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ENHANCING METHANE EMISSION MANAGEMENT IN UPSTREAM OIL AND GAS: ALIGNMENT STRATEGY OF PERTAMINA HULU ENERGI WITH OGMP 2.0 FRAMEWORK

MENINGKATKAN PENGELOLAAN EMISI METANA DI SEKTOR HULU MINYAK DAN GAS: STRATEGI PENYELARASAN PERTAMINA HULU ENERGI DENGAN KERANGKA KERJA OGMP 2.0

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ABSTRACT

This research aims to evaluate and develop a methane emission management strategy at Pertamina Hulu Energi (PHE), aligning with the international standards stipulated in the Oil and Gas Methane Partnership (OGMP) 2.0 framework. Utilizing a mixed qualitative and quantitative approach through gap analysis and the Analytic Hierarchy Process (AHP), the study identifies critical improvement areas in measurement, reporting, and verification (MRV) systems, and in setting methane emission reduction targets. The analysis demonstrates that the "OGMP 2.0 Alignment" strategy emerges as the optimal alternative, scoring highest against "Basic Compliance" and "Gold Standard". This strategy enables selective direct measurement implementation at high-priority assets while progressively enhancing governance and internal capacity. Recommendations include establishing a dedicated methane management team, leveraging international funding, and developing a cost-benefit analysis framework. This study provides practical implications to help PHE comply with international standards, improve reporting transparency, and strengthen its position in the global carbon market.

Keywords: *Methane Emissions, Emission Management, OGMP 2.0, Analytic Hierarchy Process, Pertamina Hulu Energi*

ABSTRAK

Penelitian ini bertujuan mengevaluasi dan mengembangkan strategi pengelolaan emisi metana di Pertamina Hulu Energi (PHE), dengan mengacu pada standar internasional yang diatur dalam Oil and Gas Methane Partnership (OGMP) 2.0. Menggunakan pendekatan kombinasi kualitatif dan kuantitatif melalui gap analysis dan Analytic Hierarchy Process (AHP), penelitian ini mengidentifikasi area perbaikan utama dalam sistem pengukuran, pelaporan, dan verifikasi (MRV), serta dalam penetapan target reduksi emisi metana. Analisis menunjukkan bahwa strategi "OGMP 2.0 Alignment" merupakan alternatif terbaik dengan skor tertinggi dibandingkan "Basic Compliance" dan "Gold Standard". Strategi ini memungkinkan implementasi pengukuran langsung secara selektif pada aset prioritas tinggi, sambil secara bertahap memperkuat tata kelola dan kapasitas internal. Hasil penelitian menyarankan pembentukan tim khusus pengelolaan metana, pemanfaatan pendanaan internasional, serta pengembangan kerangka kerja analisis biaya-manfaat. Penelitian ini memberikan implikasi praktis untuk membantu PHE memenuhi standar internasional, meningkatkan transparansi pelaporan, serta memperkuat posisi dalam pasar karbon global.

Kata Kunci: Emisi Metana, Pengelolaan Emisi, OGMP 2.0, Analytic Hierarchy Process, Pertamina Hulu Energi

INTRODUCTION

Climate change remains one of the most critical global challenges, driven predominantly by increased emissions of greenhouse gases (GHGs). Among these gases, methane (CH_4) is particularly potent, with a global warming potential (GWP) approximately 84 times greater than carbon dioxide (CO_2) over a 20-year period (IPCC, 2021). The oil and gas sector, especially upstream operations, significantly contributes to methane emissions through activities such as venting, flaring, incomplete combustion, and fugitive leaks from equipment and

pipelines (International Energy Agency, 2021).

Given methane's high warming potential, its effective management presents an immediate opportunity for mitigating climate change. Recognizing this, international initiatives such as the Oil and Gas Methane Partnership (OGMP) 2.0 have been established to improve transparency, accountability, and precision in methane emissions reporting within the oil and gas industry. The OGMP 2.0 framework advocates for direct, source-level methane measurement and verification, promoting a gradual improvement in reporting accuracy towards full transparency (UNEP, 2020).

In Indonesia, Pertamina, the largest state-owned oil and gas company, faces substantial pressure from global stakeholders and domestic regulations to enhance methane management and align its practices with international standards. Pertamina officially joined the OGMP 2.0 initiative in March 2024, signaling its commitment to environmental sustainability and climate responsibility. Within Pertamina, Pertamina Hulu Energi (PHE)—as the primary upstream subsidiary responsible for more than 80% of Pertamina's total methane emissions—has become a focal point for these efforts (Pertamina, 2025).

However, significant challenges remain for PHE. Current methane emissions reporting largely relies on generic estimation methods (OGMP Levels 1 and 2), which lack the precision and transparency required by OGMP standards. Additionally, existing MRV (Measurement, Reporting, and Verification) infrastructure is limited, and the absence of clearly defined internal governance and targeted methane reduction strategies further complicates implementation efforts.

This study therefore critically evaluates PHE's methane emission management strategy in the context of OGMP 2.0, identifying gaps and formulating strategic recommendations to align company practices with international expectations and contribute meaningfully to national and global emission reduction commitments.

