International Journal of Basic and Applied Sciences, 14 (7) (2025) 622-629

SPC

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/wqpynx91
Research paper

Breaking The Policy-Performance Paradox: A TwoTier Framework for Accelerating Green Technology Adoption

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Received: October 22, 2025, Accepted: November 19, 2025, Published: November 30, 2025

Abstract

This study addresses the significant disparity between Indonesia's energy conservation policy objectives and their actual implementation, developing a novel framework to promote the adoption of green technology among industrial and small- and medium-sized enterprises (SMEs). Indonesia has pledged to reduce its carbon emissions by 29–41% by 2030 as part of the Paris Agreement; however, it is only utilizing 30% of its energy-saving potential. This means there is an urgent need for comprehensive business models that connect policy and implementation while also addressing complex socio-technical issues. The research utilizes an innovative two-tier methodological framework that combines qualitative with quantitative validation. First, systemic problem structuring employs stakeholder interviews and focus group discussions to delineate policy fragmentation and socio-technical conflicts, facilitated by expert consultations with five industry professionals from Jakarta, Bekasi, and Tangerang. Second, structured questionnaires administered to 303 industrial companies in Jakarta, Tangerang, and Bekasi are checked for validity and reliability before hierarchical regression analysis is used to test organizational readiness factors. Third, participatory solution design utilizes AI-driven sentiment analysis, making it easier to objectively understand qualitative data. It also develops retrofitting finance models that work with the businesses of stakeholders. The two-tier regression and mediation model shows that policy support alone accounts for 42.6% of the variance in performance. When technology awareness, implementation capability, and employee capacity are added, this number rises to 53.6%. The framework validates that effective energy efficiency adoption necessitates the synergistic integration of top-down policy frameworks with bottom-up organizational readiness factors, contesting solely economic models while offering pragmatic insights for Indonesia's 2060 Net Zero objectives and sustainable development goals.

Keywords: *Energy Efficiency Adoption; Soft Systems Methodology; Green Technology; Policy Implementation; Organizational Readiness, Indonesia Sustainability.*

1. Introduction

Businesses are being compelled to adopt sustainable models due to climate change and the global energy crisis, particularly in the context of energy conservation services. Indonesia signed the Paris Agreement in 2015 and committed to reducing its carbon emissions by 29% on its own and by 41% in collaboration with other countries by 2030 [1]–[3]. The energy sector, which is responsible for 34% of national emissions, is a primary focus of conservation programs. [4], [5]. International Energy Agency (2022) States that only 30% of Indonesia's energy conservation potential has been utilized, underscoring the need to develop new business models to bridge the gap between policy goals and actual implementation.

The research problem centres on a significant policy-performance paradox, where lofty national objectives fail to yield efficient organizational execution. Energy conservation goes beyond just caring about the environment. The National General Energy Plan (RUEN) Lembaran Negara Republik Indonesia No. 43 (2017) Aims for a 1% annual decrease in energy intensity by 2025 by making industries, transportation, and homes more efficient. Implementation encounters enduring obstacles such as policy fragmentation, inadequate adoption of green technology, and misalignment among stakeholders. [8]. Presidential Regulation No. 22/2017 requires businesses to incorporate sustainability principles into their business models to support SDG 7 (Clean Energy) and SDG 13 (Climate Action). However, organizations are still not doing enough to achieve this goal. Most Indonesian energy service companies conduct only basic audits and do not utilize IoT or real-time monitoring. [9], [10]. Also, only 12% of Jakarta businesses use tax breaks for conservation projects. [8].

This research focuses on the implementation gap in industrial firms and SMEs in Jakarta, Tangerang, and Bekasi, analyzing how policy support mechanisms can be enhanced through organizational readiness factors to expedite the adoption of green technology and attain quantifiable performance enhancements [11]. Conventional quantitative methodologies, such as Cost-Benefit Analysis (CoBBA), fail to adequately address the complex and unstructured aspects of sustainable energy adoption, as they overlook intangible socio-cultural elements and divergent stakeholder interests [12]. Contemporary literature illustrates a division between techno-economic models that focus on financial rationality and socio-technical frameworks that highlight dynamic stakeholder interactions. Although current research demonstrates that policy frameworks affect organizational behaviour, the precise mediating pathways by which the Tier 2 Model, policies impact micro-level performance outcomes are insufficiently examined.

The scientific gap exists due to the lack of comprehensive methodological frameworks that concurrently address policy complexity via systems thinking and offer quantitative validation of implementation mechanisms. Prior studies either focus on policy analysis devoid of organizational context or investigate organizational factors without considering institutional frameworks. This methodological constraint hinders a thorough understanding of the simultaneous functioning of policy effectiveness across various organizational channels, thereby obstructing the formulation of evidence-based intervention strategies. This research builds on gaps found between policy making and organizational implementation by putting forward two main ideas:

Proposition 1: Retrofitting finance models may be synchronized with stakeholders' enterprises, since they will gain from executing an energy efficiency program, leading to reductions in energy expenditures.

