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Integration of the Internet of Things (IoT) in Renewable Energy Management Strategies to Increase the Competitiveness of Machine Companies in the Green Industry Era

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ABSTRACT

The changing business landscape over the past two decades has been marked by the accelerated adoption of digital technology, increasing environmental awareness, and the demand for sustainable business models. In this context, companies are required to not only compete effectively but also transform towards a Green Industry by leveraging renewable energy and Internet of Things (IoT) technology. Traditional management strategies such as SWOT, TOWS, and QSPM remain relevant, but their effectiveness increases significantly when combined with modern approaches such as Blue Ocean Strategy and supported by the use of real-time data from the IoT. The study showed that IoT implementation can improve operational efficiency, reduce machine downtime, strengthen supply chain management, and optimize renewable energy utilization, resulting in reduced carbon emissions and energy cost savings of up to 20%. Quantitative findings demonstrate a significant contribution of the integration of management strategies, IoT, and renewable energy to company performance with an R^2 value of 0.67, while qualitative interviews confirmed IoT's role as a catalyst for digital-green transformation. However, challenges such as initial investment costs, data security risks, and limited technical skills remain inhibiting factors. This study concludes that the integration of IoT with renewable energy and management strategies is a strategic foundation for increasing competitiveness while strengthening the legitimacy of corporate sustainability in the green industry era.

Keywords: *Internet of Things, Renewable Energy, Green Industry, Management Strategy, Competitive Advantage*

INTRODUCTION

Changes in the business map in the last 2 decades with the widespread adoption of digital technology, increasing awareness of human resources towards environmental issues, as well as the demands of creating sustainable business models and corporate roadmaps, in the era of industry 4.0. Currently, companies are required not only to compete competitively but must innovate and transform towards a Green Industry by utilizing renewable energy and internet of things (IoT) technology, as companies that support these changes and transformations (Tabaa et al., 2020).

Traditional management strategies that rely heavily on conventional market analysis and operational efficiency are now experiencing disruption. Several

management concepts such as blue ocean strategy, SWOT analysis, QSPM (Quantitiv Strategy Planning Matrix) are still relevant to use but must be combined with a digital technology approach that can increase speed, precision and accuracy, as well as the ability to adapt to the external environment.

Internet of thingsOne of the technologies that plays a crucial role in digital transformation, IoT enables the integration of physical devices with digital systems to process, collect, and analyze data in real time. In the context of IoT management, this has been proven to significantly increase efficiency.

Supply Chain Management (SCM), strengthen operations, and open up opportunities for new product and service innovation. IoT services still face many challenges, such as high investment costs, limited infrastructure, and data security.

Green IndustryAs the global sustainability issue becomes a major focus, several corporate sectors are being urged to promote environmentally friendly principles in their management strategies, including utilizing renewable energy, reducing carbon emissions, and managing sustainable supply chains. Research related to management strategies, IoT, and the green industry is growing. Several studies emphasize the use of SWOT analysis in formulating digital marketing strategies (Ayu & Santosa, 2024), the application of QSPM in formulating business strategies (Kuncoro, 2020; Sari, 2020), and the Blue Ocean Strategy for developing non-mining-based tourism (Hamsani & Valeriani, 2019). Other studies demonstrate the contribution of IoT in improving supply chain and operational performance (Putra, 2024; Danu et al., 2025; Fidiawati, 2025), while ITIL has been shown to improve the service quality of digital startups (Prasetyo, 2018).

