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Analysis of Environmental Aspects and Impacts as Reference for Planning Environmental Management System Programs in The Upstream Oil and Gas Industry (Case Study: "X" Area on P Company)

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Abstract

Upstream oil and gas industry activities have complex operational characteristics and the potential to generate various significant environmental aspects and impacts. Activities such as drilling, fluid processing, and waste management can affect the quality of water, air, soil, and ecosystems surrounding operational areas. Therefore, a systematic approach is required to identify and evaluate environmental aspects and impacts as a basis for planning effective and sustainable environmental management system (EMS) programs that comply with applicable environmental regulations. This study aimed to analyze environmental aspects and impacts associated with upstream oil and gas operations and formulate priority EMS programs through risk assessment and multi-criteria decision analysis. The methods used included interviews, field observations using questionnaires and checklists, and literature reviews. Data were analyzed descriptively and analytically to identify environmental aspects and impacts based on company policies and applicable regulations, followed by risk assessment using the State-Owned Enterprises risk matrix to determine risk levels. The Analytical Hierarchy Process (AHP) method was also applied to prioritize proposed environmental program plans. The results indicated that P Company's operational activities involved significant environmental aspects, including air emissions, liquid waste generation, hazardous waste management, noise emissions, potential oil spills, soil and water quality degradation, and contributions to greenhouse gas emissions. Based on the risk assessment results, several activities were categorized as having moderate to high risk levels, particularly those related to hydrocarbon spills and hazardous waste management. The risk controls implemented by the company were effective in reducing environmental risk levels to moderate and low categories.

INTRODUCTION

Oil and gas remain among the primary energy sources that play a strategic role in supporting economic growth, industrial development, transportation, and national energy security in Indonesia. Although the transition toward new and renewable energy continues to develop, demand for oil and gas remains relatively high, making the sustainability of upstream oil and gas operations an important factor in maintaining national energy supply stability (Indonesian Ministry of Energy and Mineral Resources, 2023). The upstream oil and gas industry encompasses various activities, including exploration, drilling, production, fluid processing, operational support facilities, and business support facilities, which are conducted continuously and involve high levels of complexity (Arifin et al., 2024; Hussain et al., 2022).

The complex operational characteristics of the upstream oil and gas industry result in various environmental aspects associated with each activity and facility (Bento, 2018; Irhoma et al., 2016, 2020). These environmental aspects include energy consumption, water utilization, air emissions, noise generation, hazardous waste management, potential oil spills, produced water, and the potential for soil, water, and air contamination (Vora et al., 2021). Drilling activities may generate drilling mud, drill cuttings, heavy equipment emissions, and risks of soil and groundwater contamination. In production facilities, potential impacts include greenhouse gas emissions, gas flaring, hydrocarbon leaks, and production wastewater generation (Fetisov et al., 2023; Ravanchi & Soleimani, 2023). Meanwhile, supporting facilities, such as hazardous waste temporary storage areas, wastewater treatment plants, power plants, and soil remediation facilities, also present potential environmental impacts if not properly managed (Sulistyono, 2015).

Area "X," managed by P Company, is one of the major oil operating areas and contributes significantly to national oil production. P Company is one of Indonesia's largest upstream oil and gas companies and is included in Area 1 Region, which is divided into several operating areas, including Area "X." Operational activities in Area "X" include drilling, gathering stations, production activities, field operations, and supporting facilities such as wastewater treatment plants, water treatment plants, hazardous waste temporary storage areas, temporary storage areas for oil-contaminated soil, power plants, substations and transmission networks, supporting laboratories, and soil bioremediation facilities (Pertamina Hulu Rokan, 2025). These activities and facilities involve the use of natural resources, energy, chemicals, and waste management practices that have the potential to generate environmental impacts.

Environmental management in Indonesia's oil and gas industry is regulated through various policies, including Law No. 32 of 2009 concerning Environmental Protection and Management, which requires business activities to prevent pollution and environmental degradation. In addition, Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management emphasizes the importance of managing environmental impacts resulting from industrial activities. In the oil and gas sector, the implementation of an Environmental Management System (EMS) refers to ISO 14001 as an international standard for organizational environmental management (ISO, 2015).

One important element in implementing an EMS is the identification of environmental aspects and impacts (Ogolo et al., 2022). This process aims to determine operational activities that have the potential to affect the environment and evaluate the significance of these impacts to establish priorities for control and management measures (Tarigan, 2021). The results of environmental aspect and impact analyses serve as important foundations for environmental program planning, development of operational procedures, establishment of environmental objectives and targets, and formulation of effective environmental management strategies (Zainuddin, 2018).

