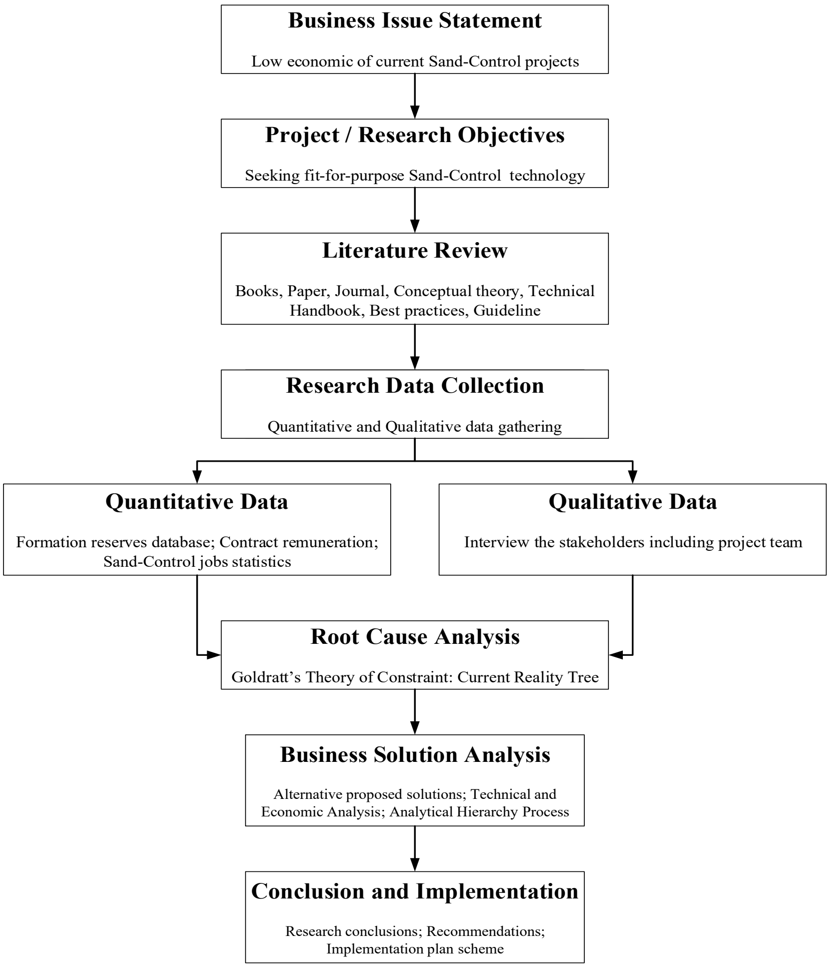

Fig. 2. Research Methodology (Source: Author, 2022).

The EKP Well Intervention team continuously look for innovations in order to produce these marginal reservoir reserves economically. Before EKP developed the diesel-based chemical sand-consolidation (DB-SCON) in 2008 and become the robust sand-control technology since 2010, the company produces the considerably still high stakes unconsolidated hydrocarbon formations with the gravel pack (completion) technology. The DB-SCON is proven as reliable, productive and efficient sand-control technology to produce the shallow unconsolidated formation's reserves. Besides, the mechanical sand-control technology using the sand-screen installation against unconsolidated shallow reservoirs are also applied as compliment of DB-SCON implementation.

The well intervention and sub-surface team rely that according to the latest economic condition, the DB-SCON technology can still economically produce reservoirs with a minimum reserve of 0.1 BCF. The gap between this figure and the average stakes per single reservoir is getting narrower, which means that the economics is getting lower accordingly. The mechanical sand-screen is assigned for low-stakes reservoir candidates (reserve below 0.1 BCF). Unfortunately, the mechanical sand-screen performance is not as good as chemical sand-consolidation performance. The EKP Well Intervention team forms a project team to conduct a validation research on alternative future sand-control technology that is robust and can increase the economics of sand-control projects. The new robust and fit-for-purpose sand-control technology is expected to answer the company's demand to have future solution which fulfil the following criteria: high reliability (success ratio), high productivity, and low investment or installation cost. Therefore, it is expected that the implementation of the new robust and fit-for-purpose sand-control technology will be able increase the economics of sand-control projects (re-open the gap of economic limit wider).

III. Research Design and Methodology

This study uses combination of quantitative and qualitative research designs. The research starts with the problem or business issue statement, followed by setting the research objective, review the relevant literatures, collecting the data (quantitatively from internal company's technical and statistical data, and also qualitatively by conducting series of interview with the stakeholders and competent and responsible personnel relevant to the sand-control projects), analyze the data (root cause analysis using Goldratt's current reality tree (CRT) and data analysis relevant to the design criteria), explore and propose alternative solutions, perform decision making analysis using analytical hierarchy process (AHP) to select the best solution among the alternatives, conduct the field trial, make the research conclusion and provide the recommendation for the implementation plan.

