

Greening Business For Sustainability: The Strategic Role of Green HRM, Innovation and Employee Behavior in Coal Power Plants in Sumatera, Indonesia

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Abstract.

This study examines the influence of Green Human Resource Management (GHRM) on Sustainability Performance (SP) in coal-fired power plants (PLTUs) in Indonesia, with Green Innovation (GI) and Employees' Green Behavior (EGB) as mediators. Results show that GHRM significantly drives both GI and EGB, and directly improves SP. Indirect effects are even stronger, as GI and EGB enhance sustainability outcomes across environmental, social, and economic dimensions. These findings confirm GHRM as a critical driver of sustainability in energy-intensive industries. Based on the results, this study contributes theoretically by integrating GHRM with the Triple Bottom Line, extending the Resource-Based View and AMO framework, and linking micro-level green behaviors to macro-level sustainability outcomes. It also highlights the contextual relevance of GHRM in high-impact industries and underscores innovation as a strategic HRM outcome. Practically, energy companies should embed sustainability in HR practices, strengthen eco-innovation, and foster green behaviors through incentives and cultural alignment. Policymakers are encouraged to enhance regulatory support, while collaboration across sectors can accelerate the diffusion of sustainable practices. Overall, aligning HRM with green strategies provides both theoretical enrichment and actionable guidance for advancing corporate sustainability.

Keywords: Green Human Resource Management; Green Innovation, Employees' Green Behavior; Sustainability Performance; Sustainability Strategy and Energy Sector.

I. INTRODUCTION

Sustainability challenges have become increasingly prominent amid accelerating industrialization and the rapid growth of global energy demand. In the era of the Fourth Industrial Revolution, industries continue to expand, driving economic progress while simultaneously contributing to escalating environmental degradation through pollution, waste generation, and the depletion of natural resources [1]. In response, the global community through the 2030 Agenda for Sustainable Development emphasizes the urgency of transitioning toward sustainable economic models that balance economic viability, social inclusion, and environmental protection. In this framework, SDG 7 (Affordable and Clean Energy) plays a crucial role in aligning national energy policies with global emission-reduction commitments. Indonesia represents a unique energy landscape, as coal remains the dominant power source underpinning national electricity supply. Coal-fired power plants (PLTUs) account for approximately two-thirds of total electricity production and continue to expand despite their significant environmental and social impacts. Studies report critical issues such as increased greenhouse gas emissions, marine ecosystem degradation, coastal abrasion, air pollution, and health problems in surrounding communities [2][3]. On Sumatra Island alone, dozens of PLTU units operate across multiple provinces, shaping both regional development and environmental risk. Although technological solutions such as clean coal technology are being explored, Indonesia's commitment to achieving net zero emissions underscores the importance of organizational, behavioral, and managerial strategies that complement technological interventions.

Within this context, human resources emerge as a strategic component in enabling sustainable transformation. The literature increasingly emphasizes that environmental management systems cannot operate effectively without a workforce that is equipped, motivated, and empowered to adopt and implement environmentally responsible practices. Green Human Resource Management (GHRM) integrates environmental principles into core HR functions such as recruitment, training, performance management,

and employee involvement. Empirical studies suggest that GHRM can enhance a firm's innovation capacity, strengthen employees' environmental awareness, and ultimately contribute to improved sustainability outcomes [4][5]. Two internal mechanisms are particularly important in high-emission sectors. First, Green Innovation (GI) including green product and green process innovation—enables organizations to reduce environmental impact while maintaining operational efficiency. Second, Employees' Green Behavior (EGB) reflects the voluntary and task-related actions of employees that support environmental goals.

