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Impact of energy management practices on environmental and firm performance: Role of energy audit, energy efficiency and top management commitment

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Abstract: This study investigates how Energy Management Practices (EMPs) influence environmental and firm performance in Saudi Arabia's manufacturing SMEs, with a focus on the roles of energy audits (EAs), energy efficiency (EE), and top management commitment (TMC). Data were collected from 594 valid responses through a survey of SME managers and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The research model examined direct, mediating, and moderating effects among EMPs, EAs, EE, environmental performance (EP), and firm performance (FP). EMPs significantly improved EAs, which in turn enhanced EE. EE positively influenced EP, while EMPs directly contributed to FP by reducing costs and optimizing resource use. However, the mediating role of EE between EMPs and EP, as well as the moderating role of TMC, was not supported. EMPs serve as a critical driver of sustainability and competitiveness, though their environmental impact is contingent on complementary organizational and contextual factors. Policymakers should promote mandatory audits, financial incentives, and capacity-building initiatives, while managers should integrate EMPs strategically to balance cost reduction with environmental stewardship.

Keywords: *Energy efficiency, Energy management practices, Environmental performance, Firm performance and energy audits.*

1. Introduction

The challenges of energy consumption in the drive towards increased industrialization and the need to support the increased energy requirements of international production systems single out EMPs as inextricable aspects of business planning for the next decade [1]. EMPs are important in harmonizing energy consumption patterns with economic and environmental objectives. In many industries, production efficiency increases as they develop, making energy efficiency (EE) crucial in reducing expenditures and increasing competitiveness. EE also supports the viability of the e-economy, making it vital for industries in their endeavors to achieve growth while embracing a sustainable environment.

EMPs are acknowledged as one of the most inexpensive strategies for enhancing energy utilization efficiency. EMPs equate to improved energy efficiency as much as energy use is optimized, waste is minimized, and EMPs keep operational costs low. They enhance industries' market standing and resilience, besides supporting sustainability and the integration of operational objectives with those related to environmental protection [2-9]. The study in Henseler et al. [10] also emphasized the function of EMPs in preventing energy use, which is central to decreasing environmental effects and pushing the sustainable development agenda forward. Since EMPs promote more sustainable and environmentally minded forms of operation, industries and affected societies and environments stand to gain. The manufacturing sector holds a significant position in the development of the global economy and consumes 22% of global energy, thus admitting its high influence on energy consumption [11]. The

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utilization of these goods puts pressure on the environment through the exploitation of non-renewable materials. This situation demands a call for innovation towards the efficient utilization of energy as well as the use of eco-friendly materials [3]. In addition, digital transformation initiatives are increasingly recognized as powerful drivers of energy efficiency in manufacturing, particularly in emerging economies [10, 12-30]. While small and medium-sized enterprises (SMEs) endeavor to implement energy-efficient technologies, given limited resources and high investment costs, their enhancement of overall performance and better sustainable impacts cannot be overemphasized [15]. Through this paper, it is found that EMPs offer SMEs the ability to incorporate green materials, improve organizational performance, and minimize the risks of investing in manufacturing plants [4-10, 12-18].

Nevertheless, despite all the apparent advantages, the theme of EMPs remains problematic in many SMEs because of the identified deficiencies in awareness and implementation. Recent systematic reviews further highlight that SMEs face a unique set of barriers and drivers in adopting energy management practices, underscoring the need for targeted support and policy interventions [9].

In Doty and Turner [7], monetary benefits are available; however, several constraints remain, such as the need for more information and funds to support adoption. Filling this gap by disseminating relevant information to SMEs may assist them in optimally unlocking EMPs' value for improved economic and environmental returns. Other factors, such as societal concerns and regulations that insist on better performance, push SMEs to adopt sustainable measures. In light of the above, EMPs are a feasible, affordable way of improving energy efficiency without expending much, thereby helping SMEs to address stakeholder claims without compromising their financial and ecological performance. The benefits of EMPs are not limited to enterprises but are connected to concrete or abstract economies and ecosystems. EMPs help reduce world energy use and mitigate environmental costs inherent to development, thus enabling significant goals like the Paris Agreement and the United Nations Sustainable Development Goals. For this reason, strategic implementation of EMPs is crucial in building a sustainable industrial ecosystem while supporting international efforts towards climate action.

