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DECISION ANALYSIS OF THE USE OF EX-TERMINATION MATERIALS FOR OPERATING COST EFFICIENCY WITH A MULTI-CRITERIA APPROACH IN AN INDONESIAN UPSTREAM OIL AND GAS COMPANY

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ABSTRACT
This study aims to develop a more effective and data-based strategy for the management of ex-termination materials in the upstream oil and gas industry, integrating ABC, VED, and FMSD methods with Analytical Hierarchy Process (AHP). The analysis was carried out by integrating the ABC-FMSD-VED matrix approach. The results showed that 21% of category A materials accounted for 80% of the total inventory value, while 85.95% of materials were included in the Deadstock category, which was not optimally utilized. The AHP analysis showed that the top priority was internal utilization, followed by borrowing, transfer, and deletion, with sensitivity tests indicating decision stability.

Keyword: ABC analysis; Ex-termination material; FMSD analysis; oil and gas industry; operational efficiency

INTRODUCTION

PT ABC is a Cooperation Contract Contractor with the Gross Split scheme in accordance with the Regulation of the Minister of Energy and Mineral Resources Number 8 of 2017 (Minister of Energy and Mineral Resources No. 8/2017), where the profit-sharing contract in upstream oil and gas business activities divides production without a mechanism to refund operating costs. With this scheme, all operating costs and risks are borne by the contractor, this encourages PT ABC to continue to look for opportunities to make operational cost efficiency in order to obtain maximum profits.

One of the opportunities for operational cost efficiency is to maximize the use of ex-termination materials. With the use of this ex-termination material, PT ABC will get savings from the cost of maintenance of production facilities from the price of materials or spare parts, this is because ex-termination materials if used by the contractor transfer of management have a value of zero. The use of ex-terminated materials at PT ABC is currently carried out by offering these materials to the user function and also some are used by other upstream oil and gas companies with a transfer mechanism. The use of ex-termination materials at PT ABC is currently not structured and systematic, only based on the highest total price of ex-termination materials without taking into account other aspects, so that when ex-termination materials are taken over from consignment stock, there are still many materials that are not properly used in the field. This causes various problems. Storing large quantities of materials without clear utilization will lead to increased maintenance costs (Perkumienė et al., 2022), the risk of material quality deterioration due to aging stock (Stock et al., 2018), and inefficiencies in warehouse management that can have an impact on the

overall supply chain (Richards, 2017). In addition, the longer the material is not used, the higher the risk of quality degradation (Mehr et al., 2020; Mierzwa-Hersztek et al., 2019; Riahinezhad et al., 2021), thus increasing the likelihood of waste and lowering its economic value.

In addition to the financial impact, suboptimal management of ex-termination materials also has environmental consequences and regulatory compliance. Regulation of the Minister of Finance of the Republic of Indonesia Number 89/PMK.06/2019 states that the utilization of State Property (BMN) from the upstream oil and gas industry must be carried out optimally to avoid wasting state assets. This regulation underscores the importance of ex-termination material management strategies that not only pay attention to the aspect of cost efficiency but also compliance with government policies. Materials that are not managed properly have the potential to become industrial waste that can have an environmental impact. Therefore, companies need to develop more systematic policies in handling ex-termination materials, including considering aspects of sustainability and social responsibility. The reuse of ex-terminated materials can also be a strategic step in supporting circular economy programs that emphasize waste reduction and resource reuse.

Deadstock In inventory management, goods have no monetary value for the company and cannot be used for production (Atmaja, 2022; Muller, 2019; Widyatmoko & Yudoko, 2024). These items must be kept in storage, which increases maintenance costs and reduces storage space. The productivity and economic value of leftover goods are not proportional to the value of the assets acquired. The rate of material turnover in the warehouse is affected by the presence of deadstock (Riza & Mulyono, 2019; Sugumaran & Sukumaran, 2019). High inventory also adds to storage costs, so companies must optimize inventory value and reduce unused items

Inventory materials are company assets that include raw materials, goods in the production process, and finished goods. The procurement and storage of goods in a company requires high costs, usually 20–40% of the price of goods each year. Therefore, a good inventory management strategy is essential to reduce costs so as to achieve the lowest total cost (Afianti & Azwir, 2017).

Previous research has shown that a multi-criteria approach in inventory management can improve the effectiveness of material management. Inventory management is the process of determining and controlling the inventory level of raw materials, goods in process, and finished goods (Pandya & Thakkar, 2016). The goal is to ensure sufficient inventory is available while keeping costs to a minimum, which makes organizations more effective and efficient. Various inventory-related costs, such as storage, ordering, and shortage costs, can increase without proper control systems, negatively impacting profitability. The implementation of good inventory control can save investment as well as help in saving space and increasing process transparency, while also supporting the smooth production and image of the organization. Inventory control methodologies include techniques such as ABC, XYZ, HML, VED, FSN, SDE, GOLF, and SOS analysis.

The analysis of the ABC-VED-FNS matrix can assist organizations in the implementation of inventory control policies and techniques, the reduction of a group of items that require more managerial monitoring and control, the prioritization of storage site plans (pick-face), reduction of the amount of time and labor costs associated with storage, retrieval, and packaging, as well as determining when products should be reordered or refilled (Gizaw & Jemal, 2021).

