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**ENHANCING PERFORMANCE OF ENERGY MANAGEMENT SYSTEMS:
EXPERIENCE OF FACILITIES MANAGEMENT CONTRACTS FROM
DEVELOPING ECONOMIC GOVERNMENT**

**Vengadesan, G.¹, Kamaruzzaman, S.N.^{1*}, Che-Ani, A.I.²,
Simmons, L.³, Lou, E.C.W.³**

*¹ Centre of Building, Construction and Tropical Architecture,
Faculty of built Environment,
UNIVERSITY OF MALAYA, KUALA LUMPUR, MALAYSIA*

*² Faculty of Engineering and Built Environment,
UNIVERSITI KEBANGSAAN MALAYSIA,
UKM BANGI, SELANGOR, MALAYSIA*

*³ Department of Engineering,
MANCHESTER METROPOLITAN UNIVERSITY,
JOHN DALTON BUILDING, CHESTER STREET, MANCHESTER, UK*

Abstract

The Energy Management Systems (EnMS) has seen rapid evolvement and development much to the effects of greenhouse gases. In Malaysia, EnMS is conceptualized as an integrated approach involving mechanical, electrical, and architectural components to achieve effective energy use and greater efficiency in buildings. The Malaysian Government have committed to achieve a Building Energy Index less than 150kWh/m²/year, but this remains a big challenge, with more than half of government contracts failing to meet the benchmark. This performance gap indicates that technical measures alone are insufficient, and that organisational and behavioural factors within facilities management contracts may strongly influence EnMS outcomes. To address this gap, this study evaluates the performance of EnMS in behavioural perspectives for Government facilities management contracts - focusing on the relationship of 15 factors in terms of its level of importance and implementation of EnMS. This research adopted an empirical study through a sequential mixed method (exploratory approach), validated questionnaires survey on 31 contracts, which was responded by the subject matter expert (energy manager) and the survey data was analysed using the Spearman Rank Order correlation (rho). Out of 15 factors tested, the results revealed that only eight is found to have significant correlation with EnMS performance. These are also supported by cross experts' interviews. A performance matrix was developed by integrating all 8 significant factors. By incorporating international BEI practices from Europe, Singapore, Japan, and the United States, this study not only offers insights for enhancing Malaysia's EnMS performance but also positions the findings within a global benchmarking context.

Keywords: High-rise Residential, Strata Residential, Commissioner of Building, Strata Management Body

² Corresponding author. Email: syahrulnizam@um.edu.my

INTRODUCTION

The energy consumption saving practices applied over the years prioritised one-off cutting measures and rapid transformation (Yuriev & Boiral, 2018). Such efforts have been in place since the late 70s, whereby the managers enable low-cost solutions by educating building users to turn off unused lights and adjusting air-conditioning system (Introna *et al.*, 2014). The effort for above statement found to be more systematic and holistic under the Energy Management System (EnMS) (Abdelaziz *et al.*, 2011). With increasing environmental pressures, more organisations have begun to adopt energy management systems in their business practices (ISO, 2015).

Studies shows that several factors directly influence the performance of energy management system through the end results reporting status for buildings. Among the important drive factors mentioned above, were relationship building towards the stakeholders and regulatory compliance (Wee and Siong, 2017). Meanwhile, the studies in Putrajaya buildings found that measuring and reporting principles for energy used currently requires in contract documentation, whilst CO₂ emission reporting is upon stakeholder's request (Wang, 2017). This is against the EnMS principal standards, which requires commitment of top management's involvement in this system.

The Sustainability Energy Development Authority of Malaysia has stressed that energy management is the way to tackle source CO₂ emission, especially during the operation stage. In line with this, the Malaysian government revealed their commitment in implementing a comprehensive energy management system in government buildings designed to be energy efficient (SEDA, 2019; Lim and Tee, 2018). BEI results for Putrajaya buildings from year 2015-2018, found that there are 55% building contracts which were unable to achieve BEI less than 150kWh/m²/year (JKR, 2018). This shows that there are persistent factors affecting the current energy management system in buildings in Putrajaya. This study seeks to identify the factors that act as barriers to reducing BEI in Putrajaya buildings, and how a deeper understanding of these factors may lead to an improvement in the performance of existing energy management systems.

