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Decision Analysis for Cleaning Method Selection of 26" HCT Shipping Line

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Abstract – **Many Oil and Energy companies are taking various efficiency and optimization measures that the pipeline facility that is no longer used for operation can be dismantled to reduce maintenance cost and inspection costs. The 26" HCT pipeline owned by Oil Energy Indonesia (OEI) has experiences leakage problems, significant thinning of pipe thickness which can lead to environmental soil pollution and hazard potential to residents around the pipeline.**
This final project aims to formulate a solution from the proposed alternative cleaning identified in the pipeline. The final project result is selection of several alternatives. Pipe condition problems were evaluated using Kepner-Tregoe (KT) Situation Analysis. The pipeline condition root and safety problem is then analyzed using KT-problem analysis and verified using 5 whys method. In obtaining alternatives that have potential as a solution to the existing problems, Value Focused Thinking method is used. Then alternative selection process uses Simple Multi Attribute Rating Technique method. Qualitative analysis is carried out through group discussions of four people who have deep knowledges and experiences.
Alternative proposed to clean the pipeline using De-oiling method.

Keywords: **Simple Multiple Attribute Rating Technique, Value Focused Thinking, Kepner-Tregoe Problem Analysis and Decison Making, Alternative Selection**

I. INTRODUCTION

Oil Energy Indonesia (OEI) has been operating in Indonesia more than 85 years ago. Currently, PT. OEI has been producing in Rokan block.

PT OEI operates under a Production Sharing Contract with the Government of Indonesia (GOI) represented by SKK Migas (Special Task Force for Upstream Oil and Gas Business Activities). More than 11 billion barrels of oil have been produced from Sumatra fields. PT. OEI is one the biggest foreign oil and gas company operates in Sumatera Island, Indonesia. PT OEI contributes about 30% of national oil production. In Sumatra operations, Chevron operates about 88 oil fields and three of them are major oilfields: Duri, Minas and Bekasap, as well as manage Dumai Wharf, the final terminal for oil transport.

Hydrocarbon Transportation (HCT) in Minas operates 36 km of 26" crude oil pipeline from Minas North Booster Station (Minas NBS) to Pinang Merah, Pungut was built in around 1958 to send oil production from the southern Rokan block (Minas and Petapahan/Kotabatak area), to Duri Tank Farm. From Duri the crude will be transported using another pipeline to Dumai to be shipped. Later, a 30" pipeline from Minas NBS to Duri was built to accommodate the increasing production from the southern area. Original design of the redundant pipeline was to handle from SLO (southern area) with peak production up to 1 MM BOPD in the 1970s. The two lines (26" and 30") are located at the same corridor and side by side at the section of Minas NBS-Pinang Merah for around 36 km.

The 30" pipeline is equipped with pigging facility, thus it could be better maintained to the pipeline. Meanwhile the 26" pipeline is not equipped with pigging facility.

SPECIFIC PROBLEM

Currently this HCT 26" shipping line is still containing remaining crude oil and there was no activities being done to clean and isolate this pipeline. Leaving this pipeline will expose a risk of environmental spill with the reason that this pipeline doesn't have good integrity anymore and potential that could damage the pipeline. Under such conditions, and along with the age of the 26" line, the 26" pipeline condition is getting deteriorated and unreliable. The 26" line condition is deteriorating and based on inspection conducted in 2012, there are 768 anomalies category 1 and 2 along the pipeline concerning the integrity of pipeline. Maintaining the 26" pipeline will add maintenance cost (inspection, pipe sleeve, insurance and also certification cost and efforts).

Additionally, continue using the aging 26" line will expose us to higher safety and environmental risk, i.e.: pipe leak, pipe rupture, etc. Cleaning and decommissioning of this 26" pipeline will reduce the above risk and potential future liabilities. HCT operations decided to stop using this 26" pipeline since 2012. The pipeline had been isolated and put into idle state since 2012, however the crude oil in the line had not been displaced. With the current SLO South oil production rate and future forecast, the 26" pipeline was assessed to be no longer required and no future utility.