With this background, this study aims to develop a more effective and data-based ex-termination material management strategy. The integration of ABC, VED, and FMSD methods is expected to provide a comprehensive solution in determining the optimal material utilization strategy. Based on this classification, ex-termination materials are obtained that are included in the AVF classification which is a very important category, as well as ex-termination materials that are included in the category C-Desirable-Deadstock which may no longer be needed. The next one can be easily mapped for its utilization strategy to be more optimal. In addition to the ABC, VED and FMSD approaches, alternative decision-making on the use of ex-terminated materials requires a more systematic and quantitative-based approach. Method Analytical Hierarchy Process (AHP) can be used to help prioritize from internal utilization alternatives, loaned, diverted or abolished. This approach considers several important criteria such as cost, level of criticality, and rate of consumption, thus providing a more objective basis for decision-making. (Sundana & Risdiyanti, 2019), this AHP method can help in determining priorities so that it can produce the best decision. AHPs can generate more varied data so that they provide clearer and more rational reasons to consider before a decision can be made.

The results of this research are expected to be a guide for upstream oil and gas industry managers in implementing a more structured and systematic policy in the management of ex-termination materials. In addition, this research also contributes to the academic literature in the field of supply chain management and inventory management, especially related to optimizing the utilization of assets that have not been utilized to the fullest. With the right strategy, companies can improve operational efficiency, reduce waste, and support the sustainability of the oil and gas industry in the future.

The formulation of the problem in this study includes three main points: first, the classification of ex-termination materials at PT ABC using ABC, FMSD, and VED analysis as well as the integration of the matrix from the three methods; second, the strategy for the use of ex-termination materials based on the integration of the same matrix; and third, the application of the AHP method to prioritize alternative material utilization based on cost criteria, criticality level, and consumption rate. The purpose of the research is to identify ex-termination materials and optimal strategies at PT ABC, as well as develop an AHP-based decision-making model. This research is expected to provide strategic guidance to optimize ex-termination materials, improve cost and storage space efficiency, add to the academic literature related to multi-criteria integration methods in materials management, and provide AHP-based recommendations for alternative efficient use of materials. The

limitation of this study is that it focuses on ex-termination materials at PT ABC, does not include non-termination materials or technical aspects related to storage operations outside of the multi-criteria classification.

This study aims to develop an effective strategy for the management of ex-termination materials in the upstream oil and gas industry, integrating ABC, VED, FMSD methods, and the Analytical Hierarchy Process (AHP). It classifies materials to determine optimal utilization strategies based on cost efficiency, criticality, and consumption rate. The research results provide structured guidelines for policy implementation, aiming to improve operational efficiency, reduce waste, and support industry sustainability. The study's findings contribute to the academic literature, offering a systematic approach for inventory management and decision-making models.

The current research introduces significant novelty by integrating ABC, VED, and FMSD analyses with Analytical Hierarchy Process (AHP) to optimize the management of ex-termination materials in the upstream oil and gas industry, a previously underexplored area (Gizaw & Jemal, 2021; Pandya & Thakkar, 2016). Unlike previous studies that focus on general inventory management or single methods, this research provides a holistic approach by prioritizing material utilization strategies based on cost efficiency, criticality, and consumption rate, supported by sensitivity analysis to ensure decision robustness (Russo & Camanho, 2015; Sundana & Risdiyanti, 2019). It also emphasizes regulatory compliance with Indonesian government regulations (Minister of Finance Regulation No. 89/PMK.06/2019) and contributes to sustainability by promoting the reuse of materials in line with circular economy principles (Lisitsa et al., 2019). Additionally, the study proposes the development of Standard Operating Procedures (SOPs) for ex-termination material management, offering practical, actionable guidelines that address gaps in existing literature and provide a comprehensive framework for improving operational efficiency and compliance in the oil and gas sector (SCM-Subholding Upstream Pertamina, 2021).

METHOD

The methods applied include data collection, data analysis, and interpretation of results to provide data-driven recommendations. Data was collected from two main sources: primary data through in-depth interviews with various resource persons such as Warehouse Officers and Senior Maintenance Supervisors, and secondary data taken from ERP systems (SAP) regarding ex-termination materials.

The data validation process is carried out by triangulating sources to ensure consistency and accuracy of information. The analysis was carried out by three methods, namely ABC analysis to classify materials based on consumption value, VED analysis to categorize materials based on importance level, and FMSD analysis to categorize based on consumption rate. Furthermore, the integration of the three methods is carried out using a matrix approach to assess risks and determine alternative priorities for the use of ex-termination materials.

To determine the priority of material utilization, the Analytical Hierarchy Process (AHP) method is applied. The steps include identifying relevant objectives and criteria, such as cost, level of criticality, rate of consumption, and storage efficiency. A paired comparison matrix is used to calculate the weight of each criterion and alternative. Consistency validation was performed by calculating the Consistency Index (CI) and Consistency Ratio (CR), and sensitivity analysis was performed to test the impact of the criterion weight change on alternative priorities.