Proposition 2: There are negligible hazards and minor obstacles for enterprises that adopt energy efficiency initiatives.

These propositions challenge traditional beliefs about implementation obstacles, suggesting that effective adoption of energy efficiency necessitates a synergistic alignment between institutional support systems and organizational preparedness elements. The research posits that policy support alone lacks sufficient explanatory power for performance outcomes, necessitating mediation through technology awareness, implementation capability, and employee capacity to attain optimal results.

This research employs a sequential explanatory mixed-methods framework, combining qualitative and quantitative analysis, to facilitate a thorough comprehension and intervention in the intricate matter of energy conservation within Indonesian industrial enterprises and SMEs. Initially, systemic problem structuring is performed through in-depth stakeholder interviews (IDIs) and focus group discussions (FGDs) to represent policy fragmentation and socio-technical conflicts visually. [12], [13]. This qualitative phase employs purposive sampling of industry experts to elucidate organisational dynamics and develop theoretically grounded measurement constructs.

Second, structured questionnaires are administered to 303 industrial firms and small and medium-sized enterprises (SMEs) in Jakarta, Tangerang, and Bekasi for quantitative validation. The quantitative phase utilizes an innovative Two-Tier Regression and Mediation Model that methodically categorizes influence mechanisms into Tier 1 model (policy support) and Tier 2 model (organizational mediators) levels. This hierarchical method enables the accurate measurement of direct policy impacts and pinpointing the exact ways in which institutional support leads to better performance in organizations. The methodological innovation consists of integrating qualitative problem structuring with advanced statistical modelling to facilitate both exploratory comprehension and confirmatory validation within a unified research framework. This method surpasses the limitations of single-method studies by providing context through stakeholder insights and ensuring that the results can be generalized to the entire Indonesian industrial sector.

The study aims to find empirical evidence of a complex policy-performance mediation model, in which institutional support is adequate through organizational readiness factors, rather than through direct causation. Expected quantitative outcomes include evidence that policy support alone accounts for considerable yet incomplete performance variance, with notable enhancement upon the inclusion of technology awareness, implementation capability, and employee capacity as mediating variables. Qualitatively, the research aims to identify specific organizational facilitators and impediments that influence policy effectiveness, encompassing cultural elements, stakeholder alignment strategies, and the dynamics of the implementation process. The combined findings demonstrate that the successful adoption of energy efficiency requires coordinated efforts across multiple levels of an organization simultaneously. This contradicts the notion of implementing policies one at a time and instead advocates for integrating policies and organizations in a way that works together effectively. The researchers aim to develop pragmatic intervention strategies, including blended finance mechanisms that link micro-credit repayment to energy savings verified by smart meters, thereby overcoming funding obstacles while maintaining accountability for performance. The framework should include diagnostic tools that help identify problems with implementation and create targeted interventions to improve both policy compliance and organizational performance. This will help Indonesia achieve its 2060 Net Zero goals and Sustainable Development Goals through evidence-based policy refinement and the development of organizational capacity.

2. Literature Review

Sustainable energy efficiency (SEE) adoption has become a crucial strategy in the global effort to combat climate change and achieve long-term sustainability objectives. It involves the integration of technological advancements, behavioural modifications, and policy frameworks designed to reduce energy consumption while maintaining economic productivity and societal welfare. [14], [15]. Although it is well-known how important it is, the rate of adoption varies significantly from region to region and sector to sector due to contextual issues. In this context, the current systematic review consolidates empirical studies from 2000 to 2023 to pinpoint prevailing drivers, enduring obstacles, and nascent discussions in SEE adoption. The review also highlights inconsistencies in the literature and identifies areas that require further research.

The scholarly discussion regarding the adoption of SEE is predominantly situated within three primary theoretical frameworks. First, techno-economic models emphasize financial rationality by assessing costs, payback periods, and return on investment. [16], [17]. Second, behavioural theories, like the Theory of Planned Behaviour, stress the importance of psychological and social factors, such as people's attitudes, how much control they think they have over their behaviour, and the social norms that are in place. [18], [19]. Third, socio-technical systems frameworks examine the dynamic interactions among institutional arrangements, technological infrastructures, and user practices. [20], [21]. A significant contention arises between supporters of technological determinism and proponents of social constructivism. For instance, researchers such as Huang (2019) and Wan et al. (2022) Argue that technological advancements—like reconfigurable intelligent surfaces and resistive RAM—naturally lead to efficiency improvements. Conversely, some emphasize that these innovations frequently fail in the absence of conducive institutional or societal frameworks. [24], [25]. This difference underscores the importance of employing integrated, multidisciplinary approaches.

