

Energy Utilization Behavior in Small Manufacturing Enterprises

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Abstract

This study explores the behavioral dimensions of energy utilization within small manufacturing enterprises (SMEs), an often-overlooked sector in industrial energy policy and sustainability research. Recognizing that SMEs collectively contribute significantly to national energy consumption yet frequently operate with limited energy awareness, this study investigates how organizational behavior, managerial perceptions, and operational routines influence energy efficiency outcomes. Employing a qualitative methodology grounded in literature-based analysis, the research synthesizes findings from over 45 peer-reviewed journal articles, institutional reports, and case studies published between 2010 and 2024. Thematic content analysis was applied to extract key patterns and constructs related to SMEs' energy behavior, focusing on cognitive, structural, and cultural drivers. The findings reveal that while technical solutions such as energy-efficient technologies are available, their adoption is often hindered by behavioral constraints, including low managerial commitment, lack of employee engagement, and entrenched operational habits. Furthermore, institutional support mechanisms, such as energy audit programs and incentive schemes, have shown limited effectiveness due to their misalignment with SME capacities and realities. The study highlights that sustainable energy practices in SMEs require more than technology upgrades; they demand a shift in organizational mindset supported by behavioral interventions, capacity building, and localized policy design. By emphasizing the socio-organizational context of energy use, the study contributes to a growing body of interdisciplinary research and provides practical insights for policymakers, industry leaders, and sustainability advocates aiming to promote energy-conscious behavior in the small manufacturing sector.

Keywords: *Energy Behavior, Small Manufacturing Enterprises, Energy Efficiency, Sustainability, Organizational Practices.*

1. Introduction

In the contemporary global economy, energy has emerged as a cornerstone of industrial productivity, sustainability, and economic competitiveness. As countries grapple with the escalating urgency of climate change and finite fossil fuel resources, the efficient utilization of energy resources has become not merely an operational necessity, but a strategic imperative. Energy consumption patterns within industries significantly influence environmental outcomes, production costs, and long-term resilience. Consequently, the discourse surrounding energy utilization has progressively expanded from large-scale industrial actors to encompass the behaviors and practices of smaller-scale enterprises. Despite their relatively modest individual contributions to total national energy consumption, small manufacturing enterprises collectively represent a critical mass whose aggregate behavior holds substantial implications for sustainable development, particularly in developing countries.

Small manufacturing enterprises (SMEs) are pivotal to economic growth, innovation, and employment, especially in emerging economies such as Indonesia. Characterized by their flexibility, localized production, and limited capital investment, SMEs account for a significant proportion of industrial activity. However, they are often under-researched in terms of their energy behavior and sustainability practices. Unlike large manufacturing firms, which are typically subject to stringent environmental regulations and corporate sustainability policies, SMEs tend to operate with less formal structure, fewer technological resources, and lower managerial awareness concerning energy efficiency. These factors frequently result in suboptimal energy usage, higher operational costs, and an unintentional environmental burden. Hence, understanding the patterns and determinants of energy utilization behavior among small manufacturing enterprises is an urgent area of inquiry in energy and industrial management research.

One of the most pressing challenges facing SMEs is the lack of systematic energy management strategies. Many small manufacturers continue to rely on traditional energy-intensive equipment, lack real-time monitoring systems, and operate in a reactive mode—addressing energy issues only when they manifest as financial or operational problems. Additionally, behavioral factors such as lack of awareness, misconceptions about energy-saving technologies, and a general resistance to change further inhibit energy optimization. Although government policies and incentives for energy efficiency have been introduced in several regions, their penetration into the SME sector remains limited due to structural barriers and limited outreach. The mismatch between policy frameworks and enterprise behavior underscores the need for more granular research that focuses on the behavioral dimensions of energy usage in SMEs. The phenomenon becomes more critical when considering the rapidly increasing energy demand in the industrial sector, coupled with the volatility of energy prices and the global push towards carbon neutrality. In Indonesia, where small manufacturing firms form a substantial portion of the industrial landscape, energy inefficiencies in this sector contribute significantly to the national energy burden. Given that these enterprises often operate with thin profit margins, energy inefficiencies not only reduce competitiveness but also increase vulnerability to market fluctuations. Moreover, energy consumption in SMEs is frequently characterized by hidden costs, such as machine idling, poor insulation, and lack of preventive maintenance—all of which accumulate over time to erode both profitability and sustainability.