Based on these conditions, research is needed to identify environmental aspects associated with various operational activities in the upstream oil and gas industry, analyze their environmental impacts, evaluate environmental risk levels, and formulate EMS programs appropriate for the operational conditions of Area "X" at P Company. This research is expected to support improvements in the company's environmental performance,

strengthen ISO 14001 implementation, improve achievement of the Corporate Performance Rating Assessment Program in Environmental Management (PROPER), and support the overall sustainability of upstream oil and gas operations.

Therefore, this study was conducted to analyze environmental aspects and impacts arising from P Company's operational activities and formulate an EMS program aligned with existing operational conditions (Zainuddin, 2018). This research is expected to contribute to the development of more effective and sustainable environmental management strategies in the upstream oil and gas industry, particularly in Area "X" at P Company. The findings provide several practical benefits. This study offers a systematic and integrated framework for identifying environmental aspects, assessing risks using a semi-quantitative risk matrix, and prioritizing EMS programs through the Analytic Hierarchy Process (AHP), which can be adopted by other oil and gas companies to strengthen their environmental management systems. The identification of significant environmental aspects and evaluation of control effectiveness provide practical guidance for improving environmental performance, ensuring regulatory compliance, and supporting PROPER achievement. Furthermore, priority programs identified through AHP analysis—including oil-contaminated soil remediation, plastic bottle waste reduction through tumbler utilization, and paper waste reduction through digitalization—provide actionable and cost-effective recommendations that balance environmental, economic, and implementation considerations. This research contributes to the development of more effective and sustainable environmental management strategies in the upstream oil and gas industry, supporting both operational sustainability and national environmental protection objectives.

METHOD

This study was conducted in Area "X" of P Company, an upstream oil and gas operational area in Bengkalis Regency, Riau Province, which was undergoing area development and production enhancement programs.

Data Collection

The research was carried out from August 2025 to May 2026 using both primary and secondary data. For this study, the data needed include:

1. Primary Data

Primary data were obtained through direct observation, questionnaires, checklists, and focus group discussions with informants relevant to the research topic. The data collection instruments were developed systematically and structurally to align with the research objectives and to describe actual field conditions. Field observations were also supported by photographic documentation as empirical evidence and to strengthen data validity.

2. Secondary Data

Secondary data were obtained from literature and company documents, archives, records, and reports from the 2023–2026 period, books, scientific journals, regulations, standards, and official publications related to the research topic. Secondary data were used to complement, compare, and strengthen the analysis results, thereby providing a stronger theoretical and empirical basis for the research findings.

Data Collection Techniques

1. Interviews and Discussions

Interviews and discussions were conducted with parties directly involved in environmental management, operational activities, area development, and the preparation of the EMS program. This technique was used to obtain more in-depth information regarding actual field conditions, the types of controls that have been implemented, and opportunities for developing environmental programs that align with the company's needs.

2. Field Observation

Field observations were carried out to obtain a factual overview of operational activities, main facilities, supporting facilities, and environmental management conditions in the research area. In practice, the observations were supported by questionnaires and checklists that were systematically developed based on the research indicators. These instruments were used to support the identification of environmental aspects and impacts, control assessment, and data collection from risk owners, environmental program development teams, and related management parties.

3. Literature Study

The literature study was conducted by reviewing company documents, books, scientific journals, regulations, standards, research articles, and official publications relevant to the research topic. This technique was used to strengthen the theoretical foundation, support the analysis process, and serve as a comparison to the primary data obtained from the field. Through the combination of these three techniques, the data obtained are expected to provide a strong basis for developing the analysis and recommendations for the EMS program.

Data Processing and Analysis Methods

Data obtained from interviews, discussions, field observations, questionnaires, checklists, and literature studies were processed qualitatively and semi-quantitatively. The data were processed through tabulation, scoring, risk classification, and analytical narrative development to describe the actual environmental management conditions in area"X" on P Company.

1. Descriptive-analytical analysis

Descriptive-analytical analysis was used to explain the environmental aspects and impacts arising from operational activities, main facilities, supporting facilities, and business support facilities in area "X" on P Company. The results were then compared with reference standards, such as ISO 14001:2015, environmental regulations, and relevant environmental management practices.

2. Environmental risk assessment

Risk assessment was conducted semi-quantitatively using a risk matrix based on the parameters of likelihood and severity, with a scale of 1–5. This assessment produced risk categories under two conditions: before control measures, or inherent risk, and after control measures, or residual risk.

3. Evaluation of control effectiveness

The comparison between inherent risk and residual risk was used to evaluate the effectiveness of the environmental controls that had been implemented. A reduction in risk category indicates that the controls are effective. Conversely, risks that remain in significant

categories indicate the need for improved control measures.

4. Determination of EMS program priorities

Environmental aspects with significant risk levels were used as the basis for developing alternative EMS programs. Program priorities were determined using the method with the support of Expert Choice software.