Several works have considered the impact of EMPs on the performance of companies, especially in developed countries; literature reviews show that the overall results demonstrate positive outcomes [8]. Second, it showed how EMPs greatly enhance energy efficiency and organizational performance. Therefore, while the existing literature presents a significant background on EMPs, research-specific knowledge regarding SMEs in developing nations still needs to be provided and researched. This opens up a research agenda examining the difference EMPs make to firm performance within such environments [15]. A comparative analysis of SMEs in developed and developing nations indicates that SMEs in the latter countries experience diverse opportunities and risks regarding adopting EMPs (Saudi Arabia's manufacturing SMEs are attractive targets for research since they are a significant source of GDP and employment. It is involved in advancing industrialization and employment opportunities in an environment with rising environmental concerns. Saudi Arabia accounts for 6.4% of global CO_2 emissions, which confirms the relevance of examining the local sustainability problems [31]. To fill this research gap, it is necessary to establish the empirical linkage between EMP, EP, and FP in Saudi Arabia.

This theory is the resource-based view (RBV). In explaining EMPs, the argument under this view is that such practices enable an organization to build valuable resources that give it a defensible competitive position [22]. They are also problematic for competitors to imitate and can be a source of sustainable competitive advantage. The RBV emphasizes that EMPs contribute to improvements in competitiveness by using resources that address both efficiency and environmental concerns. Recent evidence from the manufacturing sector further demonstrates that improvements in environmental performance are strongly linked to enhanced firm competitiveness [17]. The study in Pöschl et al. [22] posited that the increasing demand for green products allows firms to achieve a competitive advantage through various environmental management considerations. EMPs link the firm's operational objectives with the concept of environmental responsibility, making it easier for firms to address this need and identify themselves as a sustainable organization. These strategies show EMPs as a better business model with the ability to shape sustainable practices, more than the fashionable argument on differentiation.

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The most frequent application of EMPs' experience is in metering energy consumption to determine where a renewably sourced system can replace some existing installation. According to Backlund et al. [3], energy metering determines areas requiring intervention to improve energy usage. However, such practices enhance operational efficiencies; nevertheless, their effectiveness in improving environmental performance is controversial [1]. Various EMPs are known to affect the overall environmental status; however, additional studies are required to establish these EMPs' roles in environmental impact. Among others, the desired EMP implementation entails top management support. Their commitment guarantees the successful implementation and expansion of EMPs throughout production environments. According to Abdelaziz et al. [32], Andrijevskaja and Volkova [1], Ahmed et al. [33], Alanazi [2], Backlund et al. [3], Ball et al. [4], Centobelli et al. [5] and Chowdhury et al. [6], the social aspect of a program demands commensurate support from the managers to cope with impediments that arise during the implementation process. management promotes sustainability in the organization and champions energy management at the operational level.

Therefore, the emergence of pressures on public leaders to improve EMP requires invoking greater awareness and training on energy-saving technologies. Authors in Richert [23] have observed that commitment from top management has a positive and strong correlation with EMP implementation efficiency, which synergizes with behavioral corporate governance theory that also holds leadership and organizational culture in high esteem.

Recent research has further validated the moderating effect of organizational culture on the relationship between leadership and energy management effectiveness [9, 10, 12-26]. The knowledge of production flow provides leaders with an understanding of the need for and importance of energy efficiency measures to be conducted and where to invest in them [19]. Although leadership is acknowledged to support EMPs, more research is still required to establish relationships between managerial commitment towards EMPs and firm performance. Authors in Fernando et al. [14] note that more research needs to be done on how leadership can affect EMP effectiveness, specifically on how managerial interest can be aligned with the energy-efficient focus of EMPs and the overall performance of the firms.

This study aims to address the following research questions:

1. What are the antecedents of EP and FP?
2. How does EE mediate the relationship between EMPs and EP?
3. How does top management commitment moderate the relationship between A) EMPs and EE? B) EE and EP?

By exploring these questions, the study seeks to contribute to understanding how EMPs can be effectively utilized to enhance both environmental and financial performance in the manufacturing sector, particularly within SMEs in developing economies like Saudi Arabia. The research will provide insights into the mechanisms through which EMPs impact performance and the role of top management in facilitating these practices, thereby offering valuable implications for academia and industry.

2. Literature Review

2.1. Hypotheses Development

EMPs are crucial in enabling industries to improve their EE and encourage improved sustainable practices among industries. It is also important to note that the implementation of EMP is moderated by other factors such as industry scale, geographic dispersion, quality management inclination, and the priority of energy conservation [17]. These are important for tracking new technologies, improvements in energy efficiency, changes within business processes, and addressing the challenges of the implementation processes. Authors in Kim et al. [17] emphasize the significance of analyzing EMPs through two dimensions: knowledge and awareness. Previous studies often treated EMPs as a single variable, so these constituents remained unnoticed [21]. Since energy management is relatively new, understanding and awareness are core factors of EMP, particularly in the manufacturing industry. This unawareness of energy saving and the need for a better understanding of energy management present a

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significant challenge to energy efficiency programs [19, 24]. Energy-related knowledge and awareness, in particular, are usually not considered behavioral factors, even though they are often disregarded during EMPs. The above dimensions can create a synergy when applied collectively or in a coordinated manner, enabling understanding, implementation, and application of EMPs that suit manufacturing sector needs [10, 17-30, 34-41].