Currently alongside of HCT 26" pipeline, there are several spot that near with community residence. Therefore there is possibility of hazard from HCT 26" pipeline especially the hazard when pipe leaking that could effect to the local community. This condition certainly has impact both in terms of safety reason and company reputation in the eyes of public

The optimization proposed by this project is to demolish or abandon one (1) redundant pipeline, which is the 26" HCT shipping line.

Furthermore, removing this pipeline is also align with the company footprint reduction strategy and reducing operations cost for inspection and maintenance

Currently the demolishment process can be execute after the facilities have a clean condition. Meanwhile there are problem in the demolishment process for this 26" HCT pipe line due to found congeal oil inside pipeline, has up-down elevation of pipeline, across river, near to public road and close to local community.
Project team shall conduct cleaning process inside the pipeline to clean residual hydrocarbon/ congeal oil and avoid spill to environment during demolishing process. Prior to demolishing process, idling by cleaning shall be conducted to the pipelines.
Cleaning method shall be decided to achieve the best optimum cleaning work prior demolishment process
Objective of pipeline cleaning is to remove remaining crude oil contained in the pipeline to eliminate risk of loss of containment (LOC) during execution and to reduce safety risk exposed to workers. The isolation is intended to ensure the pipeline to be decommissioned is free from hazardous energy from the active pipeline system.
The objective of this research is as follows:

1. To investigate the root cause for the problem of 26" HCT shipping line
2. To find the best solution for the problem of 26" HCT shipping line

II. METHODOLOGY

This research design will explore theoretical structure of assumptions, principles or theory to support analysis on providing best alternatives or solution for company strategy.
This section will explain about the research design or conceptual framework (Figure 1) to represent the research concept, which are consists of: what is the company current conditions, what are the problem, how to solve the problem, what tools will be used and what is the expected target

ALTERNATIVES

Pipe condition problems were evaluated using the Kepner-Tregoe (KT) Situation Analysis. The root of the pipeline condition and safety problem is then analyzed using the KT - problem analysis and verified using the 5 whys method. In obtaining alternatives that have the potential as a solution to the existing problems, the Value Focused Thinking (VFT) method is used. Then the alternative selection process uses the Simple Multi Attribute Rating Technique (SMART) method. Qualitative analysis for pairwise comparisons is carried out through group discussions of four people who have deep knowledge and experience of piping engineering, project management, construction and operations. The results of the analysis are then submitted to the chief decision maker.

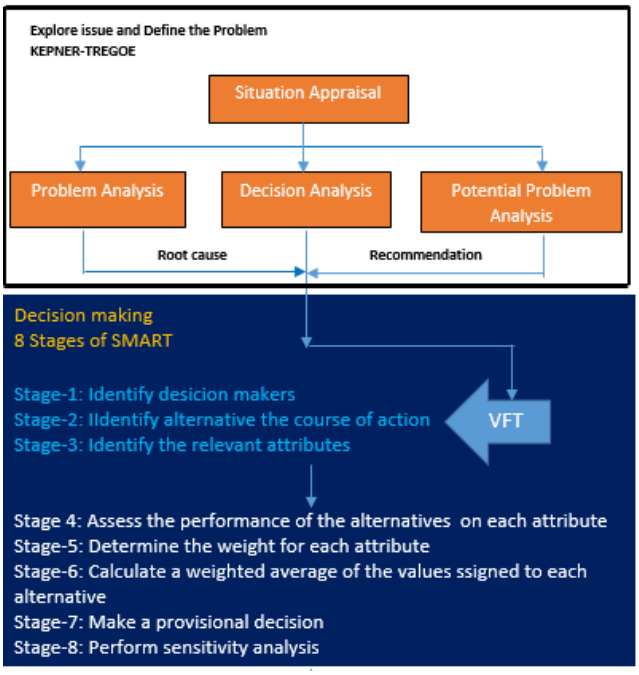

Figure 1. Research Design

TABLE 1.KT SITUATION ANALYSIS OF HCT 26" PIPELINE PROBLEM

Problem	Timing (H,ML)	Trend (H,M,L)	Impact (H,M,L)	Next Process
Risk of environmental spill caused by low integrity	H	H	H	PA
Inspection found 768 anomalies along the line	M	H	H	PA
Up-down pipeline elevation, across river, buried pipe, near to public road, near to local community	M	H	H	PA
There is congeal oil inside pipeline	H	H	H	DA

