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Green Human Resource Management and Renewable Energy Adoption in Manufacturing Firms: The Mediating Role of Organisational Environmental Commitment

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ABSTRACT

To enable the use of renewable energy, organisational support is needed. This paper explores the connection between green human resource management and adoption of renewable energy in manufacturing companies in Bangladesh with organisational environmental commitment as an intermediary. It features 370 respondents and differentiates between green recruitment and selection, green training and development, and green performance management and rewards. PLS-SEM measures the measurement and structural models. According to bootstrap inference of this analysis, 10,000 valid replications are used. Each of the 7 hypotheses is supported. The coefficients of the environmental commitment are the highest with green training and development next, then there is green performance management, and rewards next and finally the green recruitment and selection. The adoption of renewable energy is positively linked with environmental commitment. The mediation of recruitment is complementary whereas training and performance management is indirect-only. The model accounts 27.96% and 29.35% of the variation of environmental commitment and adoption respectively. The repeated cross-validation gives positive predictive relevance on all of the endogenous indicators and it reduces prediction errors as compared to the linear benchmark. The results place environmental commitment as an organisational process connecting practices that relate human resources and adoption of renewable energy. When using renewable energy to achieve renewable energy goals, manufacturing managers need to align capabilities of employees, environmental responsibility, and long-term management dedication. Cross-sectional relationships should be approached with care and further longitudinal studies are needed.

INTRODUCTION

The organisational challenge that manufacturing firms have to deal with is on how to integrate renewable energy in existing operations. In energy supply, issues of investment appraisal, production continuity, technical compatibility and accountability to perform continuously are being pursued (Ren & Hussain, 2022). The human resource practices affect the employees who analyze such decisions and run the systems that they bring about. Recruiting identifies expertise available. The knowledge to utilize the energy technologies is developed through training. Performance assessment determines what contributions to the environment an organisation pays attention to. The knowledge of these practices can be used to explain why the implementation of renewable energy varies.

The implementation of renewable energy is not just a ratification of investment proposal. Adoption incorporates adopted solutions, daily use, and inclusion of renewable sources as part of operational supply, and continued dependence on renewable sources. A manufacturing company can be very vocal about the environmental intentions and have minimal adoption in operations. On the other hand, a company could install a small system of the renewable type without inculcating the environmental concerns into the whole workforce (N.

U. Khan *et al.*, 2021). These opportunities render the interaction of the human resource management with the adoption of energy an empirical issue. Official policies and energy arrangements put in place, as well as environmental intentions, need to be discussed separately. Green human resource management looks at how the environment is integrated in the management of the employees. This paper identifies three areas namely, green recruitment and selection, green training and development, and green performance management and rewards (Chreif & Farmanesh, 2022). The dimensions focus on various organisational functions. Recruitment deals with the environmental capabilities that will be taken into account when the employees join the firm. Training concerns learning. Performance management and rewards relate to the determination and appreciation of environmental contributions. Analysis of the dimensions independently will allow evaluating their respective associations with environmental commitment and adoption of renewable energy.

The proposed mechanism of mediation is organisational environmental commitment. Commitment means long term organisational commitment towards the environment that is manifested in the priorities of managerial efforts, the perseverance effort, and consideration of environmental factors in key decision-

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making (Malik *et al.*, 2021). Employees can still have the appropriate skills without managerial assistance of how the skills can be applied. Performance targets can also not work when actions of the environment objectives are not given much focus in the investment decisions. Employee Management practices can be linked with a wider organisational readiness to adopt and continue with renewable energy solutions through commitment.

Bangladesh provides the geographical setting of the analysed respondent sample. The sample consists of manufacturing organisations which are representative of Dhaka, Gazipur, Narayanganj, Chattogram, Cumilla and Khulna. It also incorporates a number of manufacturing industries, ownership classes, and employee numbers. The diversity enables the model to study relations within a diverse range of organisational situations (Ogbeibu *et al.*, 2024). The sample is also characterized in terms of its geographical and sectoral distribution as opposed to the population in national manufacturing. These respondent frequencies cannot be used to infer national adoption rates and a documented probability sampling design is required.