This research primarily aims to evaluate and enhance the methane management strategies of Pertamina Hulu Energi by aligning current practices with the OGMP 2.0 framework. Specifically, the objectives of this research are:

1. To identify the current gaps between PHE's methane management practices and OGMP 2.0 requirements.
2. To evaluate alternative strategic approaches for improving methane emissions management using a structured decision-making approach.
3. To determine the most feasible and effective methane management strategy using Analytical Hierarchy Process (AHP).
4. To formulate a comprehensive implementation plan that considers internal capabilities, regulatory compliance, and external stakeholder expectations.

This research holds considerable significance for both the academic community and practical stakeholders in Indonesia's oil and gas sector. Academically, the study contributes by providing an integrative approach using mixed-method analysis (Gap Analysis, AHP, SWOT, and TOWS), enriching the literature on strategic methane management and sustainability practices in emerging economies.

Practically, the findings provide actionable insights for PHE and similar organizations within the industry, guiding them toward achieving higher

standards of methane emission reporting and reduction. Effective implementation of the recommended strategies can significantly enhance corporate reputation, investor trust, regulatory compliance, and support Indonesia's ambitious decarbonization targets, thereby strengthening the country's commitment to global climate initiatives.

LITERATUR REVIEW

Methane Management in the Oil and Gas Sector

Methane (CH_4) is a significant greenhouse gas emitted predominantly by the oil and gas sector. It has a much higher global warming potential (GWP) compared to carbon dioxide (CO_2), approximately 84 times greater over a 20-year horizon (IPCC, 2021). Methane emissions in upstream oil and gas operations occur primarily through four main pathways: fugitive emissions (unintentional leaks from equipment), venting (controlled releases of gas into the atmosphere), flaring (incomplete combustion of excess gases), and stationary combustion (incomplete combustion in turbines and engines) (Hamdy et al., 2024; Chauhan et al., 2024).

Effective methane management is crucial, not only for climate mitigation but also for improving operational safety, enhancing resource efficiency, and maintaining corporate reputation (Macci et al., 2024). Leading global oil companies, including ADNOC and Eni, have demonstrated proactive methane management practices through advanced technologies, structured leak detection, repair programs (LDAR), and precise emissions reporting aligned with international standards (Chauhan et al., 2024; Macci et al., 2024).

OGMP 2.0 Framework

The Oil and Gas Methane Partnership 2.0 (OGMP 2.0), established by the United Nations Environment Programme (UNEP) and the Climate and Clean Air Coalition (CCAC), serves as the global "gold standard" for methane emissions reporting within the oil and gas sector. OGMP 2.0 promotes transparency, accuracy, and continuous improvement in methane reporting through direct measurement methodologies (UNEP, 2020).

The OGMP 2.0 framework outlines five reporting levels:

- Level 1: General estimates using standard emission factors.
- Level 2: Improved estimates at the facility level.
- Level 3: Facility-specific technical calculations.
- Level 4: Direct measurements at emission sources integrated at the facility level.
- Level 5: Comprehensive reconciliation between facility-level and source-level measurements (UNEP, 2020).

Companies adhering to OGMP 2.0 must achieve at least Level 4 reporting within three to five years, develop materiality analyses, set clear methane reduction targets, and implement robust governance and verification mechanisms to ensure data credibility (UNEP, 2020).

Measurement, Reporting, and Verification (MRV)

Measurement, Reporting, and Verification (MRV) represents a structured process integral to methane management under OGMP 2.0. Accurate measurement involves utilizing advanced technologies such as Optical Gas Imaging (OGI), High Flow Samplers (HFS), Unmanned Aerial Vehicles (UAVs), drones, and satellite-based methane detection (Hamdy et al.,

2024). Effective reporting ensures systematic, transparent communication of emissions data, aligning closely with international standards. Verification, conducted by independent third parties, validates emissions measurements and reporting practices, significantly enhancing the credibility and transparency of methane management (CCAC, 2020).

Methane Mitigation Strategies

Methane mitigation encompasses actions aimed at reducing emissions across operational stages within the oil and gas industry. Primary mitigation strategies include:

- Leak Detection and Repair (LDAR): Systematic identification and timely repair of equipment leaks.
- Operational Optimization: Reducing routine venting through process improvements, closed vent systems, and vapor recovery units (VRUs).
- Enhanced Flaring Efficiency: Improving combustion processes to minimize incomplete combustion.
- Technological Upgrades: Installing low-emission or zero-emission equipment such as compressors, valves, and storage tanks.
- Infrastructure Modernization: Upgrading infrastructure to support advanced emission-control technologies (IOGP, 2025; OECD, 2024).

These technical solutions, supported by robust organizational measures, regulatory alignment, and workforce training, collectively enhance methane management effectiveness and long-term sustainability.

Summary of Relevant Studies

Several studies underscore the urgency and efficacy of improved methane management practices globally. According to the International Energy Agency (2021), over 75% of methane emissions from oil and gas operations could be mitigated using currently available technologies. Real-world case studies, such as those from ADNOC and Petronas, indicate significant reductions achievable through robust methane management strategies involving precise measurement, systematic MRV implementation, and targeted mitigation actions (Methane Guiding Principles, 2024).