In line with the research design, Fig. 2 shows the research methodology of the project.

IV. Business Issue Exploration and Data Analysis

The internal company's statistical data analysis result shows that the DB-SCON technology has more superior performance than the applied mechanical sand-screen as shown by Table I and Fig. 3. These data analysis is in line with the result of root causes analysis using Goldratt's current reality tree (CRT) which reveals the main root causes of the business issue are: high investment cost of DB-SCON, low productivity and reliability of mechanical sand-screen. The three main root causes have led to the decreasing trend of the sand-control project economics. Fig. 4 shows the CRT diagram.

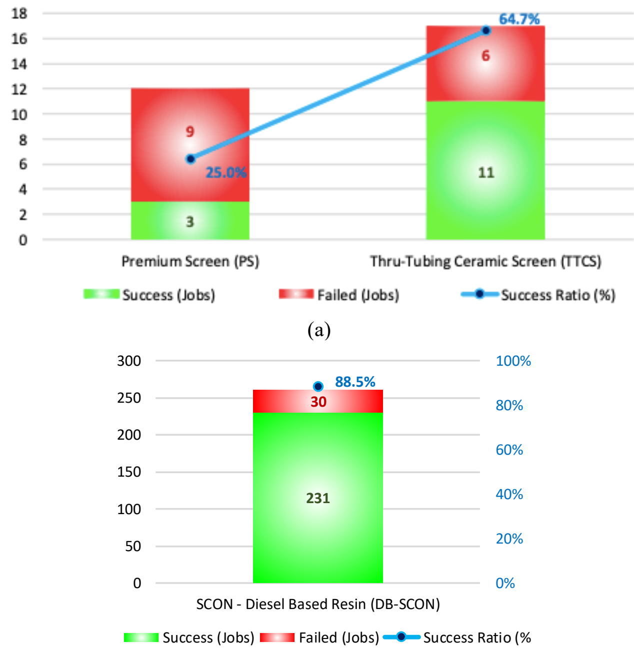

Fig. 3. Success ratio of current applied sand-control technologies; (a) Mechanical sand-screen; (b) Chemical sand-consolidation.

TABLE I: Sand-Control Technology Statistic in EKP Field A (in Swamp Area)

Sand Control Technology Type	Success (Jobs)	Failed (Jobs)	Success Ratio (%)	Investment Cost per job ($)	Average Gas Production Rate (MMscfd)	Maximum Gas Production Rate (MMscfd)
Premium Screen (PS)	3	9	25.0%	63,485.0	1.0	1.5
Thru-Tubing Ceramic Screen (TTCS)	11	6	64.7%	120,406.2	3.5	10.0
Diesel Based Resin (DB-SCON)	231	30	88.5%	281,519.0	2.5	3.8

Success Criteria Mechanical Screen	Success Criteria Chemical SCON
1. Gas rate > 1 MMscfd 2. No sand issue 3. Accumulated gas produced > 200% Investment Cost	1. Gas Rate > 2 MMscfd 2. No sand break issue 3. Accumulated gas produced > 200% Investment Cost