The key research question is based on the organisational channel through which the adoption of renewable energy is correlated with green human resource practices. The absence of a differentiated human resource measure would mask the nature in which recruitment, training and performance management are being executed in the same manner (Hayyat *et al.*, 2023). The presence of only direct relationships in a model would also miss environmental commitment as a potential intervening construct. The current analysis deals with both by estimating the independent dimensions of practice and keeping their direct links with adoption and the suggested mediator pathways.

The research is guided by three objectives. The first one is to look at the correlations of each of the green human resource dimensions with the organisational environmental commitment. The second one is to determine the connections between environmental commitment and adoption of renewable energy (Kitsis & Chen, 2023). The third will be to determine the existence of commitment in mediating the three human resource dimensions and adoption. These aims will help answer two research questions: what are the relationships between different green human resource practices and organisational environmental commitment, and what is the organisational environmental commitment explaining their relationships with adoption of renewable energy?

The research adds an empirically distinguished interpretation of human resource aspect of adoption of renewable energy. It tests seven hypotheses based on 370 analysed observations and presents measurement quality, structural relationships, mediation, explanatory power and prediction (Yue *et al.*, 2023). The contribution relates to the trend of associations and not evidence of causality over time. Recruitment maintains another direct relationship with adoption and the training

and performance management have a predominantly commitment relationship within the outlined model. This difference has a bearing on how the environmental management of employees and manufacturing energy is coordinated.

Conceptual Background and Hypothesis Development

Green human resource management in manufacturing

The manufacturing processes are based on specialised tasks that rest in managerial and operational functions. Procurement decision, use of equipment, maintenance, production scheduling and employee behaviour can influence environmental performance (Molina-Azorin *et al.*, 2021). Human resource management determines who does what and how the performance and competence are evaluated. Green human resource management uses environmental expectations in these processes. The extent to which it is applicable to renewable energy adoption is in the organisational environment established on assessing, implementing, and regularly employing the energy solutions (Ahmad *et al.*, 2023).

The three dimensions in this issue create interconnected, yet differentiable practices. Recruitment and selection find employees having the capacity to assist environmental needs. Training and development enhance knowledge of existing employees on the environmental procedures and technologies. Continued focus of environmental contributions is given through performance management and rewards (Sharma, 2023). These dimensions can support each other, yet their statistical distinctness can show the relationships between each one and consider the other practices. This is because it does not presume that every employee management activity in the environment has the same organisational implications.

Organisational routines can also be thought of as environmental practices (Aftab *et al.*, 2023). Recruitment policy, training initiative, and performance evaluation processes create recurrent anticipations as opposed to environmental statements in solitude. When these routines are regularly focusing on the environmental responsibility, employees get a better picture on what is of importance to the organization (Shoaib *et al.*, 2021). Consistency applies since the renewable energy projects might need interdepartmental collaboration and sustained post-installation care. Whether these employee management routines are reflected on broader decisions and sustained over time, a commitment to environmental values can indicate the environmental commitment of a firm.

Green recruitment and selection

Green recruitment and selection apply environmental factors to job descriptions, candidate evaluation and hiring risks where the considerations apply to the job (A. H. Khan, 2020). Not all employees have to have specialist energy expertise to be recruited through environmental

recruitment. It will make the firm determine which functions influence environmental consequences as well as to assess respective capabilities (Qiao *et al.*, 2022). Questionnaire qualifies the environmental requirements based on role relevance. The method acknowledges distinctions between technical jobs, managerial, and jobs that have less overall leverage over the use of organisational energy.