Energy audits (EAs), which are included in energy management plans (EMPs), examine past energy use, identify cost-saving possibilities, and assess the effectiveness of energy management strategies. Recent studies from the Middle East confirm that energy audits can lead to significant improvements in industrial energy efficiency [1]. It has been observed that enhanced EA performance can indeed be correlated with clear, improved energy consciousness and awareness within the enterprise, and organizations whose employees are well-versed and accordingly deployed to manage energies are marked with superior EE performance. Employees must be trained on energy conservation and saving procedures, and energy conservation committees should facilitate frequent communication to help improve energy consciousness. Therefore, these strategies assist companies in achieving the goals of periodic reviews and improving energy performance. This is equally true for specialized energy committees as it is for elaborate procedures. The best EA outcomes are achieved when the rules of engagement are well communicated and the organization has a well-developed energy data infrastructure [17]. Sharing functionality-specific improvements with the organization promotes teamwork, hence strengthening EMPs. For first-year students, the increase in average energy awareness and EA results demonstrates prospects in the firepower of awareness to enhance EE results. The research proves that energy practices should be accurate before applying energy management practices and should be implemented consecutively [16]. A comprehensive overview of EMP research is provided by Dickemann [8], who conducted a systematic review of empirical studies on energy cost accounting, efficiency, and management practices across manufacturing firms. Their findings reveal a shift in the literature from narrow cost-control perspectives to broader strategic considerations, including competitive advantage, digital integration, and regulatory compliance. This confirms that EMPs are multidimensional systems interacting with firm culture, management commitment, and institutional frameworks.

The literature review presents compelling evidence on how EMPs affect EE. Pervasive inspection of building roofs optimizes energy efficiency [42]. Similarly, energy balances were more accurate in biogas utilization, and hence, energy efficiencies were enhanced [40]. The California Portland Cement Company case demonstrated that using energy performance indicators could increase confidence through detailed assessments and improved assessment audits, and that a detailed improvement audit encourages enhanced energy performance [5]. These cases demonstrate the effectiveness of EMPs in driving improvement in the approaches towards using sustainable energy. It was proposed that,

H_1: Energy management practices (EMPs) are positively related to successful EAs of manufacturing firms.

H_2: EAs are positively related to the EE of manufacturing firms.

2.2. Energy Management Practices, Energy Audit, and Environmental Performance

EMPs are critical strategies that must be implemented to achieve industrial EE and reduce energy wastage, which causes global warming. According to the IPCC [43], Energy Management Policies (EMPs) must be adopted to reduce energy consumption and achieve sustainable development goals. This has led to the conclusion that an integrated approach to EMPs is superior to ad hoc energy conservation measures, which could be a means of realizing target energy efficiency performance [3]. Key constituent parts of EMP include identifying unique tracks on energy education known as "energy awareness" and "energy knowledge," which are vital to decision-making on energy saving. Authors in Schulze et al. [25] stress that including these dimensions in EMPs creates value for firms and enhances EE. Small and large manufacturing organizations have reinforced their energy efficiency by addressing energy-inefficient machinery, evaluating the technological energy consumption of production processes, and using the developed energy management plan data for continuous improvement [2]. This proactive protective

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strategy underscores the importance of EMPs in monitoring energy usage and implementing efficiency improvements in industries.

The interaction between EMPs and EE has been well-studied in industrial applications. In Kim et al. [17] authors state that EMP directly affects EE improvement and call for a system-driven tempo to attain the objectives. The energy management matrix provides a solid reference model for cross-sectional assessment and implementation of energy management strategies in manufacturing companies [18]. This matrix also highlights key domains of oversight, personnel education, and methodical management as critical for enhancing EE results. For instance, the best example of EMP's relevance in the United States is clear with energy-intensive manufacturing firms. These authors found that these companies adopted good EMPs that consider energy-saving a key efficiency indicator. These include everyday checks on the equipment, energy audits, and making changes that will allow the implementation of energy-saving technologies. Maintaining EMPs in these companies provides clear evidence of the reality of organized energy management practices.