Prior research shows that both innovation and behavior play essential roles in translating environmental policies into measurable sustainability results [6][7][8]. However, despite substantial global attention to the energy transition, research examining how GHRM shapes innovation, employee behavior, and sustainability performance within coal-fired power plants particularly in developing countries remains limited. This study seeks to address these gaps by investigating the influence of GHRM on Sustainability Performance (SP) in PLTU companies operating on Sumatra Island, Indonesia. The research extends previous work by examining dual mediating mechanisms Green Innovation and Employees' Green Behavior that may explain how HR-driven environmental alignment translates into sustainability outcomes across environmental, social, and economic dimensions. Additionally, this study enriches the construct of EGB by incorporating an In-Group Collectivism indicator, acknowledging the cultural dynamics that may shape collective environmental behavior within Indonesian organizational settings. By focusing on a high-impact sector that plays a pivotal role in Indonesia's energy system, this study provides theoretical contributions to the literature on GHRM and sustainability while offering practical insights for PLTU management and policymakers seeking to strengthen green transition strategies. The subsequent methodology section presents the conceptual framework and hypotheses guiding this empirical investigation, followed by the research design used to test the proposed model.

II. METHODS

This study is based on a conceptual framework that positions Green Human Resource Management (GHRM) as a strategic organizational driver influencing Sustainability Performance (SP) directly and indirectly through Green Innovation (GI) and Employees' Green Behavior (EGB). The framework, shown in Figure 1, reflects two theoretical pathways. First, GHRM is expected to stimulate Green Innovation by equipping employees with environmentally oriented knowledge, training, and incentives. Second, GHRM is theorized to strengthen Employees' Green Behavior, encouraging employees to engage in environmentally responsible actions that contribute to organizational sustainability performance. Consistent with the Triple Bottom Line (TBL) perspective, sustainability performance in this study comprises environmental, social, and economic dimensions.

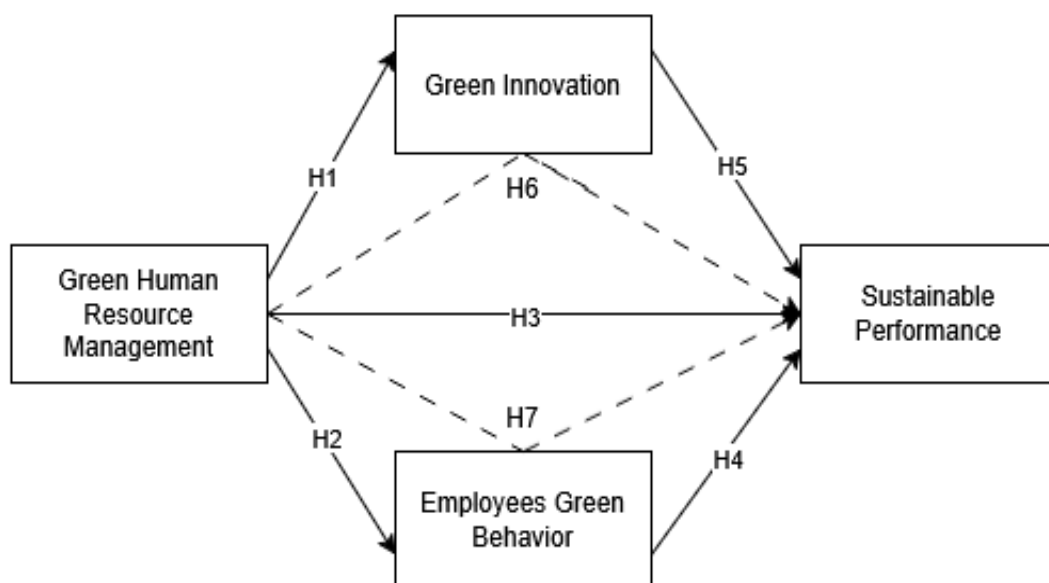


Fig 1. Research Framework

Drawing from previous empirical findings (Falcó et al., 2024; Yin et al., 2023), the study proposes seven hypotheses: that GHRM positively affects GI (H1), EGB (H2), and SP (H3); that both GI and EGB positively influence SP (H4 and H5); and that GI and EGB mediate the effect of GHRM on SP (H6 and H7). These hypotheses reflect the expectation that sustainability in coal-fired power plants emerges not only from HR-driven environmental alignment but also through the enhancement of organizational innovation capabilities and the strengthening of collective pro-environmental employee behavior. To empirically test this framework, the study adopts a quantitative, cross-sectional survey design. The research was conducted among employees of 20 coal-fired power plant (PLTU) companies operating on Sumatra Island, with a total estimated workforce of approximately 500 employees. A non-probability purposive sampling method was used to ensure that respondents possessed sufficient familiarity with the company's environmental management practices, operational processes, and innovation activities. Only employees with at least one year of tenure and who were directly or indirectly involved in PLTU operations, environmental activities, or innovation functions were included in the sample. Primary data were collected through an online structured questionnaire distributed using Google Forms.