Environmental commitment can be enhanced by recruitment, as part of the workforce is formed, and priorities are outlined when entering the work (Nureen *et al.*, 2023). Those employees who were hired with the partial consideration of environmental awareness might consider the issue of the environment when making regular decisions. Environmental job descriptions can also set expectations that can remain in place after appointment (Zhao *et al.*, 2020). Where recruitment practices always consider advancing environmental input, the company could have a better organisational foundation to make the protection of the environment a permanent agent. The anticipated correlation is the consistency of organisational commitment to environmental goals and practice of hiring.

Recruitment can also be tied to adoption via channels which do not require to be based solely on quantified commitment (Chen & Wu, 2022). An organization that employs engineers with the appropriate technical skills might gain experience in energy testing, equipment-systems, or supplier-testing. Such capabilities may assist implementation even in the circumstances when there is general environmental commitment at par (Parida *et al.*, 2023). Based on this, direct recruitment-to-adoption path is a structural model requirement, which has to be considered in mediation evaluation. The formal hypothesis however deals with the positive association of recruitment with environmental commitment; the extra path however assists in differentiating the type of mediation.

H1 suggests that green recruitment and selection have a positive impact on organisational environmental commitment within manufacturing organisations (Mahi Uddin, 2022). The directional theoretical proposition is expressed in the term influence. The level of empirical support is determined by the estimated association in the structural model. Since the observations do not provide a temporal order, a supported hypothesis does not show that a shift in recruitment procedures would lead to commitment growth in isolation (Liu & Zhang, 2022). Conceptual expectation and the limit of evidence are thus both held in the interpretation of the results.

Green training and development

Green training and development relate to learning by employees that promotes environmentally responsible work (Liu & Zhang, 2022). The tool consists of environmental responsibility training, unwarranted energy expenditure, cleaner technologies and renewable energy as well as revised procedures. These products

nab a broad organisational learning orientation having a given energy constituent (Qadeer, 2023). Uncertainty on environmental tasks can be minimized through training and enhance practical understanding that is required to adopt the environmental policies in practice. It also can make accountable the tasks that would otherwise be abstract in written organisational statements.

Commitment can be enhanced by training as environmental goals can be made more familiar and feasible (Malik *et al.*, 2020). When aware of procedures, employees can find the improvements that are relevant and clarify the managerial requirements about operations. On-going learning is also able to maintain attention since technologies, equipment and organisational priorities vary (K. Khan *et al.*, 2022). A company that has a history of investing in environmental education sends the message that environmental concerns are worth time and resources. Such communication can help to create an impression that environmental protection is an organisational continuous priority and not a momentary management fad.

H2, the hypothesis, is that green training and development has a positive effect on the organisational environmental commitment of manufacturing companies (Wiredu *et al.*, 2023). The anticipated direction indicates the role played by learning activities in the common environmental agendas. The quality of training, intensity of participation and subsequent application might be different across firms, but the instrument observes the more general existence of environmental training practices (Alenzi *et al.*, 2023). The analysis thus assesses the linkage between such practices and commitment without stating to establish the repercussions of a specific training programme or a fixed amount of training hours.

Green performance management and rewards

The green performance management and rewards involve the addition of environmental responsibility into the employee evaluation, targets, performance recognition and reward (Dian *et al.*, 2022). The practices help bring environmental expectations into the limelight in the normal management practices. The criteria used to evaluate employee work may enable them to determine the significance of environmental goals. The environmental contributions can also be recognized so that continuing attention to the tasks that will not necessarily lead to higher production level can be supported (Lee, 2020). The questionnaire measures the organisational existence of these practices and not the value of the money of individual rewards.

The commitment could be enhanced by environmental performance assessment connecting the proclaimed goals to responsibility (Vázquez-Brust *et al.*, 2023). With environmental targets in the appropriate employee evaluations, a company would have a clearer connection between the environment and organisational performance. That relationship can be reinforced by recognition and rewards when contributions to the environmental

objectives are recognized. The anticipated process is the stability of organisational attention (He *et al.*, 2023). There should be a greater degree of environmental commitment in which the management periodically reviews and appreciates the environmental contributions through set up employee management processes.