RESULTS AND DISCUSSION

Analytical Hierarchy Process (AHP) Sensitivity Test

After the AHP analysis is carried out and the priority of the use of ex-termination materials is obtained with the first priority order of alternative internal utilization, then borrowing, transfer and the last priority is the alternative of the proposed elimination. So the next important step is to conduct a sensitivity test to ensure that the priority decision on the use of ex-termination materials is the optimal solution of a decision-making, in general, sensitivity analysis is aimed at calculating the stability of the optimal solution results if there is a change in weight to several assessment parameters in decision-making. This analysis determines the extent to which the same decision will hold up with a change in priority levels. The test was carried out by simulating an increase or decrease in the weight of the criteria by 10% which was done using Expert Choice 11 software with the consideration that the results obtained were more accurate.

The sensitivity test using Expert Choice 11 software begins with determining the goals of the AHP analysis to be carried out, then entering the criteria used and alternatives to the decision. Next, enter the data of the Resource Persons and enter the weight of the paired comparison of the criteria and alternatives in the system. The results of the calculation of the AHP combination were obtained as a result of the priority weight of the criteria in the use of ex-terminated materials was the cost efficiency criterion of 7.2%, the criticality level of 54.4% and the consumption rate of 38.4% with the result of the priority of material utilization of 68.9% was an alternative internal utilization, 14.4% was borrowed, then the transfer was 8.5% and the alternative of the proposed elimination was 8.2% with a consistency ratio of 0.02 or < 1. Details of the calculation of AHP with Expert Choice 11 software as shown in Table 1 below.

Table 1. Results of Weighting Calculation of Priority Criteria and Alternatives with AHP

Yes	Criterion	Priority Weighting Criteria (%)	Alternative	Alternate Priority Weight (%)
1	Cost Efficiency	7,2	Internal Utilization	68,9
2	Criticality	54,4	Borrow Usage	14,4
3	Consumption Rate	38,4	Transfer	8,5
4			Removal	8,2

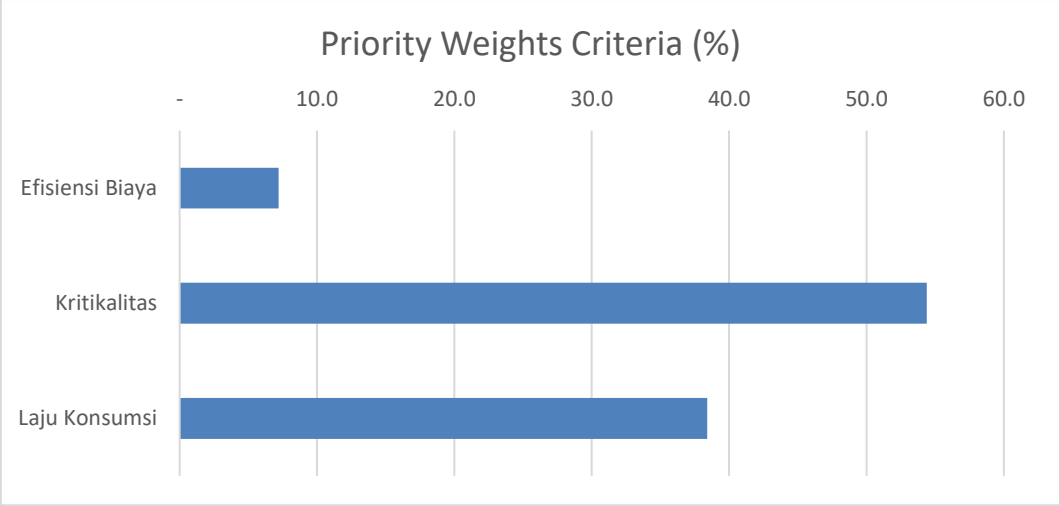

Figure 1. Results of AHP Analysis with Expert Choice 11 Priority Weights Criteria

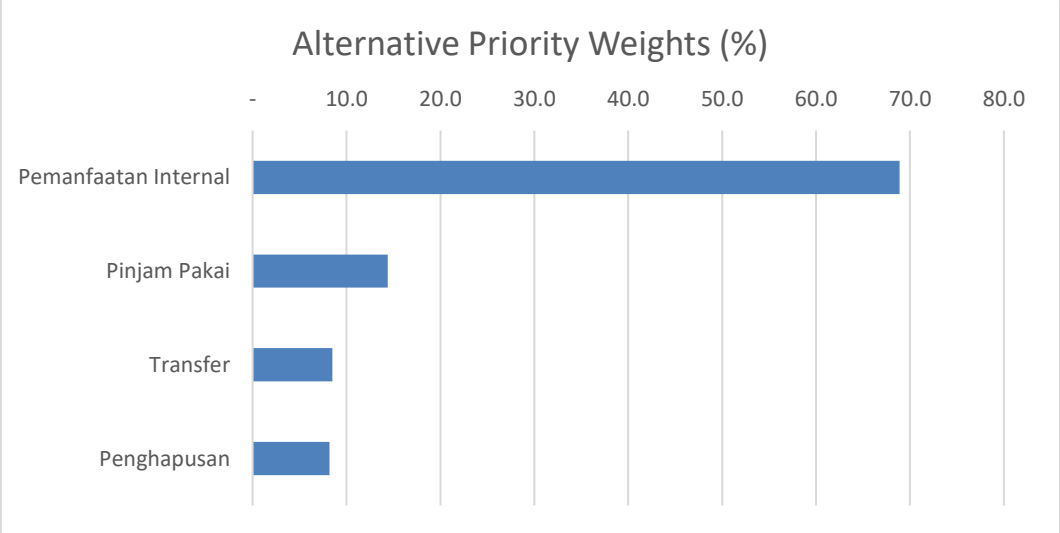

Figure 2. Results of AHP Analysis with *Expert Choice 11 Alternative Priority Weights*