Technological advances are a primary reason why people are adopting SEE. For example, grid-scale energy storage facilitates the use of renewable energy sources that are only available intermittently. [26]. Innovative building solutions, such as metadata schemas like Brick, facilitate the easier management of energy. [27]. The transportation industry has also benefited. Electric vehicles (EVs) are 18–30% more energy-efficient than cars with internal combustion engines, and autonomous driving technologies are expected to enhance their efficiency further. [28], [29]. Also, economic incentives are always a driving force. Buildings that use less energy often cost 3–5% more. [30], and industrial energy management systems can cut costs by 10–25% [31]. Policy tools, such as carbon pricing and fee-bate programs, have proven effective, particularly when combined with campaigns to raise public awareness.

Policy and regulatory frameworks are also critical. For instance, the European Union's rules on building efficiency led to a 40% increase in retrofit rates among member states. [32]. People are also more likely to purchase energy-efficient products due to appliance labelling campaigns. [33]. However, for these kinds of policies to be effective, they must be enforced, and the rules must align with the local economy and society. Even with these improvements, the widespread adoption of SEE remains limited by significant financial and informational barriers. High upfront investment costs hurt small and medium-sized businesses (SMEs) and households the most. In fact, 65% of industrial projects are put on hold because they cannot obtain the necessary funding. [34]. Split incentives between landlords and tenants frequently impede building retrofits. [35]Consumers often underestimate long-term energy savings due to information asymmetries. [36].

Behavioural and social challenges are just as important. In OECD countries, residential lighting consumption has increased by 20–30% due to the "rebound effect," where efficiency gains are offset by increased usage. [37]. Ideological opposition also contributes; for instance, specific conservative households oppose SEE measures viewed as environmentally motivated. [36]. Social networks can also unintentionally cause moral licensing, which is when people use past eco-friendly actions to justify future high-energy behaviours. [38].

In addition, systemic and infrastructural inertia create structural limitations. Energy-intensive industries frequently utilize continuous processes that are challenging to reconfigure [39], and current electricity markets may discourage demand-side reductions [40]. In many developing countries, informal energy markets make it even more challenging to implement efficiency standards. In the industrial sector, adoption is heavily influenced by the technical feasibility and potential financial benefits it offers. For instance, the textile industry has improved its energy efficiency by up to 30% by modifying its operational practices. [41]. However, heavy industries like steel have built-in thermodynamic limits, so they need to redesign their processes to make them better completely. There have also been successful energy audit programs, especially when accompanied by technical assistance.

In the construction industry, there are different ways for residential and commercial properties to adopt new technologies. Integrated design approaches are making net-zero commercial buildings more common. [42]; however, residential buildings are still slow to adopt them due to ownership fragmentation and lifestyle inertia. Smart home technologies also face more resistance—up to 60% more—among older adults unless they are made easier to use. Electrification is moving quickly in the light-duty vehicle segment of transportation. [16]. However, energy density requirements still make it hard to decarbonize the maritime and aviation sectors. Liquid hydrogen, a promising alternative fuel, is impeded by infrastructure and safety issues. The overall energy impact of autonomous vehicles remains a topic of debate, as system-level trade-offs are highly complex. [43].

Several ongoing debates continue to shape scholarly discourse. First, there is still debate about the magnitude of the rebound effect. Herring (2007) Posits that efficiency gains are predominantly undermined by behavioural adaptation; however, research in manufacturing settings demonstrates that rebounds can be maintained below 15% when coupled with resource limitations [45]. Second, there is debate about the overall Effect of digitalization. [46] On sustainability. Although AI and IoT technologies facilitate operational optimization, their manufacturing and disposal generate environmental issues throughout their lifecycle. Third, there are significant differences between developed and developing economies in terms of context. High-income countries focus on technologies that require substantial capital. [22], whereas low-income areas prioritize affordable and distributed energy systems [14]

Although the literature is growing, significant gaps remain in research. Concerns regarding distributional equity, especially the impact of SEE policies on energy poverty, are insufficiently examined. [47]. Additionally, merely 12% of studies explicitly associate energy efficiency with circular economy principles, including material lifecycle management. [48]. There is also a lack of focus on the connection between behaviour and technology, especially when it comes to how users perceive using innovative systems. [49]. Finally, additional research is necessary on geospatial dynamics, particularly regarding the impact of climate zones and urban forms on the scalability of energy-efficient solutions. [42].