HCT 26" pipeline has experienced pipe leaking for several times and have impact to local community activities around the pipeline, therefore the timing is categorized is high. The trend of having this problem categorized as high, due to this problem will occur at the pipe segment that close to the community residence and public road/facilities. The impact from this problem is categorized high, due to risk of environmental spill of the HCT 26" pipeline is slightly high and could lead to property damage due to low integrity.

HCT 26" pipeline has inspection found 768 anomalies along the line and categorized timing is medium due to pipe thinning rate can be monitored by UT (ultrasonic test) wall thickness tool. The trend categorized is high due to anomalies will get worst of the pipeline and impact categorized as high, due to can cause pipe rupture and leaking potential of pipe segment that close to the community residence and public road.

HCT 26" pipeline has up-down pipeline elevation, across river, buried pipe, near to public road, near to community residence and categorized timing is medium due to

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pipeline supported by ground base and pipe support. The trend categorized as high due to there is disruption/hazard/leaking potential of the pipeline and expose to the river and the soil. The impact categories is high due to close to community residence activities and public road.

There is found congeal oil inside pipeline as categorized high for timing due to has experienced leaking of the pipeline and have HES risk during next dismantling work. Trend shows high due to congeal oil condition may get worst and will be growth and the impact categorized is high due to pipe leaking potential which caused by pipe damage can occur near to residential/public area

There is congeal oil inside pipeline and shall be cleaned before decommissioning project execution. The selected step to resolve this issue is by Problem Analysis, by finding the most possible cause prior to improvement When the reactive action conducted for maintenance work, its required to cost and many resources. This condition is not effective to the company's operations. Considering all aspect above, the timing, trend and impact from operation and maintenance activities are considered high. The next selected process to resolve this issue is by decision analysis

TABLE 2. KT PROBLEM ANALYSIS (PA) OF RESEARCH PROBLEM RESULT

DESCRIBE THE PROBLEM: The current condition of HCT 26" pipelines has anomalies along the pipeline, congeal oil and found leaking due to low intergrity that causing property damage				
SPECIFICATION	**IS**	**IS NOT**	**DISTINCTIONS**	**CHANGES**
WHAT: • Specific object has deviation • Specific deviation	• Is the HCT 26" shipping line • Is impact to property damage .	• Is not HCT 26" shipping line • Is not impact to property damage	• leaking due to pipe damage • This location is the nearest the local community/public road/river	• Increasing number of pipeline spot thinning wall thickness
WHERE: • Object when deviation is observed	• Is observed at segment of HCT 26" pipeline that close ommunity residence	• Is observed at pipe segment that located far community residence	• The location to pubic environment	• Increasing residential area near pipeline corridor
WHEN: • The deviation observed first • Since that time has the deviation observed	• Is first observed in 2016 • Is observed continuously during routine monitoring	• Could be but is not reported before 2018 • Is observed randomly during routine monitoring	• No of housing residence near pipeline increased	• Nothing, the requirement the right of way are still same
HOW MUCH: • Object deviation volume	• Total of leakage event in the last 5 years > 5 times	• Is not clear from deviation	• More leakage event due to no of spot with thinning wall thickness expected increased	• Wall thickness of pipe will decrease in line with operational effect and the age of pipeline

POSSIBLE CAUSES	**THE MOST POSSIBLE CAUSE**
1. The condition on HCT 26" pipeline has been deteriorated, not integrity anymore and it is not comply with HES guideline, GOI Regulation, Engineering standard 2. The current pipeline location is near to public environment 3. The oil leakage to environment is consider as not safe	The condition on HCT 26" pipeline has been deteriorated, not integrity anymore and it is not comply with HES guideline, GOI regulation, Engineering standard
VERIFICATION (by 5 Whys)	