Research conducted by Macci et al. (2024) and Hamdy et al. (2024) demonstrates that enhanced MRV systems significantly improve emissions accuracy and accountability, directly contributing to effective policy implementation and industry compliance with global climate goals. Furthermore, economic assessments using Marginal Abatement Cost Curves (MACC) highlight the financial feasibility and long-term profitability of investing in methane mitigation technologies, particularly when supported by regulatory incentives and international climate financing mechanisms (OECD, 2024; UNDP, 2021).

In Indonesia, previous studies emphasize the need for alignment with international frameworks like OGMP 2.0. Research on Indonesian upstream oil and gas companies identifies significant gaps in current reporting practices, emphasizing the urgency of adopting direct measurement methodologies and transparent reporting processes to meet both national and global emission reduction objectives (Pertamina, 2025; ASEAN Centre for Energy, 2025).

In conclusion, existing literature emphasizes that effective methane management in the oil and gas sector requires integrated technical, economic, regulatory, and organizational strategies. Adopting structured frameworks like OGMP 2.0, coupled with advanced MRV

systems and targeted mitigation technologies, is essential for companies aiming to achieve compliance, enhance reputation, and contribute meaningfully to global climate action.

METHOD

Research Design

This study employed a mixed-methods research design, integrating qualitative and quantitative approaches to comprehensively evaluate methane emission management strategies at Pertamina Hulu Energi (PHE). The mixed-method approach was chosen to allow a deeper, contextual understanding through qualitative analysis, combined with structured, quantifiable insights from quantitative methods. Specifically, the research incorporated gap analysis, Analytical Hierarchy Process (AHP), and SWOT/TOWS analyses, facilitating robust decision-making and strategic recommendations.

Data Collection Methods

Primary Data Collection:

Primary data were collected through semi-structured in-depth interviews with selected respondents. The respondents were chosen purposively based on their expertise, direct involvement, and authority related to methane emission management at Pertamina and its subsidiaries. Interviews aimed to understand current practices, challenges, strategic priorities, and internal perspectives regarding alignment with the OGMP 2.0 framework. Ten experts participated in this study, including senior managers and technical specialists from Pertamina's sustainability, HSSE, production planning, and technology acceleration units, as well as representatives from external institutions such as the Global Methane Initiative (GMI) Indonesia.

Secondary Data Collection

Secondary data comprised comprehensive reviews of internal documents (e.g., company sustainability reports, internal HSSE policies), regulatory frameworks (e.g., Indonesia's Ministry of Energy and Mineral Resources Regulation No.17/2021), as well as international reports and guidelines published by the United Nations Environment Programme (UNEP), International Energy Agency (IEA), and the Oil and Gas Methane Partnership (OGMP) 2.0 framework documents. Relevant academic journals, industry white papers, and policy reports were also reviewed to support contextual and theoretical foundations.

Data Analysis Methods

Gap Analysis

The gap analysis method was initially applied to systematically identify discrepancies between Pertamina Hulu Energi's (PHE) existing methane management practices and the OGMP 2.0 framework requirements. This assessment involved a comprehensive evaluation by comparing several critical aspects, such as current emission reporting precision, measurement accuracy, target-setting practices, and governance mechanisms against the specific standards defined by OGMP. The evaluation specifically addressed the precision level of reporting (Levels 1–5 of OGMP), the thoroughness of materiality analysis procedures, the approach used for setting emission reduction targets (whether absolute or intensity-based), accuracy in quantifying emissions, and transparency in governance and reporting processes. The findings from this analysis clearly revealed significant gaps and highlighted crucial areas requiring improvement to meet OGMP 2.0 compliance standards. These insights provided essential

foundational data, informing strategic decisions in subsequent phases of the project.

Analytical Hierarchy Process (AHP)

The AHP methodology was utilized to systematically prioritize strategic alternatives for methane management. Developed by Saaty (2008), AHP is effective for complex decision-making involving multiple criteria and sub-criteria. The steps included:

1. Developing a hierarchical structure: Clearly defined goal (optimal methane management strategy), criteria (economic viability, technological feasibility, operational feasibility, risk management), and alternative strategies (Basic Compliance, OGMP 2.0 Alignment, Gold Standard).
2. Pairwise comparisons: Structured questionnaires were distributed to selected expert respondents to determine the relative importance of criteria, sub-criteria, and strategic alternatives based on Saaty's scale (1–9).
3. Calculating priority weights: The AHP software (Super Decisions version 3.2) computed priority weights to identify the most optimal strategic alternative.
4. Consistency checks: Ensured that pairwise comparisons by respondents remained consistent, with a consistency ratio (CR) threshold below 0.10, confirming reliability and validity of the findings.

SWOT and TOWS Analysis

Following the selection of the optimal strategy through AHP, SWOT (Strengths, Weaknesses, Opportunities, Threats) and TOWS (Threats, Opportunities, Weaknesses, Strengths) analyses were conducted to further refine implementation recommendations. SWOT analysis systematically assessed internal organizational capabilities (strengths and weaknesses) and external environmental factors (opportunities and threats), based on data collected from expert interviews and secondary sources.