3. Methods

This research utilizes a sequential explanatory mixed-methods design to examine the mechanisms of energy efficiency adoption within Indonesian industrial enterprises and SMEs. The study employs a two-phase methodology, wherein qualitative exploration informs quantitative validation, thereby facilitating a comprehensive understanding of the intricate organizational dynamics involved in implementing green technology.

Step 1: Structuring Problems Qualitatively and Coming Up with Hypotheses

The first qualitative phase was employed to map the complex terrain of problems and opportunities associated with adopting energy efficiency. Focus Group Discussions (FGDs) and in-depth stakeholder interviews (IDIs) were conducted with deliberately chosen experts who have extensive knowledge of implementing energy efficiency at all levels of an organization. The interview protocol was designed to elicit diverse stakeholder viewpoints from company owners and operational divisions responsible for business administration and energy-related decision-making.

Construct validity was achieved by triangulating data sources, integrating questionnaire responses with insights from focus group discussions to reflect varied organizational viewpoints. We ensured the study's internal validity by examining how real companies in the energy efficiency sector operate, focusing on real-world implementation experiences rather than hypothetical scenarios. To ensure reliability and temporal consistency, stakeholder interviews were conducted systematically from July 2025 to September 2025, facilitating cross-validation of findings across various organizational contexts. The interview results directly influenced the formulation of research propositions and directed the creation of quantitative measurement tools.

Table 1: Case Study – Expert Panel

No	Institution	Occupational
1	PT. Aditya Sriwijaya (ASW), Bekasi	Operations Director
2	PT. Mantra Wira Sriwijaya (MWS), Bekasi	President Director
3	PT. Aditya Sriwijaya, (ASW), North Jakarta	Online Selling Manager
4	WSP in the UK & Ireland, London	Senior Building Physics Consultant – Chartered Engineer
5	IS2P - Indonesian Society of Sustainability Professionals, Jakarta	Senior Researcher

Step 2: Two-Tier Regression Analysis for Quantitative Validation

The second phase built on qualitative insights by using structured quantitative analysis to test and confirm the ideas through systematic data collection and statistical modelling. This study analyzed survey responses from 303 corporate participants representing industrial enterprises and SMEs in Jakarta, Bekasi, and Tangerang. The survey instrument was designed according to themes that emerged from the qualitative phase, with questions organized into predefined thematic constructs (A–G) representing various aspects of the adoption process identified through stakeholder interviews.

Data preparation adhered to strict protocols to guarantee analytical validity. Data cleaning involved using the median to fill in missing values, ensuring that the distributional characteristics remained unchanged after removing non-numeric data and identifiable information. To ensure that all item responses were consistent and easy to analyze, they were systematically coded alphabetically according to their construct block. We chose median imputation to fill in missing values while keeping the central tendency and structure of Likert-type distributions.

The comprehensive measurement framework includes a Two-Tier Regression analysis that utilizes a 42-item Likert survey to create distinct outcome variables for evaluating green technology projects across various areas of an organization. The structured dataset comprises nine important latent components, which were confirmed through confirmatory factor analysis (CFA). The measurement model's validity and reliability were thoroughly verified, with composite reliability (CR) scores for each construct ranging from 0.80 to 0.91, demonstrating excellent internal consistency. All factor loadings exceeded the recommended level of 0.70, and the Average Variance Extracted (AVE) values for all latent variables were above 0.50, indicating convergent validity.

Table 2: Latent Variables

Construct Code	Construct Name	Indicators (Observed Variables)
TA	Technology Awareness	Likert scale 1 - 5
EC	Employee Capacity	Likert scale 1 - 5
TI	Technology Implementation	Likert scale 1 - 5
FS	Financial Support	Likert scale 1 - 5
IM	Incentives & Motivation	Likert scale 1 - 5
PS	Policy Support	Likert scale 1 - 5
MR	Market Readiness	Likert scale 1 - 5
SE	Stakeholder Engagement	Likert scale 1 - 5
PI	Performance Impact (adoption)	Likert scale 1 - 5

Combining qualitative insights with quantitative validation yields a complex two-tier regression modelling framework that systematically divides influence mechanisms across different levels of an organization. This method was designed to identify the complex ways in which policy changes lead to changes in performance, which is what the qualitative phase discovered when examining the different levels of organizational change.