LITERATURE REVIEW

A study by IEA (2014) defined that the energy demand will increase by 37% in the next 25 years. This rising demand has driven many countries to start implementing other incentives or mandatory programmes such as EnMS (Du Plessis, 2015). The Malaysian Government has committed to be a part of this effort to minimise energy consumption and usage. According to Perbadanan Putrajaya (2015), the Government had set and lead by an example for Putrajaya buildings whereby had overcome existing floor area coverage is much higher

(33.6%) for Government office building compared to the commercial buildings (8.8%). This was followed by enforcement of a mandatory EnMS in the Government Facilities Management and Maintenance (FMM) contract which applies to all the 31 Government building contracts in Putrajaya (JKR, 2018). However, 17 Government agencies building contract in Putrajaya still unable to achieve a BEI less than 150kWh/m²/year (JKR, 2018). This research seeks to determine the factors which affect the implementation and success of EnMS systems.

The findings from this research compare BEI data from Government agency buildings in Putrajaya, to identify where there are failures in meeting Key Performance Index (KPI). The outcomes inform the Malaysian Government (building stakeholders) in developing improvements to the current system and ensuring that the energy management system loop is complete.

Driving Elements Influencing Performance of Energy Management Systems

According to Centobelli *et al.* (2018), the efficiency for an energy management system, is influenced by either drivers (positive) or barriers (negative). Similarly, Siciliano et al (2015) identified that under the ISO 50001 environment, several driving factors which influence the success of an EnMS. These factors are illustrated in Figure 1 and can be summarised as:

- Policy intervention: Approach for stakeholders to engage and performance requirement as their policy.
- Enterprise management activities: Strategic planning and commitment level.
- Institutional support: The effectiveness of training programmes and reporting system.
- Technology and methodology push: The involvement of service provider innovation.

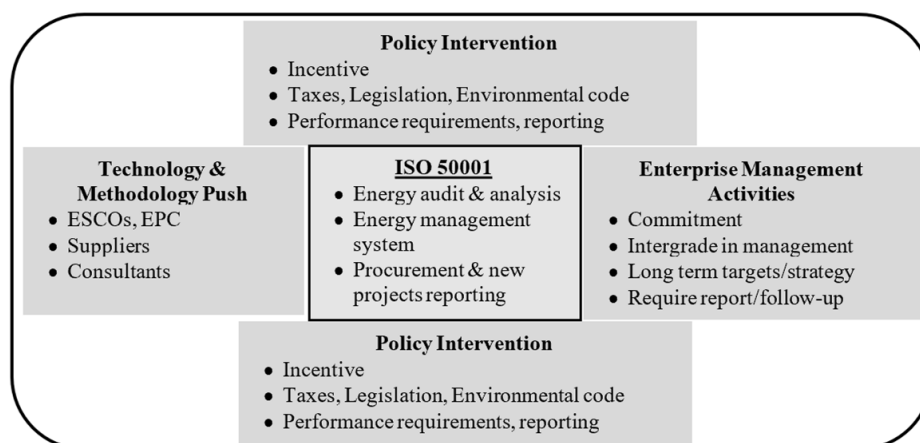


Figure 1: Favourable factor driving for Energy Management System (Siciliano et al., 2015)

Regulatory Compliance and Leadership

Regulatory compliance is critical factor in the effective implementation of an Energy Management System (EnMS) (Okereke, 2007). Stakeholder engagement further ensures the voluntary adaptation of EnMS, as emphasized by Wee and Siong (2017). Strong leadership is essential in managing and negotiating changes with stakeholders (Nishida & Hua, 2011). Effective stakeholder engagement enhances program execution (Chakraborty & Roy, 2013), whereas poor engagement leads to overlooked energy management initiatives (Halkos & Skouloudis, 2016). Aligning strategic vision with energy initiatives fosters cultural engagement (Huang, 2018; Farneti & Guthrie, 2009).

Compared to developed nations, Malaysia's progress in energy efficiency policies been relatively slow. The country's energy intensity remains high, indicating a need for more effective policy implementation and international collaboration (El-Awad, 2006). The absence of a specific legal framework for energy efficiency in Malaysia highlights a gap that many countries have addressed through comprehensive legislation. Implementing such a framework could enhance Malaysia's energy management efforts (Ghazali et al., 2023). Countries like China have implemented aggressive carbon pricing strategies, leading to significant energy consumption reductions. Malaysia's decarbonization efforts, while ambitious, face challenges in achieving similar outcomes due to structural and financial barriers (Gunawan et al., 2023).

