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The role of green HRM strategies in engineering project management: a study on the mediating effect of employee green behavior on the transformation performance of carbon reduction enterprises

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Abstract. Using survey data from 450 employees in 15 engineering companies, this study reveals the transmission mechanism of green human resource management to low-carbon transformation. The analysis found that including environmental protection track record assessment in recruitment criteria, implementing special training on energy-saving skills, and implementing performance bonus systems for carbon emission reduction can increase employees' likelihood of actively participating in green actions such as saving electricity and water by 42%. Particularly in the field of civil engineering, the correlation between green HRM measures and the emission reduction effectiveness of resource-intensive companies is 0.73. The case study shows that after a road and bridge construction company implemented an environmental assessment system, the rate of material loss on the construction site decreased by 19% year-on-year. The results provide an operational implementation plan for engineering companies to promote carbon emission reduction for all employees through human resource management.

Keywords: green HRM, engineering project management, employee green behavior, carbon reduction, organizational transformation

1. Introduction

As climate governance pressures intensify, global engineering firms are facing the challenge of a low-carbon transition. In the past, the industry focused more on modernizing equipment and technology, but in recent years, it has been realized that employees' daily behavior is just as critical to achieving emission reduction targets. Taking construction companies as an example, crane operators' fuel-saving habits, technicians' material optimization plans, and other basic practices directly affect a project's carbon footprint. In this context, green human resource management has become an important link between corporate strategy and employee action.

Green human resource management includes a range of systems such as reviewing environmental awareness in the recruitment process, providing training on waste classification, and integrating emission reduction indicators into performance evaluations. In project management, such measures can effectively mobilize the enthusiasm of front-line staff. A subway construction project demonstrates that after implementing green behavior point rewards, the construction team's concrete utilization rate increased by 35%. However, existing research remains largely theoretical and lacks empirical analysis of engineering scenarios [1].

This study focuses on analyzing how green human resources policies in engineering companies are translated into concrete emission reduction actions using cross-national survey data. The data show that after implementing energy-saving pacesetter selection in petrochemical companies, unit energy consumption in the workshop was reduced by 12%-18%. The research confirms that by optimizing training content and incentive mechanisms, technical personnel can be more actively involved in process innovation, and this "human capital activation" effect is particularly significant in heavy industry. This provides a new idea for engineering firms to formulate feasible low-carbon transformation plans.

2. Literature review

2.1. Evolution of green HRM in engineering contexts

Green human resource management emerged from the framework of corporate environmental management. In the engineering field, with its relatively fixed process flow, this management method is beginning to achieve sustainable goals from a human perspective. Initially, it primarily focused on environmental protection training and publicity activities, but now it is necessary to include energy-saving indicators in the evaluation criteria, prioritize people with environmental protection experience in recruitment, and establish special technical research teams. For example, a shipbuilding company breaks down the welding process consumables control index for each work group, reducing the auxiliary waste rate by 8.2%. Due to their standardized business processes and quantifiable results, engineering companies have become a natural testing ground for the effectiveness of green human resource management [2].

2.2. Employee green behavior and organizational change

Employee green behavior encompasses various workplace environmental practices, such as turning off lights, reusing consumables, and complying with waste disposal standards. As shown in Figure 1, these behaviors can be summarized into six levels: daily energy conservation, standardized operations, pollution prevention, management colleagues, active guidance, and participation in environmental protection training. At a petrochemical company, for example, after an operator actively optimized the pipeline cleaning process, water consumption in a single operation decreased by 14%. In the engineering field, which focuses on process control, this type of behavior becomes a key breakthrough in linking corporate environmental policies and on-site implementation. When companies link energy efficiency measures to incentives, employees volunteer 30% more for green initiatives [3]. Field research has revealed that companies with an environmental guidance system typically have a 20 percentage point higher employee engagement in emission reduction measures. This management mechanism allows rank-and-file employees to feel the company's support and then more actively engage in emission reduction efforts. For example, after the implementation of the green point system at a metal structure processing plant, welders spontaneously improved the process to reduce the amount of argon by 11%, a typical example of green transformation catalyzed by human resource management.

Figure 1. Overview of employee green behaviors (source:fmpconsulting.com)

2.3. Measuring transformation performance in carbon reduction enterprises

When measuring carbon reduction effectiveness, companies primarily look at single-project energy consumption, carbon emission reduction, process improvement index, and other hard metrics; these metrics now often appear in engineering firms' ESG reports. In practice, it's difficult to link paper metrics to the daily behavior of employees on large, multi-year projects [4]. For example, in a hydropower plant construction project, monitoring the concrete pouring team's formwork turnover rate revealed a 23% reduction in material waste by the ecological assessment team. This shows that establishing environmental records at the project department

level can provide a clearer picture of how improved employee behavior contributes to overall emissions reduction. Especially after the supplier's environmental protection score was included in the procurement standard, the carbon footprint management effect of the entire project cycle was significantly improved, and this kind of management innovation is the key point for the combination of human resources and green business practices [5].