5. AHP analysis

Analysis was carried out by developing a decision hierarchy consisting of objectives, criteria, and program alternatives. The criteria used included environmental, economic, and technical implementation aspects. Weighting was conducted through pairwise comparisons using Saaty's 1–9 scale to obtain global priority values.

6. Determination of program recommendations

The result of the analysis was a priority ranking of EMS programs. The program with the highest priority value was selected as the main recommendation to support improvement of environmental performance, regulatory compliance, and sustainable environmental management in area "X" on P Company.

RESULTS AND DISCUSSION

Identification of Aspects, Impacts, and Environmental Risk Assesment (Inherent Risk)

Identification of environmental aspects, impacts, and risk levels under inherent risk conditions in area "X" of P Company was conducted to describe the potential environmental risks arising from all operational activities before the implementation of controls (Tarigan, 2021). This process includes the identification of environmental aspects from main activities, such as drilling and production, as well as supporting facilities, such as the hazardous waste temporary storage facility, centralized mud treating facility, wastewater treatment plant and water treatment plant, which interact with environmental media such as air, water, and soil.

Based on these aspects, various environmental impacts were identified, including air, water, and soil pollution, ecosystem disturbance, and greenhouse gas emissions. Subsequently, the risk level was determined based on the parameters of likelihood and severity. Under inherent risk conditions, the risk level generally falls within the medium-to-high category because the existing control measures have not yet been considered.

The identification of environmental aspects and impacts, as well as risk assessment in upstream oil and gas activities in area "X" on P Company, was conducted across all operational activities, main facilities, supporting facilities, and business support facilities. The results indicate that the main environmental aspects include energy and chemical use, air emissions, production fluid management, hazardous waste generation, noise, and potential hydrocarbon spills.

In drilling activities, production facilities, gathering stations, wastewater treatment plant, water treatment plant, hazardous waste temporary storage facilities, oil-contaminated soil temporary storage facilities, power plants, and substations, the potential environmental impacts include air, water, and soil pollution; increased greenhouse gas emissions; ecosystem disturbance; noise; and risks to workers' health and the surrounding environment. These impacts are mainly influenced using of drilling mud, drill cuttings, flaring, produced water, treatment sludge, hazardous waste storage, combustion emissions, and potential leaks of oil, gas, chemicals, and transformer oil.

The risk assessment results show that most environmental aspects fall within the medium to high-risk categories, while several aspects in drilling activities, power plants, and substations are classified as very high risk, particularly those related to potential blowouts, fires, gas leaks, and hazardous material spills. Therefore, these aspects are classified as significant environmental aspects that require priority control and management in the planning of the environmental management system.

Risk Control

Risk control in area "X" of P Company refers to the hierarchy of controls, starting with elimination and substitution where possible, such as reducing the use of hazardous materials or optimizing processes to minimize waste. Engineering controls are then applied, including the use of waste treatment systems, secondary containment, and emission control technologies. Control measures are also strengthened through administrative controls, such as the implementation of standard operating procedures (SOPs), worker training, routine inspections, and environmental monitoring systems. As the final layer of control, personal protective equipment (PPE) is used to minimize worker exposure.

Based on the discussion of risk controls across various facilities and activities in area "X" of P Company, it can be concluded that environmental risk management has been implemented systematically and structurally, referring to the principles of the hierarchy of risk controls. Most environmental aspects fall within the medium to high-risk categories, particularly in activities involving hazardous and toxic materials, wastewater, air emissions, and potential spills and leaks. Therefore, the control approach focuses not only on managing impacts but also on preventive efforts at the source.

The implemented risk controls show a dominance of administrative controls, such as the application of SOPs, technical work instructions, HSE policies, personnel training, and routine inspection and maintenance programs. This approach serves as the main foundation for ensuring that all operational activities are carried out in accordance with applicable standards and regulations. However, these administrative controls are strengthened by engineering controls, such as the use of secondary containment, wastewater treatment systems such as wastewater treatment plant and water treatment plant, oily collectors, clay liners, as well as energy efficiency and emission control technologies. This combination indicates an integration of procedural and technical controls in reducing risk levels.

For risks with high severity levels, such as fire, explosion, gas leaks, and hazardous waste spills, emergency preparedness is implemented through site-specific emergency response programs, the provision of spill kits, early detection systems, and the involvement of emergency response teams. This approach ensures that when risks cannot be fully prevented, their impact can be minimized quickly and effectively.

From a sustainability perspective, risk control has also been directed toward the principles of resource efficiency and substitution, such as the use of more environmentally friendly fuels, energy-saving programs, and the replacement of hazardous materials with safer alternatives. This indicates that the control measures are not only operational in the short term but also support long-term environmental performance.