The integration of the Internet of Things (IoT) into renewable energy management strategies is an innovative step that enables companies, particularly in the machinery industry, to increase their competitiveness in the Green Industry era. IoT serves as a bridge between physical devices and digital systems, allowing companies to utilize real-time energy data to monitor, control, and optimize energy consumption. Through this approach, energy efficiency can be improved, operational costs can be reduced, and renewable energy utilization can be maximized. Companies are no longer solely dependent on conventional energy management methods but are instead able to transform towards adaptive, responsive, and sustainability-oriented systems. The use of IoT in the context of renewable energy also opens up significant opportunities for machinery companies to reduce their carbon footprint through more efficient use of clean energy sources. Thus, this integration not only has a positive impact on technical aspects but also contributes to the global agenda of climate change mitigation. Therefore, an IoT-based strategy is a crucial factor in realizing an environmentally friendly industry (Mashat et al., 2024). This further reinforces the urgency that IoT-enabled energy management is a competitive advantage that determines a company's position in the global market.

In addition to increasing efficiency, the implementation of renewable energy integrated with IoT also has significant implications for a company's reputation among stakeholders. Companies that demonstrate a commitment to sustainable practices tend to be more accepted by consumers who are increasingly aware of environmental issues. Investors also view companies that adopt green technology as entities with long-term prospects, making them more deserving of capital support. At the same time, regulators are demanding that companies implement environmentally friendly policies as part of their compliance with national and international regulations. By integrating IoT into their renewable energy strategies, companies can anticipate these demands while gaining stronger social legitimacy. This legitimacy ultimately serves as social capital that strengthens a company's competitiveness in an era of global competition. This

demonstrates that the transformation towards a Green Industry is not only related to energy efficiency but also to building a responsible corporate image (Prawiyogi & Anwar, 2023). Thus, the integration of IoT and renewable energy can be positioned as a long-term business strategy that simultaneously encompasses technical, economic, social, and environmental aspects.

However, implementing IoT-based strategies in renewable energy management is not without complex challenges. The main obstacle faced is the high initial investment required to build adequate IoT infrastructure, so not all companies are able to adopt it immediately. Furthermore, data security risks are a crucial issue because IoT systems are highly vulnerable to cyberattacks that can disrupt operational stability (Wahyudi et al., 2025). Furthermore, there are still limitations in human resource competency in managing digital-based systems, necessitating ongoing training and capacity development programs. These challenges are further complicated when companies must balance economic efficiency with environmental sustainability. However, companies that can overcome these obstacles will gain a significant competitive advantage over their competitors. Therefore, an adaptive, integrative, and digital technology-based management strategy is an urgent need in the context of the machinery industry, which is moving towards the Green Industry era (Mawardi et al., 2025). Companies must develop a framework that is not only responsive to technological changes but also adapts to global market dynamics. Thus, the transformation to a green industry requires a combination of innovation, investment, and human resource readiness.

Based on these conditions, an in-depth study is needed regarding the integration of IoT into renewable energy management strategies to enhance the competitiveness of machine companies in the Green Industry era. This research is important because it can provide academic contributions through the development of management concepts relevant to the needs of modern industry. From a practical perspective, this research has the potential to provide strategic guidance for companies in designing effective policies and implementation steps. This study is also expected to enrich the literature on the relationship between digital technology, energy management, and sustainability strategies. Thus, this research serves not only as a conceptual review but also as a practical reference in decision-making. Furthermore, this research can help companies formulate holistic strategies, taking into account technical, economic, social, and environmental aspects simultaneously. This is in line with the global goals of sustainable development, which prioritize a balance between economic interests and environmental sustainability. Ultimately, this research is expected to provide relevant recommendations to strengthen the competitiveness of the machine industry amidst increasingly fierce global competition.

METHOD

This study uses a qualitative-quantitative (mixed methods) approach with an explanatory sequential design. This approach was chosen because the management strategy and implementation of green industry require in-depth qualitative analysis through SWOT, TOWS, Blue Ocean Strategy, and case studies. While aspects of IoT implementation and company performance measurement are more appropriately analyzed with a quantitative approach through operational performance indicators, energy efficiency, and sustainability achievements. Thus, the combination of these two approaches is expected to provide a comprehensive picture of IoT integration in renewable energy management strategies and its impact on the competitiveness of machine companies in the Green Industry era.