Energy Cost Saving and Performance Evaluation

Organizations that adopt EnMS recognize the link between energy management and cost reduction (Wee & Siong, 2017; Wong & Zapantis, 2013). Cost-saving initiatives include BEI reduction, CAPEX and APEX savings, ROI across

different timeframes, and long-term asset benefits of retrofitting. Performance evaluation is vital, with clear KPIs and periodic reviews ensuring continuous improvement (Thollander & Palm, 2013; Huang, 2018). Top management plays a key role in maintaining the plan's effectiveness.

Building Reputation, Stakeholder Relations, and Environmental Awareness

EnMS implementation enhances an organization's reputation, competitiveness, and productivity (Pellegrini-Masini & Leishman, 2011; McCarty et al., 2011). Strong stakeholder relationships support energy program execution and investment in sustainability (Chakraborty & Roy, 2013), while weak engagement limits energy reporting (Halkos & Skouloudis, 2016). Cultural awareness of energy management impacts CO2 reduction and environmental responsibility (Scholtens & Kleinsmann, 2011; Shaari et al., 2020; Ali et al., 2019). Organizational values and attitudes play a role in adopting best practices (Nakamura et al., 2001; Huang, 2018; Wee & Siong, 2017).

Scope of Area and Energy Management Personnel

ISO 50001:2018 aims to improve energy performance by defining controlled coverage areas (Huang, 2018). Large coverage areas may reduce efficiency, necessitating zonal energy committees (Aldhshan et al., 2021; Centobelli et al., 2018). Designating energy controllers at various levels helps optimize energy use (Thollander & Palm, 2013). Intelligent systems can enhance EnMS effectiveness (Parvin et al., 2021; Mohd Aman et al., 2021). The competency of energy managers, determined by education, experience, and continuous training, is critical to EnMS success (Huang, 2018; Basri et al., 2021). A dedicated energy manager role is necessary for efficiency (Thollander & Palm, 2013).

Energy Planning, Budgeting, and Organizational Support

EnMS planning involves reviewing current practices, identifying risks and opportunities, and developing strategic outputs (Huang, 2018; Johansson & Thollander, 2018). Sufficient budgeting based on sub-metering calculations, rather than per square meter or occupancy, is essential to avoid investment barriers (Johansson & Thollander, 2018; Centobelli et al., 2018). Full top management support ensures resource allocation for EnMS objectives (Centobelli et al., 2018; Hamdan et al., 2025).

Simplicity, Visualization, and Energy Awareness

Simpler EnMS frameworks are more effective in achieving baseline goals (Huang, 2018), while complex technological systems may hinder adoption (Centobelli et al., 2018). Visualizing energy efficiency outcomes raises awareness, and energy-saving competitions with rewards enhance engagement

(Johansson & Thollander, 2018; Muszaffarsham, 2022). These initiatives contribute to reducing greenhouse gas emissions and promoting sustainable energy practices.

RESEARCH METHODOLOGY

Exploratory Sequential Mixed Method

This study employed an exploratory sequential mixed-method approach for data collection and analysis. This design is particularly suited for studies that begin with qualitative exploration to identify key issues, followed by quantitative analysis to validate findings. Such an approach provides both flexibility and depth, allowing researchers to uncover root causes of complex problems while ensuring empirical validation. These attributes have been widely recognised in methodological literature (Cooper et al., 2006; Zikmund, 2003). In the context of this research, the method was used to identify and validate factors influencing EnMS performance by incorporating the perspectives of certified energy managers through energy audit reports, validation interviews, and a structured survey.

The Malaysian Government contracts require energy audit reports to be submitted and audited by the third independent competent Energy Service Company (ESCO) for every year in the contract. A total of 31 contracts collected over 4 years were reviewed to identify factors leading to positive BEI performance results. From these reports, the top five BEI performers were identified for expert interviews based on the five best BEI reduction. This selection process allowed for recommendations from the successful energy managers on achieving best performance in energy management.