Studies in different settings also support the link between EMPs and EE. The author in Ahmed et al. [33] stresses that firms enjoying EMPs in place experienced tangible gains in EE, thereby stressing the value of systematic energy-saving approaches. Similarly, the study in Henseler et al. [10] looked at the impact of EMPs on Malaysian manufacturing firms implementing ISO 14000. According to their study, the certified firms realized better energy efficiency by constantly following energy management standards and practices. The experience of Malaysian manufacturing companies shows that certification and standardized environmental management practices raise energy efficiency. These companies achieved improved energy use by incorporating energy-efficient technologies and personnel awareness. The agreement of ISO 14000 stresses the importance of international standards for corporate environmental excellence and improvement of the environment. It was therefore postulated, after reviewing the literature, that,

H_5: EMPs are positively related to the EE of manufacturing firms.

Manufacturing organizations are highly concerned with EMP to improve EP and EE, with equal benefits being considered due to cost reclaim and environmental impact. EMPs' support to firms on the best energy use along the product life cycle improves EP. The author in Schulze et al. [25] points out that with an appropriate understanding of EE, it is possible to reduce energy use throughout the diverse types of production phases and consequently achieve higher levels of EP performance. The accomplishments of incorporating EMPs with cleaner production technologies are substantial. Authors in Zeng et al. [44] and Zhang et al. [45] studied how companies adopting EMPs (Energy Management Practices) benefit in terms of their environmental performance. Cleaner production technologies mean balancing energy requirements with sustainable energy by helping firms lessen adverse ecological effects. Moreover, those firms that emphasize EMP implementation have enhanced effects in energy saving as well as environmental effects minimization [2, 4-10, 12-30, 33, 34]. Such efforts also do not only improve the value of EP but also increase the firm's sustainability index.

Empirical studies have also justified the relationship between EE and EP. The study in Li et al. [18] also proved that manufacturing firms measuring higher EE show better EP results. This relationship arises from using efficient energy technology since these technologies reduce energy costs and enhance production processes. Additionally, the degree of adjustment of EP improves with the level of cost savings that can be realized out of such technologies, on average, across firms. They facilitate feedback, control, and adjustment of resource use, waste minimization, and the creation and achievement of higher environmental performance. In addition to technology use, EMPs enhance firms' functional capabilities. Manufacturing firms boost their environmental efficiency through the performance of controlled activities aimed at assessing and evaluating the efficiency of energy usage. This EMP-driven exercise includes energy audits, employee training, and forming energy committees, which comprise some activities that enhance EP. According to Tanaka [34], systematic EMPs establish a positive relationship between saving factors and ecological outcomes, proving the importance of strategic energy management:

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H_4 EE is positively related to the EP of manufacturing firms

H_5 EE mediates the positive relationship between EMPs and the EP of manufacturing firms.

FP and other commonly used FP metrics, such as return-on-assets (ROA), return on investment (ROI), and stock price, reveal that making money is the most important goal of a manufacturing firm [18]. Authors in Pöschl et al. [22] offered new metrics for evaluating financial success, such as growth in revenue or profit, and return on equity or cash flows. Companies in the manufacturing sector should evaluate their FP to guarantee a return on investment (ROI) before implementing an EMP. EMPs positively affected the bottom lines of Japanese manufacturing companies [25]. The businesses improved their FP by raising "energy awareness" and providing training to boost "energy knowledge" across the board. In light of this discussion, the following hypothesis was advanced,

H_6 EMPs are positively related to the FP of manufacturing firms.

Table1.
Prior Literature on Energy Management and Efficiency.

Chowdhury, et al. [6]	Industrial sector in Saudi Arabia	Energy efficiency, Energy management practices	Sustainability, Energy efficiency	EMPs significantly enhance energy efficiency and contribute to sustainability goals in industrial processes.
Shashi, et al. [46]	Saudi Arabian SMEs	Leanness, Innovativeness	Environmental performance, Financial performance	Leanness and innovative practices positively influence environmental and FP, with EMPs as mediators.
Vesal, et al. [37]	Gulf Cooperation Council (GCC) countries	Customer relationship management, Eco-sustainability	Brand value, Sustainability	Eco-sustainability initiatives drive better customer relationships and increased brand equity.
Sola and Mota [28]	Gulf industries	Energy-saving technologies	Energy efficiency, Innovation	Adoption of advanced technologies is key to improving EE and fostering innovation in Gulf industries.
Centobelli, et al. [5]	Saudi Arabian SMEs	Environmental policies, Lean management	Sustainability, Operational competitiveness	Environmental policies and lean management practices enhance sustainability and competitiveness.