Based on the root cause result from KT Problem Analysis above that the condition on HCT 26" pipeline has been deteriorated, not integrity anymore and it is not comply with Company HES guideline, GOI regulation, engineering standard, it needs to solve the problem for the pipeline condition. The thinning of pipe thickness able to cause damage and reduce the strength of pipeline. Pipeline leaking is not comply to HES guideline. There is congeal oil inside pipeline also not comply with engineering standard and have potential to damage inside the pipeline. Therefore, the pipeline condition with the problem required to find the solution to solve the issue in order to meet the compliance aspects

To verify KT Problem Analysis, the verification process is conducted by five whys below,

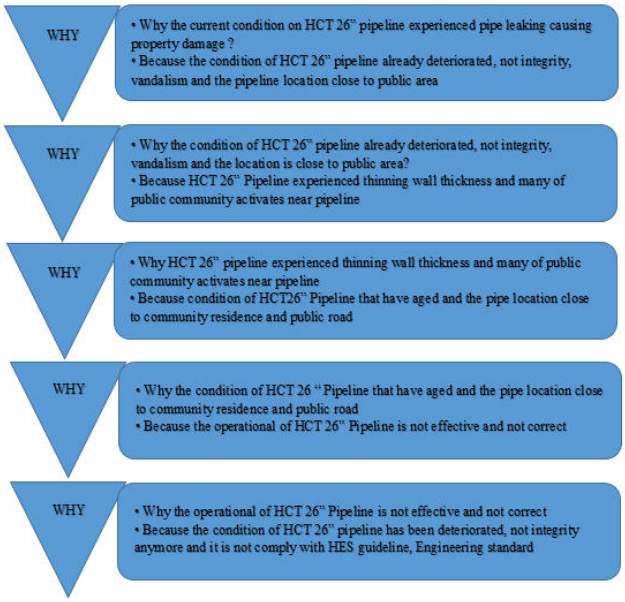


Figure 3. 5 Five Whys analysis

In generating possible alternative to solve the issue, a Focus Group Discussion (FGD) was held by involving expertise in OEI. Those expertise is Project Manager, Construction Engineer, Pipeline Engineer and Operation Representative.

Cleaning Method Alternatives :

1. Air Pigging
2. Water Pigging
3. Crude Pigging
4. Deoiling

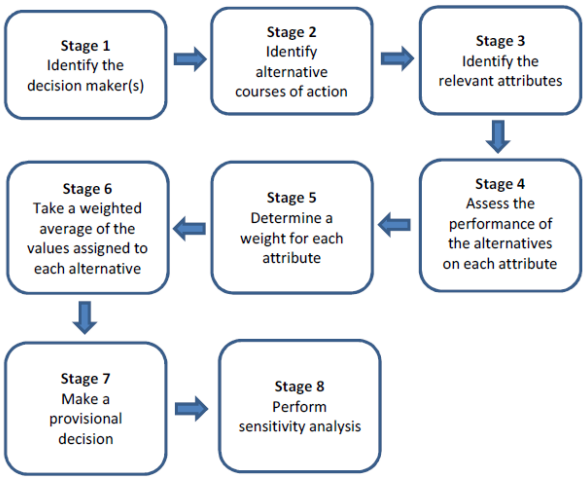


Figure 4. SMART process flow diagram

From Value Focused Thinking (VFT) method, the decision maker, the objective, the alternative solution will be identified. The alternatives were developed based on previous project and discussion or interview with some expertise in the company

III. RESULT

1) Stage 1: Identify decision maker(s)

The decision maker of this project is project team as group decision making process. The project team has the highest interest in this project. The decision maker is collaborated and discussed to Decision Executive and Review Board (DRB) during decision making process

2) Stage 2: Identify alternative courses of action

The project team already identified four (4) alternatives for cleaning methods available to be used in this project including the cost estimation

TABLE 3 . THE CLEANING METHODS ALTERNATIVES AND COST ESTIMATION

No	Alternatives	Cost Estimation
1	Air Pigging	$US 1.500.000
2	Water Pigging	$US 3.600.000
3	Crude Pigging	$US 1.370.000
4	Deoiling	$US 150.000