Subsequently, the TOWS matrix was employed to strategically integrate internal and external factors, thereby identifying actionable strategic pathways. The Strength–Opportunity (SO) strategies involved leveraging internal capabilities to effectively capitalize on external opportunities. Meanwhile, Weakness–Opportunity (WO) strategies aimed at mitigating internal shortcomings to better harness these external possibilities. Strength–Threat (ST) strategies focused on utilizing the organization's existing strengths to counter external threats, whereas Weakness–Threat (WT) strategies were crafted specifically to address internal weaknesses while simultaneously reducing exposure to external risks. This integrative analytical approach offered comprehensive and practical insights, enabling the formulation of strategic recommendations aligned with organizational capacities and compliance with international standards.

RESULT AND DISCUSSION

Gap Analysis Findings

The gap analysis highlighted significant disparities between Pertamina Hulu Energi's (PHE) current methane management practices and the standards required by the OGMP 2.0 framework. The key gaps identified are listed in Table 1.

The Gap Analysis revealed substantial areas requiring improvement in Pertamina Hulu Energi's (PHE) current methane management compared to the OGMP 2.0 framework. Predominantly,

PHE's methane emission reporting has relied on generic estimation methods categorized under Levels 1 and 2, whereas direct measurement methods at Levels 4 and 5 were infrequently employed and confined primarily to specific pilot projects. Additionally, the conducted materiality analyses were only basic, lacking detailed assessments at the emission-source level, thus impeding precise tracking and management of emissions. Although Pertamina Holding had set a broad target of a 40% emission reduction by 2030, PHE itself had not established explicit methane emission reduction targets that fully aligned with OGMP guidelines. Furthermore, reporting scope predominantly covered operated assets, with minimal disclosure of emissions from joint venture or non-operated assets. Another critical shortcoming was the absence of a dedicated governance structure and the lack of a detailed, methane-specific implementation roadmap, which would be essential to effectively guide methane mitigation efforts.

Table 1. Gap Analysis Summary

OGMP 2.0 Component	PHE's Current Practice	Required Improvement
Reporting Level	Level 1-2 (Estimation-based)	Upgrade to Levels 3-4 (Direct measurement-based)
Materiality Analysis	Limited & general	Detailed emission-source materiality assessment
Target Setting	General 40% emission target	Specific methane targets (absolute/intensity)
Reporting Scope	Operated assets only	Comprehensive (including non-operated assets)
Governance	No dedicated methane unit	Establish dedicated methane governance unit

Source: research result

Table 1 presents a summary of the gap analysis comparing Pertamina Hulu Energi's (PHE) current methane management practices with the requirements outlined in the OGMP 2.0 framework. The analysis identifies key areas requiring significant improvements.

Currently, PHE's reporting practices are predominantly based on estimation methods (Levels 1-2 according to OGMP 2.0 standards). These estimation methods rely heavily on generalized emission factors rather than actual measurement at the source. To align with OGMP 2.0, it is essential to upgrade to Levels 4 and 5, which emphasize direct measurement-based reporting. This transition will improve accuracy and credibility, aligning PHE with international best practices.

Regarding materiality analysis, the current state at PHE is limited and generally applied. There is a need for a more detailed and specific emission-source assessment to accurately identify critical methane emission sources within operations. Conducting a detailed materiality analysis is crucial, as it provides clarity on the priority emission sources, enabling targeted and efficient mitigation efforts.

In the area of target setting, PHE currently applies a general corporate-level target of 40% emissions reduction. While this demonstrates corporate commitment, it lacks specificity regarding methane emissions. To fulfill OGMP 2.0 requirements and enhance clarity for stakeholders, specific methane reduction targets—both absolute and intensity-based—need to be clearly defined. These targets will enhance accountability and transparency in methane management performance.

For the reporting scope, the current practice is limited to operated assets, excluding non-operated or joint-venture

assets. To achieve comprehensive and transparent reporting as per OGMP 2.0 standards, PHE needs to expand its reporting scope to include non-operated assets as well. Expanding this scope ensures completeness and consistency in methane emission reporting across all assets associated with PHE operations, thus meeting investor expectations and regulatory compliance.

Finally, in terms of governance, PHE lacks a dedicated methane governance unit. Currently, methane management responsibilities are dispersed across different departments. Establishing a dedicated governance structure or unit specifically responsible for methane management will provide clear accountability, enhance internal coordination, and ensure effective implementation and monitoring of methane mitigation strategies.

Analytical Hierarchy Process (AHP) Results

AHP analysis was conducted to identify the optimal methane management strategy among three alternatives: Basic Compliance, OGMP 2.0 Alignment, and Gold Standard. Evaluated against criteria of technological feasibility, economic viability, operational feasibility, and risk management, the OGMP 2.0 Alignment strategy emerged as the highest-ranked option.

In selecting an effective methane management strategy for Pertamina Hulu Energi (PHE), this study employed the Analytical Hierarchy Process (AHP) method. To ensure a comprehensive evaluation, several criteria and sub-criteria were identified based on literature reviews, expert interviews, and organizational needs. These criteria were grouped into two categories: **Must** (mandatory criteria) and **Wants** (desired but non-mandatory criteria).