2.3. Moderating Role of Top Management Commitment

The following analysis establishes top management's role in adopting and deploying EMPs based on the existing literature on strategic leadership and corporate governance. Some participate in policy-making, teaching organizational culture, linking employee champions, and committing organizational sustainability goals into strategic management plans [4]. It reveals why diversity in the top management team matters in decision-making and innovation [27]. Agency theory is one of the conventional frameworks for analyzing corporate governance, focused on decision-making, control, and the delegation of resources by managers [24]. However, it concentrates on the economic factors that can restrain firms from addressing societal and environmental issues. For this reason, the behavioral theory of corporate governance offers a more profound approach by involving human and social realities in decision-making [34]. This behavioral view helps firms move past the situation where top management fills the framework of 'bounded rationality,' enabling decisions that are more acceptable and sustainable socially [28]. According to behavioral theory, imitating economic and human-behavioral factors is essential to attain sustainable and competitive organizational goals. According to Erdiaw-Kwasie et al. [12], senior management adopting a behavioral lens has enhanced effective and, more importantly, sustainable energy management. Such a dual approach fosters strategic alignment where firms address pollution through EMPs that minimize energy losses and promote efficiency [16].

The success of EMP implementation depends on the skills, knowledge, and attitudes of top management. Without support from manufacturing firms, the following competitive advantages and

sustainability goals may not be achievable [4]. A significant fact about upper management is that it is their duty to encourage employee involvement and stakeholder engagement, in addition to determining goals for energy management. Authors in Fernando and Hor [13] insist on strategic commitment as a key prerequisite for identifying top-line energy goals and engaging all organizational levels in achieving those goals. In addition, firms with good top management support commonly incorporate high technology for increased production and efficiency, decreased expenses, and improved EE. Long-run visions and guidelines focusing on employees drive established firms to incorporate EMPs more effectively while technical know-how in EE, along with long-run perspectives [44]. For these reasons, it enriches the EP and enhances the company's sustainable development activities:

H_7. Top management commitment moderates the positive relationship between EMPs and the EE of manufacturing firms.

H_8. Top management commitment moderates the positive relationship between EE and the EP of manufacturing firms.

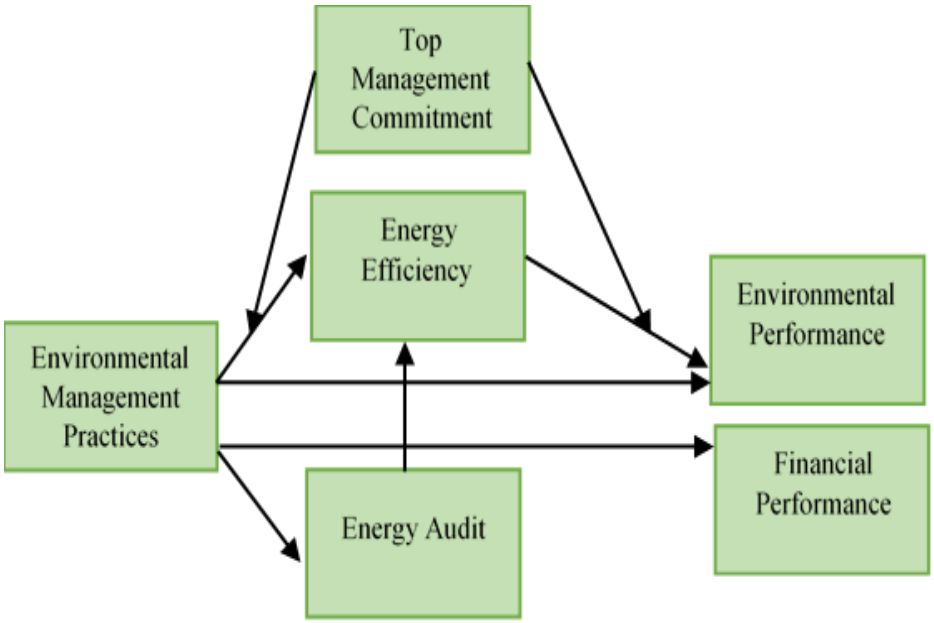

Figure 1.
Research Model.

3. Methodology

Because of their disproportionately high energy consumption and carbon emissions, manufacturing companies are an ideal research subject for energy management studies [36]. Manufacturing companies in Saudi Arabia were the subjects of data collection because of their significant role in environmental degradation [6]. A small- and medium-sized manufacturing firm in Saudi Arabia was selected. It was an obvious choice since 18% of Saudi Arabia's industrial production occurs there. The country produces more chemicals and textiles, especially denim, than any other nation and ranks second in the world for pharmaceuticals [47].

Manufacturing companies, specifically SMEs, were used as the sampling units for this study. The sampling element consisted of senior-level managers, top management, or owners. The sampling units in the District Industry Centre were selected using a convenience sampling approach. To gather objective data, we contacted small and medium manufacturing companies in Saudi Arabia through an intercept survey from October 2023 to February 2024. After obtaining their consent over the phone, 900 respondents were personally approached at the companies' premises. Over six months, 637 responses

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were received, approximately 70% of which had incomplete or partial questionnaires. After eliminating responses with missing values, 594 usable responses remained for analysis.