The difficulties may be experienced when poorly defined targets are used or incentives are used to motivate limited compliance (Ren & Hussain, 2022). Employees can focus on the activities which can be easily measured and unaddressed environmental decisions which are more rigorous. General recognition can be of limited impact as well when investment decisions overlook environmental goals (N. U. Khan *et al.*, 2021). These possibilities justify incorporation of organisational environmental commitment as a mediator. The model looks at the relationship between performance management and reward practice and adoption based on a larger commitment that goes beyond the individual appraisal processes.

H3 hypothesises that green performance management and rewards have positive effects towards environmental commitment of the organisation in manufacturing companies (Chreif & Farmanesh, 2022). This hypothesis involves the aggregate dimension that is given by the four indicators. The analysis will not be able to separate recognition and financial incentives or even identify the contribution of individual appraisal criteria. A positive coefficient shows that there is a stronger linkage between stronger reported practices and stronger commitment even after taking into consideration recruitment and training (Malik *et al.*, 2021). It does not ascertain that all types of environmental incentives will yield identical organisational response.

Organisational environmental commitment and energy adoption

Organisational environmental commitment demonstrates the role of environmental protection in the organisational priorities and decisions (Ogbeibu *et al.*, 2024). Its indicators touch on priority at the core, commitment of the senior manager when extra effort is needed, taking into account the environment in critical decisions, and continuous enhancement. The issue of commitment is not just limited to the presence of a written environmental policy. A policy can be used to express expectations in a formal manner and commitment can be used to explain whether the different expectations can be used to direct the organisational behaviour or not (Hayyat *et al.*, 2023). This is the key difference in understanding the deployed adoption of renewable energy.

The implementation of renewable energy presents decisions that may influence the operational structures and allocation of resources (Kitsis & Chen, 2023). The long-term environmental commitment can help in these decisions by ensuring environmental goals remain pertinent as conflicting organisational demands take place. Cooperation among managers in charge of employees,

production and energy systems can also be encouraged through commitment. These are the mechanisms that give a conceptual foundation to anticipate a positive relationship with adopted implementation (Yue *et al.*, 2023). The research variable is perceived organisational adoption as opposed to audited generation capacity, cost of installed system, and separately validated volumes of energy procurement.

H4 suggests that the organisational environmental commitment has a positive relationship with renewable energy adoption in manufacturing companies (Molina-Azorin *et al.*, 2021). The theoretical direction believes in the long-term priorities which encourage implementation and long-term usage. There is also a possibility of an alternative sequence: Companies that already make use of renewable energy can get closer to the creation of a stronger environmental commitment via experience. The cross-sectional analysis does not show a definite distinction between these sequences (Ahmad *et al.*, 2023). The hypothesis thus gives the given direction of the model evaluation whereas the discussion considers the coefficient as an association that fits the direction.

Mediating relationships and conceptual framework

Mediation assesses the possibility of the relationships between green human resource practices and adoption to have an indirect element via commitment. The recruitment could bring environmental consciousness and skills that empower organisational commitments (Sharma, 2023). Training has the potential to change environmental goals into interpretations of duties and work-related experience. Those goals can be reinforced by performance management via evaluation and recognition. It seems that commitment is likely to bridge the gap between these different practices and the organisational adoption of renewable energy (Aftab *et al.*, 2023). The suggested mechanism is common, with the strength of each indirect relationship possibly varying.

H5: The organisational environmental commitment hypothesises that there is a positive indirect correlation between green recruitment and selection and renewable energy adoption (Shoaib *et al.*, 2021). Green training and development have the positive indirect relationship postulated in H6. H7 hypothesizes the positive indirect association between green performance management and rewards (A. H. Khan, 2020). The hypotheses test a particular pathway in place of a cumulative indirect impact of all human resource practices. This difference allows an evaluation of the presence of commitment that is consistent on the three dimensions.