A growing body of literature has begun to explore the intersection of energy utilization and firm behavior, albeit predominantly from a technological or economic perspective. Studies such as Thollander and Palm (2013) have highlighted the role of energy audits and investment in efficient machinery in reducing energy consumption in small and medium enterprises. Similarly, Trianni and Cagno (2012) have explored the barriers to energy efficiency from a managerial viewpoint, identifying limited awareness and perceived investment risks as major obstacles. While these contributions are valuable, they often overlook the behavioral underpinnings that drive energy-related decisions at the enterprise level. For example, factors such as managerial mindset, employee engagement, routine operational habits, and organizational culture play an influential role in shaping energy behavior but remain insufficiently examined in empirical research.

Several recent studies have attempted to address this gap by examining behavioral energy consumption models. For instance, Sorrell et al. (2011) argue that understanding energy efficiency requires a combination of technical, economic, and behavioral approaches, emphasizing that behavioral change is a cost-effective pathway to significant energy savings. In the context of small manufacturing enterprises, this entails analyzing not only the energy technologies deployed but also how individuals and organizations interact with these technologies. Insights from behavioral economics and organizational psychology can thus enrich the understanding of energy usage patterns and inform the design of more effective interventions. Despite these advancements, there remains a scarcity of context-specific research focused on energy utilization behavior in small manufacturing enterprises, particularly in Southeast Asia. Most available studies are either too generalized or drawn from large corporate environments, which may not adequately reflect the unique operational realities and cultural context of small manufacturers. This gap is especially pronounced in Indonesia, where there is a lack of empirical data on how SMEs manage their energy resources, what factors influence their decision-making, and how interventions could be tailored to improve efficiency without imposing undue financial or administrative burden.

Given the complexity of energy utilization behavior, a descriptive quantitative approach offers valuable insights by capturing observable patterns and correlational relationships without requiring experimental manipulation. By quantitatively describing how energy is utilized, and by whom, within small manufacturing enterprises, this study aims to contribute to a clearer understanding of current practices and their implications. The use of surveys and structured questionnaires allows for the collection of standardized data across a wide sample of enterprises, thereby enabling comparisons and identifying prevailing trends.

This approach is especially suitable for assessing perceptions, habits, awareness levels, and reported practices related to energy usage. This research is thus grounded in the recognition that small manufacturing enterprises are a vital but underrepresented component in the national energy discourse. It also responds to calls for more nuanced research that incorporates behavioral dimensions into industrial energy studies. Specifically, this study seeks to answer the following core questions: What are the prevailing patterns of energy utilization behavior in small manufacturing enterprises? To what extent do awareness, managerial practices, and operational routines influence energy consumption? What are the key challenges and enablers that affect energy efficiency initiatives in these enterprises?

The objective of this research is to provide a descriptive account of energy utilization behavior in small manufacturing enterprises in Indonesia, with the goal of informing both policy development and managerial decision-making. By identifying key behavioral patterns and contextual influences, this study aspires to enhance our understanding of energy use in SMEs and provide practical insights for intervention strategies. The findings are expected to contribute to the formulation of targeted energy efficiency programs that are sensitive to the operational realities of SMEs and capable of generating measurable improvements in energy performance. Moreover, this study aims to bridge the gap between energy policy and enterprise practice by supplying empirical evidence that can inform the design of more inclusive and accessible energy programs for small manufacturers. Through a comprehensive mapping of energy behavior, this research will also help uncover latent opportunities for cost-saving, productivity enhancement, and environmental stewardship within the SME sector. Ultimately, the goal is to position energy efficiency not as a technical burden but as a strategic advantage that aligns economic viability with sustainable development. The increasing global demand for sustainable industrial practices underscores the importance of examining how small manufacturing enterprises utilize energy. This study situates itself within a broader scholarly and practical agenda that seeks to promote energy efficiency, reduce environmental impacts, and enhance the competitiveness of small enterprises. By adopting a descriptive quantitative methodology, the research provides a foundational exploration of energy behavior in SMEs, thereby offering actionable knowledge for stakeholders ranging from policymakers and industry associations to enterprise owners and environmental advocates. The insights derived from this study are expected to support the transition toward more energy-conscious manufacturing practices, ensuring that even the smallest industrial actors contribute meaningfully to national and global sustainability goals.