Each of these constructs was measured on a 7-point Likert scale, where "1 = strongly disagree" and "7 = strongly agree." The study used two constructs, "energy awareness" and "energy knowledge," measuring EMPs, which were adopted in Henseler et al. [10]. The EA scale was measured using five items from the study of Henseler et al. [10]. The 5-item EE scale and 5-item top management commitment scale were also adopted from Henseler et al. [10]. To measure performance, such as the five-item EP scale, we used the work of Gupta and Kumar [16]. The 5-item FP scale was adopted in the study of from [35].

4. Data Analysis

PLS analysis is widely used in social science to check the stability of structural models and their outer models, and to test the path coefficients to determine their significance. The PLS technique has become increasingly popular in research due to its advantages; for instance, it can estimate latent variables even when non-normality is an issue, and it is suitable for research studies conducted on small to medium-sized sample collections [22]. SEM is a broad umbrella that covers two sub-approaches: the structural and the measurement models. Authors in Pons et al. [21] and Tonn and Martin [35] defined the structural model as being employed to estimate the connections between the dependent and independent constructs and measures, while the measurement model is designed to define connections between the construct and measure with their indicators. This is a reflective study. Therefore, we employed the SEM reflective measurement procedure. Confirmatory measurement tests were performed on the outer model using the PLS algorithm method. The bootstrapping procedure with 5000 resamples was employed to test the significance of path coefficients and loadings [20].

4.1. Validity

To ensure the analysis's internal and external validity and reliability, this study first employed the PLS-SEM method in combination with the Smart PLS algorithm to test the quality of the measurement model. Authors in Pöschl et al. [22] noted that, for the first stage, it is appropriate to use competitive reliability over what is widely known as Cronbach's alpha. The study in Dickemann [8] described that loadings greater than 0.70 were used for all the items presented in Table 2. The measurement model's convergent validity was analyzed by employing the criteria of Sample Smart Reliability and Construct Validity, including factor loadings, Cronbach's alpha, composite reliability, and average variance extracted [22-30, 34-41, 44, 45, 48]. Table 2, to validate the internal consistency of the constructs, uses Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). The composite reliability value and Cronbach's alpha estimate are presented, showing that the construct indicators contributed to the greater variability of the latent construct than the recommended threshold of 0.7. Similarly, the average variance extracted, which informs the extent of the variability of indicators attributable to the construct, was above the minimum recommended value of 0.5 [22].

Table 2.
Validity Statistics.

Variables	Factor Loadings Ranges	Cronbach Alpha	CR	AVE
Energy Management Practices (EMPs)	0.856-0.918	0.961	0.967	0.788
Energy audit (EA)	0.825-0.895	0.914	0.935	0.743
Energy Efficiency (EE)	0.881- 0.889	0.867	0.918	0.790
Environmental performance (EP)	0.874-0.927	0.887	0.930	0.816
Firm Performance (FP)	0.821-0.889	0.880	0.917	0.735
Top Management Commitment (TMC)	0.812-0.849	0.892	0.92	0.698

4.2. *Discriminant validity*

Gordić et al. [15] recommended checking discriminant validity using the heterotrait-monotrait ratio (HTMT). The method involves two endogenous variables to estimate their likelihood. The HTMT measure should be 0.90 or lower. If the value exceeds this, discriminant validity is questionable [15]. The pilot results reported in Table 3 confirm the discriminant validity of the incorporated latent variables in the model.

Table 3.
Discriminant validity statistics.

Variables	EMPs	EA	EE	FP	TMC
Energy Management Practices (EMPs)					
Energy audit (EA)	0.537				
Energy Efficiency (EE)	0.574	0.849			
Environmental Performance (EP)	0.500	0.343	0.427		
Firm Performance (FP)	0.430	0.457	0.488	0.841	
Top Management Commitment (TMC)	0.641	0.594	0.675	0.569	0.597

4.3. *Structural Equation Modelling* (SEM)