Expert Interview

A total of five certified energy managers were selected for interview. They were chosen from organizations representing the five best BEI performers (out of total 31 contracts). This constituted a sample size of 16% of the 31 contracts collected as per recommended by Creswell (2002). The additional criteria including possession of a valid Certified Energy Manager (CEM) credential, a minimum of five years of professional experience in building energy management, direct involvement in implementing energy conservation measures, and an active role in organizational decision-making related to energy efficiency.

The interviewees were asked to verify the factors influencing BEI highlighted as part of the literature review and further identify any other contributing factors which influence the performance of energy management systems. Additionally, the interview served as a pre-test for the questionnaire, to avoid misleading information or misinterpretation of the results for phase three of the study.

Structured Questionnaire Survey

Information drawn from the expert interview was used to improve the questionnaire survey. Bernard (1994) identifies that for questionnaires to inform the results of a study, the sample should include experts with experience in their field. According to this a total of 31 energy managers were selected to undertake the questionnaire in a face-to-face environment. Prior to completing the questionnaire, participants were invited to watch an EnMS training video via YouTube as per shown by BSEEP (2017), in order to generate ideas on the performance of EnMS being applied by Public Work Department (PWD). The questionnaires were divided into three sections: Section 1: Demographic Background of Respondents and Scope of Building; Section 2: General Information on Performance of Energy Management Application; and Section 3: Effect of Main Factors on Energy Management Performance. The questionnaires survey is tabulated in 5-point Likert scales which allows the respondent to pick a choice according to their working condition. Data was analysed using the Statistical Package for the Social Sciences (SPSS) software version 24. Ranking Analysis, Correlation Analysis and Spearman, were conducted in order to examine the relationship between factors and the performance of an energy management system.

ANALYSIS AND DISCUSSION

Data Analysis

The statistical analysis presented in this section was derived from the structured questionnaire survey conducted with 31 certified energy managers, each representing one government facilities management contract in Putrajaya. Data was analysed through descriptive statistic (ranking analysis) and inferential statistic (correlation analysis) using the SPSS version 24 by interpreting the primary data base on the mean, mode, median, variance and standard deviation. In order to examine the relationship between factors, the inferential statistic was carried out using correlation analysis. Spearman's rank order correlation was used for the analysis of the questionnaire. Interview data, by contrast, were analysed qualitatively and used primarily to validate and cross-check the survey findings, rather than being subjected to statistical testing.

Result by Each Factor

The Spearman's correlation results for significant value (p) and correlation coefficient (rho) are shown in Table 1. In total 8 factors were identified as having a significant influence on the relationship between the importance of and the level of implementation for an EnMS performance. Therefore, all 8 factors were considered in making recommendations. These results indicate that 3 strong and

positive relationship are regulation compliance, energy cost saving and performance evaluation.

Table 1: Results for Each Factor of Spearman's Correlation

Factor Tested	Significant	Retain/ Reject	Rho	Description
1) Energy Planning Process	0.509	Reject	0.123	-
2) Correct Energy Cost Allocation	0.050	Retain	0.352	*
3) Regulation Compliance	0.000	Retain	0.686	**
4) Scope of Area	0.037	Retain	0.376	*
5) Energy Controller	0.288	Reject	0.197	-
6) Healthy Competition	0.800	Reject	0.047	-
7) Energy Cost Saving	0.001	Retain	0.575	**
8) Performance Evaluation	0.001	Retain	0.570	**
9) Leadership	0.074	Retain	0.325	Selected since have relationship base on rho value
10) Relationship with Stakeholder	0.030	Retain	0.391	*
11) Organisation Support	0.310	Reject	0.188	-
12) Competency Level	0.326	Reject	0.182	-
13) Environmental Awareness	0.170	Reject	0.253	-
14) Building Reputation	0.460	Reject	0.138	-
15) Simplicity in Technology	0.024	Retain	0.405	*

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Results by Key Group

The summary results for key group as shown in Table 2 revealed that only 3 key groups were identified to be significant; planning, monitoring and measurement, and management at the level of 0.05 and 0.01 receptively. Furthermore, the key group of monitoring and measurement has a strong and positive relationship (rho) .658 between the importance and the level of implementation for EnMS performance.