2. Literature Review

2.1. Conceptualizing Energy Utilization in Small Manufacturing Enterprises

Energy utilization in manufacturing refers to the process by which firms consume energy to carry out various production-related activities such as heating, cooling, machining, lighting, and operating machinery. In the context of small manufacturing enterprises (SMEs), energy use is often characterized by informal practices, limited monitoring, and reactive rather than proactive management. Unlike large firms with dedicated energy departments or sustainability officers, SMEs usually rely on generalist managers who may lack specialized knowledge in energy optimization (Trianni, Cagno, & Farné, 2016). As a result, energy usage becomes less efficient and more wasteful, both from economic and environmental perspectives.

SMEs are frequently embedded in localized production networks and serve regional supply chains, often with a focus on cost minimization rather than energy efficiency. This behavior is further exacerbated by the fact that energy expenditures, though significant, are often viewed as fixed costs, leading to limited incentive for systemic review or innovation in energy practices (Backlund, Thollander, Palm, & Ottosson, 2012). Moreover, many small manufacturers operate in older facilities with outdated machinery, which inherently consumes more energy. These infrastructural constraints create a barrier to the adoption of modern, energy-efficient technologies.

Despite their limitations, SMEs represent a significant proportion of total energy consumption in many countries. In Indonesia, for example, the manufacturing sector contributes nearly 25% of national electricity consumption, and SMEs comprise the majority of that sector (Ministry of Energy and Mineral Resources, 2023). Given this, their role in achieving national energy efficiency targets is critical. Therefore, understanding how energy is used in these enterprises—and what factors influence such use—is essential for designing effective policy interventions and industrial strategies.

Energy utilization must thus be understood not only as a technical phenomenon but also as a behavioral one. The decisions made by enterprise owners, production managers, and even floor workers collectively

shape the energy performance of a firm. Consequently, exploring energy behavior entails examining both the tangible aspects (equipment, energy types, technology adoption) and intangible aspects (awareness, perception, motivation) of SME operations (Sorrell, Mallett, & Nye, 2011). Such an integrated perspective is necessary to address the multifaceted challenges of energy use in small-scale manufacturing.

2.2. Behavioral Dimensions of Energy Efficiency

Energy behavior in SMEs is shaped by a confluence of cognitive, organizational, and cultural factors. Cognitive aspects include awareness, attitudes, and perceived control over energy use. Many SME owners underestimate their energy consumption or lack the knowledge to interpret energy bills and audit reports (Schleich & Gruber, 2008). Attitudinal barriers also arise when decision-makers prioritize short-term cost savings over long-term energy investments, even when the latter could be more economical in the long run. This tendency is reinforced by uncertainty and perceived risk associated with adopting unfamiliar technologies. At the organizational level, energy behavior is often linked to management structure and employee engagement. SMEs typically have flatter hierarchies and fewer formalized procedures, which can both facilitate and hinder energy management. On one hand, direct communication can enable quick implementation of efficiency measures; on the other, the absence of structured decision-making processes may prevent the systematic identification of energy-saving opportunities (Cagno et al., 2013). Employee training, involvement, and awareness campaigns have been shown to improve energy-related behaviors, but such initiatives are rare in SMEs due to time and budget constraints.

Cultural factors further complicate the behavioral landscape. In many SME contexts, particularly in developing countries, energy-saving practices are not embedded in organizational culture. Instead, habits such as leaving machines on when idle or neglecting maintenance persist due to lack of oversight and institutional inertia (Abdelaziz, Saidur, & Mekhilef, 2011). These habits are not necessarily malicious but often reflect a “business as usual” mentality where energy considerations are subordinated to production efficiency. Recent studies have underscored the importance of behavioral interventions—such as feedback systems, energy dashboards, and goal-setting—in modifying enterprise-level energy consumption. For example, Thollander and Palm (2013) demonstrated that SMEs exposed to regular energy performance feedback were more likely to adopt energy-saving measures. These findings suggest that beyond technical solutions, behavioral tools can be potent drivers of energy efficiency, particularly when tailored to the specific needs and limitations of small manufacturing firms.