3) Stage 3: Identify the relevant attributes

The selected alternative is expected to have low total capital cost, easiness for cleaning preparation, easiness and safest of cleaning execution plan with minimum disruption to operation and minimum utilization special manpower and tools, also the alternative is expected with the fastest project schedule. The desired stated (the want) that consider fundamental objective are the values that have relevance with the end objective (the must). Those values become the attribute or criteria to the relevant alternatives as generated for selection to cleaning HCT 26" pipeline plan

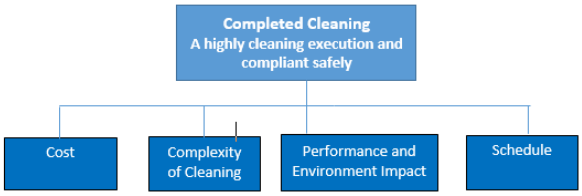


Figure 5. Value tree and attribute

TABLE 4. ATTRIBUTE DESCRIPTION

No	Attribute	Description
1	Cost	Cost required for cleaning execution alternative
2	Complexity of Cleaning	The complexity of cleaning activity include with manpower and tools required during cleaning execution
3	Performance and Environment Impact	Performance and environment impact for cleaning execution alternative
4	Schedule	Total duration that required to cleaning preferred alternative until completed cleaning

TABLE 5. THE SCORING MATRIX FOR THE "BENEFITS" ATTRIBUTES

BENEFIT ATTRIBUTE	SCORING MATRIX		
	1	3	5
Cost	>US$ 1.500.000	US$ 500.000 - US$ 1.500.000	< US$ 500.000
Complexity of Cleaning	Construct major equipments is needed	Construct some equipments is needed	Construct minor equipment is needed
Performance and Environment Impact	Higher risk of pipe leak and stuck in the long pipe	Medium risk of pipe leak and minor stuck in the long pipe	Lower risk of pipe leak and no stuck in the long pipe
Schedule	>4 months	2-4 months	< 2 month

4) Stages 4: Assess the performance of the alternatives on each attribute.

There are four (4) alternative of cleaning method that will be assessed with the four (4) decision criteria by use the score with range 1 – 5

TABLE 6. THE SCORING FOR EACH ALTERNATIVE

Criteria	Air Pigging	Water Pigging	Crude Pigging	Deoiling
Cost	3	1	3	5
Complexity of cleaning	5	1	3	4
Performance and Environment Impact	3	2	3	4
Schedule	3	1	1	5

5) Stage 5: Determine a weight for each attribute

Based on the discussion, performance and environment Impact is the most important benefits criteria. Criteria about the complexity of cleaning and schedule is the second important criteria.

TABLE 7. THE SWING WEIGHT FOR EACH CRITERIA

No	Criteria	Weight
1	Cost	80
2	Complexity of cleaning	90
3	Performance and Environment Impact	100
4	Schedule	90
	Total Raw weight	**360**

Normalizing the weight for each selection criteria can be done by dividing swing weight score in each attribute with the total raw weight as shown in table 8 below

TABLE 8. THE NORMALIZED WEIGHT FACTOR FOR EACH DECISION CRITERIA

No	Attribute/Criteria	Weight	Normalized Weight
1	Cost	80	0.22
2	Complexity of cleaning	90	0.25
3	Performance and Environment Impact	100	0.28
4	Schedule	90	0,25
	Total Raw weight	**360**	**1.00**

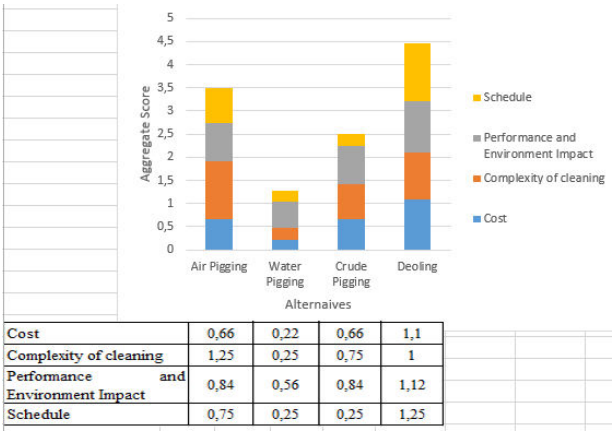
6) Stage 6: For each alternative, take a weighted average of the values assigned to that alternative
Calculate the aggregate score of each alternative by multiplying each score in Table 6 with normalizing weight from Table 8 and obtain total score below.