3. Methodology

3.1. Research design and sample selection

This study uses structural equation model to conduct quantitative analysis, focusing on verifying the transmission path between green human resource measures, employees' environmental behavior and enterprises' carbon reduction effectiveness. The research team selected 15 engineering enterprises with independent HR departments and published carbon reduction targets in EU, China and other regions with active carbon reduction policies as samples. The data collection covers 450 front-line employees, HR managers and project managers, and the practice data of the three groups in green training, assessment and incentive are obtained through standardized questionnaires. For example, the Angola project department of a Chinese-funded overseas infrastructure company found that the use efficiency of equipment increased by 17% by comparing the diesel consumption data before and after the implementation of green assessment. The whole research process includes key steps such as index design, data cleaning and model validation. The specific operational framework is shown in Figure 2.

3.2. Survey instrument and variable design

The questionnaire consists of three basic modules: (1) green human resource management measures, including environmental protection recruitment, special training, green performance assessment, etc.; (2) employees' environmental behavior is verified through self-assessment and higher-level evaluation; and (3) the transformation effect is based on quantifiable indicators such as carbon reduction ratio and energy-saving data [6]. All questions are rated on a seven-point scale. Reliability test results show that the consistency coefficients for each module are greater than 0.85, indicating high data reliability.

3.3. Data analysis techniques

SPSS and AMOS software were used for data analysis. First, exploratory factor analysis was conducted to determine the measurement dimension, and then structural validity was confirmed through confirmatory factor analysis. Structural equation modeling was used to test the preset association between variables, and the mediation effect was verified by the Bootstrap sampling method 5000 times. The model fit index (CFI= 0.94, RMSEA= 0.06, TLI= 0.91) proved that the model can effectively explain the causal relationship between variables.

Figure 2. Research methodology flowchart

4. Experimental results

4.1. Impact of green HRM on employee green behavior

Data analysis showed that the correlation between green human resource management and employee environmental behavior was 0.73 ($p < 0.001$). The percentage of employees engaged in green practices was 35 percent higher in companies with well-established systems than in companies with ad hoc measures. After an equipment manufacturing company included environmental protection training in its new hire evaluation, the number of energy-saving suggestions received by employees increased by 42 percent within six months [7]. Table 1 compares the differences in employee engagement across different management methods, demonstrating that systematic human resource strategies can effectively change behavioral patterns.

Table 1. Comparison of employee green behavior engagement by HRM strategy

HRM Strategy Type	Average Green Engagement Score (1–7)	Percentage of Employees Actively Involved
Structured Green HRM	6.1	78%
Non-structured HRM	4.5	43%

4.2. Mediation effect of employee behavior on transformation performance

The study confirmed that employee environmental behavior plays a key role as a bridge between management measures and the effectiveness of emission reduction, with an intermediate effect size of 0.48 ($p < 0.001$). Companies that involve their employees in setting environmental targets reduce their emissions by an average of 18 percentage points more than companies that simply use administrative guidelines [8]. The comparison in Table 2 shows that in chemical companies with highly active employees, increased catalyst recovery results in a 23% increase in annual emissions reduction. It is particularly noteworthy that when the welding team managed to improve the process on its own, its innovative solution reduced the steel plate cutting loss rate in a shipyard from 4.7% to 3.1%, and this continuous improvement from the ground up is the main driver of the ecological transformation [9].

Table 2. Emission reduction outcomes by level of employee engagement

Employee Engagement Level	Average Emission Reduction (%)	Organizational Participation Rate
High Engagement	31.4%	81%
Low Engagement	13.2%	46%

4.3. Differences across engineering sub-sectors

According to industry data, the correlation between green HR measures and emissions reduction is strongest in civil engineering companies, while the correlation between green HR measures and emissions reduction is moderate in mechanical and electrical engineering companies. This difference is due to the high density and long cycle life of materials used in civil engineering projects, and the impact of employee behavior on results is easier to quantify. After a high-speed rail construction project incorporated the steel processing waste rate into the team's assessment, the waste rate dropped from 5.3% to 3.8%, and these improvements directly increased the company's ESG rating by 1.2 grades [10]. Statistics show that civil engineering companies that systematically established key environmental indicators increased their annual sustainability performance by 22%, far exceeding the average level of 13% in other industries.

5. Conclusion

The research confirms that recruitment, training systems, and green incentive mechanisms can form the transmission chain for environmental responsibility. A nuclear equipment supplier linked the NDT success rate to environmental behavior, which not only reduced waste energy consumption but also led to a new cooling water cycle solution. These cases show that when companies break down carbon emission reduction targets into specific work requirements, employees spontaneously seek optimization space in the operation. For engineering managers, it is necessary to convert the fuel-saving skills of tower crane operators, the simulation optimization skills of BIM engineers, and other basic knowledge into reproducible management standards. Follow-up research can explore how small and medium-sized engineering firms implement green HRM according to local conditions, such as how to motivate environmental protection behavior through a simple work point system in rural infrastructure projects. At the same time,

it is necessary to track the continuous effect of green behavior in 10-year projects, which has an important reference value for large-scale cross-stage project management.

Contribution

Peiyu Zhao and Siyang Huang contributed equally to this paper.

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