There is a slight difference in the weights of priority criteria and alternatives between the manual AHP calculation in Excel and Expert Choice 11 as shown in Table 4.26 below. This can be possible because in calculations using *excel* only use the number of 3 digits after the comma so that there is rounding of numbers, besides that the normalization process in manual calculations is simpler so that it produces different levels of precision in the calculation results using Microsoft excel and expert choice 11. However, these slightly different results do not significantly affect the priority weight of the decision results and also the consistency.

Table 2. Comparison of Excel Calculation Results with Expert Choice 11

No	Criterion	Priority Weighting Criteria (%)		Alternative	Alternate Priority Weight (%)	
		Excel	*Expert Choice*		*Excel*	*Expert Choice*
1	Cost Efficiency	7,1	7,2	Internal Utilization	68,23	68,9
2	Criticality	54	54,4	Borrow Usage	14,68	14,4
3	Consumption Rate	38,9	38,4	Transfer	8,8	8,5
4				Removal	8,29	8,2

The sensitivity test was carried out to reduce and add priority weights to the priority weights of the cost efficiency criteria. The test by reducing the priority weight of the cost efficiency criterion from 7.2% to 6.2% obtained the result of the priority weight of criticality to 54.9% from the previous 54.4% and the consumption rate from 38.4% to 38.8% with the priority weight of the use of ex-termination materials for internal utilization from 68.9% to 69.0%, then the alternative to borrow and use remained at 14.4%, then the transfer alternative was also fixed at 8.5% and the alternative of the proposed elimination was also applied at 8.2%.

Furthermore, from this sensitivity test, the priority weight of the cost efficiency criterion was added to the priority weight of the cost efficiency criterion from 7.2% to 8.4% and the result was obtained that the priority weight of the criticality criterion became 53.7% from the previous 54.4% and the priority weight of the consumption rate criterion changed to 37.9% from the previous 38.4% and the priority weight of the use of ex-termination materials for internal utilization alternatives remained at 68.9%, For borrowing alternatives, it remains at 14.4%, then for transfer alternatives, 8.5% is also raised and finally, for alternative proposals, the deletion proposal also remains at 8.2%.

Table 3. Tabulation of Sensitivity Test Results on Cost Efficiency Criteria

Uji Sensivitas dengan menurunkan dan menaikan bobot prioritas Kriteria Efisiensi Biaya								
No	Kriteria	Bobot Prioritas Kriteria (-10%)	Bobot Prioritas Kriteria (%) Original	Bobot Prioritas Kriteria (+10%)	Alternatif	Bobot Prioritas Alternatif (-10%)	Bobot Prioritas Alternatif (%) Original	Bobot Prioritas Alternatif (+ 10%)
1	Efisiensi Biaya	6,2	7,2	8,4	Pemanfaatan Internal	69,0	68,9	68,9
2	Kritikalitas	54,9	54,4	53,7	Pinjam Pakai	14,4	14,4	14,4
3	Laju Konsumsi	38,8	38,4	37,9	Transfer	8,5	8,5	8,5
4					Penghapusan	8,2	8,2	8,2

