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Decision Making of Inactive Facilities Decommissioning and Site Restoration Project Alternative Selection by Implementing KT and Combination of SMART-AHP

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Abstract - **Several surface facilities were built more than 40 years ago and have been out of service for years due to operational reasons and low-efficiency issues. PT. Pacific Energy Indonesia (PT PEI) shall carry out decommissioning and site restoration of inactive facilities in a very limited resources and time due to end of concession. Site Restoration with full-remediation method is not doable. Fit-for-purpose scope of work shall be generated. This research purpose is to formulate a viable solution to achieve objective of decommissioning and site restoration, address risk of health, environment, safety, reputation, and shall be completed within Production Sharing Contract (PSC) period. Environment, health and safety issues have been assessed using Kepner Tregoe (KT) Situation Appraisal. Root causes is analyzed using KT Problem analysis and verified by fishbone diagram method. In order to obtain valuable potential alternatives, Value Focused Thinking (VFT) method is implemented. Combination of Simple Multi-Attribute Rating Technique (SMART) – Analytic Hierarchy Process (AHP) method is used to analyze alternatives and select the best alternative. Considering cost and benefit related to operation and execution aspect, decommissioning, leave fence and continue site restoration by new operator is selected as the highest priority alternative since it provides highest benefit and requires acceptable cost.**

Keywords - **Analytic Hierarchy Process, Decision Making, Kepner Tregoe, Simple Multi-Attribute Rating Technique, Value Focused Thinking**

I. INTRODUCTION

PT. Pacific Energy Indonesia (PT. PEI) is an Oil and Gas company that operates in Indonesia for more than 90 years. PT PEI holds a 100 percent owned and operate interest under Production Sharing Contract (PSC) model that expires in August 2021. It produces a significant portion of the nation's oil production.

The upstream oil and gas industry has the potential to cause severe environmental degradation if not handled properly, not only to the physical environment, but also to the health, culture, economic and social structure of local communities. Abandonment and Site Restoration (ASR) is an important concern in oil and gas upstream industry, especially while approaching end of concession contract. ASR as post-operation activities for permanent closure of wells and decommission production facilities and its supporting facilities, including permanent dismantle, as well as carrying out environmental restoration in the concession area of Upstream Oil and Gas businesses.

Several surface facilities have been out of service for years due to operational reasons, low-efficiency, and spare part availability issues. In line with reservoir depletion, production from fields also declines that causes some facilities to operate far below their original design capacity and leads to low-efficiency of the facility. To minimize operation and maintenance cost, these facilities were deactivated and diverted production fluid to a nearby facility. Due to inactive for several years and minimum/without maintenance and inspection, these facilities are potentially could harm people and/or environment by collapsing at corroded area and create hydrocarbon spill to environment.

Nine facilities are included in no future utility and high-risk category. Recommended action for these facilities is decommission all equipment inside the gathering station /test station (GS/TS) and continue with site restoration.

PT. PEI should consider limited time to execute decommissioning and site restoration due to end of concession in August 2021. Resource also needs to be considered since Construction Service - Work Unit Rate (CS-WUR) Contractors who hold contract in PT. PEI have ramp down their employees since 2019. Rehiring, badging, and training process will require extra time. To execute all of sites in parallel, a huge number of people and heavy equipment is required to complete all decommissioning and site restoration to return the site into its original condition. Recently SKK Migas requires PT PEI to continue drilling program that has been stopped several years ago to anticipate production decline especially during transition to new operator. This program will require massive resources and should be considered since it will employ similar resources. Based on above condition, execution of decommissioning and site restoration with full remediation method is not doable considering very limited time and resources. A viable solution with fit-for-purpose scope of work shall be generated to achieve objective of decommissioning and site restoration, address risk of HES, safety and reputation, and shall be completed within Production Sharing Contract (PSC) period.

Combination of Simple Multiple Attribute Rating Technique (SMART) and Analytic Hierarchy Process (AHP) is applied to analyze alternatives and select the

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best alternative to execute decommissioning and site restoration of inactive facilities.

This paper consists of 5 chapters. First chapter will introduce the company and background of the problem that occur in this research. Second chapter will elaborate more detail on conceptual framework and research design will be applied. Third chapter will explain steps in generating possible alternatives and evaluating each alternative by implementing SMART and AHP theory. Fourth chapter will discuss comparison of alternatives. Fifth chapter will conclude the research.