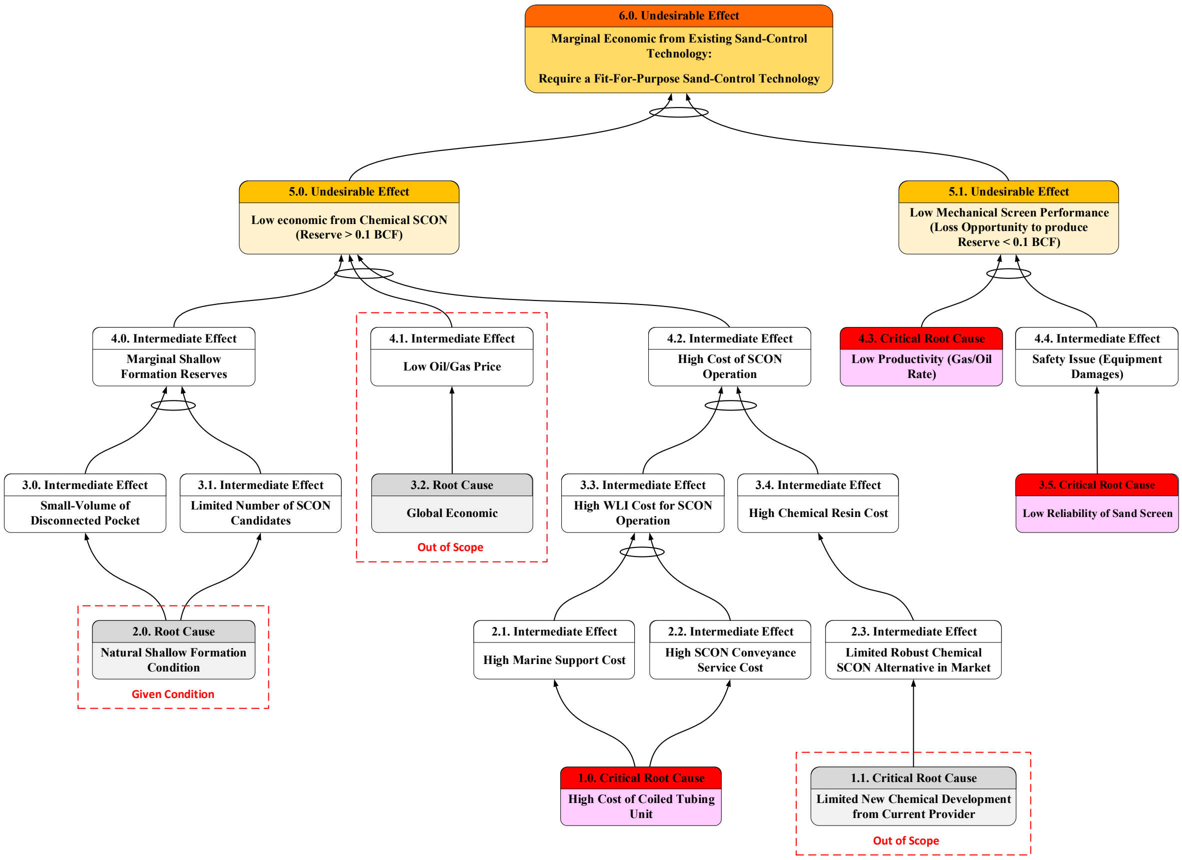

Fig. 4. Current reality tree (CRT) diagram.

V. Business Solution Alternatives

According to the required criteria of the new expected robust and fit-for-purpose sand-control technology, the following are the proposal of business alternative solutions:

A. Water-Based Chemical Resin Sand-Consolidation (WB-SCON)

Water-based chemical resin sand-consolidation is newly introduced and applied as contingent solution when the injectivity test prior chemical resin pump into formation indicates unexpected result.

TABLE II: Diesel and Water-Based Chemical Resin Comparison

Description	Diesel-Based Chemical Resin	Water-Based Chemical Resin
Applied for minimum reservoir permeability (injectivity limitation)	250 mD	50 mD
Average rock strength after treatment (UCS)	1,000-2,000 psi	800 psi
Maximum applied drawdown pressure	30 bars	10 bars
Maximum applied velocity	4 m/s	2 m/s
Required duration time for curing process	14 days	14 days
Recommended allowable gas rate (related to the drawdown pressure)	2.5 MMscfd	1.5 MMscfd
Maximum field-experienced gas rate	3.8 MMscfd	2.0 MMscfd
Current reliability (job success ratio)	88.5%	86.7%
Investment cost per job (Field A / swamp case)	$281,519	$175,906

If the injectivity test result does not allow to pump the diesel-based fluid (high viscosity) into formation, then the water-based chemical resin (lower viscosity) is on-site decided to be used as chemical resin sand-consolidation treatment fluid. The overall operation is similar with normal sand-consolidation with diesel-based resin, using coiled tubing equipped with pumping unit.

B. High Erosion Resistant Sand Screen (HERSS)

Mechanical sand-screen is well known as a simple and relatively cheap sand-control technique. Unfortunately, since the beginning of its application in EKP, its performance is still far from the expectation with the average success ratio of is only 48.3%. The failures are typically because screen plugging and eroded by the sand flow-cut. Majority of mechanical sand-screen are materially made by metal, stainless-steel with low resistant to the erosion due to sand flow-cut. The latest thru-tubing ceramic-made sand-screen (TTCS) has been implemented for the last two years with considerably better performance than metal-made screen, however still inferior compared with DB-SCON. There is no report that mentioning that ceramic screens are eroded by sand flow-cut, it is mainly due to the ceramic material is naturally higher-resistant to sand erosion. However, it is very sensitive to a physical impact. Since it is conveyed and set by slickline unit, this situation is unavoidable.