Overall, environmental risk control in area "X" of P Company has applied a layered control concept, consisting of a combination of administrative controls, engineering controls, substitution, and emergency preparedness. This approach has proven capable of reducing the

risk level of significant potential environmental impacts to a more controlled condition. Therefore, the implemented risk control system supports safe operations, regulatory compliance, and alignment with the principles of environmental protection and sustainable development.

Risk Assessment After Control (Residual Risk)

Based on the identification of environmental aspects and impacts, as well as the evaluation of controls applied across all operational and supporting facilities in area "X" of P Company, the implementation of environmental controls has generally been proven to significantly reduce environmental risk levels. This is indicated by the shift in risk categories from the initial condition, or inherent risk, which was predominantly in category III–V, to residual risk in category I–II. This reduction shows that technical, administrative, and operational controls have been effective in reducing both the likelihood of occurrence and the severity of environmental impacts.

In main facilities such as drilling activities, oil and gas well production and maintenance, gathering stations, and power plants, risk reduction mainly occurred in aspects related to hazardous waste spills, air emissions, fluid leaks, and soil and water pollution. Controls through containment systems, preventive maintenance, routine inspections, operational SOPs, and emergency response systems were able to reduce risks to an acceptable level.

In waste management facilities such as hazardous waste temporary storage facilities, oil-contaminated soil temporary storage facilities, wastewater treatment plant, water treatment plant, and Soil Bioremediation, residual risks particularly those related to leachate seepage, potential water pond overflow, chemical use, and treatment system failure. These risks are system-based and process-based, meaning that the effectiveness of controls depends heavily on system reliability, facility integrity, and consistent operational monitoring.

Meanwhile, in supporting facilities such as offices, cafeterias, clinics, laboratories, substations, and fire stations, the dominant residual risks are generally related to energy consumption, resource use, domestic waste, and indirect emissions. These risks tend to remain in category II because they are recurring impacts arising from routine operational activities.

Overall, the implementation of environmental controls in area "X" of P Company has been able to reduce environmental risks to an acceptable level in accordance with the planning principles of ISO 14001:2015. However, several aspects still require continuous control, particularly fire and gas leaks, leachate seepage, treated wastewater discharge, energy use, and domestic waste generation. Therefore, strengthening monitoring, evaluating control effectiveness, implementing preventive maintenance, improving resource efficiency, and developing prevention-based environmental programs are essential to support continuous improvement in environmental performance.

Determination of the EMS Program Plan

The determination of the EMS program plan is an important stage to ensure that environmental management in area "X" of P Company is carried out systematically, measurably, and sustainably. The program is developed based on the identification of environmental aspects and impacts, compliance evaluation, environmental performance achievements, and the company's risk and opportunity analysis. The results of this evaluation

are used to determine priority programs that can improve environmental performance, support business objectives, and strengthen the company's commitment to sustainability.

In relation to PROPER assessment, the EMS program plan serves as an instrument to demonstrate that environmental management is not only focused on regulatory compliance but also on achieving beyond-compliance performance. Therefore, the planned programs need to be aligned with PROPER criteria, such as energy efficiency, emission reduction, water conservation, waste management, biodiversity protection, and community empowerment.

The environmental program plan in area "X" of P Company is developed based on key aspects that still have opportunities for improvement, including energy and fuel use, water consumption, hazardous and non-hazardous waste generation, greenhouse gas emissions, and resource use. In terms of hazardous waste management, the proposed programs include the reuse of used lubricant drums as hazardous waste containers and the treatment of oil-contaminated soil through on-site remediation. These programs aim to reduce the use of new containers, decrease the volume of waste sent to third parties, and accelerate environmental recovery.

In addition, the high consumption of single-use drinking water bottles and paper indicates the need for waste reduction programs through the provision of refill drinking water facilities, the use of tumblers by workers, document digitalization, and double-sided paper use. Each program is designed with measurable objectives, targets, and performance indicators so that its implementation effectiveness can be regularly monitored and evaluated. Thus, the EMS program plan is expected to support continuous improvement in environmental performance and strengthen the company's readiness to achieve beyond-compliance performance.

Define Criteria for EMS Program

The next stage is to determine the assessment criteria that will be used as a basis for evaluating and comparing alternative EMS program plans. These criteria are structured to ensure that the decision-making process does not only consider one aspect but includes a variety of factors relevant to the research objectives. The determination of criteria was carried out through literature studies, the results of the identification of environmental aspects and impacts, as well as discussions with parties who understand the operational conditions and environmental management in the area "X" on P Company.