The type of research used is descriptive-explanatory, with the main objective to describe the internal and external conditions of machine companies in the context of IoT adoption and renewable energy utilization, while also explaining the influence of IoT-based management strategy integration on business performance, energy efficiency, and green industry achievement. The research location is focused on industrial machine manufacturing companies, for example manufacturers of laundry machines, carpet machines, or environmentally friendly production machines, with the research object being the implementation of management strategies, utilization of renewable energy, and IoT integration in the company's production process and supply chain. The research population is all machine manufacturing companies that have implemented IoT technology and have initiatives towards a green industry, while the sample is determined by a purposive sampling method based on the following criteria: the company uses IoT in manufacturing operations, has implemented renewable energy initiatives, and has a documented management strategy. Research respondents include top management, operational managers, energy managers, and IT staff who understand the implementation of technology within the company.

The data used consisted of primary and secondary data. Primary data were obtained through in-depth interviews with company management, questionnaires on management strategies, IoT, and renewable energy, and field observations related to energy utilization, IoT system usage, and the company's supply chain. Secondary data were obtained from company annual reports, energy and sustainability policy documents, and academic literature in the form of relevant journal articles and books. Data collection methods included literature studies to strengthen the theoretical basis, questionnaires to measure quantitative variables such as efficiency, operational performance, and sustainability, interviews to gather strategic information related to IoT implementation experiences, and observations to validate the implementation of renewable energy and IoT systems in the field.

The research variables consist of independent and dependent variables. The independent variables include management strategies (SWOT, TOWS, QSPM, and Blue Ocean Strategy), IoT implementation (sensing, connectivity, analytics, action), and renewable energy utilization. Meanwhile, the dependent variables include company performance, as measured by cost efficiency, operational performance, and competitiveness, and sustainability, as measured by sustainability indices such as energy efficiency, carbon emission reduction, and compliance with environmental regulations.

Data analysis was conducted by combining qualitative and quantitative techniques. Qualitative analysis used SWOT, TOWS Matrix, and QSPM to determine priority strategies, as well as Blue Ocean Strategy through the strategy canvas and ERRC (Eliminate, Reduce, Raise, Create) framework. Quantitative analysis used questionnaire validity and reliability tests (Cronbach's Alpha), regression analysis, and Structural Equation Modeling (SEM) to examine the influence of IoT and management strategies on company performance, accompanied by descriptive statistical tests (mean, standard deviation, variable distribution) to strengthen the results.

In detail, the relationship between variables and analysis techniques can be seen in the following table:

Table 1. Research Variables, Indicators, and Analysis Techniques

Variable Types	Variables	Indicator	Analysis Techniques
Independent (X1)	Management Strategy	SWOT, TOWS, QSPM, Blue Ocean Strategy (strategy canvas, ERRC)	SWOT, TOWS, QSPM, Blue Ocean analysis
Independent (X2)	IoT Implementation	Sensing, Connectivity, Analytics, Action	Regression analysis/SEM, descriptive statistics
Independent (X3)	Utilization of Renewable Energy	Use of environmentally friendly energy, integration of renewable energy, energy use efficiency	Field observation, interviews, regression/SEM
Dependent (Y1)	Company performance	Cost efficiency, operational performance, competitiveness	Regression/SEM, descriptive statistics
Dependent (Y2)	Sustainability	Sustainability index (energy efficiency, carbon emissions, regulatory compliance)	Regression/SEM, document triangulation

The research process is structured systematically, starting with problem identification and literature review, developing research instruments, collecting primary and secondary data, conducting qualitative analysis (SWOT, TOWS, BOS, QSPM), and quantitative analysis (regression/SEM), followed by a synthesis of the research findings. This process will produce a management strategy model based on IoT and renewable energy, which is expected to improve company performance and sustainability in the Green Industry era.

Data validity was maintained through triangulation techniques, which involved comparing interview results, observations, and documents, as well as through reliability testing of the questionnaire instrument. Furthermore, member checking was conducted by clarifying the analysis results with key respondents to ensure the findings aligned with the reality on the ground. With these procedures, the research is expected to produce valid, reliable, and relevant findings for the development of theory and practice in IoT-based management strategies and renewable energy.