The Two-Tier Regression and Mediation model divides the influence chain into two levels. Tier 1 looks at contextual variables through Policy Support (PS); Tier 2 looks at mediating organizational factors like Technology Awareness (TA), Technology Implementation (TI), and Employee Capacity (EC). The amalgamation of qualitative problem structuring and quantitative validation results in two unique regression models:

Model 1 (Tier 1 model): Predicting green technology adoption using variable Policy support.

$$Y\_Performance\ Improvement = \beta 0 + \beta 1\ (Policy\_Support) + \varepsilon$$

Model 2 (Tier 2 model): Examines how market dynamics influence the relationships between Performance Improvement, Technology Awareness (TA), Technology Implementation (TI), and Employee Capacity (EC).

$$Y\_Performance\ Improvement = \beta 0 + \beta 1\ (Policy\_Support) + \beta 2\ (Technology\_Implementation) + \beta 3\ (Technology\_Awareness) + \beta 4\ (Employee\ Capacity) + \varepsilon$$

This sequential mixed-methods approach ensures that quantitative results are grounded in actual organizational experiences, while also providing statistical generalizability across the Indonesian industrial sector. The methodological integration facilitates a thorough understanding of energy efficiency adoption mechanisms from both exploratory and confirmatory perspectives, addressing the complexity inherent in organizational sustainability transitions.

4. Result & Discussion

AI-Powered Sentiment Analysis Protocol

We used Google NotebookLM to conduct sentiment analysis on expert interviews from July to September 2025, in order to ease objectivity when examining qualitative interview data. The process involved three steps: Firstly, verbatim interview transcripts were uploaded unchanged to NotebookLM to retain the nature of the language patterns. Secondly, we used standardised prompts to determine the sentiment about something: "Analyse the sentiment expressed in responses regarding [specific topic]." Thirdly, the classification of sentiment was validated through triangulation, where AI-generated sentiment scores were juxtaposed with independent manual coding by two researchers (Cohen's kappa = 0.82, indicating considerable agreement).

The AI analysis was constructive in identifying sentiment patterns across numerous interviews that might otherwise have been overlooked due to researcher bias. For instance, the words "company" and "retrofitting finance" were consistently associated with positive sentiment, appearing in 78% of all positive statements. In contrast, phrases referring to "time constraints" and "resource limitations" were associated with concerns over implementation issues. However, we acknowledge our limitations: the sentiment classification of NotebookLM operates at the level of the statement, making it unlikely to capture sarcasm, cultural references, and other subtleties of meaning. This tool also cannot capture non-verbal cues present in face-to-face interviews. In light of these limitations, we employed sentiment analysis as a supporting tool, in conjunction with traditional thematic analysis, rather than as an independent interpretive method. All significant findings obtained through sentiment analysis were cross-checked against the original interview transcripts and integrated into the broader stakeholder discussion framework.

Proposition 1: Retrofitting finance models may be synchronized with stakeholders' enterprises, since they will gain from executing an energy efficiency program, leading to reductions in energy expenditures.

The authors examine the alignment of retrofitting finance models with stakeholder firms, positing that these entities would benefit from implementing an energy efficiency program, resulting in reduced energy expenditures. The authors found that "company" was linked to favourable attitudes using sentiment analysis. The results align with the respondents' assertions on "retrofitting finance." The summary addresses the inquiry: "From your experience, how do you involve various organizational tiers in discussions regarding energy efficiency?" Could you elucidate a scenario in which divergent stakeholder viewpoints emerged about energy investments, and how they were reconciled? What measures guarantee that all perspectives—particularly those of technical personnel or junior staff—are really considered in energy decision-making?

- Uses clear communication strategies and regular meetings to ensure everyone is informed and involved in energy decisions; unfortunately, time and resource limitations can make it challenging to maintain consistent engagement across all levels - expert ANI
- Encourages collaboration between technical and non-technical teams, ensuring junior staff voices are considered in decision-making, but Conflicting interests sometimes slow down progress and require mediation to reach consensus - expert FIT

The summary addresses the inquiry: "How do you reconcile extensive stakeholder engagement with the pragmatic constraints of time, resources, and operational requirements in energy efficiency planning?" What alterations may make a comprehensive strategy more practicable?

- Advocates for balancing stakeholder involvement by prioritizing the most impactful discussions to save time and resources; however, risk of some stakeholders feeling excluded due to limited engagement opportunities - expert ASW
- Promotes efficient energy use with simple, direct strategies that work within resource constraints; however, simplification may overlook complex stakeholder needs or systemic improvements - expert SAWA

Proposition 2:There are negligible hazards and minor obstacles for enterprises that adopt energy efficiency initiatives.

The summary addresses the enquiries: "In what manner does your organization presently assess and substantiate energy efficiency investments?" How can you amalgamate qualitative insights—such as organizational cultural preparedness or community impact—with conventional quantitative indicators like payback period?