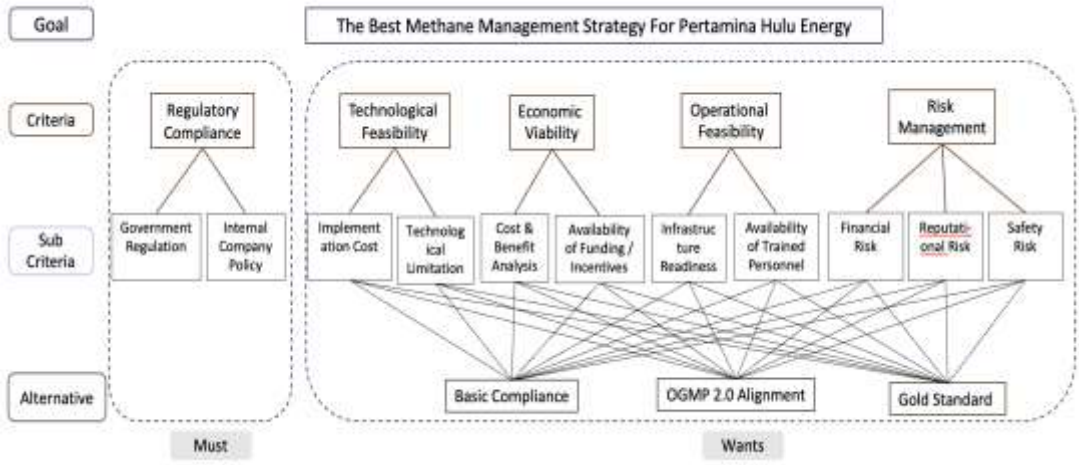

Figure 1. AHP Hierarchy Structure for Strategic Alternatives

Based on a comprehensive review and expert insights, three methane management strategy alternatives were identified for evaluation:

1. Basic Compliance
   Fulfilling only minimal regulatory requirements, primarily using emission estimation (OGMP Levels 1-2).
2. OGMP 2.0 Alignment (Intermediate Level)
   Selectively implementing higher accuracy methane measurement (OGMP Levels 4-5), targeting key operational sites.

3. Gold Standard (Advanced Level) Comprehensive and immediate implementation of direct measurement-based MRV (OGMP Levels 4-5) across all relevant operational assets.

Table 2. summarizes the calculated weight results for each criterion and sub-criterion from the AHP analysis.

Table 2. AHP Criteria and Sub-Criteria Weights

AHP Hierarchy Result	Weighted (%)
Criteria	
Technological Feasibility	14,48
Economic Viability	47,68
Operational Feasibility	21,68
Risk Management	16,14
Sub Criteria	
Implementation Costs	79,25
Technological Limitations	20,74
Cost-Benefit Analysis	65,37
Availability of Funding	34,63
Infrastructure Readiness	31,85
Availability of Trained Personnel	68,14
Financial Risks	45,05
Reputational Risks	16,58
Safety Risk Reduction	38,36
Alternative	
Basic	33,71
OGMP 2.0 Alignment	39,86
Gold Standard	26,43

Source: research result

The results of the Analytical Hierarchy Process (AHP) used to identify priority criteria and sub-criteria influencing Pertamina Hulu Energi's (PHE) methane management strategy decisions. The analysis reveals stakeholder preferences and highlights the critical factors that must be prioritized in decision-making.

Economic Viability (47.68%) emerges as the highest priority among the evaluated criteria, suggesting that stakeholders regard economic considerations as the most critical factor in methane management decisions. Within this criterion, Cost-Benefit Analysis (65.37%) stands out as the most influential sub-criterion. This indicates that decision-makers place significant importance on ensuring methane mitigation investments are economically justified and financially sustainable over the long term. Emphasis on economic viability implies that PHE must rigorously evaluate the economic returns of methane management projects, considering both the immediate costs and long-term benefits.

Following economic considerations, Operational Feasibility (21.69%) is identified as the second most important criterion. Within this criterion, the Availability of Trained Personnel

(68.15%) is highlighted as crucial. This result underscores the necessity for skilled human resources who are adequately trained to implement advanced methane detection technologies and mitigation strategies effectively. The focus on operational feasibility and personnel training suggests that successful implementation of methane management initiatives at PHE will depend greatly on addressing workforce capability gaps.

The criterion of Risk Management (16.15%) is ranked third, highlighting that stakeholders acknowledge potential risks associated with methane management initiatives. Among the sub-criteria, Financial Risks (45.05%) are prioritized, reflecting concerns about investment uncertainties, potential cost overruns, and the long-term financial impacts of methane mitigation programs. Mitigating these financial risks will require careful planning, clear financial strategies, and possibly leveraging external financial support.

Lastly, Technological Feasibility (14.48%) is recognized as important, but relatively less critical compared to economic and operational factors. Within this criterion, the sub-criterion Implementation Costs (79.26%) is considered highly significant. This finding indicates stakeholders' concerns about the substantial upfront investment required for implementing advanced methane measurement and mitigation technologies. To address this, PHE may need to explore cost-effective technologies, external funding, and phased implementation strategies to manage technological implementation costs effectively.