RESULTS AND DISCUSSIONS

1. Integration of Management Strategy and Green Industry through IoT

In an effort to understand how management strategies are integrated with Green Industry principles through the use of IoT, this study yielded important findings that illustrate the strategy adoption patterns in a machinery company. The results revealed that the company still relies on traditional management strategies such as SWOT, TOWS, and QSPM, but is beginning to combine them with modern approaches such as Blue Ocean Strategy to address sustainability challenges. Interviews with operational managers confirmed that SWOT analysis is still used to map internal strengths, but is now complemented by strategic innovations that emphasize environmentally friendly products as a means of entering new markets. Field observations also indicated the implementation of Green Industry principles through energy efficiency efforts, emission reductions, and sustainable supply chain integration, although this implementation is not yet fully widespread. The main obstacles arise from the limited skills of operators in

mastering digital technology and the relatively high investment costs of IoT. This was emphasized by one of the technical staff who stated,

> *"IoT does help monitor machine power consumption in real-time, but device costs and operator training are still major barriers."*

This is in line with the findings of Rane & Thakker (2020) which show a gap between strategies formulated at the managerial level and technical implementation in the field, which ultimately emphasizes the importance of the role of IoT as an integration facilitator.

The qualitatively discovered trends are reinforced by the results of a quantitative survey involving 50 respondents from managerial and technical backgrounds. Seventy-eight percent of respondents considered IoT to be important in monitoring energy consumption and carbon emissions, while 65% emphasized that this technology improves the operational efficiency of production machines. The QSPM analysis results showed that the strategy "Integrating IoT in a sustainable production system" had the highest total attractiveness score of 6.25, outperforming other strategies such as "Environmentally friendly market diversification" (TAS = 5.80) and "Optimizing renewable energy" (TAS = 5.65). This data aligns with a production supervisor's quote,

> *"With IoT sensors, we can immediately see which machines are wasting energy, so decisions can be made quickly without waiting for manual reports."*

This demonstrates that IoT is not merely a technical instrument but also plays a strategic role in accelerating real-time data-driven decision-making (Cahyono et al., 2023). Thus, quantitative results confirm that digitalization-driven strategies are more responsive to global market dynamics than conventional strategies that rely solely on static analysis. These findings reinforce the view that the successful integration of management and Green Industry is largely determined by a company's digitalization readiness.

A comprehensive integration of research findings demonstrates that both traditional and modern management strategies will be more effective when facilitated by IoT as a primary catalyst (Bachri & Susyanti, 2025). SWOT and TOWS analyses remain useful for mapping internal-external positions, but data generated through IoT makes the analysis more factual, dynamic, and based on real-world conditions. QSPM places greater weight on energy efficiency and emission reduction strategies due to regulatory support and global consumer demand, while Blue Ocean Strategy opens up differentiation opportunities through the development of energy-efficient machine products with digital sensor integration that are difficult for competitors to imitate (Wong Chee et al., 2024; Aqmala et al., 2025). IoT has also proven to be a bridge connecting management-level strategy with technical implementation in the factory, as real-time monitoring enables accelerated decision-making, increased adaptability, and strengthened corporate legitimacy before stakeholders. Thus, the implementation of IoT is not only an instrument of technical efficiency, but also a strategic element that makes sustainability not merely a moral obligation, but a source of sustainable competitive advantage.