Business issue of this research is how PT. PEI can meet relevant Government of Indonesia (GOI) regulations and compliance to carry out decommissioning and site restoration of inactive facilities in a very limited time.

II. METHODOLOGY

In the beginning of the framework, Kepner Tregoe (KT) tools of Problem Solving and Decision Making are utilized to define problems, explore the issues and search for recommendation. Situation analysis of Kepner Tregoe (KT) is applied to appraise the issue and select the suitable technique for resolution. Problem Analysis, Decision Analysis and Potential Problem Analysis of Kepner Tregoe (KT) are performed following the result from the situation analysis.

This research will implement Simple Multiple Attribute rating technique (SMART) process flow for decision making process. SMART has 8 main stages as the research framework foundation. Value Focused Thinking (VFT) and Analytic Hierarchy Process (AHP) applied as part of SMART 8 stages. Value Focused Thinking (VFT) method is implemented for stage 1, stage 2, and stage 3 of Simple Multiple Attribute Rating Technique (SMART), while Analytic Hierarchy Process (AHP) is applied in the stage 4, stage 5, and stage 6.

A team consist of five experts were formed to share their knowledge and experiences in order to appraise, judge and rate the level of importance in the process of performing situational analysis, developing alternatives and set pairwise comparison matrices. The team consist of representatives from project team, operation & maintenance team, engineering team and construction team. Group discussion and interviews were performed to gather information from participants based on their experience, knowledge and perspective.

Below conceptual framework and research design are demonstrated to determine best alternative to solve problem to fulfil requirements, most efficient cost and maintain health, environment, and safety.

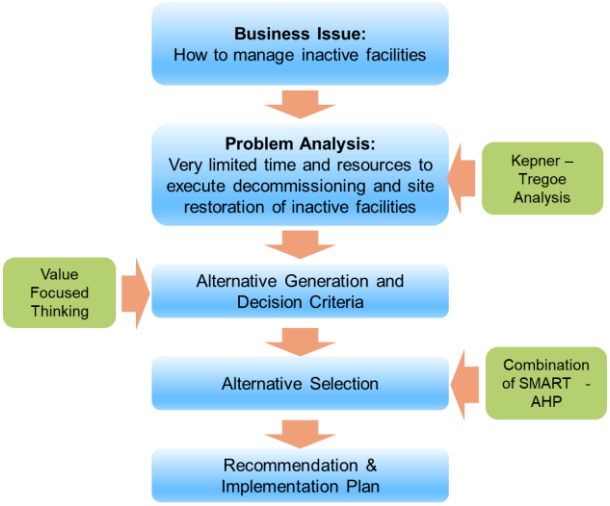

Fig. 1. Conceptual Framework.

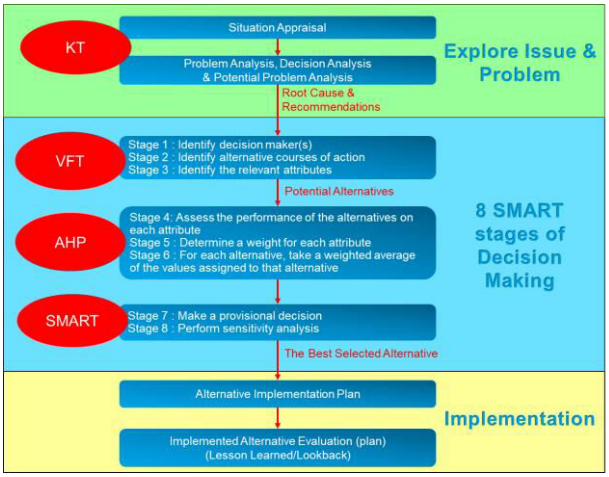

Fig. 2. Research Design.

Combination of SMART and AHP method has several advantages compared to standalone AHP or SMART method for decision making, such as;

a. Direct rating of qualitative parameters can be avoided by performing pairwise comparison
b. Simplicity of comparing two alternative or attribute only at any one time while performing AHP pairwise comparison
c. Provisional decision can be performed to allow trade-off between cost and benefit
d. Sensitivity analysis for change of attributes weight can be performed

KT situation appraisal is performed as shown in below table to determine timing, trend, impact and next process, whether Problem Analysis (PA), Decision Analysis (DA) or Potential Problem Analysis (PPA).