The criteria covered in the AHP process to achieve the goals are:

1. Environmental Impact

Environmental criteria are used to assess the extent to which an alternative program is able to provide benefits to improving the company's environmental performance. The assessment of this criterion is focused on the program's ability to reduce or prevent negative impacts on the environment, reduce environmental risk levels, improve the efficiency of natural resource utilization, and support pollution prevention efforts. Programs that have the greatest potential in reducing environmental impacts and increasing protection of environmental media such as air, water, soil, and ecosystems will receive higher scores. This criterion is important because the main goal of implementing an Environmental Management System is to improve environmental performance in a sustainable manner.

2. Economic Aspects

Economic criteria are used to assess the feasibility of the program from the cost aspect required during the implementation process. The assessment of this criterion considers the amount of initial investment, operational and maintenance costs, the need for supporting resources, and the potential economic benefits that the company can obtain, such as material use efficiency, reduced waste management costs, or resource use savings. Programs that able to provide environmental benefits at a more cost-efficient time will have better value. Consideration of economic aspects is needed so that the resulting program recommendations are not only effective from an environmental perspective, but also realistic to be implemented according to the company's capabilities.

3. Implementation

Implementation criteria are used to assess the level of convenience and readiness of the company in implementing an environmental program. The assessment of these criteria includes the availability of the required technology, the readiness of human resources, training needs, suitability with the company's operational conditions, ease of integration with existing systems, and the chances of successful implementation of programs in the field. Programs that can be implemented more easily, do not require complex operational changes, and are supported by adequate resources will achieve higher value. These criteria are important to ensure that prioritized programs can be implemented effectively and sustainably.

Determining Alternative for EMS Program

The proposed alternative environmental program plan prepared in this study is based on the results of the identification of environmental aspects and impacts as well as the analysis of the level of environmental risk in area "X" on P Company. There are three alternative programs that are the object of assessment, namely the hazardous waste reduction program plan, the plastic bottle waste reduction program plan, and the paper waste reduction program plan.

1. Hazardous Waste Reduction Program Plan

Hazardous Waste Reduction Program plan is an effort to minimize the generation of hazardous and toxic material waste resulting from operational activities and supporting activities in the area "X" on P Company. This program focuses on applying the principle of waste minimization from the source through controlling the use of materials, optimizing work processes, and reusing materials that can still be used.

Alternative proposals for the hazardous waste reduction program are:

a. Use of used container for hazardous waste packaging
b. Oil contaminated soil processing with on-site bioremediation method

2. Plastic Bottle Waste Reduction Program Plan

The plan for the plastic bottle waste reduction program is an effort to reduce the generation of single-use plastic waste derived from the consumption of bottled drinking water by workers in the area "X" on P Company. This program can be carried out through the implementation of a policy on the use of tumblers for all workers supported by the provision of drinking water refilling facilities in the work area. In addition to aiming to reduce the amount of plastic waste produced, this program is also expected to increase the awareness and participation of workers in implementing a more environmentally friendly work culture. By reducing the use of single-use plastic bottles, companies can reduce the burden of

domestic waste management and support efforts to reduce environmental pollution due to plastic waste.

3. Paper Waste Reduction Program Plan

The paper waste reduction program plan is an effort to reduce the use of paper in administrative and reporting activities through the implementation of a digital system or online reporting and double-sided paper use policy. This program encourages the use of information technology in the communication process, document distribution, administrative approval, and electronic data storage. The implementation of the program is expected to reduce paper consumption, reduce waste generation, increase resource use efficiency, and reduce the need for physical document storage space.

Determination of Priority Scale

The determination of the priority scale is carried out after weighing each criterion or alternative environmental program plan proposal that has been carried out using Expert Choice software. In the proposed hazardous waste program plan, the alternative program proposal that is the first on the priority scale is oil contaminated soil processing with on-site remediation method with a value of 0.603 or 60% followed using used container for hazardous material packaging of 0.397 or 40%. In the proposed plastic bottle reduction plan, the alternative proposal for the use of tumblers for all workers is in first place with a value of 0.833 or 83% followed by using bottled drinking water of 0.167 or 16%. In the proposed paper waste reduction program plan, the alternative proposal for a paper waste reduction program with online reporting system and double-sided paper use is the first with a value of 0.855 or 85%, followed by the conventional paper use of 0.145 or 14%.