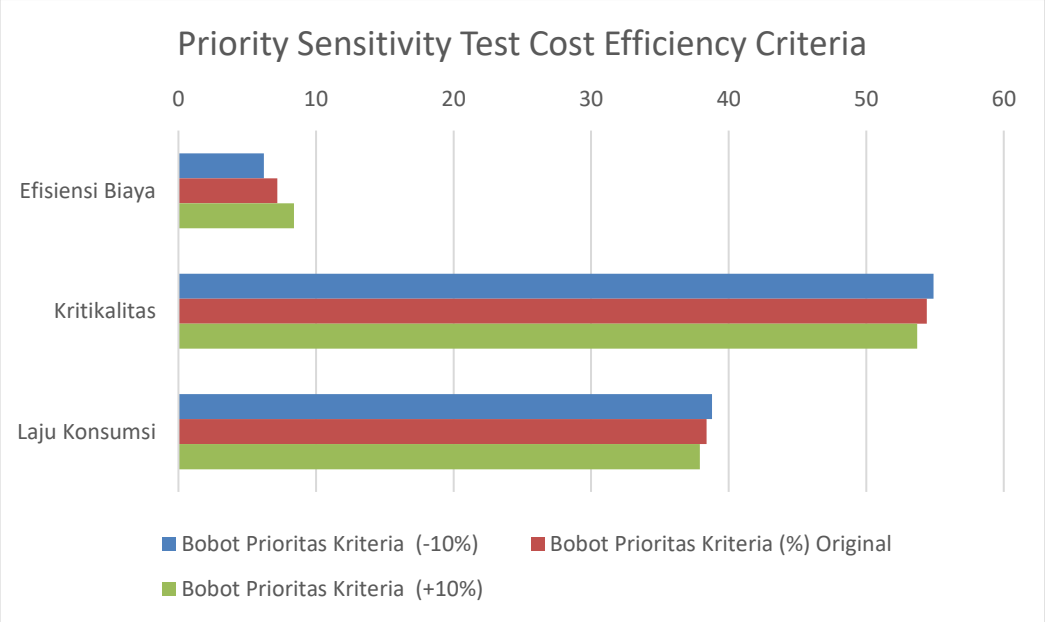

Figure 3. Weight Graph Priority Sensitivity Test Cost Efficiency Criteria

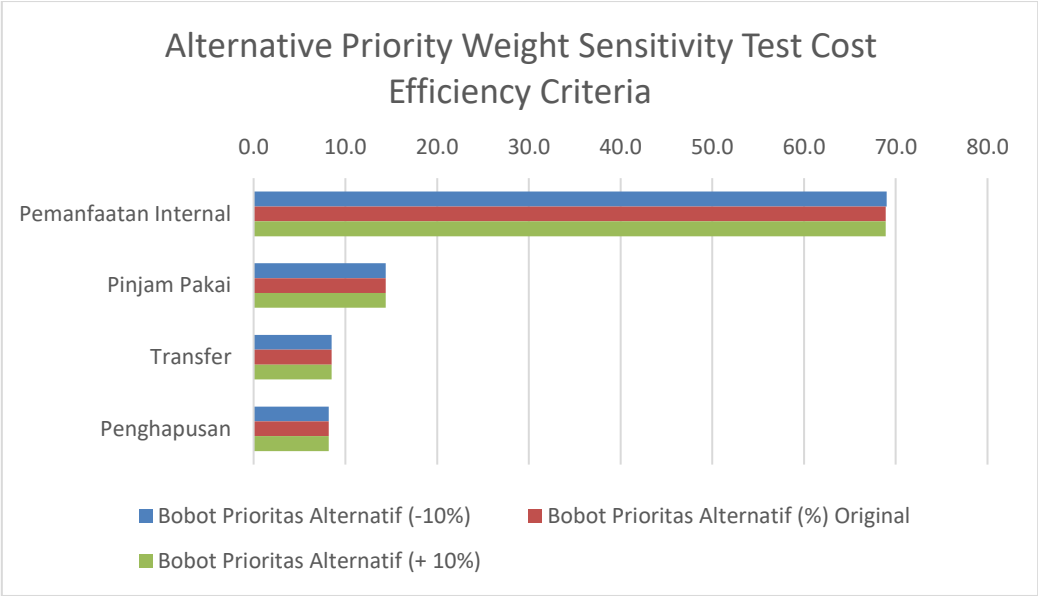

Figure 4. Alternative Priority Weighting Graph on Cost Efficiency Criteria

Furthermore, to test the level of sensitivity, a priority weight was reduced and added to the priority weight of the criticality criterion. The test by reducing the priority weight of the criticality level criterion from 54.4% to 44.4% obtained the result of the priority weight of cost efficiency to 8.8% from the previous 7.2% and the consumption rate from 38.4% to 46.9% with the priority weight of the use of ex-termination materials for internal utilization from 68.9% to 68.5%, then the alternative to borrow from 14.4% to 14.5%, then the alternative transfer from 8.5% to 8.6% and the alternative of the proposed elimination to 8.4% where previously it was 8.2%.

The next step of this sensitivity test is to test the addition of priority weight to the priority weight of the criticality criterion from 54.4% to 64.5% and the result is obtained that the priority weight of the cost efficiency criterion becomes 5.6% from the previous 7.2% and the priority weight of the consumption rate criterion changes to 29.2% from the previous 38.4% and the priority weight of the use of ex-termination materials for alternative internal use is obtained to 69.3% from the previous 68.9%. followed by 14.2% for borrowing alternatives to 14.2% from the previous 14.4%, then for transfer alternatives 8.4% from the previous 8.5% and finally for alternative proposals for elimination from 8.2% to 8.0%.

Table 4. Tabulation of Sensitivity Test Results on Criticality Criteria

Uji Sensivitas dengan menurunkan dan menaikan bobot prioritas Kriteria Kritikalitas								
No	Kriteria	Bobot Prioritas Kriteria (-10%)	Bobot Prioritas Kriteria (%) Original	Bobot Prioritas Kriteria (+10%)	Alternatif	Bobot Prioritas Alternatif (-10%)	Bobot Prioritas Alternatif (%) Original	Bobot Prioritas Alternatif (+ 10%)
1	Efisiensi Biaya	8,8	7,2	5,6	Pemanfaatan Internal	68,5	68,9	69,3
2	Kritikalitas	44,4	54,4	64,5	Pinjam Pakai	14,5	14,4	14,2
3	Laju Konsumsi	46,9	38,4	29,9	Transfer	8,6	8,5	8,4
4					Penghapusan	8,4	8,2	8,0