In this study research, the project team introduces new sand-screen type which made by zircon-based metal. This material is proven can resist better against the sand erosion by maintaining necessary ductility, thus more resist to the physical impact. Table III shows the mechanical sand-screen performance comparison for the applied screen types.

TABLE III: MECHANICAL SAND-SCREEN PERFORMANCE COMPARISON

Description	Premium Screen	Ceramic Screen	High Erosion Resistant Screen
Screen Material	Stainless Steel	Ceramic	Zircon
Maximum applied drawdown pressure	30 bars	60 bars	50 bars
Maximum applied velocity	1.1 m/s	2.2 m/s	1.3 m/s
Recommended allowable gas rate (related to the drawdown pressure)	1.0 MMscfd	3.5 MMscfd	2.5 MMscfd
Maximum field-experienced gas rate (specific case)	2.5 MMscfd	10.0 MMscfd	5.0 MMscfd
Current Reliability (Job Success Ratio)	25.0%	64.7%	88.2%
Investment cost per job (Field A / swamp case)	$63,485	$120,406	$83,486

C. Sand Management (SM)

The term sand management refers to the meaning that the unconsolidated hydrocarbon formation is produced without sand-control at the reservoir depth in the well. The production is managed through a monitoring and controlling the well pressures, produced-fluid rates and the sand influx. The sand management has never been fully applied to drain a hydrocarbon formation reserves, however the practices has been implemented for certain duration period when the well is producing at the first time temporarily through testing barge or sand filter unit during clean-up post perforation operation. These periods of times used to verify that the well is not producing sand at acceptable certain choke opening (corresponds to certain flow rate) before the well is put on production line permanently.

VI. BUSINESS SOLUTION ANALYSIS AND STUDY RESULT

The study uses Analytical Hierarchy Process (AHP) that developed by Thomas Lorie Saaty as decision-making tool to select the best solution among the above proposed alternatives. The following Fig. 5 show the process of the problem decomposition into hierarchy in the context of this study to determine the most robust and fit-for-purpose sand-control to produce marginal reserves.

The AHP process analysis starts by making the pairwise comparison according to Saaty's AHP pairwise comparison index. The index indicates the relative importance between each pair of decision criteria and alternatives based the project team's judgement rate considering other involved competent personnel (sub-surface team, well performance team, safety method, and asset well intervention engineers) and the interview results as shown by Fig. 6.

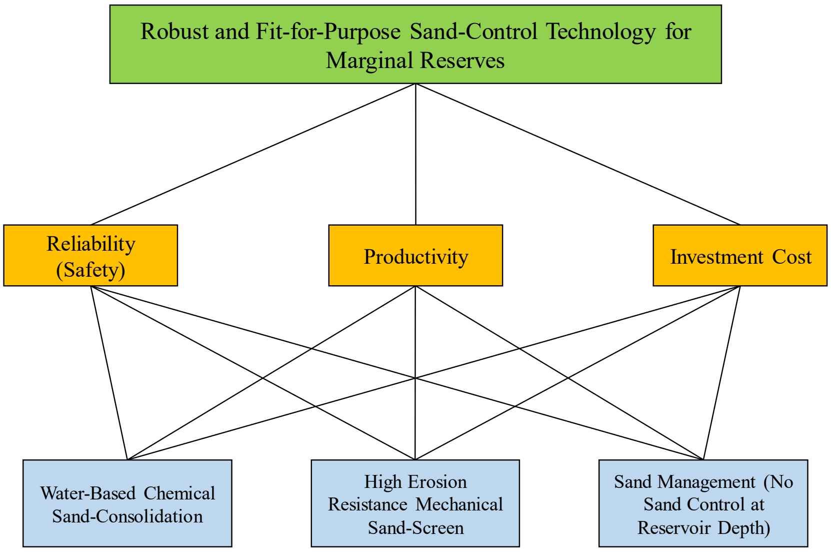

Fig. 5. Criteria and alternative solutions.