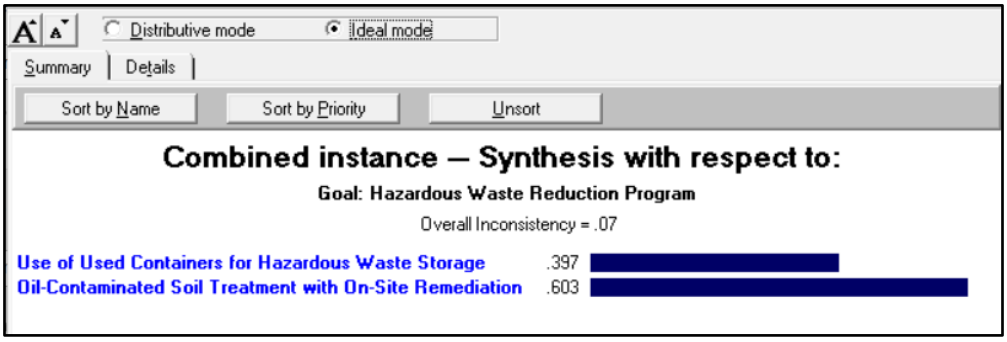

Figure 1. Alternative priority scale of proposed hazardous waste reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

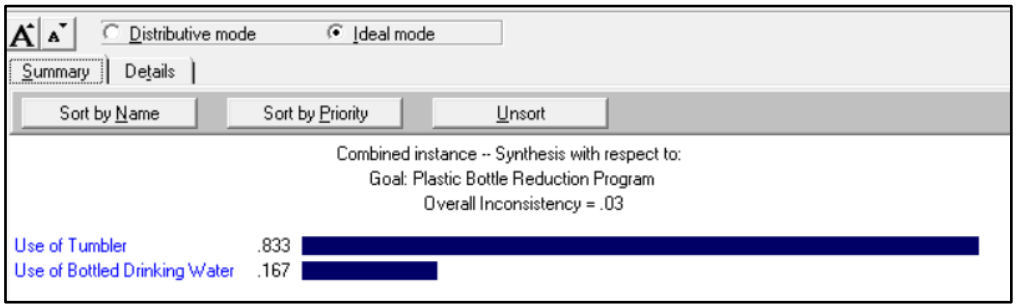

Figure 2. Alternative priority scale proposed for plastic bottle reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

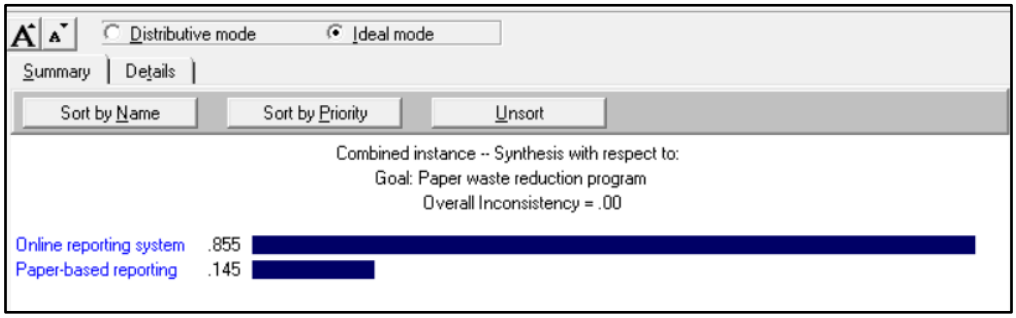

Figure 3 Alternative priority scale proposed paper waste reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

Determination of Alternative Environmental Program Plans

The determination of alternative environmental program plan proposals for operational activities in the area "X" on P Company can be determined based on the results of AHP with Expert Choice software which uses the results of questionnaires from 5 respondents. Determination of alternatives to hazardous waste by reducing program plan proposals, plastic bottle reduction, and paper waste reduction are the main objectives of the AHP, then identify the criteria and alternatives of each program plan proposal.

In the proposed hazardous waste reducing program plan, the inputs of the five respondents were combined and then their weight was analyzed in Expert Choice software. Environmental impact is a very important criterion in determining the alternative proposed hazardous waste reducing program plan with a value of 0.667 or 66%. An alternative to the proposed hazardous waste reducing program that is an important priority is oil contaminated soil processing with on-site bioremediation with a value of 0.607 or 60%. This proposed alternative program is considered the most important because it can effectively reduce the hazardous waste produced in the form of oil-contaminated soil at a more affordable cost than other repair alternatives and is easily implemented in the area "X" on P Company.