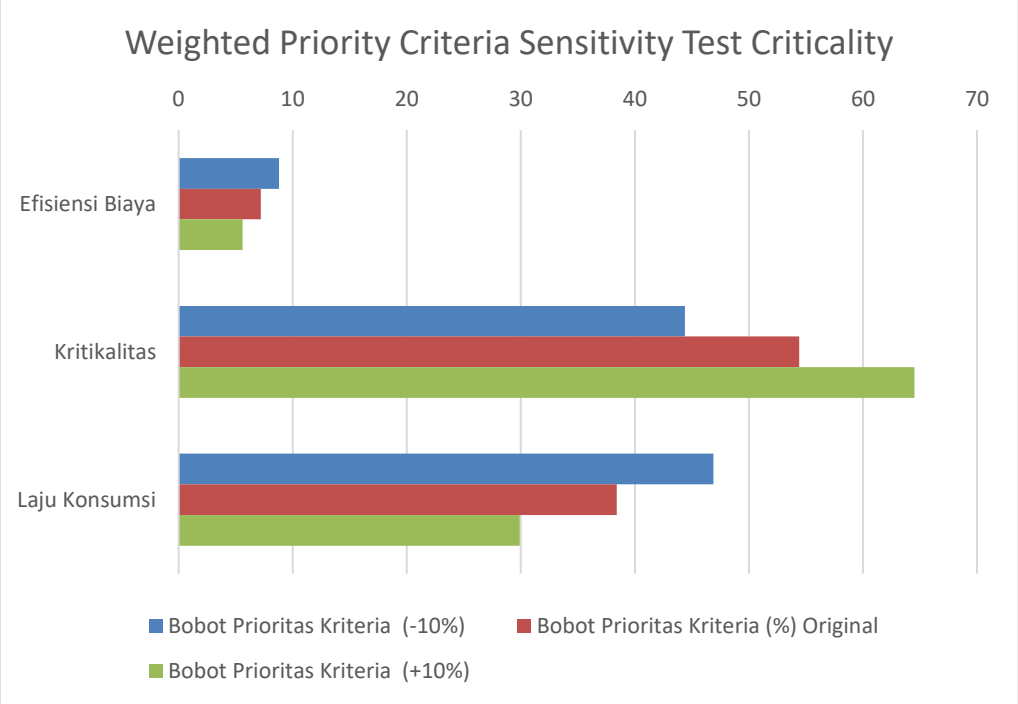

Figure 5. Priority Weight Graph Sensitivity Test Criticality Criteria

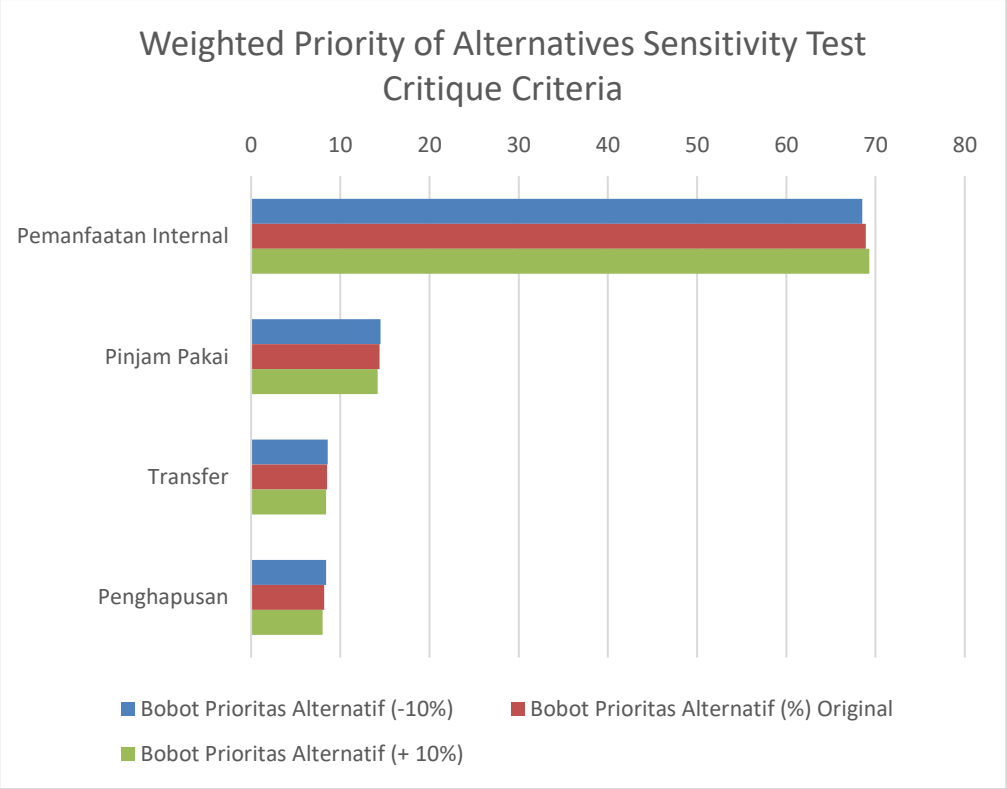

Figure 6. Alternative Priority Weights Graph on Criticality Criteria

Furthermore, the sensitivity level test was carried out on the priority weight of the consumption rate criteria. The test by reducing the priority weight of the consumption rate criterion from 38.4% to 37.3% obtained the result of the priority weight of cost efficiency to 7.3% from the previous 7.2% and the level of criticality remained at 55.4% and obtained the priority weight of the use of ex-termination materials for internal utilization from 68.9% to 69.0%, then the alternative borrowing and use remained at 14.4%, then the alternative transfer was also fixed at 8.5% and the priority weight of the alternative for the proposed elimination was also It is still 8.2%.