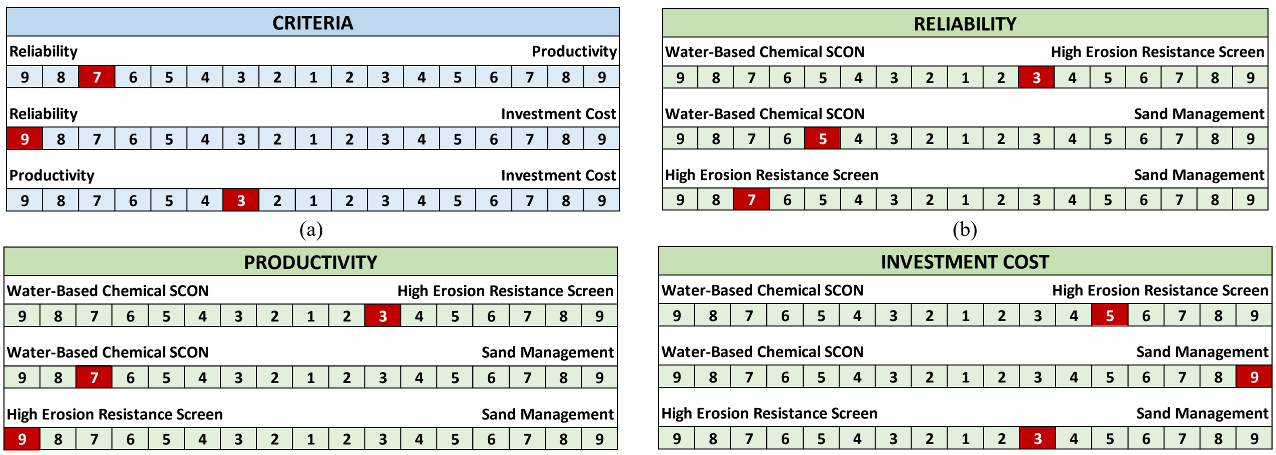

Fig. 6. Pairwise Comparison: Project Team's Judgement Rate: (a) Criteria; (b) Reliability; (c) Productivity; and (d) Investment Cost.

Based on the above pairwise comparison index, then the process continues by making the pairwise comparison matrixes (PCM) of decision alternatives versus criteria and criteria versus criteria as shown by the following Table IV, Table V, Table VI and Table VII. The consistency ratio (CR) verification indicates that all pairwise comparison matrixes (PCM) are all consistent (CR < 0.1). Then the priority rankings are obtained and used to determine the final ranking of each alternative solution, as shown in Table VIII.

TABLE IV: PCM ALTERNATIVES VERSUS CRITERIA (RELIABILITY)

Reliability	WB-SCON	HERSS	SM	Priority
WB-SCON	1.000000	0.333333	5.000000	0.282839
HERSS	3.000000	1.000000	7.000000	0.643389
SM	0.200000	0.142857	1.000000	0.073772
Sum of Priorities = 1		Consistency Ratio (CR) = 0.056476 (CR < 0.1)		

TABLE V: PCM ALTERNATIVES VERSUS CRITERIA (PRODUCTIVITY)

Productivity	WB-SCON	HERSS	SM	Priority
WB-SCON	1.000000	0.333333	7.000000	0.294638
HERSS	3.000000	1.000000	9.000000	0.648619
SM	0.142857	0.111111	1.000000	0.056743
Sum of Priorities = 1		Consistency Ratio (CR) = 0.070082 (CR < 0.1)		

TABLE VI: PCM ALTERNATIVES VERSUS CRITERIA (INVESTMENT COST)

Investment Cost	WB-SCON	HERSS	SM	Priority
WB-SCON	1.000000	0.200000	0.111111	0.063736
HERSS	5.000000	1.000000	0.333333	0.267399
SM	9.000000	3.000000	1.000000	0.668865
Sum of Priorities = 1		Consistency Ratio (CR) = 0.025182 (CR < 0.1)		

TABLE VII: PCM CRITERIA VERSUS CRITERIA

Criterion	Reliability	Productivity	Investment Cost	Priority
Reliability	1.000000	7.000000	9.000000	0.776592
Productivity	0.142857	1.000000	3.000000	0.154898
Investment Cost	0.111111	0.333333	1.000000	0.068510
Sum of Priorities = 1		Consistency Ratio (CR) = 0.070811 (CR < 0.1)		

The final AHP analysis result shows that High Erosion Resistance Sand Screen (HERSS) comes as the best solution and considered as very superior among the three proposed alternatives with final result at 61.8%.

VII. SOLUTION AND IMPLEMENTATION PLAN

The AHP analysis has determined that the new mechanical sand-control technology, High Erosion Resistance Sand Screen (HERSS) is the most fit-for-purpose sand-control technology to produce the marginal unconsolidated formation reserves in EKP. As mentioned in section I, this study is conducted for shallow well development in Field A (swamp area) considering the availability of the sand-control candidates, low operation cost for trials, and relatively low operation complexities. However, the future implementation will not be limited to this specific field only, and it will be extended to other applicable swamp and offshore fields.