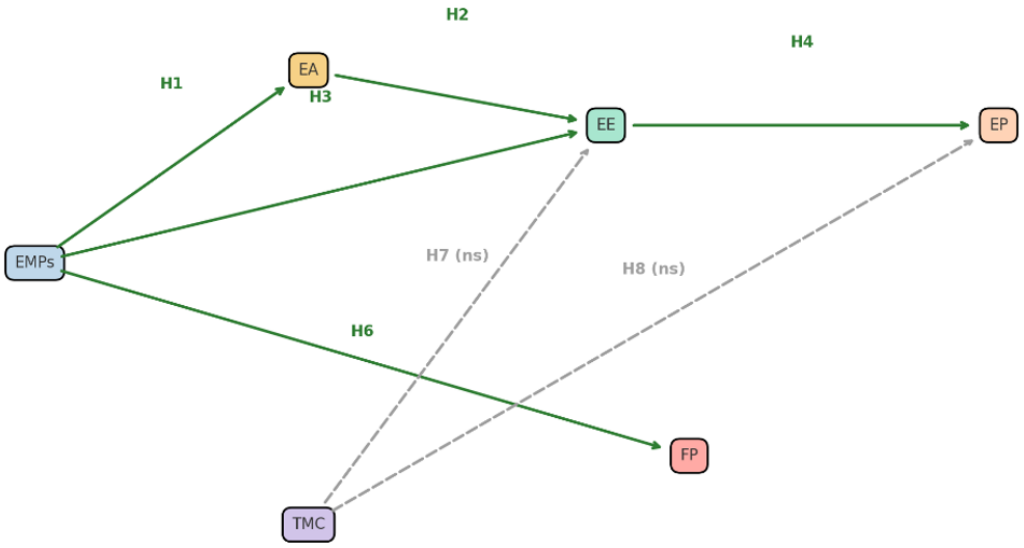

Figure 2.
Final Structural Equation Model (SEM) Results.
Note: Solid green = Supported ($p < 0.05$) | Dashed gray = Not supported (ns)
Mediation (H5: EMPs → EE → EP) = Not supported

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Table 4.
Results.

Hypothesis	Original sample	Standard deviation	T statistics	P value	Decision
H1: EMPs -> EA	0.506	0.035	14.574	0.000	Supported
H2: EA -> EE	0.604	0.032	19.161	0.000	Supported
H3: EMPs-> EE	0.096	0.040	2.421	0.016	Supported
H4: EE -> EP	0.235	0.051	4.560	0.000	Supported
H5: EMPs -> EE -> EP	0.006	0.006	0.907	0.365	Not Supported
H6: EMPs -> FP	0.403	0.040	10.187	0.000	Supported
H7: TMC x EMPs -> EE	-0.013	0.023	0.567	0.571	Not Supported
H8: TMC x EE -> EP	0.013	0.026	0.476	0.634	Not Supported

The results reveal several significant relationships. H1 confirms a strong positive influence of EMPs on EA ($\beta = 0.506$, $p < 0.001$), underscoring the pivotal role of employee practices in enhancing environmental awareness. Similarly, H2 establishes a robust relationship between EA and EE ($\beta = 0.604$, $p < 0.001$), indicating that higher environmental awareness significantly drives employee engagement. Additionally, H3 suggests a direct but weaker positive link between EMPs and EE ($\beta = 0.096$, $p < 0.05$), highlighting the partial contribution of EMPs to employee engagement. H4 demonstrates a significant positive effect of EE on EP ($\beta = 0.235$, $p < 0.001$), emphasizing that engaged employees are instrumental in achieving better environmental outcomes. Furthermore, H6 establishes that EMPs significantly and positively influence FP ($\beta = 0.403$, $p < 0.001$), reinforcing the financial benefits of employee practices.

H5, which hypothesized an indirect effect of EMPs on EP through EE, is not supported ($\beta = 0.006$, $p > 0.05$). This suggests that employee engagement may not act as a significant mediator between EMPs and EP. The moderating role of TMC also shows non-significant results. H7 (TMC moderating the EMPs-EE relationship) and H8 (TMC moderating the EE-EP relationship) both yield insignificant effects ($\beta = -0.013$, $p > 0.05$; $\beta = 0.013$, $p > 0.05$, respectively). These findings imply that top management commitment does not significantly alter these relationships.

5. Discussions

This study provides significant insights into the relationships between energy management practices (EMPs), energy audits (EAs), energy efficiency (EE), environmental performance (EP), and firm performance (FP) within Saudi Arabia's manufacturing SMEs. EMPs were confirmed as pivotal in driving energy awareness and EAs, aligning with the assertions in Henseler et al. [10] that systematic practices enhance energy consciousness. The results corroborate prior research, which found that structured energy audits are instrumental in identifying energy inefficiencies, ultimately fostering enhanced EE and EP [18, 37].

The findings underscore the substantial role of EAs in mediating the relationship between EMPs and EE. Energy audits enable firms to benchmark and monitor their energy use, providing actionable data for efficiency improvements [5]. This mediation effect aligns with previous studies, suggesting that comprehensive audits are fundamental in bridging the gap between theoretical EMP frameworks and practical energy efficiency outcomes [16]. The robust relationship between EMPs and EAs highlights the necessity for SMEs to institutionalize EMPs as a foundation for sustainable energy management strategies. The direct relationship between EE and EP highlights the environmental benefits of adopting efficient energy systems, consistent with [34, 38] who demonstrated the dual economic and environmental advantages of cleaner production technologies. The results further validate the significance of EE as a critical driver of EP, emphasizing that energy-efficient practices reduce resource waste and enhance overall environmental outcomes. This finding is particularly relevant for Saudi Arabia's SMEs, where environmental concerns and regulatory pressures necessitate improved EP measures.