The next step of this sensitivity test is to test the addition of priority weights to the priority weight of the consumption rate criteria from 38.4% to 39.4% and the results are obtained that the priority weight of the cost efficiency criterion is 7.1% from the previous 7.2% and the priority weight of the criticality level criterion changes to 53.5% from the previous 54.4% and the priority weight of the use of ex-termination materials in all alternatives remains unchanged from the results of the initial test.

Table 5. Tabulation of Sensitivity Test Results on Consumption Rate Criteria

Uji Sensivitas dengan menurunkan dan menaikan bobot prioritas Kriteria Laju Konsumsi								
No	Kriteria	Bobot Prioritas Kriteria (-10%)	Bobot Prioritas Kriteria (%) Original	Bobot Prioritas Kriteria (+10%)	Alternatif	Bobot Prioritas Alternatif (-10%)	Bobot Prioritas Alternatif (%) Original	Bobot Prioritas Alternatif (+ 10%)
1	Efisiensi Biaya	7,3	7,2	7,1	Pemanfaatan Internal	69,0	68,9	68,9
2	Kritikalitas	55,4	54,4	53,5	Pinjam Pakai	14,40	14,4	14,4
3	Laju Konsumsi	37,3	38,4	39,4	Transfer	8,5	8,5	8,5
4					Penghapusan	8,2	8,2	8,2