Prior to the main data collection phase, a pilot test involving 30 PLTU employees was conducted to verify item clarity, reliability, and validity, ensuring that all indicators were well understood by respondents. The study uses four latent variables measured through 50 validated indicators: GHRM (22 indicators) operationalized through green hiring, green training and involvement, and green performance management and compensation; GI (8 indicators) measured through green product and green process innovation; EGB (6 indicators) derived from prior validated scales and expanded to include an In-Group Collectivism indicator to reflect collective environmental motivation; and SP (14 indicators) reflecting environmental, social, and economic performance. Following established guidelines for Structural Equation Modeling–Partial Least Squares (SEM-PLS), a minimum sample size of 250 respondents was determined based on the number of indicators and the ten-times rule [9]. SEM-PLS was selected as the analysis technique due to its ability to handle complex models with multiple mediators and reflective constructs, as well as its predictive orientation. Data analysis followed a two-stage approach. First, the measurement model was assessed to evaluate indicator reliability, internal consistency, convergent validity, and discriminant validity. Second, the structural model was tested to examine the significance of the direct and indirect relationships proposed in hypotheses H1–H7. Bootstrapping was conducted to determine the statistical significance of each path and to evaluate the mediating effects of GI and EGB. Secondary data from company reports, government publications, academic articles, and relevant regulatory documents were used to complement the interpretation of findings and strengthen contextual understanding.

III. RESULT AND DISCUSSION

This study investigates how Green Human Resource Management (GHRM) influences Sustainability Performance (SP) in coal-fired power plant (PLTU) companies across Sumatra, Indonesia, with Green Innovation (GI) and Employees' Green Behavior (EGB) functioning as mediating variables. As PLTUs remain the backbone of Indonesia's electricity system while simultaneously being a major source of environmental degradation, understanding how human resource systems, employee behavior, and innovation collectively shape sustainability outcomes is crucial for addressing national and global climate commitments. The findings presented in this chapter provide both empirical insights and conceptual interpretation of how sustainability-oriented HR practices can transform high-impact industries. Data were collected using an online structured questionnaire distributed to employees working at 20 PLTU companies in Sumatra. The distribution process took place over two weeks from the fourth week of June to the first week of July 2025 facilitated through HR departments at each plant to ensure broad and accurate representation. Confidentiality and voluntary participation were emphasized to enhance the reliability of responses.

A total of **255 employees** participated in this study, representing a technically skilled and operationally embedded workforce. Their demographic characteristics reflect the typical structure of energy-generation organizations: the workforce is overwhelmingly male (99.2%), with most respondents holding diplomas or bachelor's degrees and working primarily in engineering, maintenance, and operations job

functions that directly affect environmental performance and sustainability practices. More than half of the respondents have worked for six to ten years, implying a stable internal environment conducive to the adoption of long-term sustainability initiatives. The majority of participants are based in South Sumatra, one of Indonesia's largest hubs for coal-fired power production. The demographic distribution of respondents is presented in Table 1 below:

Table 1. Demographic distribution

Variables	Indicators	Frequency	Percent
Gender	Female	2	0.8
	Male	253	99.2
Education Level	Bachelor's Degree (S1)	90	35.3
	Diploma (D1–D3)	102	40
	High School / Vocational School	61	23.9
	Master's Degree (S2)	2	0.8
Job Position	Manager / Superintendent	19	7.5
	Senior Manager / General Manager	5	2
	Staff / Operator	131	51.4
	Supervisor / Foreman	100	39.2
Department	Administration / Support	10	3.9
	Engineering / Maintenance	120	47.1
	Health, Safety, and Environment (HSE)	6	2.4
	Operations	118	46.3
	Planning and business dept	1	0.4
Years in Company	0 - 5 Years	38	14.9
	11 - 15 Years	66	25.9
	6 - 10 Years	137	53.7
	More than 15 Years	14	5.5
PLTU Province	Bengkulu	14	5.5
	North Sumatera	14	5.5
	South Sumatera	226	88.6
	Sumatera	1	0.4
	Total	255	100