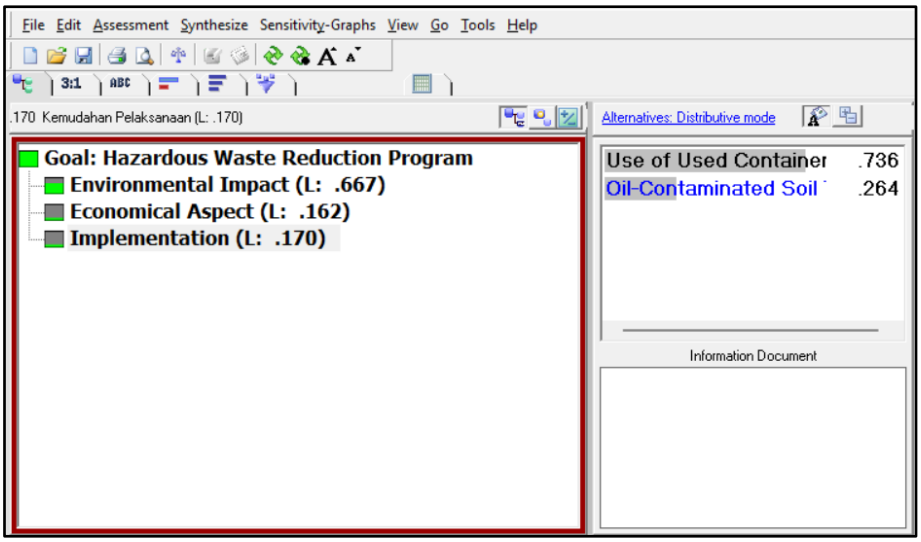

Figure 4. Results of Expert Choice analysis for alternative proposed hazardous waste reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

In the proposed plastic bottle reduction program plan, results from the five respondents were combined and then their weight was analyzed in Expert Choice software. Environmental impact is a very important criterion in determining the alternative to the proposed plastic bottle reduction plan with a value of 0.548 or 54%. The alternative program proposal in the form of the use of tumblers by all workers is an important priority to be carried out with a value of 0.833 or 83%. The alternative proposed program is considered the most important because it can effectively reduce the generation of plastic bottle waste at a lower cost in the long term compared to the alternative of using bottled water which requires greater procurement costs, and the generation of more bottle waste so that a lot of plastic bottle waste management costs are required.

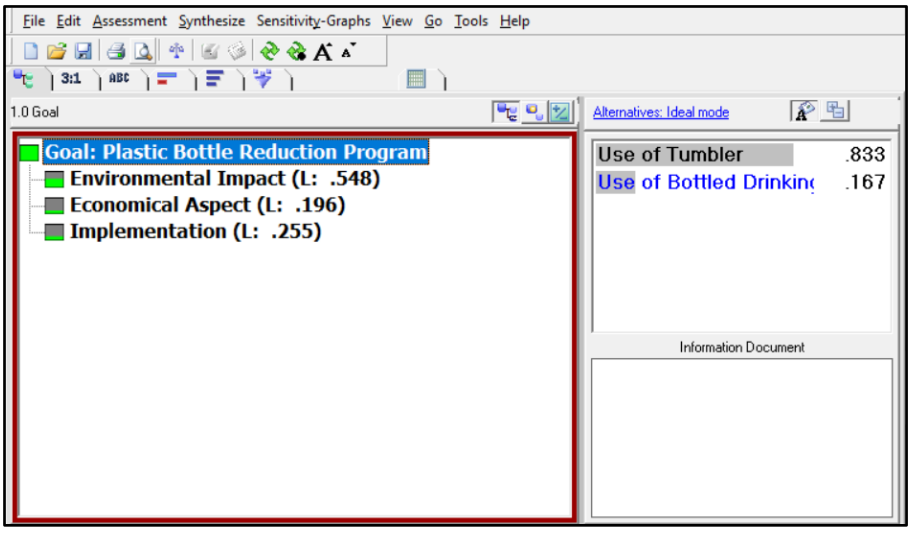

Figure 5. Results of Expert Choice analysis for alternative proposed plastic bottle reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

In the proposed paper waste reduction program plan, inputs from the five respondents were combined and then analyzed for weight in Expert Choice software. Environmental impact is a very important criterion in determining the alternative proposed paper waste reduction plan with a value of 0.603 or 60%. Alternative program proposals in the form of a program to reduce the use of online reporting system and double-sided paper use are important priorities to be carried out with a value of 0.855 or 85%. The alternative proposed program is considered the most important because it can effectively reduce the generation of plastic paper waste and less paper procurement costs in the long term compared to the alternative to conventional paper use which requires greater procurement costs, and the generation of more paper waste so that considerable management costs are required.

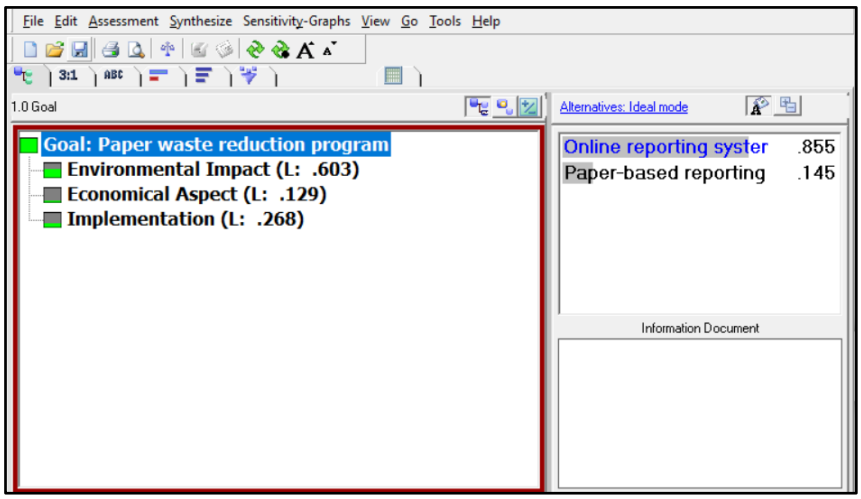

Figure 6. Results of Expert Choice analysis for alternative proposed plastic bottle reduction program plan