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TABLE I
KT SITUATIONAL APPRAISAL

Situation/Problem/Issue	Timing	Trend	Impact	Process
Public entering inactive facility area that lead to theft case and land encroachment	L	L	M	PA
Asset collapse due to aging and corrosion	M	M	H	PPA
Decommissioning and site restoration project do not complete in timely manner	H	H	H	DA

Note: L (Low), M (Medium) and H (High)

PT PEI experienced public entering inactive facility. They encroached the area by utilize ponds to raise fishes and stole some assets. Based on Problem Analysis and verified by fishbone diagram, root cause of public entering inactive facility area that lead to theft case and land encroachment issue is unattended inactive facilities without security standby onsite to secure the inactive facility and broken/corroded fence.

TABLE II
KT PROBLEM ANALYSIS OF PUBLIC ENTERING INACTIVE FACILITIES

Possible Causes	The Most Possible Cause
1. Unattended inactive facilities without security standby onsite to secure the inactive facility and broken/corroded fence 2. The locations are adjacent to local community 3. The local residents' needs for basic needs have increased 4. Local community behaviour and condition in certain area	Unattended inactive facilities without security standby onsite to secure the inactive facility and broken/corroded fence
Verification: Fishbone Diagram (Fig. 3)	Unattended inactive facilities without security standby onsite to secure the inactive facility and broken/corroded fence

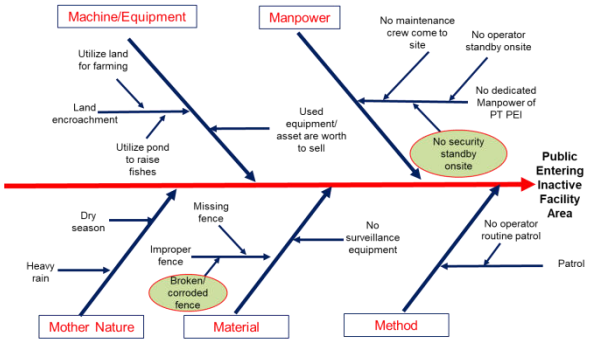

Fig. 3. Fishbone Diagram of Public Entering Inactive Facility Area

Based on KT Potential Problem Analysis of asset collapse in inactive facilities, several action items from potential problem analysis are recommended as follows:

- Operation team and Maintenance team are recommended to install hard barricade to prevent personnel approaching the aging and corroded equipment that has falling/collapse risk.
- Existing fences required to be maintained by Operation and Maintenance team and keep warning sign to not enter the facility for unauthorized personnel to avoid trespassing of unauthorized personnel prior to completion of decommissioning and site restoration activities.
- Existing dikes are recommended to be kept to contain hydrocarbon spill, prior to tanks, boots and other equipment being dismantled.
- Project team and Operation team are recommended to install temporary guard for inactive equipment that has falling risk and adjacent to active equipment.

Fishbone diagram is also developed to find root causes for decommissioning and site restoration execution do not complete prior to EOC issue to have relevant alternatives during alternative generation process to develop a robust strategy to address these risks.

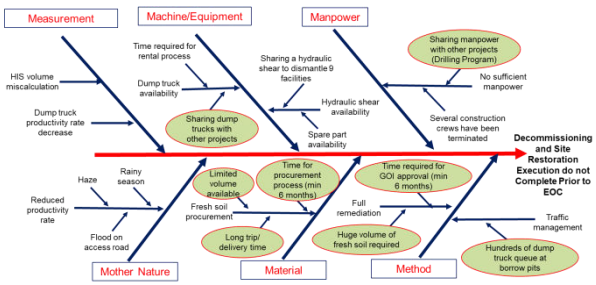

Fig. 4. Fishbone Diagram of Decommissioning and Site Restoration Execution do not Complete Prior to EOC

Based on above fishbone diagram, several dominant factors below as root causes of decommissioning and site restoration execution do not complete prior to EOC.