TABLE 9 TOTAL AGGREGATE SCORE OF WEIGHTED AVERAGE

No	Cleaning Methods	Aggregate Benefit
1	Air Pigging	3.50
2	Water Pigging	1.28
3	Crude Pigging	2.50
4	Deoiling	4.47

7) Stage 7: Make a provisional decision

The Cost and Benefit Analysis is conducted to give more comprehensive information for Project team including Decision Maker and DRB Members prior to take the final decision about selected cleaning methods prior demolishment project execution



Cost	0,66	0,22	0,66	1,1
Complexity of cleaning	1,25	0,25	0,75	1
Performance and Environment Impact	0,84	0,56	0,84	1,12
Schedule	0,75	0,25	0,25	1,25

Figure 6. Aggregate Scoring for All Alternatives with the "Benefits" Attributes

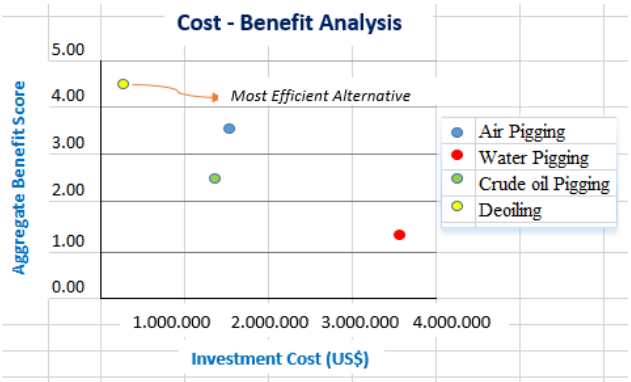


Figure 7. Cost – Benefit Analysis for Each Alternative

There is 1 (one) alternative that can be selected in term of Cost & Benefit attributes. Those alternative is De-oiling.

Based on the Cost and Benefit Analysis (highest benefit with available budget), the project team choose the alternative by using De-oiling for cleaning method execution. De-oiling is the most effective and efficient method to remove residual hydrocarbon inside the 26" HCT pipeline.

8) Stage 8: Sensitivity Analysis
To evaluate how robust the solution, the sensitivity analysis can be done. Sensitivity analysis shows how the changes in the decision criteria's weight can influence its aggregate score.
Sensitivity analysis can be calculated by changing the raw weight and computing each decision criteria to the weight. In this research, sensitivity analysis is used to evaluate the robustness of Alternative 2 (De-oiling) in criteria "Complexity of Cleaning" and "Performance and Environment Impact.

The sensitivity analysis result in "Complexity of Cleaning" criteria is shown in table 10 which conclude that the changing on weight of cost will not have significant impact on the selected alternative.

The Alternative 4 De-oiling is still has the highest aggregate score among the other solution.

TABLE 10. SENSITIVITY ANALYSIS FOR "COMPLEXITY OF CLEANING" CRITERIA

No	Alternatives	Current Aggregate Score	Raw Weight				
			0	40	60	80	100
1	Air Pigging	3.50	3,00	3,26	3,36	3,46	3,54
2	Water Pigging	1.28	1,37	1,32	1,30	1,29	1,27
3	Crude oil Pigging	2.50	2,33	2,42	2,45	2,49	2,51
4	Deoiling	4.47	4,63	4,55	4,52	4,49	4,46