Overall, the AHP analysis clearly demonstrates that economic viability—particularly thorough cost-benefit evaluations—is paramount. At the same time, operational readiness through trained personnel, effective management of financial risks, and controlled technological implementation costs represent significant supportive factors for successful methane management at PHE. This prioritization provides critical insights that can guide strategic decisions and resource allocation to ensure effective methane management aligned with OGMP 2.0 standards.

After synthesizing weights and analyzing each alternative against defined criteria, final priority rankings for alternative strategies were calculated, the OGMP 2.0 Alignment strategy emerged as the most preferred alternative, balancing economic viability, operational feasibility, technological practicality, and manageable financial risks. This intermediate approach was recognized as optimal due to its selective yet impactful methane mitigation capability, reflecting stakeholder priorities and practical implementation considerations.

SWOT and TOWS Analysis

The SWOT and TOWS analyses were conducted to systematically evaluate Pertamina Hulu Energi's (PHE) strategic preparedness to align its methane management strategy with the Oil and Gas Methane Partnership (OGMP) 2.0 framework. These analyses identified critical internal and external factors affecting PHE's strategy, offering a robust foundation for practical and strategic decision-making.

The SWOT analysis revealed that PHE possesses notable internal strengths, such as strong corporate commitment and successful MRV pilot experiences. However, substantial weaknesses were also noted, particularly regarding high implementation costs, inadequate trained personnel, and limited governance structures.

Externally, opportunities such as international funding support, growing ESG demands from investors, and potential access to carbon credit markets present significant advantages. Conversely, threats include weak regulatory enforcement and financial challenges associated with managing methane emissions in marginal fields.

Tabel 3. Strength (S) & Weakness (W)

S1	Top-Level Commitment and ESG Alignment
S2	Operational Experience in GHG Inventories
S3	MRV Pilots Achieving OGMP Level 4 and 5
S4	Growing Internal Awareness of OGMP Requirements
W 1	High Implementation Costs
W 2	Absence of Comprehensive Cost-Benefit Analysis
W 3	Shortage of Trained Personnel in Methane-Specific Tools
W 4	No Dedicated Methane Team or Governance Structure
W 5	Lack of a Methane-Focused Implementation Roadmap

Source: research result

Table 4. Opportunities (O) & Threats (T)

O1	International Support and Funding
O2	Collaborate with Reputable National Research Institutions
O3	Access to Voluntary Carbon Markets
O4	Potential Operational Cost Savings
O5	Rising ESG Demands from Investors and Lenders
T1	Weak Regulatory Enforcement
T2	Cost-Risk Misalignment for Marginal Assets
T3	Risk of Delayed Credibility in International Forums
T4	Integration Challenges with Legacy Systems

Source: research result

TOWS Analysis Results and Strategic Recommendations

The TOWS matrix synthesizes SWOT insights to provide actionable strategic recommendations.

Tabel 5. TOWS Strategy Pairing

	Strengths (S)	**Weaknesses (W)**
	S1 Top-Level Commitment and ESG Alignment S2 Operational Experience in GHG Inventories S3 MRV Pilots Achieving OGMP Level 4 and 5 S4 Growing Internal Awareness of OGMP Requirements	W1 High Implementation Costs W2 Absence of Comprehensive Cost-Benefit Analysis W3 Shortage of Trained Personnel in Methane-Specific Tools W4 No Dedicated Methane Team or Governance Structure W5 Lack of a Methane-Focused Implementation Roadmap
Opportunities (O)	**SO Strategies:** Leveraging Strengths to Exploit Opportunities	**WO Strategies:** Addressing Weaknesses by Leveraging Opportunities

O1 International Support and Funding O2 Collaboration with Research Institutions O3 Access to Voluntary Carbon Markets O4 Potential Operational Cost Savings O5 Rising ESG Investor Demands	**S3O1:** Expand successful MRV pilot projects (S3) using available international funding and support (O1, O5). **S1O2:** Strengthen ESG communication (S1) to enhance credibility among investors and lenders (O5) and to access voluntary carbon markets (O3). **S2O3:** Utilize operational GHG inventory experience (S2) to pursue further operational cost savings (O4).	**W4O1:** Establish a dedicated methane management unit (W4), utilizing international support and funding (O1). **W3O2:** Develop structured internal training programs (W3) in collaboration with reputable national research institutions (O2). **W5O3:** Create a detailed methane implementation roadmap (W5) leveraging external funding and expert inputs (O1, O2).
Threats (T)	**ST Strategies:** Leveraging Strengths to Mitigate Threats	**WT Strategies:** Minimizing Weaknesses and Avoiding Threats
T1 Weak Regulatory Enforcement T2 Cost-Risk Misalignment for Marginal Assets T3 Risk of Delayed Credibility Internationally T4 Integration Challenges with Legacy Systems	**S1T1:** Leverage top-level ESG commitment (S1) to proactively adopt advanced MRV and mitigation strategies, thereby reducing credibility risks internationally (T3). **S3T2:** Expand proven MRV pilots (S3) into marginal assets strategically, minimizing cost-risk misalignment (T2). **S4T3:** Utilize existing internal OGMP awareness (S4) to proactively manage regulatory gaps and challenges (T1).	**W2T1:** Conduct comprehensive cost-benefit analyses (W2) specifically targeting marginal assets, addressing cost-risk misalignment (T2). **W5T2:** Enhance integration planning to address legacy system challenges (T4) through the creation of a clear methane-focused implementation roadmap (W5). **W3T3:** Rapidly improve personnel capabilities (W3) to manage implementation risks and ensure timely international compliance (T3).