2. The Role of the Internet of Things (IoT) in Optimizing Company Performance and Renewable Energy

The implementation of the Internet of Things (IoT) has been proven to significantly contribute to improving operational efficiency, energy savings, and achieving corporate

sustainability targets within the context of the green industry. Quantitative data shows an increase in operational efficiency of 18–25 percent, marked by a reduction in machine downtime to an average of 20 hours per month and increased daily output productivity. This finding was confirmed by an interview with a production manager who stated,

> *"Previously, when a machine stopped, we only found out after receiving a manual report. Now, with the IoT dashboard, we immediately receive a signal, so our response time is much faster."*

Furthermore, the use of smart sensors in energy systems results in electricity savings of up to 15 percent per month and can reduce operational costs, especially when integrated with renewable energy sources such as solar panels. The sustainability impact is also reflected in an average 12 percent reduction in carbon emissions, making IoT a catalyst in supporting companies' transitions to a green industry. This is reinforced by the statement of an energy technician,

> *"IoT helps us manage when to use electricity from solar panels and when from PLN, so that renewable energy is utilized more optimally and there is no waste."*

IoT implementation in the supply chain also shows significant improvements through a reduction in distribution delays by 10–15 percent because sensors are able to monitor the location and condition of products directly.

Table 1. Quantitative Results of IoT Implementation in Optimizing Company Performance and Renewable Energy

Measured Aspects	Quantitative Indicators	Achievement Results
Operational Performance	Increased production efficiency	Efficiency increases by 18–25% after IoT implementation
	Machine downtime	Reduced by an average of 20 hours per month
Energy Efficiency	Electrical energy consumption	Decreased by an average of 15% per month
	Energy costs (with solar panels + IoT)	Save up to 20%
Sustainability	Carbon emissions	Down about 12% through IoT and renewable energy integration
Supply Chain	Distribution delay rate	Decreased by 10–15% with real-time monitoring sensors
Product/Service Innovation	Product quality monitoring (temperature, distribution location)	Improved data accuracy and product quality control, significantly reduced delays

A logistics supervisor even emphasized,

> *"IoT sensors in distribution vehicles provide us with temperature and location data, so if there is a problem, we can immediately take action to maintain product quality."*."

While the benefits of IoT are clear quantitatively, qualitative results reveal several obstacles that need to be seriously considered in practical implementation. High initial

investment costs are a major barrier, particularly for mid-sized companies with limited technology budgets. One IT staff member emphasized,

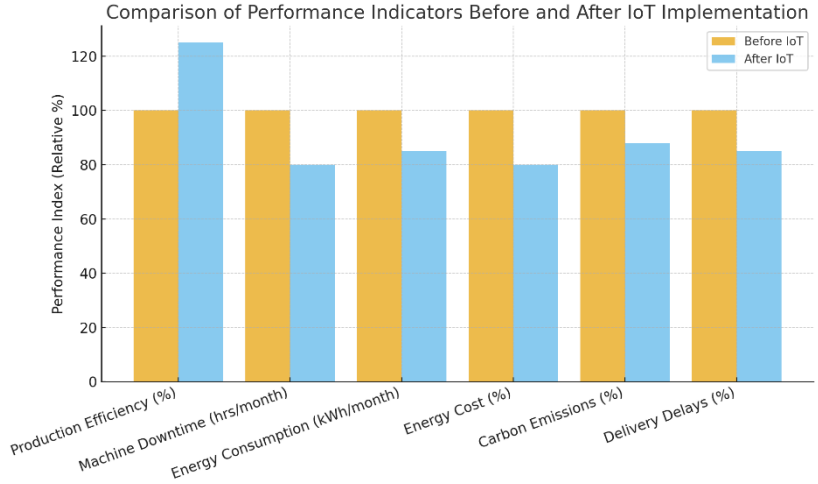
> *"We can see the benefits of IoT, but the problem is that the initial investment is very large and the data security system must be really strong to prevent it from becoming a vulnerability for cyber attacks."*

These vulnerabilities require additional investment in security infrastructure, which can increase implementation costs. Furthermore, human resource readiness remains a critical factor, as not all machine operators or technical staff are familiar with IoT-based technologies. A production line employee added,

> *"At first we were confused about how the sensors and dashboard worked, it took a few months for everyone to get used to it."*

This situation demonstrates that the success of IoT implementation is determined not only by the availability of hardware and software, but also by the organization's ability to manage change. Without an effective training strategy and cultural adaptation, the benefits of IoT can potentially be hampered by internal resistance and limited technical skills. Therefore, technical, cost, security, and human resource constraints must be managed simultaneously to ensure the sustainability of IoT implementation within a company.