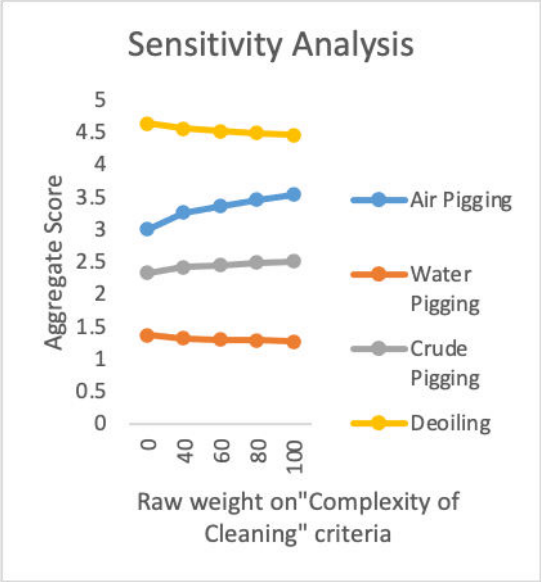


Figure 8. Sensitivity Analysis for Weight on "Complexity of Cleaning" Criteria

TABLE 11. SENSITIVITY ANALYSIS FOR "PERFORMANCE AND ENVIRONMENT IMPACT" CRITERIA

No	Alternatives	Current Aggregate Score	Raw Weight				
			0	40	60	80	100
1	Air Pigging	3.50	3,69	3,60	3,56	3,53	3,50
2	Water Pigging	1.28	1,00	1,13	1,19	1,24	1,28
3	Crude Pigging	2.50	2,31	2,40	2,44	2,47	2,50
4	Deoiling	4.47	4,65	4,57	4,53	4,50	4,47

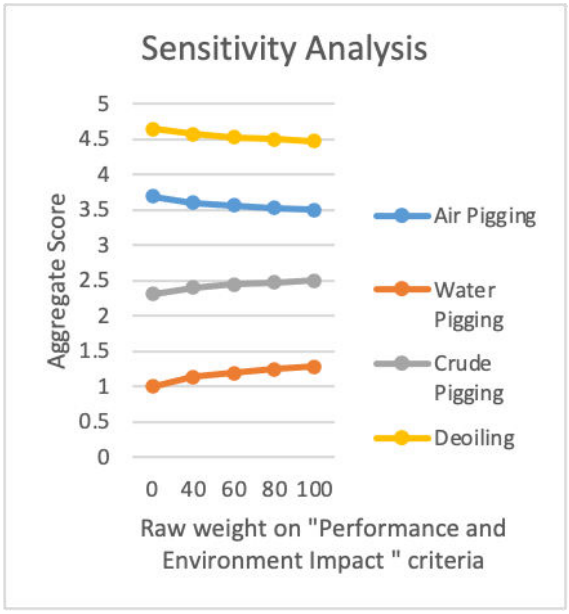


Figure 9. Sensitivity Analysis for Weight on "Performance and Environment Impact" Criteria

IV. DISCUSSION

One of the tools for problem solving and decision making, Kepner-Tregoe (KT), will be used for issues exploration and defining the problem. Situational analysis, will be conducted to select the suitable process to find the solution from the issue. The root cause of the problem as the result from problem analysis and the recommendation from potential problem analysis will be abstracted with the decision that need to be made from situation analysis. KT Method has been used for decision making based on criteria that could minimize the lost. The structure of KT Method is to compile the information and conduct evaluation to situation and the result that will be achieved. The Kepner-Tregoe processes are universally applicable, regardless of cultural setting or the content against which they are applied. This methodology was introduces as the way to make unbiased decision to limit the conscious and unconscious biases that draw attention away from the outcome

Decision making is an essential aspect of human life, so there is no dimension that is free from decision making. Regardless of the complexity of the mental process of decision making, each individual determines the problem and wants the results according to their desires. Decision making is a complex process, and many factors influence it such as biological, physiological, psychological, and socio-cultural environment.