The theoretical framework has five constructs and seven structural paths (Qiao *et al.*, 2022). Each of the following predicts commitment: recruitment, training, and performance management. Commitment predicts adoption. The three human resource dimensions are also the predictors of adoption that can be used to allow mediation classification. There are seven hypothesised relationships, four directed and three indirect (Nureen

et al., 2023). The extra direct paths are estimated to be analytically complete, and are not allocated any extra hypothesis numbers. This specification maintains the original hypothesis form and does not make a restrictive assumption that mediation should not have direct relationships.

The joint pattern of indirect and direct coefficients is used to classify mediations (Zhao *et al.*, 2020). A positive significant direct relationship and positive indirect relationship means that there exists a complementary mediation. The presence of a strong indirect relationship and no direct relationship imply that the mediation is indirect but not direct in the estimated model (Chen & Wu, 2022). The latter category does not indicate that the direct relationship is actually zero in the population. It shows that the available analysis shows the supporting component mediated without a further direct component at the reported inferential threshold.

MATERIALS AND METHODS

Research design and analytical scope

In the research, quantitative organisational survey framework, partial least squares structural equation modelling are used. The analysis is about relationships among five constructs which are measured using managerial reports (Parida *et al.*, 2023). The respondent represents the unit of the manufacturing firm or manufacturing unit to which the questionnaire is covering. The unit of analysis observed in the sample analysed is the respondent record. These units should be distinguished in that the results available are not recorded as to whether each respondent is a different firm. On that note, the sample will be referred to as 370 respondents as opposed to 370 verified and independent manufacturing companies.

The design measures the targeted explanatory relationships and their predictive abilities. It has renewable energy users and respondents that have not used renewable energy currently. The non-users would have to be excluded, which would limit the variation in the result and reduce the capability of the study to investigate the differences in adoption. The source questionnaire clearly advises non-users to respond in terms of the lack of current adoption. Planned projects are not counted as implemented use. This difference determines the desired result and facilitates interpretation of the adoption indicators.

The research sources at hand include the questionnaire specific to the study and the filled analytic tables. Such materials define the constructs measured, respondent profile, model specification, and numerical outcome (Mahi Uddin, 2022). They fail to define this fieldwork period, distribution channel of the surveys, sampling frame, recruitment process, the invitations of a number of invitations and the response rate. The procedures can never be rebuilt based on the sample size analysed. The methodological account thus explains the reported design and analysis without attributing undocumented fieldwork

features and purporting national representative sampling process.

Respondent eligibility and sample characteristics

There are three conditions of eligibility in the questionnaire. The respondents must now be employed in a manufacturing company, a minimum of one year in the particular company and must have adequate knowledge on human resource practices, environmental policies and energy decisions. The following are some of the suitable positions, which are human resource management, sustainability management, operations management, plant management, senior executive responsibilities. The criteria help in informed organisational reporting. The workbook contains full analysed profile distributions, but does not break out separately the screening frequencies or exclusions of each question of eligibility.

The analysis has 370 observations. The respondents will be the representatives of seven manufacturing industries and six destinations in Bangladesh (Liu & Zhang, 2022). The size of workforce varies between less than 50 workers to a minimum of 1,000 workers. It has domestic privates, foreign privates, joint venture and state ownerships. These attributes will give a diverse sample of organisations. They are descriptively used in the given analysis and are not incorporated as the structural control variables in the provided model. Their potential role in the estimated relationships is a problem that still awaits the research.

Measurement instrument

This tool has 21 substantive indicators in five constructs. There are four indicators of recruitment, training, performance management and adoption. There are five of environmental commitment. The responses are in the form of a five-point scale of agreement, which includes strongly disagree to strongly agree. They have another do-not-know option, other than a neutral answer, which is simply termed as missing information. All the substantive indicators reported have 370 valid observations. This makes the measurement tables being analysed complete, but does not indicate whether there was prior processing of records (excluding them) or some other missing-data treatment.