Table 2: Results for Key Group of Spearman's Correlation

Factor Tested	Significant	Retain/ Reject	Correlation Coefficient (rho)	Description
1) Planning	0.004	Retain	0.497	**
2) Operation	0.075	Reject	0.325	-
3) Monitoring and Measurement	0.000	Retain	0.658	**
4) Management	0.038	Retain	0.374	*
5) Training and Development	0.106	Reject	0.296	-
6) Technology	0.366	Reject	0.168	-

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Result by 8 Selected Significant Factor Only

As displayed in Table 3, the significant level was identified to be stronger when tested for Spearman's correlation involved only 8 selected significant factors. The results indicate at a level of 0.01 between the variables. The strong relationship (rho) of .557 had showed that all these 8 variables were most crucial of this research.

Table 3: Result for 8 Selected Significant Factor Only of Spearman's Correlation

Factor Tested	Significant	Retain/ Reject	Correlation Coefficient (rho)	Description
1) Significant Factor only (8 factors)	0.001	Retain	0.557	**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Current Energy Management Performance Matrix

The energy management matrix developed as part of this research is used to identify the current state of energy management in an organisation. The current energy management performance of an organisation can be tabulated using the AEMAS energy management matrix (Quyen and Le, 2012). The AEMAS energy management matrix can be adapted for this research to measure the performance level of implementation for EnMS by using the analysis results for correlation coefficient value in order to demonstrate the current performance.

In the current AEMAS matrix, rows describe levels of sophistication whilst columns show key management. The matrix was modified such that rows represent correlation coefficient value (rho) and columns describe the 8 significant key factors which were chosen for discussion and recommendation purposes. As shown in Figure 4, the pattern for current performance matrix of energy management revealed that unbalanced shape can be seen from the 8 significant factors. Corresponding to that, the current energy management matrix proves that the unbalanced shape tallies with Government commitment to achieve BEI less than 150kWh/m²/year. This unbalanced pattern requires several recommendations, in order to close the gap between the actual implementation and energy management literature.

The findings identify distinct barriers in Malaysian government buildings that elucidate why over half of the Putrajaya contracts failed to achieve the BEI target. Cultural barriers consist of limited awareness among users, perceiving energy-saving practices as temporary rather than ingrained. Organizational barriers stem from fragmented agency responsibilities and inadequate training budgets, impeding the growth of specialized knowledge among energy managers. Barriers that pertain to policy stem from the differences

observed in national objectives (like BEI being less than 150 kWh/m²/year) compared to the enforcement of FM contracts, which suffer from poor monitoring and insufficient penalties for non-adherence. By embedding these impediments within cultural, organizational, and policy structures, the analysis frames statistical outcomes and emphasizes the hurdles of converting governmental pledges into practical application.

These challenges align with existing research. Yuriev and Boiral (2018) indicated that energy-saving initiatives often lack depth due to insufficient integration, reinforcing identified cultural barriers. Wee and Siong (2017) found that in Malaysia, fragmented organizations and inadequate reporting hinder effective EnMS implementation, reflecting the organizational limitations discovered in this study. Likewise, Okereke (2007) and Nishida & Hua (2011) underscored that policy objectives often falter without robust enforcement and stakeholder engagement, paralleling the disparity between Malaysia's BEI goals and their actualization in FM contracts. All in all, the blending of these revelations with historical data suggests that overcoming these issues demands technological growth, cultural adjustments, organizational solidarity, and stricter enforcement of regulations to foster significant development in energy management.

Solution Diagram

Based on the detailed findings from the significant factors identified in the survey analysis, supported by expert interview outcomes and verification against relevant provisions of the PWD Facilities Management contract specifications, several targeted suggestions were proposed to enhance the performance of EnMS. Each suggestion reflects a combination of significant factors, as emphasised by experts, who highlighted that integrated management across these factors is necessary to achieve better performance. This relationship is further illustrated in the Solution Diagram (Figure 4), which simplifies the suggestions and demonstrates how the significant factors influence the research.

The adapted performance matrix from AEMAS serves as a diagnostic tool for analyzing EnMS implementation in governmental FM contracts. The matrix's rows depict correlation coefficients (ρ) that signify the relationship strength between importance and implementation, while the columns represent eight critical factors, including regulatory compliance and stakeholder relations. The matrix's unbalanced configuration reveals implementation asymmetries, with regulatory compliance being robust and technology adoption lacking.