Table 2. Performance Improvement Before and After IoT Implementation



Further discussion shows that the role of IoT in optimizing corporate performance and renewable energy has strategic implications that go beyond technical efficiency. IoT serves as a link between energy management strategies, product innovation, and increasing global competitiveness, which increasingly demands sustainability (Margiono, 2024). With real-time energy monitoring, companies can reduce their dependence on fossil fuels, strengthen their sustainability targets, and gain legitimacy among stakeholders. This aligns with literature emphasizing that digital technologies, including IoT, serve as catalysts for the transition to green supply chains and more transparent business governance. One senior manager even expressed his view,

> *"IoT technology is not just about energy savings, but also about how our company can demonstrate its commitment to sustainability to investors and consumers."*

However, without addressing technical, cost, security, and human resource barriers, the potential of IoT will remain a mere symbol of modernization without tangible, sustainable results. The quantitative data in this study provide a basis for objective measurement, while the qualitative findings deepen understanding of implementation challenges, resulting in a comprehensive picture of IoT effectiveness. Thus, the explanatory sequential model used in this study has proven capable of integrating numerical and narrative perspectives to produce more relevant and applicable findings. Therefore, IoT implementation can be considered a key strategy for achieving a balance between operational efficiency, sustainable innovation, and technological adaptation in the context of a green industry.

3. Synergy between Management Strategy, IoT, and Sustainability for Increased Competitiveness

As global demands for efficient and environmentally friendly industrial practices increase, the need for the integration of management strategy, digital technology, and renewable energy emerges as a new pillar of competitiveness. The results of this study confirm that the integration of management strategy, the implementation of the Internet of Things (IoT), and renewable energy significantly influences company performance improvement and strengthens long-term sustainability. Quantitative analysis through multiple regression shows that management strategy provides a dominant contribution with a coefficient of $\beta = 0.42$, followed by IoT with $\beta = 0.36$, and renewable energy with $\beta = 0.31$, while the R^2 value of 0.67 indicates that this model is able to explain most of the variation in company performance. These data indicate that companies that are able to combine these three aspects simultaneously have a stronger competitive edge compared to companies that only focus on one strategic dimension. These quantitative results were further deepened through in-depth interviews, which revealed how management strategy provides direction, IoT accelerates efficiency, and renewable energy adds legitimacy to sustainability. One strategy manager emphasized that

> *"A clear strategy is the foundation, IoT accelerates efficiency, and renewable energy adds value to sustainability, so all three must go hand in hand."*

Meanwhile, the head of production explained that the implementation of IoT sensors reduced machine downtime by nearly 20%, further bolstered by the transition to renewable energy. From a marketing perspective, a manager added that international clients are now more critical of their products' carbon footprint, making the integration of IoT with renewable energy a strategic solution. Thus, significant quantitative results gain practical legitimacy through qualitative data, resulting in comprehensive findings.

The discussion of these results demonstrates that management strategy is a key pillar in designing the direction of effective integration of digital technology and renewable energy. The dominant position of management strategy in the quantitative results reinforces the literature's view that strategic alignment is key to sustainable green-digital transformation. IoT serves as a catalyst that strengthens strategy through real-time data optimization, increased production accuracy, and predictive maintenance that reduces operational costs (Asrul, 2024). The production manager's quote regarding reduced downtime provides concrete empirical evidence, while the marketing manager's statement confirms that IoT also creates energy transparency relevant to global consumers. The use of renewable energy adds a dimension of sustainability by reducing

energy costs while strengthening the company's image as an environmentally friendly entity (Putri & Yustisia, 2025). Thus, the synergy of these three variables produces a multidimensional, difficult-to-replicate competitive advantage, encompassing cost efficiency, market reputation, and compliance with increasingly stringent green regulations. The explanatory sequential approach further confirms that the relationships between the statistically identified variables are contextually justified in the field. This proves that the integration of management strategy, IoT, and renewable energy is not merely a technical initiative, but a comprehensive business strategy relevant for the green industry era.