Following the demographic assessment, descriptive statistics were analyzed to understand respondents' perceptions across the four core constructs: GHRM, GI, EGB, and SP. Overall, the descriptive scores demonstrate moderate to strong agreement, suggesting that PLTU companies have begun integrating sustainability-oriented initiatives, particularly in areas related to green training, performance management, and environmental involvement. Green process innovation is perceived as more developed than product-related innovation, reflecting the operational emphasis of PLTUs on efficiency, emissions control, and pollution reduction. EGB indicators reveal strong collective behavioral tendencies, where employees encourage and remind one another to act responsibly consistent with the collectivist cultural context of Indonesian workplaces. Sustainability performance indicators show balanced progress across environmental, social, and economic dimensions.

The analysis of this study begins with evaluating the structural relationships among Green Human Resource Management (GHRM), Green Innovation (GI), Employees' Green Behavior (EGB), and Sustainability Performance (SP) using Partial Least Squares Structural Equation Modeling (PLS-SEM). After confirming that all measurement indicators met the criteria for reliability and validity, the structural model was examined to assess the significance, magnitude, and direction of the hypothesized relationships. Before discussing the theoretical implications, it is essential to present the empirical results generated from the bootstrapping procedure. The PLS-SEM analysis produced a set of **path coefficients**, *t-statistics*, and *p-values* that determine whether each hypothesis is supported. To guide interpretation, a coefficient greater than zero indicates a positive relationship, while statistical significance is established when $p < 0.05$ and the *t-statistic* exceeds the critical threshold [10]. The complete results are summarized in the following table, which forms the basis of the subsequent discussion.

Table 2. Path Coefficient

Hypotesis	Path Structure	Path Coefficient	T statistics	P values	Description	Medation Type
H1	GHRM -> GI	0.726	12.669	0.000	Supported	Direct
H2	GHRM -> EGB	0.739	13.560	0.000	Supported	Direct
H3	GHRM -> SP	0.230	3.081	0.002	Supported	Direct
H4	GI -> SP	0.380	3.893	0.000	Supported	Direct
H5	EGB -> SP	0.289	3.350	0.001	Supported	Direct
H6	GHRM -> GI -> SP	0.276	3.648	0.000	Supported	Partial Mediation
H7	GHRM -> EGB -> SP	0.214	3.314	0.001	Supported	Partial Mediation

The results show a clear and consistent pattern in which all proposed relationships were statistically supported. First, GHRM demonstrates a **strong and significant positive effect on Green Innovation**, with a high path coefficient (0.726) and a t-statistic far exceeding the critical value. This finding reinforces the idea that environmentally focused HR practices establish foundational capabilities—through training, recruitment, and green-oriented performance systems—that enable employees to generate eco-innovative ideas and adopt environmentally friendly processes. Within PLTU operations, where emission control, waste management, and energy efficiency are central challenges, GHRM acts as a key enabler of innovation-driven sustainability improvement. Similarly, GHRM shows a **significant positive effect on Employees' Green Behavior**, indicated by a path coefficient of 0.739. These results confirm that green HR practices effectively build environmental awareness and ethical responsibility among employees. The presence of In-Group Collectivism—introduced as a cultural indicator in this study—also strengthens this relationship by showing how shared values and peer reinforcement shape pro-environmental conduct. This is particularly relevant in PLTU work environments characterized by close team-based coordination, where collective behavior can amplify sustainable outcomes. GHRM is also found to have a **direct positive effect on Sustainability Performance** (path = 0.230). Although smaller than the indirect paths, this direct effect highlights that embedding sustainability into HR systems—through green training, evaluation, and rewards—provides immediate performance benefits. These outcomes include improved environmental compliance, enhanced social responsibility, and increased operational efficiency. The analysis further reveals that both mediators—GI and EGB—play significant roles in shaping sustainability outcomes.