Initially, the implementation of this new robust and fit-for-purpose sand-control technology was expected can save $27.4 million of potential cost saving as the result of the shifting of sand-control technologies from the existing base-case technology. However, EKP is considering the challenges and opportunities during the new technology implementation plan. The biggest challenge of the industrialization (implementation) phase plan is that the HERSS screens are not locally produced, therefore there will be long lead delivery time for massive utilization. The proper stock management in the well intervention workshop will play an important role to cope the operation needs. In the meantime, the company has a very interesting opportunity from the utilization of ex-used HERSS sand-screen. Even though it will not eliminate the installation cost as it installed in the well for its first utilization, but it is capable to reduce significantly the investment cost from $83.5 to $61.8 thousand (25.9% reduction of the investment cost) for swamp field application.

TABLE VIII: PRIORITY RANKING OF THE ALTERNATIVE SOLUTIONS

	Reliability	Productivity	Investment Cost		Criteria
WB-SCON	0.282839	0.294638	0.063736	Reliability	0.776592
HERSS	0.643389	0.648619	0.267399	Productivity	0.154898
SM	0.073772	0.056743	0.668865	Investment Cost	0.068510
Matrix		[3 × 3]		[3 × 1]	
Priority Ranking of the Alternatives					
WB-SCON	(0.282839 x 0.776592) + (0.294638 x 0.154898) + (0.063736 x 0.068510				27.0 %
HERSS	(0.643389 x 0.776592) + (0.648619 x 0.154898) + (0.267399 x 0.068510)				61.8 %
SM	(0.073772 x 0.776592) + (0.056743 x 0.154898) + (0.668865 x 0.068510)				11.2 %

TABLE IX: EXPECTED COST SAVING OF SAND-CONTROL PROJECT 2023(*)

Sand Control Workload Planned in Work Program 2023	Field	No of Wells /Jobs	Existing Sand-Control Cost Per Job ($)	Fit-For-Purpose Sand-ControlCost Per Job ($)	Potential Losses ($)
Gravel Pack Wells	Swamp	0	1,065,800.5000	83,486.4350	-
	Offshore	8	1,293,112.5933	153,304.2192	9,118,467.0
Chemical SCON	Swamp	58	281,519.0220	83,486.4350	11,485,890.0
	Offshore	5	692,498.9782	153,304.2192	2,695,973.8
Mechanical Screen	Swamp (*)	38	120,406.2350	83,486.4350	1,402,952.4
		36	120,406.2350	61,840.2350	2,108,376.0
	Offshore (*)	28	190,224.0192	153,304.2192	1,033,754.4
		9	190,224.0192	131,658.0192	527,094.0
Estimation of Total Potential Losses					28,372,507.6