Source: author analysis and expert's insights

The integrated analyses (Gap Analysis, AHP, SWOT, and TOWS) consistently confirm that strategic alignment with OGMP 2.0 through selective implementation of advanced MRV practices is the optimal approach for PHE. This method balances economic viability, operational feasibility, technological practicality, and strategic risk management. Implementing these strategies not only addresses internal weaknesses and

mitigates external threats but also capitalizes on significant external opportunities. Ultimately, aligning with OGMP 2.0 strategically positions PHE as a responsible leader in methane management, enhancing global credibility, fulfilling national decarbonization commitments, and effectively managing internal and external stakeholder expectations.

Table 6. Consolidated Strategic Themes and Descriptions

No	Strategic Theme	Description
1	Strengthening MRV Implementation and Expansion	Expand successful MRV pilots using international funding (e.g., World Bank, EDF, JOGMEC) to proactively manage regulatory risk and enhance global credibility.
2	Dedicated Methane Governance and Institutional Capacity	Establish a dedicated methane management unit, strengthen internal governance, collaborate with reputable research institutions, and build structured training programs to address personnel skills gaps.
3	ESG Integration and Enhanced Investor Communication	Leverage strong ESG commitment to improve transparency, attract ESG-focused investors, and utilize carbon markets through strategic disclosures and robust ESG reporting.
4	Economic Optimization and Risk Management	Conduct detailed cost-benefit analyses targeting economic viability, especially for marginal assets, prioritize strategic investments based on materiality, and ensure financial sustainability of mitigation measures.
5	System Integration and Implementation Roadmap	Develop a clear methane-focused implementation roadmap addressing legacy system integration, detailing milestones, infrastructure needs, training programs, and comprehensive risk mitigation plans for seamless operational integration.

Interpretation of Results

The findings from this study underscore significant gaps between Pertamina Hulu Energi's (PHE) current methane emission management practices and the international standards set by OGMP 2.0. The gap analysis revealed that PHE predominantly relies on generic emission factors (Levels 1 and 2 of OGMP reporting), suggesting considerable room for improvement, particularly in direct source-level measurement and reporting transparency. The identified gaps in target-setting mechanisms and the lack of a dedicated governance structure further reinforce the urgency for PHE to enhance strategic methane management practices to meet stakeholder expectations and regulatory requirements.

The Analytical Hierarchy Process (AHP) analysis identified OGMP 2.0 Alignment as the most optimal strategic choice, primarily driven by criteria related to economic viability and operational feasibility. Economic considerations, specifically cost-benefit analysis, emerged as the most influential factor in the decision-making process, reflecting practical considerations for resource allocation and return on investment. Operational feasibility, particularly the availability of trained

personnel, was also highlighted as a critical concern, indicating a significant internal capacity-building requirement.

SWOT and TOWS analyses further supported the findings from the gap and AHP analyses by highlighting critical internal strengths, such as PHE's top-level commitment and previous pilot project successes, balanced by considerable weaknesses including high implementation costs and insufficient dedicated governance structures. Externally, opportunities from international funding mechanisms, investor interest in ESG metrics, and potential carbon credit monetization provided clear strategic pathways, while threats like weak regulatory enforcement and financial feasibility concerns for marginal fields indicated areas requiring careful risk mitigation strategies.

Theoretical Implications

This research significantly contributes to existing theoretical frameworks by systematically integrating Gap Analysis, Analytical Hierarchy Process (AHP), SWOT, and TOWS analyses to address complex methane emission management issues in the oil and gas sector. By combining qualitative and quantitative methodologies, it validates structured, multi-criteria decision-making theories in environmental sustainability contexts. The study reinforces the theoretical understanding of governance structures, highlighting centralized methane-specific governance as essential for effective environmental management. It further extends knowledge regarding the critical role of economic viability assessments—especially cost-benefit analyses—in developing sustainable strategies. Additionally, this research theoretically emphasizes the significance of materiality assessments for investment prioritization and targeted mitigation actions, enriching the literature on sustainable resource allocation.