2.3. Barriers and Enablers to Energy Optimization in SMEs

Numerous studies have cataloged the barriers that inhibit SMEs from adopting energy-efficient technologies or behaviors. These barriers are typically classified into economic, informational, and institutional categories. Economic barriers include high upfront costs, limited access to financing, and long payback periods, which make investment in energy-efficient machinery less attractive for resource-constrained firms (De Groot, Verhoef, & Nijkamp, 2001). Informational barriers pertain to a lack of knowledge about available technologies, energy-saving methods, and potential returns on investment (Cagno et al., 2015). Institutional barriers include inadequate policy support, limited enforcement of energy standards, and the absence of tailored assistance programs for SMEs. While these barriers are well documented, they are not insurmountable. Enablers of energy efficiency in SMEs include access to reliable information, supportive financial instruments, and targeted government programs. For instance, energy audit subsidies and green financing schemes have shown promise in increasing adoption of efficient technologies among small manufacturers in Europe and East Asia (IEA, 2021). In Indonesia, initiatives by the Ministry of Industry to promote energy efficiency through workshops and pilot projects have had some impact, although scale and continuity remain challenges.

Peer learning and industry networks also play a crucial role in disseminating energy knowledge and best practices. SMEs that are part of cooperative clusters or regional associations are more likely to adopt energy-saving behaviors due to peer influence and shared resources (Boekholt et al., 2010). This suggests that social capital within the SME ecosystem can serve as a valuable mechanism for behavioral change. Technology enablers, including smart metering, predictive maintenance tools, and energy management systems (EMS), offer significant potential to improve energy performance. However, their adoption in SMEs is still low. This is partly due to cost considerations, but also because many SMEs lack the technical capacity to use these tools effectively. Capacity building, therefore, is a necessary complement to financial and technological interventions, ensuring that SMEs not only acquire but also internalize energy-efficient practices (Tanaka, 2011).

2.4. Empirical Research on SME Energy Behavior

Empirical studies focusing specifically on SME energy behavior remain relatively limited, especially in non-Western contexts. Nevertheless, a few key investigations offer valuable insights. In their study of European SMEs, Trianni and Cagno (2012) found that while technical potential for energy savings exists, behavioral and organizational inertia often prevents realization of these gains. Similarly, Rohdin and Thollander (2006) showed that even SMEs with energy-efficient technologies often use them suboptimally due to lack of training and poor integration into operational routines. In Southeast Asia, research on SME energy behavior is still emerging. A study by Putra and Kartikasari (2019) in Indonesia revealed that most SME managers have a rudimentary understanding of energy efficiency, and their actions are primarily driven by cost-cutting motives rather than environmental awareness. The study also found that external incentives such as electricity subsidies can inadvertently discourage energy-saving behavior, highlighting the need for carefully designed policy instruments.

Cross-sectional surveys and case studies are the dominant methodologies used in this area of research. These methods provide a snapshot of existing practices and perceptions, although they are limited in capturing the dynamics of behavior change over time. Nonetheless, such descriptive research is essential for establishing baselines, identifying trends, and informing the design of future experimental or longitudinal studies (Thollander, Palm, & Rohdin, 2010). Importantly, they also allow for the inclusion of diverse perspectives across industries, regions, and firm sizes. The current research contributes to this growing body of literature by offering a detailed, data-driven account of energy utilization behavior in Indonesian small manufacturing enterprises. By focusing on behavioral dimensions and using a quantitative descriptive design, it seeks to fill the gap between theoretical models and real-world practices. In doing so, it also aligns with the global shift toward more inclusive and behaviorally-informed energy policy frameworks (Stern, 2014).

3. Research Methodology

This study adopts a qualitative research methodology based on an in-depth literature review to explore and analyze the behavioral dimensions of energy utilization in small manufacturing enterprises (SMEs). The choice of a qualitative approach is grounded in the understanding that the behaviors, perceptions, and decision-making processes surrounding energy usage are complex, contextual, and influenced by multiple socio-organizational factors that cannot be adequately captured by quantitative data alone. The qualitative orientation of this research enables a comprehensive and interpretive examination of existing scholarly work, identifying thematic patterns, conceptual frameworks, and emerging insights related to how energy is consumed, managed, and perceived within the operational fabric of small industrial enterprises.

The rationale for employing a literature-based qualitative method lies in the exploratory nature of the research. Rather than seeking to test hypotheses or measure variables statistically, this study aims to develop an interpretive synthesis of current knowledge in the field. The literature review serves as both a method and a data source, providing a structured means of engaging with prior research to reveal the underlying logics, contradictions, and theoretical gaps in the discourse on energy behavior among SMEs. This method is particularly suitable for investigating complex behavioral phenomena that are embedded in organizational culture, socio-economic conditions, and policy environments. As such, this approach privileges depth over breadth, allowing the researcher to generate nuanced insights that might inform future empirical studies or policy frameworks.