- Sharing manpower and equipment with other projects,
- Huge volume of fresh soil required for each gathering station to implement site restoration with "full

remediation method" scope of work. This method requires minimum 6 months to obtain approval from Government of Indonesia
- PT PEI has only limited volume of fresh soil at one borrow pit and requires minimum 6 months for fresh soil procurement and local GOI approval process.
- Delivery time from borrow pit to inactive facility areas with an average distance of 50 km and traffic management at borrow pit

III. RESULTS

A. *Generate Alternatives*

A focus group discussion was held in generating relevant and possible alternatives by involving experts in PT PEI. Relevant and possible alternatives solutions for compliant inactive facilities are as follows:

1. **Maintain inactive facilities**
   - Leave inactive facility as it is
   - Assign dedicated security officers to guard the inactive facilities
   - Conduct routine inspection to ensure integrity of inactive equipment
   - Maintain all fences to avoid trespass of unauthorized personnel
   - Install guard to protect active equipment from collapsed inactive equipment
2. **Decommissioning, close pits and site restoration by housekeeping method**
   - Decommission all equipment inside inactive gathering station and test station
   - Obtain all required permits from GOI to conduct housekeeping method of site restoration
   - Scrap 30 cm hydrocarbon impacted soil (HIS) on surface of separation pits and cooling ponds
   - Back fill all open pits and ponds with fresh soil
   - Conduct regreening
3. **Decommissioning, leave fence and continue site restoration by new operator**
   - Decommission all equipment inside inactive gathering station and test station
   - Maintain all fences to avoid trespass of unauthorized personnel
   - Conduct security patrol
   - Continue site restoration execution by new operator

B. *Generate Attributes*

The value drivers are listed, structured, and linked to describe mean-end objectives relationship as shown below

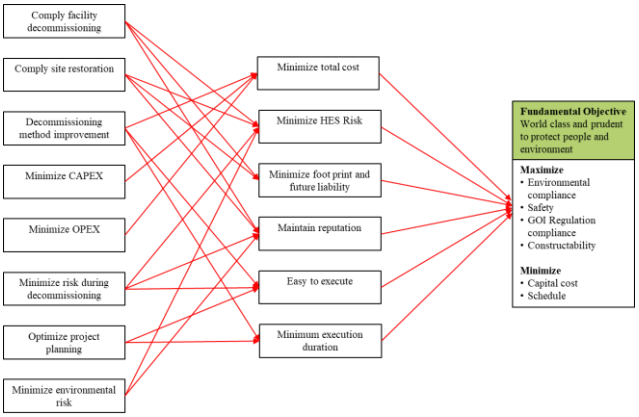

Fig. 5. Objective Network

Objective network above is translated into several important attributes to generate relevant alternatives. Attribute's definitions are described in the following table.

TABLE III
ATTRIBUTE DEFINITION

No.	Attribute	Description
1.	HES compliance	Compliance to all applicable GOI regulations, company's standards and eliminate future liability
2.	Maintenance	Maintenance efforts to prevent inactive facility from collapsing and / or being stolen
3.	Schedule	Estimate timeline and duration required for decommissioning and site restoration of inactive facilities to obtain compliance
4.	Expenditure	Capital expenditure required for decommissioning and site restoration of inactive facilities and operating expenditure to maintain inactive facilities
5.	Constructability	Easy to execute with minimum safety risk during decommissioning and site restoration

C. *AHP - Pairwise Comparison & Synthesizing*

Pairwise comparison as the next step in AHP method is performed for qualitative rating. Numerical ratings were used to determine prioritization and important level of each alternative and attributes compared to others. Group discussion and interviews were performed to gather information from participants based on their experience, knowledge, and perspective. Consistency check is performed to ensure no conflicting occur during rating process. Consistency of numerical rating judgement process shall be maintained within acceptable degree due to it is important to ensure validity of the process and judgement.

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Alternative rank is determined by summing the result of the attribute weight times the preference of each alternative with respect to the attributes. The alternative with highest score will be selected as preferred alternative. Following is the detail calculation of weighted aggregate for decommissioning and site restoration execution decision.

TABLE IV
WEIGHTED AVERAGE VALUE FOR DECOMMISSIONING AND SITE RESTORATION

Alternative	AHP Aggregate of Benefit	Rank
Maintain inactive facilities	0,308	Rank 2
Decommissioning, close pits and site restoration by housekeeping method	0,222	Rank 3
Decommissioning, leave fence and continue site restoration by new operator	**0,470**	**Rank 1 (Preferred)**

Based on AHP method and calculation above, alternative that has the highest benefit score is Decommissioning, leave fence and continue site restoration by new operator alternative. However, to determine best alternative, both benefit and cost need to be considered. SMART method as the next step is implemented for provisional decision to trade between cost and benefit.