The solution diagram enhances the matrix by consolidating the eight factors into a unified framework, demonstrating their interactions on EnMS performance. For instance, leadership enhances compliance and organizational support, whereas appropriate budgeting facilitates accurate cost allocation and performance evaluation. This integrated viewpoint reinforces the essential

requirement of a varied strategy to enhance EnMS outcomes, supplying policymakers and facility supervisors with a hands-on guide for targeted progress.

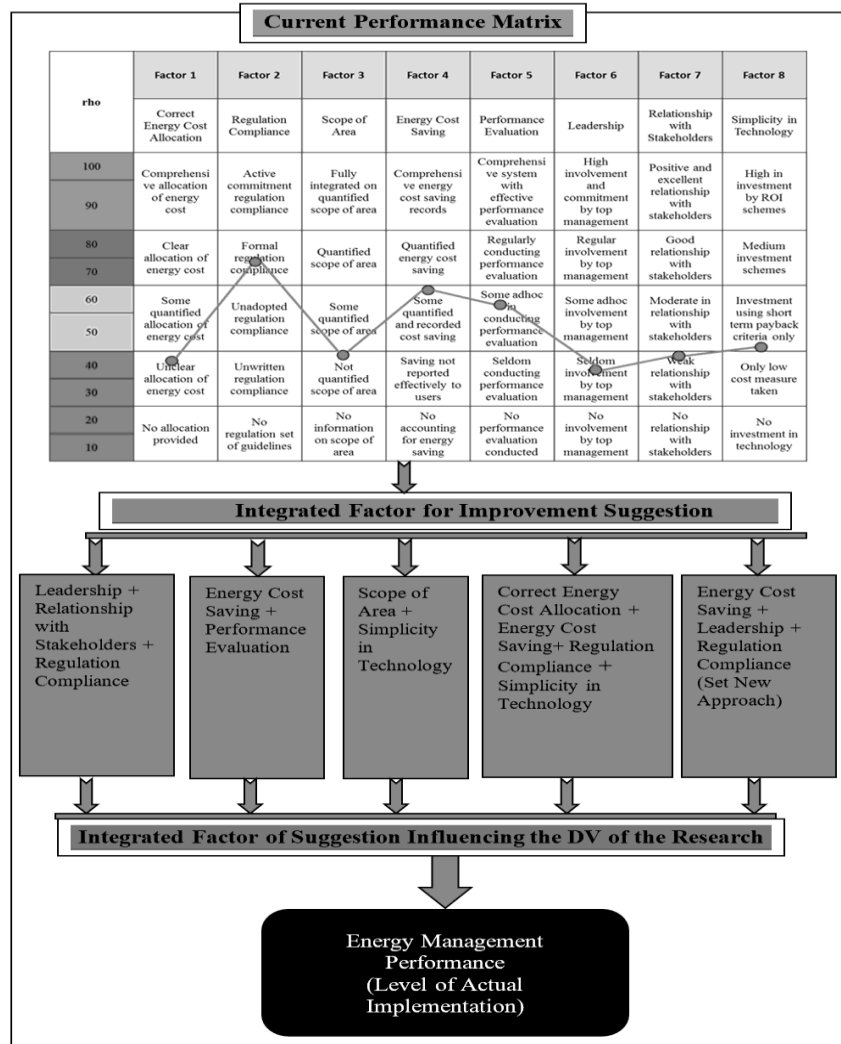


Figure 2: Solution Diagram illustrating the integration of significant factors influencing EnMS performance, based on survey results, expert interviews, and PWD contract verification.

CONCLUSION

This study established a behavioural framework for EnMS performance in government FM contracts, identifying eight key factors influencing implementation. The results reveal that successful leadership, involvement of stakeholders, and awareness of cultural factors are key to advancing regulatory compliance, performance assessments, and financial savings in Malaysian public buildings. A performance matrix and solution diagram serve as both diagnostic instruments and actionable improvement roadmaps. Nonetheless, the study faces limitations. It is confined to government buildings in Putrajaya, and the limited sample of 31 contracts may not adequately reflect practices in other regions or sectors. Additionally, the focus on behavioural aspects may neglect potential advancements from emerging technologies. Later research must broaden its view to take into account diverse construction types and regions, and delve into how intelligent systems like AI and IoT could optimize the effectiveness of EnMS. Comparative analyses between developing and developed nations would also augment the generalizability of the results and offer valuable insights for Malaysia and other nations aiming for sustainable energy management.

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