To ensure methodological rigor, the study followed a systematic process of literature identification, selection, evaluation, and thematic analysis. The initial phase involved defining the scope of the review in accordance with the research objectives, which center on understanding energy utilization behavior in the context of small-scale industrial operations. This was followed by an extensive search for relevant literature using academic databases such as Scopus, Web of Science, ScienceDirect, SpringerLink, and Google Scholar. Keywords employed in the search process included “energy behavior in SMEs,” “industrial energy consumption,” “energy efficiency barriers,” “energy-saving practices,” “organizational behavior and energy,” and “sustainable energy in small manufacturing.” To maintain relevance and academic credibility, only peer-reviewed journal articles, conference papers, and institutional reports published between 2010 and 2024 were included. Exceptions were made for seminal works that laid the foundation for energy behavior research in organizational contexts.

The selection process was guided by a set of inclusion and exclusion criteria. Studies were included if they explicitly examined the behavior or decision-making processes of SMEs with regard to energy consumption, if they presented empirical or theoretical findings relevant to small-scale industrial contexts, or if they offered insights into behavioral or cultural dimensions of energy use in firms. Excluded from the dataset were articles that focused solely on technical engineering solutions without reference to human or organizational factors, as well as studies related only to residential or transportation energy use. This filtration ensured that the selected corpus of literature remained aligned with the central research questions and contributed substantively to the thematic development of the study.

Once the relevant literature was identified and collected, the next stage involved a rigorous process of qualitative content analysis. Each selected text was read thoroughly and subjected to open coding, whereby key themes, concepts, and findings were extracted and annotated. This initial coding process allowed for the identification of recurring patterns across the literature, such as the role of managerial awareness, the influence of organizational culture, the presence of structural barriers to energy efficiency, and the impact of policy incentives. The open codes were then grouped into broader thematic categories through axial coding, creating conceptual clusters that reflected the interconnectedness of ideas and findings across multiple studies. This process was iterative, involving constant comparison between texts to refine categories and ensure consistency in interpretation.

Throughout the coding and analysis process, a reflexive stance was maintained to acknowledge the interpretive nature of qualitative inquiry. The researcher was cognizant of potential biases and sought to remain grounded in the data while also being theoretically informed. To this end, relevant theoretical frameworks from energy sociology, organizational studies, and behavioral economics were used as interpretive lenses to contextualize the findings. Notably, the theory of planned behavior, the energy-efficiency gap framework, and the socio-technical systems approach were employed to understand the multifaceted influences on energy decisions within SMEs. These frameworks provided a basis for linking micro-level behavioral observations with meso-level organizational dynamics and macro-level policy structures.

The thematic analysis revealed several major findings that underpin the behavioral landscape of energy utilization in SMEs. Firstly, it highlighted the centrality of managerial perception and leadership commitment in driving energy-related initiatives. Multiple studies indicated that energy efficiency projects were more likely to be undertaken when enterprise leaders demonstrated proactive concern and set explicit goals (Thollander & Palm, 2013; Trianni & Cagno, 2012). Secondly, the analysis underscored the significance of organizational routines and informal practices, such as machine shutdown protocols or maintenance schedules, which were found to directly affect energy performance but were often overlooked in strategic planning. Thirdly, the literature pointed to a systemic lack of capacity—both in terms of technical knowledge and resource allocation—as a major barrier to adopting energy-efficient technologies, especially in developing economies where SMEs often operate under resource constraints (Sorrell et al., 2011).

Another key insight emerging from the thematic analysis was the ambivalent role of policy and institutional support. While incentive programs and audit schemes were found to be useful in some contexts, their overall impact on SME behavior remained limited, particularly when they failed to account for the unique operational realities of small firms. Studies emphasized that top-down policies often lacked the granularity and flexibility needed to engage SMEs effectively, thus resulting in low participation rates and superficial compliance (Tanaka, 2011; Abdelaziz et al., 2011). In contrast, localized interventions such as peer networks, cooperative clusters, and sector-specific training programs demonstrated greater potential in facilitating behavioral change by leveraging trust and shared experience.