Comparatively, these findings align closely with existing studies, such as those by Hamdy et al. (2024), Macci et al. (2024), and the International Energy Agency (2021), which underscore the necessity for precise methane measurement and robust reporting frameworks like OGMP Levels 4 and 5. Consistent with OECD (2024), this study also emphasizes economic viability as a pivotal aspect of methane reduction strategies, particularly when supported by financial incentives and international funding. Further theoretical alignment is seen with Methane Guiding Principles (2024), highlighting governance reforms as foundational for enhancing compliance, stakeholder credibility, and strategic implementation effectiveness. Finally, the SWOT/TOWS methodology utilized reinforces strategic management literature, confirming that leveraging internal strengths and external opportunities significantly improves organizational effectiveness and strategic execution (Weihrich, 1982; Gurel & Tat, 2017). Overall, this research advances existing theoretical insights by providing an integrated, context-specific framework tailored to methane management in Indonesia's upstream oil and gas industry, balancing operational, economic, technological, regulatory, and governance dimensions.

Practical Implications

The study's results carry important strategic implications for both PHE and the broader Indonesian upstream oil and gas sector. Firstly, the identified necessity for alignment with OGMP 2.0 offers a clear and structured roadmap for methane emission management enhancement, emphasizing selective and gradual implementation of advanced

direct measurement technologies. Strategic implications include prioritizing investments in high-impact assets and adopting a phased approach toward achieving higher reporting levels (Levels 4 and 5 of OGMP 2.0), enabling manageable resource allocation and ensuring operational sustainability.

The emphasis on economic feasibility and cost-benefit considerations indicates that PHE must develop and institutionalize robust financial assessment frameworks, such as marginal abatement cost curves (MACC), to justify investments in methane mitigation technologies clearly. Furthermore, the critical requirement for trained personnel necessitates comprehensive capacity-building initiatives and collaborations with international organizations and local research institutions to strengthen internal competencies and ensure effective technology utilization.

From a governance perspective, the study underscores the strategic importance of establishing a dedicated methane management task force or unit within PHE. Such a specialized unit would facilitate effective coordination, enhance data management transparency, ensure consistent compliance with international standards, and strengthen internal accountability mechanisms.

Practical Implications

This study provides substantial practical insights and guidance for Pertamina Hulu Energi (PHE) and other organizations within the oil and gas sector aiming for effective methane emission management. Firstly, it highlights the need for a phased, structured transition from basic estimation-based reporting to direct measurement-based approaches (OGMP Levels 3–4). Organizations can practically apply these insights by progressively upgrading their Measurement, Reporting, and Verification (MRV) methodologies to enhance data accuracy, regulatory compliance, and international credibility.

Moreover, this research underscores the critical importance of establishing a dedicated governance structure for methane management. Practically, this implies organizations should consider forming specialized teams or units to coordinate methane management activities, ensuring accountability, effective strategy implementation, and coherent resource allocation.

Another crucial practical implication relates to workforce training and capability-building. Organizations must prioritize targeted investments in employee development, leveraging partnerships with academic institutions or external agencies to bridge personnel skill gaps in methane detection and mitigation technologies.

Additionally, the findings encourage organizations to strategically leverage international financial and technical assistance. By actively pursuing international funding opportunities, carbon market mechanisms, and ESG-oriented investment partnerships, companies can significantly offset the high costs associated with advanced methane management technologies, making sustainability initiatives economically feasible.

Finally, the research advocates conducting comprehensive cost-benefit analyses and developing materiality-based investment plans to address financial and operational risks, particularly in marginal or older assets. Practically, organizations should prioritize methane mitigation measures based on emission source significance,

economic sustainability, and operational feasibility.

In conclusion, these expanded practical implications offer actionable strategies for industry practitioners, guiding effective methane management alignment with international standards (OGMP 2.0), enhancing global credibility, fulfilling stakeholder expectations, and achieving tangible progress in corporate sustainability and national decarbonization commitments.

CONCLUSION

This study evaluated methane emission management strategies at Pertamina Hulu Energi (PHE) by aligning the company's current practices with the international Oil and Gas Methane Partnership (OGMP) 2.0 framework. Utilizing mixed-method approaches—including Gap Analysis, Analytical Hierarchy Process (AHP), SWOT, and TOWS analyses—the research systematically identified critical areas requiring improvement and assessed strategic alternatives.

Key conclusions from this research are as follows:

1. Significant Gaps Identified
   The current methane management practices at PHE revealed considerable gaps compared to OGMP 2.0 requirements. The primary shortcomings included inadequate direct measurement methodologies (reporting predominantly at OGMP Levels 1 and 2), limited coverage and accuracy in emissions reporting, unclear methane-specific reduction targets, and an absence of a dedicated governance structure.
2. Optimal Strategic Pathway Identified
   The Analytical Hierarchy Process (AHP) clearly indicated that aligning with OGMP 2.0 (OGMP 2.0 Alignment strategy) represented the most effective and feasible option for PHE. This strategy balanced economic viability, technical practicality, operational ease, and effective risk management, highlighting cost-benefit analysis and internal capacity building as crucial decision-making factors.
3. Strategic Insights from SWOT and TOWS Analysis
   PHE benefits from substantial internal strengths, such as top-level corporate ESG commitment and successful MRV pilot projects, yet faces significant weaknesses including high implementation costs and limited trained personnel. Externally, the company can leverage opportunities such as international financial support and growing investor interest in ESG metrics but must address threats related to weak domestic regulatory enforcement and operational cost challenges in marginal fields.

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