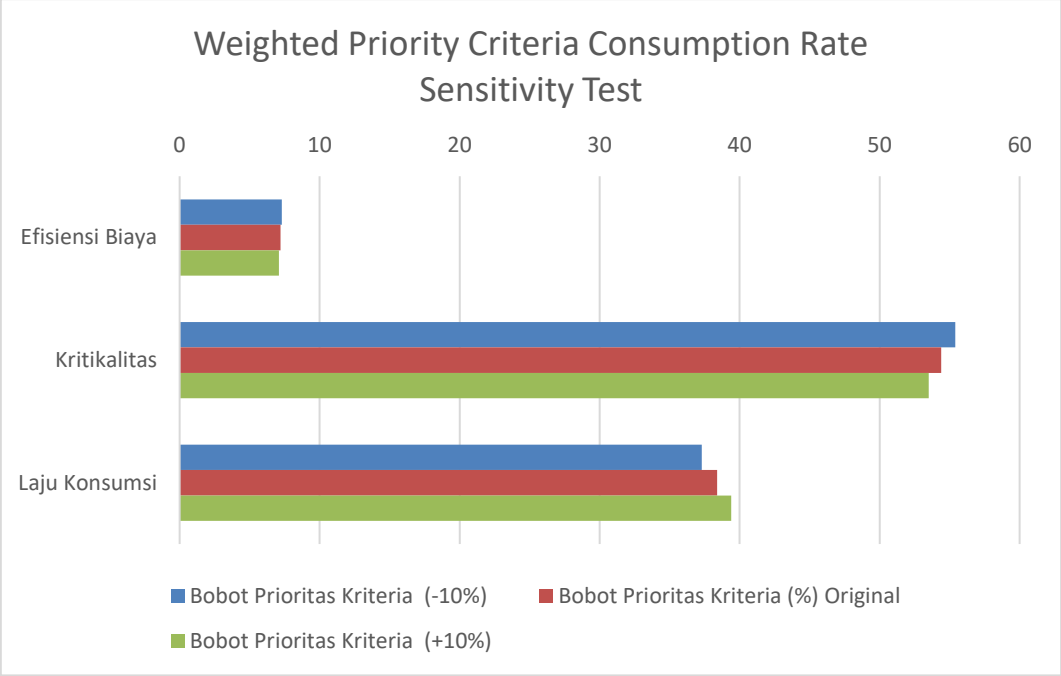

Figure 7. Weight Graph Priority Sensitivity Test Consumption Rate Criteria

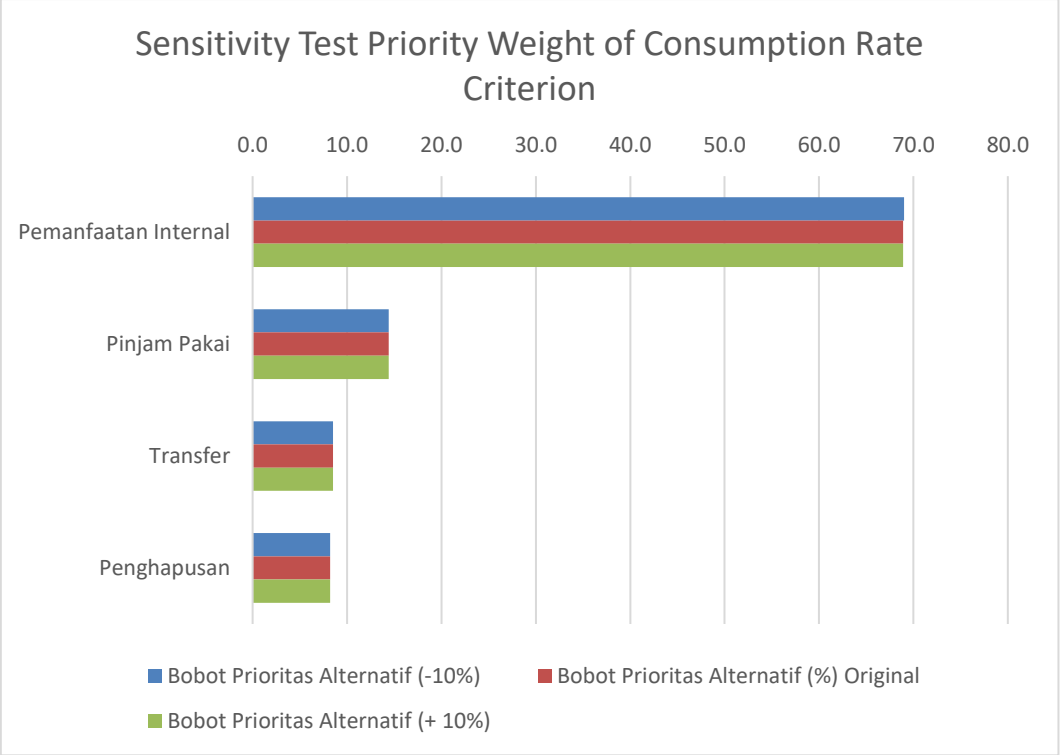

Figure 8. Alternative Priority Weight Graph on Consumption Rate Criteria

Based on the results of the sensitivity test by increasing and decreasing the priority weight on all criteria, the priority for the use of the material is internal utilization, borrowing, transfer and the last priority is the proposed elimination there is no change in priority. Based on the results of this calculation, it can be concluded that the decision to use ex-terminated materials with the priority order of internal utilization, borrowing, transfer and proposed elimination is an optimal and stable solution.

Managerial Implications

The results of this study are expected to be useful in assisting management in making decisions related to the management and utilization of ex-termination materials. Some of the practical implications of this study are as follows.

Companies can Maximize the Utilization of Ex-Termination Materials

The results of the ABC-FMSD-VED matrix integration analysis showed that ex-termination materials can be classified into several categories based on value, criticality level and consumption rate. This allows companies to determine strategies to maximize the use of ex-termination materials by focusing on materials that have high value, critical and frequent use. Materials that are classified as category A (high value), vital materials and also have a high level of use can be immediately reserved for transfer from consignment *stock* to *active stock*, so that they can be controlled and monitored better and can be used in the maintenance process process so that it will help reduce storage costs and increase operation

efficiency. The use of ex-terminated materials internally can reduce the cost of new procurement, especially for materials that are of zero value to the company. This is in line with the goal of operational cost efficiency in the upstream oil and gas sector in general and specifically for companies that use gross split contract schemes so as to increase the potential to make a profit. The use of ex-termination materials is strongly emphasized on the development of internal projects before considering new procurement. Materials that are not used internally can be considered as a loan option or transfer to another oil and gas company, this will reduce storage and maintenance costs. The use of digital technology allows for increased information dissemination and the provision of ex-termination materials to be maximized.

Companies Can Rearrange Material Storage

The results of the analysis of ex-termination materials can be used to review the storage layout of inventory materials and ex-termination materials in storage warehouses. Materials that fall into the *fast moving* category can be stored on shelves and areas close to the material dispensing area and are easy to access, reducing material handling activities and costs. So that the material layout is more optimal in supporting the operation process.

Companies Must Increase Compliance with Government Regulations

Ex-termination materials are State Property (BMN) that must be managed in accordance with government regulations. Errors in management can lead to liability for the company. Companies in the management of ex-termination materials must comply with PMK regulation No. 140/PMK.06/2020. The company needs to ensure that all ex-termination materials are managed in accordance with applicable regulations, including removal, borrowing, and transfer processes. For this reason, it is necessary to conduct periodic internal audits to ensure that the management of ex-termination materials is in accordance with regulations and does not pose legal risks.

Companies Need to Develop Ex-Termination Material Policies and SOPs

At this time, PT ABC does not have a TKO or special SOP for the management of ex-termination materials, so it is necessary to develop a special SOP/TKO for the management of ex-termination materials, including the process of internal utilization, borrowing, transfer, and disposal. Furthermore, it is necessary to socialize the SOP/TKO to all related parties, including warehouse staff, inventory management, and user functions.

CONCLUSION

The study concludes that the classification of ex-termination materials at PT ABC using ABC, VED, and FMSD analysis revealed that 21% of category A materials accounted for 80% of the total inventory value, while 85.95% were categorized as Deadstock, indicating suboptimal utilization. The integration of these analyses recommends prioritizing internal

utilization of high-index materials and proposing deletion for low-index materials. The AHP analysis confirmed that internal utilization is the top priority, followed by borrowing, transfer, and deletion, with stable decision outcomes indicated by sensitivity tests. Companies are encouraged to adopt an integrated material management system focusing on efficient utilization and removal of Deadstock, while future research should explore additional methodologies, advanced technologies, and regulatory impacts to further improve inventory management practices.

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