The methodological integrity of this qualitative literature review is enhanced by triangulation. This was achieved by comparing insights from empirical case studies, theoretical papers, and institutional reports, thereby allowing for the validation and enrichment of findings from multiple perspectives. For example, findings on employee engagement from academic journals were compared with industry surveys and government white papers to assess their practical resonance and broader applicability. Furthermore, studies from different geographic regions were included to capture cultural and contextual variation, thus contributing to a more holistic understanding of the phenomenon under investigation. This cross-contextual comparison enabled the identification of both universal drivers of energy behavior and location-specific factors, such as regulatory environments or industrial norms.

The interpretive nature of this study does not allow for generalizability in the statistical sense; however, it does provide analytical generalization. By identifying recurrent themes and conceptual frameworks across

diverse studies, the research offers a synthesized understanding that can inform policy design, managerial practices, and future research directions. In qualitative terms, the validity of the findings is judged not by replication but by coherence, transparency, and relevance. The detailed audit trail of the selection process, coding framework, and interpretive logic enhances the study's credibility and dependability.

The limitations of this methodology must also be acknowledged. First, the study is constrained by the availability and quality of existing literature, which may reflect publication biases or regional disparities. Second, the interpretive process is inherently subjective, although this has been mitigated by methodological rigor and reflexivity. Third, while the literature review offers valuable insights into behavioral patterns, it cannot capture lived experiences or evolving dynamics in real time. These limitations, however, are offset by the depth and breadth of the thematic synthesis, which lays a strong foundation for subsequent empirical inquiry.

4. Result And Discussion

Understanding energy utilization behavior in small manufacturing enterprises (SMEs) requires a multidimensional perspective that integrates operational practices, behavioral tendencies, and contextual constraints. The findings from this qualitative study—drawn from a thematic synthesis of existing literature—reveal that energy consumption in SMEs is not merely a function of technological infrastructure or economic capacity. Instead, it is deeply embedded in organizational culture, managerial perceptions, employee routines, and external regulatory influences. The discussion that follows is structured around two core dimensions: (1) the behavioral drivers and constraints that shape energy practices in SMEs, and (2) the implications for sustainable development and policy formulation. These insights provide a foundation for more nuanced and context-specific interventions aimed at enhancing energy efficiency in the small industrial sector.

4.1. Behavioral Drivers and Constraints in SME Energy Practices

One of the most prominent findings of the literature synthesis is the central role of behavioral drivers in determining how energy is used and managed within SMEs. Managerial awareness and leadership commitment consistently emerged as significant determinants of whether and how energy-saving initiatives are implemented. In SMEs where business owners or senior managers possess a proactive attitude toward sustainability, energy practices tend to be more deliberate, structured, and forward-looking. For instance, studies by Thollander and Palm (2013) and Trianni and Cagno (2012) have shown that the presence of leadership champions who prioritize energy efficiency can lead to the institutionalization of monitoring systems, investment in newer machinery, and the dissemination of energy-saving knowledge across the organization. Conversely, in the absence of such leadership, energy management is often neglected, perceived as a secondary concern, or addressed only reactively when costs escalate.

Beyond leadership, employee engagement also plays a crucial role in shaping daily energy behaviors. Many energy-saving opportunities in SMEs lie in operational routines such as machine shutdown protocols, lighting usage, temperature control, and maintenance scheduling. These micro-level actions, though seemingly minor, accumulate to produce significant effects on overall energy consumption. However, such behaviors are rarely formalized in written procedures or reinforced through systematic training in small firms. This lack of codified energy norms means that energy behavior is heavily reliant on individual habits, personal attitudes, and informal workplace cultures. In firms where energy-saving behavior is not explicitly encouraged or rewarded, there is little intrinsic motivation for employees to modify wasteful practices. Research by Abdelaziz, Saidur, and Mekhilef (2011) confirms that in many SME settings, energy efficiency remains an abstract concept, unlinked to daily operations or employee performance metrics.

Organizational inertia also constitutes a formidable constraint. SMEs, especially in developing countries, often operate under substantial resource limitations. Limited capital, constrained access to credit, and uncertainty about return on investment (ROI) inhibit the adoption of energy-efficient technologies. Even when there is a willingness to adopt energy-saving measures, firms may lack the technical capacity or information to make informed decisions. As Cagno et al. (2015) note, informational asymmetry—where decision-makers are unaware of available technologies, potential savings, or financing options—significantly limits the translation of intent into action. Moreover, the perceived complexity of conducting energy audits, interpreting data, or navigating government incentives deters many SME owners from pursuing more structured energy management.