Green Innovation exhibits a positive and significant impact on sustainability performance (path = 0.380), demonstrating that eco-efficient technologies and optimized processes are essential for reducing environmental harm while maintaining operational effectiveness. This aligns with the broader literature emphasizing innovation as a strategic mechanism for achieving environmental and economic balance in high-emission industries. Employees' Green Behavior also positively influences sustainability performance (path = 0.289). As employees are responsible for the daily execution of environmental practices—such as waste handling, energy conservation, and adherence to environmental SOPs their pro-environmental behavior becomes the behavioral foundation of sustainability success. In the PLTU context, where operational precision directly affects pollution and resource consumption, this relationship becomes particularly salient. The mediation analysis strengthens these observations. Green Innovation partially mediates the influence of GHRM on sustainability performance, showing that HR-driven environmental alignment translates into technological and process-based improvements that enhance sustainability outcomes. Likewise, Employees' Green Behavior emerges as a significant partial mediator, demonstrating that behavioral alignment acts as the human pathway through which green HR systems deliver sustainable performance. Taken together, these findings underscore that sustainability performance in PLTU companies is shaped by a combination of strategic HR practices, innovation capability, and pro-environmental behavior. GHRM serves as the central mechanism that integrates these elements, enabling organizations to transition from compliance-driven environmental management toward proactive sustainability strategies.

IV. CONCLUSION

This study concludes that Green Human Resource Management (GHRM) plays a pivotal role in enhancing sustainability performance within coal-fired power plant (PLTU) companies in Indonesia. All seven hypotheses were empirically supported, demonstrating both direct and indirect pathways through

which GHRM contributes to environmental, social, and economic outcomes. The findings confirm that GHRM significantly strengthens Green Innovation (GI) and Employees' Green Behavior (EGB), indicating that environmentally oriented HR practices such as green recruitment, dedicated environmental training, and sustainability-based performance appraisal effectively develop employees' capability and motivation to innovate and act in environmentally responsible ways. These practices foster a stronger sustainability culture, where pro-environmental norms become embedded in daily operations. Beyond these behavioral and innovation outcomes, GHRM is also shown to have a direct positive effect on sustainability performance, reinforcing the strategic role of human capital when aligned with sustainability objectives in high-impact industries. The results further reveal that both GI and EGB independently enhance sustainability performance, suggesting that improvements in technology, operational processes, and employee engagement collectively shape the organization's long-term sustainability achievements. Mediation analysis demonstrates that GI and EGB partially channel the influence of GHRM toward sustainability performance, highlighting innovation and behavior as critical mechanisms through which HR systems generate broader sustainability impacts.

The integration of in-group collectivism within the EGB construct offers additional nuance by showing that culturally embedded collective values strengthen pro-environmental behavior within the Indonesian organizational context. Overall, this research enriches the sustainability management literature by extending the Resource-Based View (RBV) and the Ability–Motivation–Opportunity (AMO) frameworks, illustrating that green-oriented human resource systems function not only as strategic organizational resources but also as catalysts that stimulate innovation and collective environmental engagement. Within a sector characterized by substantial environmental intensity, the findings emphasize that GHRM can serve as a transformative enabler that integrates organizational innovation and employee behavior to enhance sustainable performance. The theoretical implications of the study affirm that green-oriented human capital is a crucial strategic resource within environmentally intensive sectors, and the research sheds light on the multi-level linkages between micro-level employee behavior and macro-level sustainability outcomes. Practically, the results underscore the need for PLTU companies to embed sustainability principles throughout HR processes—recruitment, training, performance evaluation, and employee involvement to cultivate a green organizational culture that supports innovation and operational sustainability. For policymakers, the findings highlight the importance of developing supportive regulations, incentives, and cross-sector collaborations that encourage the adoption of GHRM and green innovation in the energy industry, thereby accelerating the transition toward sustainable energy practices in Indonesia.

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