* The impact of reutilization of ex-used HERSS

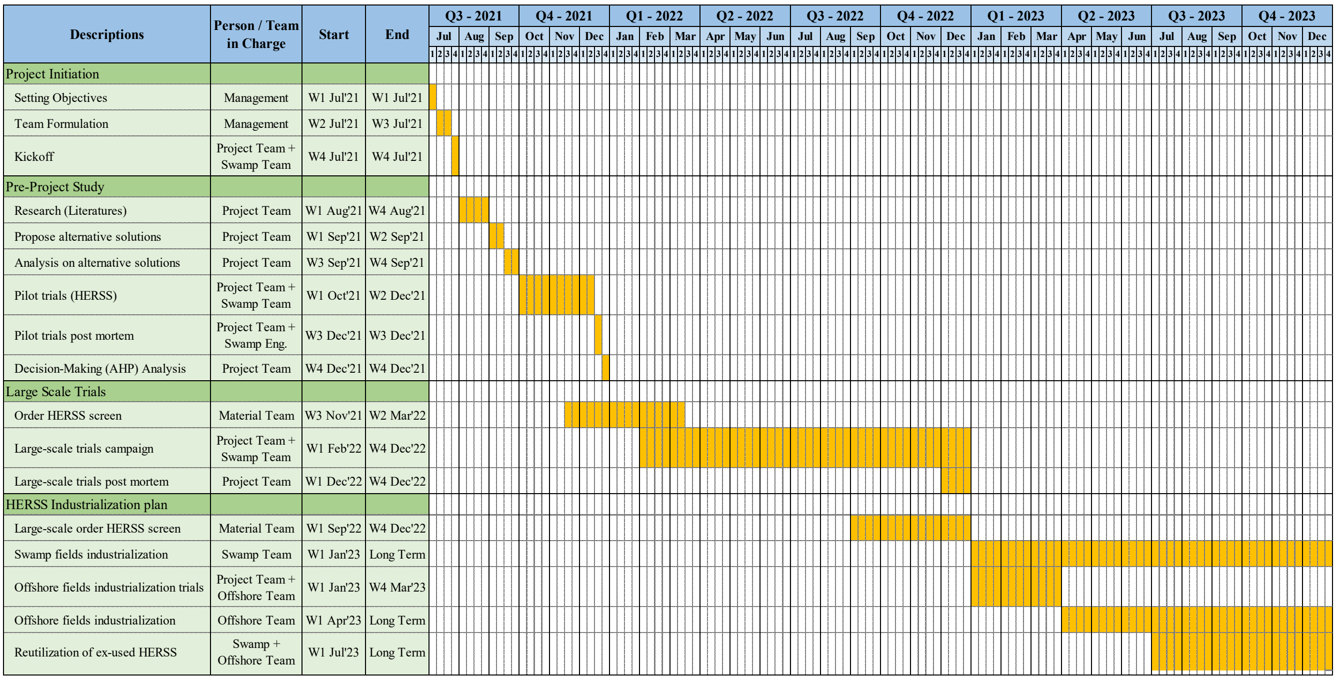

Fig. 7. The project study timeline and HERSS industrialization plan.

Based on the field trial experience the majority of HERSS returned from the wells are still in considerably good condition, therefore the well intervention department determines the target to utilize the ex-used HERSS screens by 25% of the total number of installations in 2023 for the first stage. The allocation of the reutilization plan is designed as 20% (36 jobs) for swamp and 5% (9 jobs) for offshore fields application. Careful planning combined with proper and careful implementation of stock management, and taking full advantage of this opportunity, the new sand-control technology industrialization realization potentially can achieve more than the initial target. Table IX shows that by taking full advantage of HERSS reutilization, the company can increase the cost savings to $28.4 million (an increase of 3.6% from the initial target).

Fig. 7 shows the complete project study timeline and the implementation (industrialization) plan of the new robust and fit-for-purpose sand-control technology application in EKP marginal unconsolidated formation's reserves.

VIII. Conclusions and Recommendations

A. Conclusion

The following are the conclusions of the study research to find the robust and fit-for-purpose sand-control technology application to produce marginal unconsolidated formation's reserves in EKP:

1. The trend of decreasing shallow unconsolidated sandstone formation reserves is the main factor that led to the decreasing of economic trend in the context of producing these unconsolidated formations in EKP. The average of a single shallow unconsolidated formation reserve is 0.34 BCF in the period 2021-2022, which continuously decreased from 1.07 BCF per formation/reservoir before 2014. Even though the completion type has been adapted to this trend accordingly, the decreasing reserves trend has pushed continuously the economic aspect closer to the limit. Besides, the trend of increasing produced-sand volume in the production facilities has increased the maintenance cost leading to an increase of operation cost.
2. The root causes analysis using Goldrat's current reality tree concludes that there are three main root causes of this decreasing economic trend, as follows:
   a. The current robust sand-control technology, diesel-based chemical sand consolidation requires high investment cost because it requires very expensive coiled tubing service.
   b. The current mechanical sand-screen technology demonstrates a very low reliability.
   c. The mechanical sand-screen demonstrates very low productivity.
3. The project team uses the Analytical Hierarchy Process (AHP) as decision-making tool to select the best solution among the three proposed alternatives based on three criterions. As the result, high erosion resistance sand screen, HERSS is selected as the most fit-for-purpose sand-control technology that fit to PHM context to produce the marginal shallow unconsolidated formation reserves. The HERSS technology is very dominant where it reaches the highest priority rank score at 61.8%.
4. The HERSS success ratio during the real large-scale field trials reaches 88.2% can compete the current robust chemical sand-consolidation technology (88.5%). It significantly improves the mechanical screen reliability from the average of 64.7% up to 88.2% success ratio. The reliability of this sand-control technology is proven as highly reliable as expected by the stakeholders (sub-surface development, production facility and well performance team). This success is very important to unlock the very marginal unconsolidated formation reserve (below 0.1 BCF) which could not be unlocked with current reliable sand-control technology due to economic limitation and previous low reliable mechanical screen.
5. The HERSS productivity satisfies the project study team and stakeholders with the capability to produce the gas

rate at 2.5 MMscfd without any sand-issue during the entire production. Furthermore, it has potential to increase the production up to 5.0 MMscfd for a particular case whenever the well parameter allows it. The production from wells using HERSS technology is far more satisfying than wells using premium screens (average production at 1.0 MMscfd). It is beneficial for company's strategy to accelerate production from shallow wells whenever necessary.