- Utilises structured evaluation processes that integrate financial metrics with broader considerations, such as cultural readiness. Unfortunately, aligning diverse qualitative and quantitative factors can complicate decision-making - expert ASW
- Integrates both traditional financial metrics and qualitative factors, creating a balanced evaluation of energy investments, but complex integration may require extra time and resources to ensure accuracy - expert ANI

The summary addresses the enquiries: "Can you elucidate the cultural factors—both facilitative and obstructive—that impact the implementation of sustainable energy practices within your organization?" In what ways do these elements influence organizational changes that foster a more energy-conscious culture? What differentiates organizations that effectively execute energy efficiency and robust technology solutions?

- Emphasizes how cultural values shape adoption, with open communication promoting positive change, but hierarchical structures can hinder participation and limit innovative ideas - expert FIT
- Identifies external influences like media as powerful tools to promote sustainable practices; however, external pressures may not always align with internal organizational realities, causing friction - expert ATS

The summary addresses the inquiry: "According to your experience?" What encouraging advancements do you see in the decision-making processes around organizational energy efficiency?

- Identifies progress in integrating sustainable practices into decision-making and fostering long-term efficiency goals; unfortunately, implementation remains inconsistent due to varying levels of commitment across departments - expert ASW
- Advocates for widespread, equitable energy development and accessible efficiency solutions, but a broader reach can be difficult to achieve without sufficient resources and clear policies - expert SAWA

A qualitative methodology employing two-tier regression analysis was utilised to examine sequential relationships among adoption constructs. Before regression modelling, validity and reliability evaluations confirmed the robustness of the construct measurement. The Cronbach's alpha values ranged from 0.85 to 0.93, and the Kaiser-Meyer-Olkin (KMO) test yielded a value higher than 0.80, indicating that the sample was sufficient and that the results were consistent. All indicators exhibited significant loading on their respective constructs, thereby confirming convergent validity. The Variance Inflation Factor (VIF) was used to check for multicollinearity. It was found that all predictors had a VIF of 2.0, indicating no multicollinearity problems. The linearity of the logit was evaluated and validated for all continuous predictors. The Hosmer–Lemeshow test revealed that the model was sufficiently accurate ($p > .05$). Classification accuracy exceeded 85% across all models, with ROC–AUC values ranging from 0.91 to 0.98, indicating excellent discriminative proficiency. Assessments of validity and reliability were conducted before regression modelling. The Kaiser-Meyer-Olkin (KMO) measure exceeded the recommended threshold (> .80), and Bartlett's Test of Sphericity produced significant results ($p < .001$), thereby confirming sample adequacy and factorability. Cronbach's alpha (α) was used to test reliability, and all of the constructs showed good to excellent internal consistency ($\alpha > .70$), as shown in Table 3. All constructs exceeded the threshold values (Cronbach's $\alpha > 0.70$; KMO > 0.80), demonstrating strong construct validity and reliability suitable for regression modelling.

Table 3: Validity & Reliability Testing

Construct	Cronbach's α	KMO & Bartlett's Test
Technology Awareness (TA)	0.86	KMO=0.82; Bartlett's p<.001
Employee Capacity (EC)	0.88	KMO=0.84; Bartlett's p<.001
Technology Implementation (TI)	0.85	KMO=0.81; Bartlett's p<.001
Financial Support (FS)	0.87	KMO=0.83; Bartlett's p<.001
Incentives & Motivation (IM)	0.84	KMO=0.82; Bartlett's p<.001
Policy Support (PS)	0.89	KMO=0.85; Bartlett's p<.001
Market Readiness (MR)	0.91	KMO=0.86; Bartlett's p<.001
Stakeholder Engagement (SE)	0.92	KMO=0.88; Bartlett's p<.001
Performance Impact (PI)	0.93	KMO=0.89; Bartlett's p<.001

The multicollinearity assessment confirms model reliability, with all predictors maintaining acceptable VIF values below the critical threshold of 5 (VIF < 5 is ideal), as shown in Table 4. The very high VIF (15.88) for "Constructs" is likely due to it being a composite or higher-order construct that encompasses the other four variables (PS, TI, TA, EC). This leads to mathematical redundancy, where "Constructs" can be almost entirely predicted from the combination of their sub-dimensions, resulting in significant multicollinearity. Even with this problem, the regression is still okay because the other variables have safe VIF values (2.15–2.76), which are all well below the critical threshold of 10. This means that there is no problematic multicollinearity among them. All predictors also have t-values above 2.5, which means that the coefficient estimates are stable and reliable. The multicollinearity only affects one variable, not the entire model, so the regression remains helpful in examining the individual effects of PS, TI, TA, and EC. However, the "Constructs" coefficient should be read with caution because it is very similar to other predictors. This validates the statistical integrity of incorporating behavioural and perceptual factors into the performance prediction model.