D. SMART - Provisional Decision

SMART aggregate score is obtained from AHP aggregate of benefit score times 100 and plotted on Y axis. Cost of each alternative is plotted on X axis. Alternatives have higher return and lower risk for a given expected return are shown on the red dash line, called efficient frontier. The efficient frontier and cost and benefit trade are shown in Fig. 6.

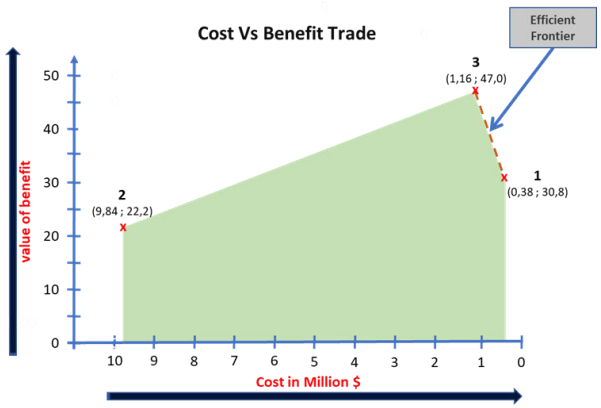

Fig. 6. Provisional Decision for Decommissioning and Site Restoration of Inactive Facilities

Alternatives 1 and 3 lie on efficient frontier. Alternative 2 is dominated by alternative 3. Alternative 3 has the highest value of benefit, but it has higher cost compared to alternative 1.

TABLE V
PROVISIONAL DECISION FOR DECOMMISSIONING AND SITE RESTORATION

Alternative		3	
		$ 1,16 MM	47,0
1	$ 0,38 MM	$ 0,78 MM	16,1
	30,8	$ 0,05 MM/point	

Alternative 1 has $ 0,78 million cost less compared to alternative 3, but alternative 3 has 16,1 points of benefit higher. Value of benefit will cost $ 0,05 million per point. Alternative 1 is attractive from cost point of view because it requires less expenditure even though it has a lower value of benefit as a trade-off.

HES compliance is important for the company in order to ensure safety, protect people and environment. Alternative 3 is still favorable since it has significant value of benefit, especially HES compliance benefit as a dominant attribute. To move from alternative 1 to alternative 3 do not require huge amount of cost. Alternative 3 will cost $ 0,78 million higher than alternative 1, and equal to $ 0,05 million per point. PT. PEI Management has agreed with the cost of alternative 3. However, further sensitivity analysis will be implemented to see stability of the solution.

E. SMART - Sensitivity Analysis

Sensitivity analysis is conducted to check impact of change in weight of attribute. Sensitivity analysis is implemented by changing weight of Operation and Execution subcategory into 0 and 1. Attribute of each category will change proportionally according to its original ratio weight. Attributes of Operation subcategory are HES Compliance and Maintenance. While attributes of Execution subcategory are Schedule and Constructability.

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TABLE VI
AGGREGATE OF WEIGHTED VALUE

No.	Alternative	Operation = 0 Execution = 1	Base Case Operation = 0,592	Operation = 1 Execution = 0
1.	Maintain inactive facilities	0,647	0,308	0,075
2.	Decommissioning, close pits and site restoration by housekeeping method	0,061	0,222	0,333
3.	Decommissioning, leave fence and continue site restoration by new operator	0,291	0,470	0,592

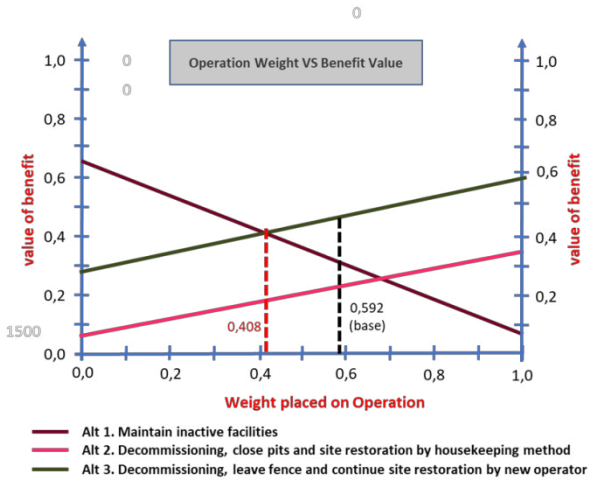

Fig. 7. Sensitivity Analysis for Decommissioning and Site Restoration of Inactive Facilities

Alternative 1, which is maintain inactive facilities alternative, is the most attractive on the total operations weight lower than 0,408 as shown on above figure. Alternative 3, which is decommissioning, leave fence and continue site restoration by new operator alternative is the most attractive on the total operations weight higher than 0,408.