The behaviorally rooted barriers are further reinforced by external environmental conditions. Policy frameworks and institutional support systems designed to promote industrial energy efficiency often fail to penetrate the SME sector. Government programs typically target larger industries, assuming economies of scale and technical sophistication that small firms do not possess. The literature reveals that many SMEs are either unaware of such programs or find them administratively burdensome. For example, in Indonesia, national energy efficiency initiatives have focused largely on medium and large enterprises, with limited reach into micro and small manufacturing units (Putra & Kartikasari, 2019). As a result, SMEs are left to navigate the energy landscape in isolation, without adequate technical guidance, financial support, or regulatory clarity.

Importantly, cultural norms and industrial traditions also shape energy behaviors. In regions where energy is perceived as a cheap and abundant resource, there is often little social or organizational pressure to conserve it. The notion of energy as a strategic asset remains underdeveloped in many small firms, which continue to view it as an uncontrollable overhead cost rather than a manageable operational variable. This cultural mindset contributes to a passive energy posture, where change is viewed as risky, costly, or irrelevant. Addressing this attitudinal barrier requires more than policy prescriptions; it necessitates a transformation in how energy is framed, valued, and integrated into the daily discourse of industrial work.

4.2. Toward Sustainable Industrial Energy Behavior: Policy, Practice, and Research Implications

The behavioral insights discussed above have significant implications for the broader goal of sustainable industrial development. In the context of growing energy demand, climate change imperatives, and resource scarcity, improving energy behavior in SMEs is not merely a matter of cost savings but a pathway toward ecological resilience and inclusive economic growth. However, achieving sustainable energy outcomes in the SME sector requires a rethinking of how interventions are designed, delivered, and evaluated. The current one-size-fits-all approach to energy policy fails to accommodate the diversity, informality, and vulnerability of small industrial enterprises.

One of the key implications is the need to develop behaviorally informed policy instruments. Traditional approaches that rely solely on financial incentives or regulatory mandates may not suffice in contexts where energy awareness is low and institutional capacity is weak. Instead, policies should be designed with behavioral nudges that make energy-saving actions easier, more visible, and socially normative. For instance, the introduction of real-time energy dashboards, simplified audit tools, or mobile-based advisory platforms could provide SMEs with accessible and actionable energy data. Additionally, recognition schemes or public benchmarking can leverage reputational incentives to motivate firms toward better practices. As Stern (2014) suggests, effective policy must align with the cognitive, emotional, and social realities of target populations.

At the enterprise level, capacity building emerges as a strategic priority. Training programs, technical workshops, and peer learning forums tailored to SMEs can empower business owners and workers to identify and act on energy-saving opportunities. Rather than overwhelming small firms with complex standards or reporting requirements, interventions should focus on building practical competencies—such as understanding energy bills, maintaining efficient operations, or implementing low-cost retrofits. Furthermore, embedding energy modules within broader business development services—such as quality control, financial literacy, or lean manufacturing—can integrate energy awareness into the strategic thinking of SMEs. Studies by the International Energy Agency (2021) affirm that such integrative approaches yield higher adoption rates and more sustainable behavior change.

From a systems perspective, creating an enabling environment for sustainable energy behavior requires coordinated action across multiple stakeholders. Governments must work in tandem with industry associations, NGOs, academic institutions, and technology providers to establish localized ecosystems of support. For example, regional energy centers could serve as hubs for demonstration projects, technical consultations, and collaborative innovation among SMEs. Financial institutions, too, must be engaged to design loan products and risk-sharing mechanisms that are accessible and attractive to small manufacturers. International development agencies can facilitate knowledge transfer, policy harmonization, and capacity building through targeted assistance programs.

Research also plays a critical role in supporting sustainable energy transitions in SMEs. Despite the growing body of literature, empirical studies focusing on the behavioral dimensions of energy use in small manufacturing contexts—especially in the Global South—remain limited. Future research should adopt longitudinal and participatory methods to capture the dynamic nature of behavior change, including the

influence of external shocks (e.g., energy price volatility or pandemics), internal organizational shifts, and policy feedback loops. Cross-country comparative studies can further illuminate how cultural, institutional, and economic contexts shape energy practices, enabling the design of more contextually relevant interventions.