Table 4: Tier 2 Regression Coefficients

	Coef.	Std. Err.	t	VIF
Constructs	0.5787	0.1780	3.2502	15.8755
PS (Policy Support)	0.2704	0.0613	4.4091	2.2197
TI (Technology Implementation)	0.1798	0.0663	2.7109	2.7637
TA (Technology Awareness)	0.1992	0.0580	3.4322	2.1488
EC (Employee Capacity)	0.1689	0.0673	2.5093	2.6282

Table 2 illustrates a hierarchy between organizational factors and performance improvement. Policy support is the primary driver at the Tier 1 model, accounting for 42.6% of performance variance on its own. This significant explanatory power underscores the crucial role of supportive policies in the success of organizations. The Tier 2 model analysis reveals that incorporating technology implementation, technology awareness, and employee capacity into policy support enhances the accuracy of predictions. This comprehensive model accounts for 53.6% of performance variance, indicating a substantial 11% improvement compared to policy support alone. The statistically significant F-statistic (76.57, $p < 0.001$) confirms that the model is robust and can be trusted to predict performance outcomes across different types of organizations.

Table 5: Tier 1 & Tier 2 Model Regression Modelling Summary

	Tier 1 model	Tier 2 model
Predictor	Policy Support (PS)	Policy Support (PS), Technology Implementation (TI), Technology Awareness (TA), Employee Capacity (EC)
Outcome	Performance Improvement (PI)	Performance Improvement (PI)
R^2 / Adjusted R^2	0.426 - Policy support alone explains ~42.6% of the variance in performance.	0.536 - These combined predictors explain ~53.6% of the variance.
F-Statistic		76.57 ($p < 0.001$) - model is statistically significant.

Table 5 illustrates that the optimal conditions for the successful adoption of green technology are when top-down policy support and bottom-up organizational readiness are combined. The foundational policy framework is significantly enhanced by the implementation of technology, increased awareness, and enhanced employee capacity, with explanatory power increasing by more than 11 percentage points. The beta coefficients indicate which factors are the most effective predictors of a company's performance. They also demonstrate that successful green tech adoption requires both institutional support and grassroots organizational skills to work in tandem.

A hierarchical regression and mediation framework was utilized to analyze the interconnections between Tier 1 model - policy support, and Tier 2 model - organizational behaviour in the context of green technology adoption. In Tier 1, policy support (PS) alone accounted for a significant portion of the variance in firm performance improvement (PI), exhibiting an R^2 of 0.426. In Tier 2, the addition of behavioural and perceptual variables—technology awareness (TA), technology implementation (TI), and employee capacity (EC)—enhanced the model's explanatory power to an adjusted R^2 of 0.536, with all predictors exhibiting acceptable multicollinearity ($VIF < 5$). Beta coefficients indicated that both policy and organizational readiness factors had a significant impact on outcomes at the firm level. The results collectively highlight the significance of merging top-down policy frameworks with bottom-up behavioural enablers to enhance sustainability performance in business environments. The mixed-methods approach, which combines qualitative stakeholder analysis with two-tier regression modelling, provides a more nuanced understanding of how policies encourage the use of green technology. [50]. Combining AI-driven sentiment analysis with Google Notebook and traditional statistical modelling provides a comprehensive view of how to enhance an organization's performance.

The qualitative analysis, conducted through expert interviews and focus group discussions, corroborates both propositions while also exposing implementation challenges. In relation to Proposition 1 (synchronizing the retrofitting finance model with stakeholder enterprises), sentiment analysis revealed positive correlations between the term "company" and favourable perceptions of "retrofitting finance." [13]. Expert testimonials disclosed strategic advantages while underscoring operational limitations. Expert ANI stressed the need for "clear communication strategies and regular meetings to make sure everyone is informed," but also said that "time and resource limitations can make it hard to keep everyone involved at all levels." Similarly, Expert FIT emphasized the importance of collaboration between "technical and non-technical teams to work together," while also acknowledging that "conflicting interests can slow down progress and require mediation to reach consensus." [12].

For Proposition 2 (negligible hazards and minor obstacles), the qualitative evidence offers a more intricate perspective. Expert ASW showed that evaluation processes can be complicated by "structured evaluation processes that combine financial metrics with broader considerations like cultural readiness." They also said that "aligning diverse qualitative and quantitative factors can complicate decision-making." This finding contradicts the notion that "negligible hazards" exist, as it demonstrates that implementing energy efficiency can be a complex process [34].

The analysis of the cultural dimension revealed both enabling and hindering factors. Expert FIT stressed that "cultural values shape adoption, with open communication promoting positive change," and that "hierarchical structures can hinder participation and limit innovative ideas." Expert ATS said that "external influences like media can be powerful tools to promote sustainable practices," but warned that "external pressures may not always align with internal organizational realities, causing friction." [51].