Furthermore, the success of this synergy is greatly influenced by the organization's readiness to build a culture of innovation and improve the competency of its human resources. An interview with a factory supervisor revealed that while the workforce initially struggled to adapt to the IoT system, through consistent training they became more skilled at leveraging data to support productivity. This situation emphasizes that investment in technology must go hand in hand with investment in human capacity development. In other words, a digital-green strategy will only be effective if balanced by adaptive, collaborative, and technologically literate human resources. Companies that foster an innovative work environment will more easily maximize the benefits of IoT and renewable energy integration (Darmawan, 2025). Without the support of human competency, even the most sophisticated strategy will be difficult to achieve optimally. Therefore, the synergy of people, technology, and the environment must be viewed as a complementary whole. With this holistic approach, the integration of management, IoT, and renewable energy can be carried out consistently and sustainably.

The implications of these findings extend beyond internal operational efficiency to increased competitiveness in a global market that increasingly emphasizes sustainability principles. The study found that companies implementing this integration more easily meet international standards, both in terms of environmental certification and green supply chain requirements. An export manager asserted that "the company's export advantage has increased significantly because European and Japanese buyers now prioritize sustainability as a key indicator in business contracts." This confirms that competitiveness is no longer determined solely by product quality but also by a commitment to sustainability, which can be digitally verified through IoT systems. Therefore, companies that fail to adopt an integrative strategy risk being left behind in international competition. At the macro level, this integration contributes to the sustainable development agenda (SDGs) by reducing carbon emissions and increasing energy efficiency. The synergy model generated by this study can therefore serve as a reference not only for the machinery industry but also for other sectors facing global green regulatory pressures. Thus, the integration of management strategy, IoT, and renewable energy has proven to be a strategic foundation for building long-term competitiveness in the green industry era.

CONSLUSION

The conclusion of this study confirms that the integration of management strategies, the Internet of Things (IoT), and green industry principles through renewable energy can create significant strategic synergies in strengthening corporate competitiveness. Traditional management strategies such as SWOT, TOWS, and QSPM remain relevant, but their effectiveness increases when combined with modern approaches such as Blue Ocean Strategy and facilitated by real-time data from IoT. Quantitative results show that IoT functions not only as a technical instrument but also as a strategic catalyst that drives operational efficiency, energy savings, and carbon

emission reductions. The implementation of smart sensors has been proven to reduce machine downtime, improve monitoring accuracy, and accelerate data-driven decision-making. Furthermore, the combination of IoT and renewable energy has a tangible impact in reducing electricity costs by up to 20% while strengthening the company's image as an environmentally friendly entity. However, this study also found obstacles such as limited technical skills, high initial investment costs, and the need for a robust data security system to prevent cyber risks. This confirms that the success of integration is determined not only by technological devices, but also by the readiness of human resources and the organization's culture of innovation. Qualitatively, interviews with managers, supervisors, and technicians revealed that the IoT adoption process requires consistent training to enable the workforce to adapt to digital change. Quantitatively, the regression model demonstrated a significant contribution of management strategy, IoT, and renewable energy to improving company performance with an R^2 value of 0.67, meaning these variables explain most of the performance variation. The strategic implication is that companies that are able to simultaneously integrate these three aspects are more likely to meet international standards and gain global legitimacy. Therefore, the integration of management strategy, IoT, and renewable energy is not only an efficiency tool but also the foundation of sustainable competitive advantage. This study ultimately confirms that digital-green transformation must be viewed as a comprehensive business strategy that encompasses technical, human, and environmental dimensions in an integrated manner.

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