6. The HERSS is capable to accelerate the production, even though the average production is at similar gas rate to chemical sand-consolidation, but the well production with sand-screen can be accelerated two weeks earlier in swamp fields due to elimination of chemical curing time. It even better for offshore wells, the well with HERSS can be produced 3-4 weeks earlier than if the chemical sand-consolidation is applied. These durations are including the offshore coiled tubing (1-2 weeks) and 2 weeks of chemical curing time period.
7. As a simple but fit-for-purpose technology, the HERSS helps the company to significantly reduce the investment cost comparing to the existing robust sand-consolidation by 68% (swamp fields application) per job. It also requires less investment cost than the ceramic sand-screen technology (30.7% cost reduction) per job. In offshore fields application, it reduces the investment cost by 77.9% compared to chemical sand-consolidation and 19.4% compared to ceramic screen installation cost.
8. The simplicity of HERSS installation operation reduces the associated HSSE risks which mainly caused by the shift of well intervention mean from coiled tubing to slickline mode. The coiled tubing operation involves heavier equipment (lifting risks), more complex operations (higher marine-associated risks) and chemical handling (higher personnel injury and environmental-damaged risks). The well intervention team obtains their expectation to have safer operation. The investment cost of HERSS reutilization is estimated as $61.8 thousand, decreases from $83.5 thousand (25.9% reduction) of using new HERSS screen. By targeting that 25% of the sand-screen jobs are utilizing the ex-used HERSS, it brings the impact of 3.6% increase of company profits compared to the initial target.
9. As the selected robust and fit-for-purpose technology solution that will replace sand-consolidation, with a full implementation plan as the industrialization phase, the company has potential cost optimization up to $27.4 million from sand-control work program in 2023. The realization of this potential cost optimization during industrialization phase can be further increase to $28.4 million (3.6% increase) by implementing a careful proper execution plan, proper and careful stock management in workshop, and taking full advantage by reutilization 25% of ex-used HERSS (retrieved from well of its first installation). It also reduces the formation cut-off reserves to 0.01 BCF (compared to 0.1 BCF, the initial figure before the research is carried-out) which will widely open the portfolio or opportunity to produce the very marginal formation reserves that are previously uneconomic.
10. The HERSS screen is highly reliable technology to unlock the very marginal unconsolidated formation reserve, below 0.06 BCF (new-recalculated figure based on this research considering current economic situation) which could not be unlocked with current chemical sand-consolidation technology. Therefore, this new approached has opened new production portfolio to produce the wells from the unconsolidated formations with reserves below 0.06 BCF with the new economic cut off at 0.02 BCF per single formation for swamp fields. This new portfolio is opened without decreasing the reliability of the sand-control technology. Even the cut-off is potentially could be lower down to 0.01 BCF per single formation if EKP well intervention team could maximize the reutilization of ex-used HERSS returned from the previous sand-control jobs.

B. *Recommendations*

Following the experiences during the entire study research period, the following recommendations are proposed to avoid some potential obstacle during the full implementation (industrialization) period and future research:

1. The industrialization of the HERSS technology will also covers the other fields in EKP, both swamp and offshore in order to maximize the investment cost optimization and standardize the business process of sand-control technology application in the company.
2. Further sand management (no sand-control) study need to be carried out for the very marginal reserves (below 0.01 BCF) in order to prepare the future since the average reserves per single formation is decreasing. The objective of the research is to find the fit-for-purpose sand-management technique application which covers the reliable and fit-for-purpose material of surface sand-monitoring equipment, cheaper perforation technique, more efficient post-perforation clean-up procedures, remote operation mode for offshore fields, etc.
3. In order to further increase the economics of the sand-control project for offshore fields, it is recommended to proceed the HERSS installation using remote operation, thus the investment cost will be reduced significantly (37.2% reduction) from the utilization of offshore accommodation working barge. Further light study / research need to be carried out to consider / review the operations and safety aspects for proper implementations.
4. Well intervention material and workshop team needs to be ready for massive redress / recondition in the effort to target reutilization of 25% ex-used HERSS screen from the first jobs. It potentially reduces the investment cost by 13.9% (in swamp) and 14.1% (in offshore) compared to new HERSS screen installation, even could raise up to 51.3% reduction in offshore when the ex-used HERSS installation job is performed under remote operation mode. As the result, it can increase the company's cost saving by 3.6% from the total sand-control projects in 2023.
5. The HERSS sand screen is considered as long-lead-item with four (4) months delivery time. It is recommended that the material team manage and implement the minimum stock policy will become the key success to enter the industrialization phase.

6. Well Intervention department needs to establish cooperation with domestic manufacturer to produce the HERSS screen locally. This aims to shorten the delivery lead times and potentially lower screen prices due to import costs.

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