The quantitative analysis offers substantial statistical corroboration of the qualitative findings via a hierarchical modelling methodology. The two-tier regression framework systematically divides effects into Tier 1 Model (contextual), Tier 2 Model (mediating), and Tier 3 Model (outcome), addressing measurement validity issues through thorough reliability testing. All constructs exhibited outstanding internal consistency (Cronbach's α ranging from 0.84 to 0.93) and sample adequacy ($KMO > 0.80$), while multicollinearity evaluations validated model reliability ($VIF < 2.0$ for all predictors).

At the Tier 1 Model, policy support shows a significant independent effect, accounting for 42.6% of the variation in green technology adoption outcomes. However, the model's ability to predict outcomes improves significantly when Tier 2 Model organizational factors are incorporated. The enhanced framework, which encompasses technology awareness, implementation capability, and employee capacity, increases the explained variance to 53.6%, indicating an 11-percentage-point improvement that corroborates the qualitative observation that policy effectiveness is contingent upon organisational readiness factors, rather than solely on institutional support.

The convergent evidence from both methodological approaches illustrates that policy effectiveness functions through multiple channels concurrently, contesting the predominance of purely techno-economic models in energy efficiency literature. [16], [31]. Policies offer vital contextual support, but their effectiveness is greatly enhanced when organizations have internal enablers such as awareness, implementation capability, and human capacity. This finding resolves the apparent contradiction between Expert ANI's optimism regarding "clear communication strategies" and Expert FIT's apprehensions about "conflicting interests," indicating that successful implementation necessitates both institutional frameworks and advanced organizational management skills.

The mixed-methods validation mitigates the constraints associated with single-approach studies. The qualitative aspect elucidates contextual subtleties and implementation obstacles that quantitative models often overlook. In contrast, the statistical analysis provides generalizable evidence from the 303-firm sample that individual case studies cannot offer. [52]. The research recognizes its methodological constraints. The AI-driven sentiment analysis, although it mitigates researcher bias, may oversimplify the intricate emotions and motivations of stakeholders. Furthermore, the cross-sectional quantitative design is unable to definitively establish causality, notwithstanding the robust theoretical framework supporting the proposed mediation pathways.

The results indicate that effective policy outcomes necessitate the synergistic integration of top-down institutional frameworks with bottom-up organizational readiness, resulting in multiplicative effects that enhance performance optimization in contexts of green technology adoption. These findings align with the TOE-DOI frameworks in SME technology adoption research and enhance the comprehension of policy mediation mechanisms. They underscore that policy impact is profoundly influenced by organizational readiness, rather than policy directives being adequate in isolation. This supports socio-technical systems perspectives that highlight the dynamic interplay among institutional, technological, and behavioural factors. [53].

5. Conclusion

The research resolves the enduring controversy between technological determinism and social constructivism by illustrating that neither technology nor policy functions independently. Our findings corroborate prior assertions that technological innovations necessitate conducive institutional frameworks, while concurrently affirming research on technology's catalytic function when appropriately executed. The mediation analysis demonstrates that effective adoption of green technology necessitates coordinated advancement at Tier 1 Model (policy), and Tier 2 Model (organizational), thereby reinforcing established socio-technical systems frameworks.

This research theoretically enhances energy efficiency adoption theory by amalgamating Soft Systems Methodology with quantitative modelling, thereby addressing the conceptual disparity between qualitative problem structuring and quantitative forecasting. The framework illustrates that organizational readiness factors—technology awareness, implementation capacity, and employee capability—function as essential transmission mechanisms for policy effectiveness, thereby enhancing TOE-DOI frameworks within SME contexts. This theoretical contribution contests the notion that policy directives solely instigate organizational change; it demonstrates that policies attain effectiveness by influencing firm behaviours and perceptions.

The research offers practical insights for Indonesia's ambitious carbon reduction targets for 2030 and its Net Zero goals for 2060, from an implementation standpoint. The blended finance mechanism, which links paying back microloans to energy savings verified by smart meters, solves funding problems that prevent 65% of industrial projects from proceeding due to high upfront costs. The stakeholder-integrated platform design addresses information asymmetries, facilitating mobile-based energy tracking and collaborative management among users, service providers, and governments.

The core of the study is to demonstrate that for energy transitions to be sustainable, they must be planned and executed simultaneously by individuals at all levels of an organization. Instead of implementing policies one after another, success comes from combining institutional support with factors that make an organization ready to change. This discovery has significant implications for policymakers responsible for creating interventions that simultaneously enhance regulatory frameworks and develop internal organizational capacities. The framework serves as a diagnostic tool for practitioners to identify implementation barriers and formulate targeted interventions that optimize both policy adherence and performance outcomes, thereby accelerating Indonesia's progress toward sustainable industrial development.

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