If the weight of operation subcategory is increased, alternative 3 become more attractive. On the other hand, if the weight of execution subcategory is increased over operation subcategory, alternative 1 become more attractive.

PT PEI has a priority on compliance because it will have a huge impact if it is not fulfilled. Especially in the period that is approaching the end of concession, incompliance can lead to future liability. By putting priority on compliance, operations subcategory that has HES compliance as one of its attributes will have a greater weight when compared to the execution subcategory. Hence, decommissioning, leave fence and continue site restoration by new operator alternative is the favorable alternative.

IV. DISCUSSION

The result of AHP method shows the alternative 3, decommissioning, leave fence and continue site restoration by new operator alternative is the preferred alternative since it has the highest aggregate score that shows highest benefit among all alternatives, but this alternative is not the lowest cost.

According to provisional decision of SMART to trade cost and benefit, the preferred alternatives are those located on the efficient frontier. There are two alternatives lie on the efficient frontier, which are alternative 1 and alternative 3. Alternative 1 (maintain inactive facilities) offers the lowest cost. However, alternative 3 (decommissioning, leave fence and continue site restoration by new operator) is still favorable since it has significant value of benefit, especially HES compliance benefit as a dominant attribute. HES compliance is important for the company to ensure safety, protect people and environment. To move from alternative 1 to alternative 3 do not require huge amount of cost. Alternative 3 will cost $ 0,78 million higher than alternative 1, and equal to $ 0,05 million per point.

Based on sensitivity analysis of SMART, if weight of execution subcategory that consist of schedule and constructability is increased, alternative 1 (maintain inactive facilities) is the preferred alternative. In contrary, if weight of operation subcategory that consist of HES compliance and maintenance attribute is increased, alternative 3 (decommissioning, leave fence and continue site restoration by new operator) is the preferred alternative. Approaching end of concession, HES compliance become a priority requirement, not only to ensure safety, protect people and environment but also to maintain reputation and minimize future liability. In addition, footprint can be reduced by implementing alternative 3. To fulfil the HES compliance, execution subcategory that include schedule attribute is also has significant impact considering available time is very limited. Based on group discussion, we considered HES compliance has higher priority than schedule. Therefore, operation subcategory has higher priority and group decided alternative 3 is the favorable alternative.

According to above analysis, alternative 3 which is decommissioning, leave fence and continue site restoration by new operator is chosen as the highest priority. Decommissioning, leave fence and continue site

restoration by new operator alternative is selected for decision of decommissioning and site restoration issue to obtain world class and prudent oil and gas operator in protecting people and environment as defined as fundamental objective.

By implementing Decommissioning, leave fence and continue site restoration by new operator alternative, PT. PEI can meet relevant Government of Indonesia (GOI) regulations and compliance to carry out decommissioning and site restoration of inactive.

V. CONCLUSION

Several surface facilities have been out of service for years due to operational reasons and low-efficiency issues and PT PEI shall carry out decommissioning and site restoration of inactive facilities to meet with relevant regulations in very limited period and resources

PT PEI defines and focuses on important values that considered as decision criteria, such as HES compliance, maintenance, schedule, expenditure, and constructability

Consequences from current inactive facilities issues are public entering the inactive facilities cause theft case and land encroachment, equipment integrity decreases due to aging and corrosion which can lead to collapse risk, injury, and environmental pollution. This can lead to future liability for the company and corporation.

Three possible alternatives are generated and evaluated using AHP and SMART method, which are maintain inactive facilities (alternative 1), decommissioning, close pits, and site restoration by housekeeping method (alternative 2) and decommissioning, leave fence and continue site restoration by new operator (alternative 3). AHP analysis for benefit category combined with SMART provisional decision and sensitivity analysis allow to analyze from multiple points of view.

According to analysis, by considering cost and benefit related to operation and execution aspect, decommissioning, leave fence and continue site restoration by new operator is selected as the most preferable alternative since it provides the highest benefit and requires acceptable cost.

The selected alternative is treated as a project and managed by Project Management concept. Several actions need to be conducted for implementation of selected alternative.

- Develop Project Team Charter, including Resources Plan
- Stakeholder Management Plan
- Scope Management Plan
- Project Schedule

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