Source: Authors' analysis using Expert Choice software, 2026

PROPER Achievement Plan Roadmap

The PROPER roadmap prepared in this study is based on the results of the identification of environmental aspects and impacts, assessment of environmental risk levels before and after control, and the results of the priority of environmental program plans using AHP method. The results of the study show that the dominant environmental aspects in the area "X" on P Company include the use of hazardous materials, the generation of domestic waste in the form of single-use plastic bottles, and the use of paper in administrative and reporting activities. Therefore, these three aspects are the focus in the preparation of a roadmap to improve PROPER performance.

Based on the results of the research, area ‘X” on P Company*'s* PROPER roadmap begins with strengthening compliance aspects to ensure that all controls on significant environmental aspects have been implemented effectively. This stage is the foundation for maintaining or achieving Blue-rating PROPER.

Furthermore, the company entered beyond compliance phase through the implementation of prioritized environmental programs using the AHP method, namely the hazardous waste reduction program, the tumbler program to reduce plastic bottle waste, and the reporting digitization program to reduce paper use. The implementation of the program is

expected to be able to increase resource efficiency and support the achievement of Green-rating PROPER.

In the next stage, the company strengthens the environmental culture through the integration of programs to all work units, increasing worker participation, and implementing periodic monitoring and evaluation. This stage aims to ensure the sustainability of the program and encourage the creation of environmental innovations in a sustainable manner.

The final stage is directed at achieving Gold-rating PROPER through the development of innovations that not only provide benefits to the company but also create benefits for the community and stakeholders. Thus, the proposed roadmap is not only oriented towards improving the PROPER rating but also becomes an EMS implementation strategy that supports the sustainability of upstream oil and gas industry operations in area "X" on P Company.

CONCLUSION

Based on the analysis conducted in Area “X” of P Company, upstream oil and gas activities were found to involve complex environmental aspects and impacts, including energy and fuel consumption, chemical and hazardous material use, waste generation, air emissions, wastewater generation, noise, and potential hydrocarbon spills or leaks. These aspects may affect air quality, water quality, soil conditions, natural resource utilization, and greenhouse gas emissions, particularly in drilling activities, gathering stations, power plants, oil-contaminated soil temporary storage areas, and waste treatment facilities. The inherent risk assessment showed that most environmental aspects were categorized as medium to high risk, particularly those associated with oil spills, chemical leaks, leachate seepage, treatment system failures, blowouts, fires, explosions, and electrical system failures. However, the implementation of multilayered controls, including standard operating procedures (SOPs), inspections, environmental monitoring, waste management practices, secondary containment systems, equipment maintenance, personnel training, and emergency preparedness, was able to reduce environmental risk levels. Based on the Analytic Hierarchy Process (AHP) analysis, the priority Environmental Management System (EMS) programs proposed included oil-contaminated soil treatment through on-site remediation, the use of tumblers by workers to reduce plastic bottle waste, and paper reduction through online reporting systems and double-sided printing. Overall, environmental aspect and impact analysis served as an important basis for EMS program planning in accordance with ISO 14001:2015 Clause 6 and supported regulatory compliance, environmental performance improvement, and PROPER Beyond Compliance achievement.

Based on the findings, several recommendations are proposed. First, P Company should implement the priority EMS programs identified through the AHP analysis, particularly oil-contaminated soil treatment through on-site bioremediation, to accelerate environmental recovery and reduce hazardous waste disposal costs. Second, the company should strengthen environmental monitoring and evaluation systems to ensure the effectiveness of implemented controls, particularly for high-risk aspects such as hydrocarbon spill prevention and leachate management. Third, to support the PROPER roadmap toward Green and Gold ratings, the company should integrate the tumbler program and paperless reporting systems across all work units, accompanied by employee awareness campaigns and

regular performance evaluations. Fourth, P Company should consider expanding the AHP-based prioritization approach to other operational areas to ensure systematic and consistent EMS program planning. Finally, the company should establish a continuous improvement mechanism through periodic reviews of environmental aspects and impacts, particularly as operational activities evolve, to maintain alignment with ISO 14001:2015 requirements and emerging environmental regulations.

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