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The study also demonstrates the direct positive impact of EMPs on FP, suggesting that strategic energy management contributes to cost reduction and resource optimization, key determinants of financial success [27]. The results align with the study in Wong [39] framework that highlights the competitive advantage gained through eco-efficient practices. This link between EMPs and FP underscores the economic viability of sustainability-focused strategies for SMEs in resource-constrained environments. However, the mediating role of EE between EMPs and EP was not supported, suggesting that other unexamined factors might influence this relationship. While EE is crucial for enhancing EP, its mediating effect might be diluted by contextual variables such as industry-specific challenges or the technological capacity of firms [10]. Further research is required to explore these nuances and establish a comprehensive understanding of the interplay between EMPs, EE, and EP.

Top management commitment (TMC) was hypothesized to moderate the relationships between EMPs, EE, and EP, yet the findings revealed non-significant effects. This deviation from prior literature [12, 3west] suggests that leadership support alone may not be sufficient to influence these dynamics in the context of Saudi SMEs. Instead, the interplay of organizational culture, employee engagement, and external pressures may be more decisive in shaping energy management outcomes. The study's alignment with the behavioral theory of corporate governance highlights the importance of integrating human and social dynamics into energy management frameworks [36]. While TMC is a critical enabler of EMP adoption, its role as a moderator may require more nuanced approaches, such as targeted training programs and incentives for managerial accountability in energy efficiency initiatives.

6. Conclusion and Policy Implications

This study confirms that structured energy-management practices (EMPs) in Saudi manufacturing SMEs are more than a compliance exercise; they are a strategic lever that simultaneously lowers costs and strengthens environmental stewardship. EMP-driven energy audits sharpen managers' awareness of consumption hot spots, driving statistically significant gains in energy efficiency (EE) and, in turn, better environmental performance (EP). Direct links from EMPs to firm performance (FP) also suggest that "doing well by doing good" is already a reality for resource-constrained plants in Saudi Arabia.

Unexpectedly, the mediating role of EE between EMPs and EP, and the moderating role of top-management commitment (TMC), were weak. That gap points to latent organizational frictions, skill shortages, fragmented data flows, or technology deficits that blunt the full eco-efficiency dividend of EMPs despite supportive leadership rhetoric. The findings therefore reinforce recent large-sample evidence that audits cut unit energy costs only when complemented by robust follow-through mechanisms.

Overall, the results position EMPs as a necessary but not yet sufficient pillar for Saudi SMEs to compete in an era of tightening carbon and efficiency benchmarks.

The findings of this study offer several clear policy implications for strengthening energy management practices (EMPs) in Saudi SMEs. First, making energy audits mandatory for SMEs above a defined energy-consumption threshold would ensure widespread adoption of efficiency benchmarks; this is supported by SASO's ISO 50001 case study showing that such audits deliver substantial savings at minimal cost [49]. To encourage uptake, the government should introduce an "SME EnMS Voucher" program similar to successful models in Europe, providing small grants for metering and consulting services, thereby accelerating ISO 50001 certification and energy-efficiency (EE) gains [29]. At the same time, industrial electricity-tariff rebates should be structured to reward firms for meeting audit-based EE targets. This is an essential step to align with the IEA's projection that Saudi Arabia must achieve a 4% annual energy-intensity reduction to meet its climate goals, quadrupling the current pace [50]. Importantly, policy should not focus solely on technology or audits but also on managerial capacity. Peer-learning networks and sectoral business associations have proven effective in amplifying energy strategies and audit implementation [15] and Saudi Arabia would benefit from funding such platforms.

Several limitations should be noted regarding this study. This study examined the impact of top-level management's commitment as a moderator of EP. Energy management practices could be further studied

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by including moderating variables such as firm size, industry type, and stakeholder pressure. Secondary data on financials and EP could be used to improve the findings further. Future studies can utilize longitudinal data to determine whether energy management practices have a causal effect on firm performance. While this research specifically focuses on manufacturing companies in Saudi Arabia, practitioners should consider using models tailored to different sectors or nations. No information was gathered regarding the status of ISO 14001 or ISO 50001 from the manufacturing firms that comprised the sample for this study. Consequently, the model can be applied in future research with ISO 14001 or ISO 50001 certified companies, or comparisons can be made based on their financial or EP performance. Additionally, other non-monetary indicators of economic performance may provide valuable insights for future research.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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