SMART is one of the method to decide multiple objectives. This method has been used widely due to its simplicity and transparency. By using this method, the decision maker from any different background could be easily to use this method and understand with the recommendation. This method is used in this research due to ease of use in practical to perform faster decision

making. The method of analysis of a finite set of alternatives. The performance of each alternative is expressed in grades on numerical scales, which are evaluated through a direct-rating procedure.
The analysis involved is transparent, so the method is likely to yield an enhanced understanding of the problem and be acceptable to the decision maker who is distrustful of mathematical "black box" approach. This technique is widely applied because of the simplicity of both the response required of the decision maker and the manner in which these responses are analyzed

V. CONCLUSION

1. Currently this 26" shipping line is still containing crude oil and there was no activities being done to clean and isolate this pipeline. Leaving this pipeline as it is will expose to risk of environmental spill with the reason that this pipeline doesn't have good integrity anymore that could damage and leaking the pipeline. Furthermore, removing this pipeline is also aligned with the company footprint reduction strategy and reducing operations cost for inspection and maintenance.
2. Based on Kepner-Tregoe Problem Analysis, the root cause from the issue on 26" pipeline is because the condition of HCT 26" Pipeline has been deteriorated and it's not comply with HES guidelines, GOI regulation and Engineering Standard. This root cause also has been verified by using 5 whys method.
3. The potential consequences from the issue is the HCT 26" pipeline has impact to environment and public area due to leakage event on the pipeline related deterioration and pipe rupture.
4. Based on the analysis using SMART, the recommendation for the alternative to cleaning the HCT 26" pipeline issue is by choose De-oiling method to execute cleaning process to the pipeline.
   This selection has been considered the cost and benefit in term of project effectiveness

VI. IMPLEMENTATION PLAN

The implementation and execution plan are the supporting document and information in addition to research proposal result as part of the decision maker consideration to endorse or reject the project. Comprehensive implementation will convince the Decision Maker that the selected alternative is ready for the next stage for cleaning flow process plan and execution phase.
The implementation and execution plan will consist of following items,

1. Project team charter and resource plan
   The execution of this alternative will be handled by Project Team from Facility Engineering Team. During execution of cleaning phase, all activities will be managed by Asset Retirement project, Facility Engineering team.
2. Stakeholder analysis and engagement plan
   Stakeholders are individuals and groups, both inside and outside the organization, who can influence the success of the project, and/or anyone who can be impacted by project execution. Stakeholder Management refers to the body of knowledge that is focused on the achievement of strategic objectives
3. Contracting plan
   The cost of HCT 26" shipping line cleaning project will be charged to JDE AFE. This project not in SR (service request) system but in JDE system and utilized RUR (Resources Unit Rate) Contract for the de-oiling execution
4. Project Risk analysis and contingency plan
   For better project planning, any potential risk that could affect the project execution shall be identified in the beginning. Some potential risk and uncertainty things that identified then will be mitigated to minimize the impact. All of potential risk and the mitigation plan that already identified, then will be accommodated through contingency plan on project cost and schedule

REFERENCES

[1] Cleland, David R., Ireland, Lewis R., 2010, "Project Management, Strategic Design and Implementation", 4th Edition, *McGraw-Hill*.
[2] Goodwin P., Wright, G, 2005, Decision Analysis for Management Judgement", 3rd Edition, A John Wiley and Sons, Ltd., Publication.
[3] Keeney, Ralph L., 1996, "Value-Focused Thinking: Identifying Decision Opportunities and Creating Alternatives", *Elsevier Science B.V.*, pp. 537-549
[4] Keeney, Ralph L., McDaniels, Timothy L., 1992, "Value Focused Thinking about Strategic Decision at BC Hydro", *the Institute of Management Sciences,* pp. 94-109
[5] Kepner, Charles H, Tregoe, Benyamin B, 1981, "The New Rational Manager", New Jersey, Princeton Research Press
[6] Project Resources Company, 2011, Corporate Project Management Handbook. 2nd Edition.
[7] Siallagan, Manahan, 2020, Simple Multiple Attribute Rating Technique, Course Handout of Decision Making and Negotiation.
[8] Sunitiyoso, Yos, 2020, Problem Analysis System Approach and Simple Multiple Attribute Rating Technique, Course Handout of Decision Making and Negotiation.