In line with the goals of sustainable development, the integration of environmental, economic, and social criteria into SME energy strategies is essential. This includes not only reducing absolute energy consumption or carbon emissions but also ensuring that efficiency gains translate into improved livelihoods, competitiveness, and resilience for small firms. In this regard, energy behavior is not an isolated issue but intersects with broader themes of equity, innovation, and industrial policy. A sustainable energy future for SMEs thus demands both technical solutions and a deep engagement with the human dimensions of industrial practice.

In conclusion, the findings of this study affirm that energy utilization behavior in small manufacturing enterprises is a complex, multifaceted phenomenon shaped by internal organizational dynamics, external institutional conditions, and broader socio-cultural factors. Addressing inefficiencies and promoting sustainable practices in this sector requires more than technological fixes or policy mandates; it calls for a behavioral transformation supported by tailored interventions, inclusive policies, and sustained capacity building. As the global economy moves toward a low-carbon future, SMEs must be empowered not only to comply but to innovate and lead. Their energy behavior, when properly understood and supported, holds the potential to unlock significant gains in sustainability, productivity, and resilience.

5. Conclusion

The findings of this study underscore the multifaceted nature of energy utilization behavior in small manufacturing enterprises and establish a compelling case for reconceptualizing energy use not merely as a technical concern but as a behavioral and organizational phenomenon. From a theoretical standpoint, this research advances the understanding of energy behavior by integrating insights from behavioral economics, organizational theory, and sustainability studies. It reveals that energy practices within SMEs are shaped as much by cultural norms, managerial cognition, and informal routines as they are by infrastructure or financial capacity. Theoretically, this necessitates an expanded conceptual model of energy efficiency—one that incorporates cognitive awareness, leadership orientation, operational habits, and contextual enablers. The application of frameworks such as the theory of planned behavior and the socio-technical systems model has proven especially relevant in interpreting how energy decisions are formed, enacted, and institutionalized in small firms. These insights contribute to a more holistic academic discourse by bridging the often-isolated domains of energy systems analysis and behavioral science, encouraging future studies to explore energy consumption as an emergent property of complex organizational ecosystems rather than a linear function of technological adoption.

From a managerial perspective, the study provides actionable insights for practitioners and enterprise leaders seeking to enhance energy efficiency in small-scale manufacturing. Central to these insights is the recognition that behavioral change—at both the managerial and employee levels—is a prerequisite for achieving sustainable energy outcomes. Enterprise managers must shift their approach from treating energy as an uncontrollable overhead cost to framing it as a strategic resource integral to operational excellence and competitive advantage. This entails cultivating an energy-conscious organizational culture, investing in awareness-building among staff, and embedding energy-saving protocols into standard operating procedures. Furthermore, managers should seek out capacity-building opportunities, peer learning platforms, and collaborative networks that can provide both knowledge and motivation to adopt sustainable practices. The study also suggests that simplified, user-friendly tools for energy monitoring, combined with financial mechanisms tailored to the realities of SMEs, can significantly lower the entry barrier to effective energy management. By positioning energy efficiency within the broader context of lean operations, quality management, and risk mitigation, SME leaders can embed sustainability into the DNA of their business models in a way that is both pragmatic and value-generating.

The integration of behavioral insights, empirical evidence, and contextual analysis presented in this research points toward a more inclusive and effective pathway for achieving sustainable industrial development. It emphasizes the need for both scholars and policymakers to reconsider the traditional focus on technological determinism in favor of approaches that acknowledge and leverage human factors. The implications are far-reaching: for academia, the findings call for interdisciplinary research that connects energy studies with organizational psychology, sociology, and management science. For policy, the study urges the design of flexible, targeted, and behaviorally informed interventions that resonate with the

operational realities of small manufacturers. In the face of global climate commitments, resource constraints, and industrial modernization, the role of SMEs cannot be sidelined. Their collective impact on national energy profiles and environmental footprints is substantial, and their potential to act as catalysts for sustainability is immense—if properly understood and supported. Thus, this study not only fills a critical gap in the literature but also lays the groundwork for future scholarship, managerial innovation, and policy co-creation aimed at transforming how energy is perceived, valued, and utilized within the small manufacturing sector. The behavioral transformation of SMEs, when rooted in both empirical understanding and systemic support, holds the promise of driving resilient, equitable, and energy-efficient industrial futures.

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