The five constructs are all assessed as reflective measurement blocks in the provided analysis. The indicators are seen as the manifestations of the respective organisational behaviour or state of affairs (Qadeer, 2023). Measurement evaluation involves outer loadings, Cronbach alpha, rho, composite reliability, average variance extracted. The instrument is study specific. Its planning document suggests that it has been expertly planned and pilot tested, yet the materials provided do not define that they were done. No boast of prior instrument validation in the field is therefore made.

Structural estimation and inference

The structural model estimates three predictors or

environment commitment and four predictors of adoption. The model of adoption incorporates dedication and the three human resource dimensions. The direct, indirect, and total relationships reported by bootstrap inference are based on 10,000 valid replications. The workbook provides the coefficients, standard errors, *t* statistics, normal-approximation *p* values and confidence bounds. The interval bounds are recreated as indicated. The source materials do not specify independently their nominal confidence level and interval construction method.

The decisions of hypothesis are based on the direction and confidence intervals reported. The fact that the coefficient is positive and the interval is not zero corroborates the postulated positive association (Malik *et al.*, 2020). When it is necessary, *P* values are presented to three decimals or less than 0.001. The *p* values of the workbook are normal approximations, which are not empirical bootstrap *p* values. Specific indirect coefficients assess each mediation hypothesis. In the classification of complementary and indirect-only mediation, direct and indirect are taken as a whole.

Inner variance inflation factors are used to determine structural collinearity. *R* squared and adjusted *R* squared are used to measure the explanatory performance of commitment and adoption. Effect sizes measure the

value of individual predictors by measuring changes in explained variance in the absence of a predictor. The metric to assess prediction is five repeats of ten-fold cross-validation. The 1,850 prediction records per indicator that results are actually repeated predictions of the 370 observations, and not extra respondents or an external validation sample that is recruited independently.

Ethical provisions and reporting boundaries

A voluntary participation, withdrawal before submitting the questionnaire, confidentiality, and an informed consent statement is presented in the questionnaire (K. Khan *et al.*, 2022). It does not require any personally identifiable data and asks those who do not want to participate to quit. These clauses outline the planned participant safeguards. There is no documentation of an ethics committee decision, completion rates of consent, and implementation history in the available resources. Beyond what is provided in the instrument, there is no claim of ethical approval and completed consent procedures.

RESULTS AND DISCUSSION

Respondent and organisational profile

Table 1 explains the respondents (370) and the organisations they represented. The highest position

Table 1: Respondent and organisational profile

Variable	Category	n	%
Position	HR manager/officer	62	16.76
Position	Operations/production manager	81	21.89
Position	Plant/factory manager	65	17.57
Position	Senior executive/director	84	22.70
Position	Sustainability/environment manager	78	21.08
Tenure	1–3 years	93	25.14
Tenure	4–6 years	94	25.41
Tenure	7–10 years	86	23.24
Tenure	More than 10 years	97	26.22
Sector	Cement and construction materials	62	16.76
Sector	Chemicals and plastics	52	14.05
Sector	Engineering and metal products	48	12.97
Sector	Food and beverages	50	13.51
Sector	Leather and footwear	43	11.62
Sector	Pharmaceuticals	62	16.76
Sector	Textile and apparel	53	14.32
Employees	1,000 or more	61	16.49
Employees	250–499	63	17.03
Employees	50–249	84	22.70
Employees	500–999	77	20.81
Employees	Fewer than 50	85	22.97
Firm Age	11–20 years	89	24.05
Firm Age	5–10 years	104	28.11
Firm Age	Fewer than 5 years	82	22.16

Firm Age	More than 20 years	95	25.68
Ownership	Domestic private	192	51.89
Ownership	Foreign	47	12.70
Ownership	Joint venture	55	14.86
Ownership	State	76	20.54
Location	Chattogram	67	18.11
Location	Cumilla	58	15.68
Location	Dhaka	65	17.57
Location	Gazipur	70	18.92
Location	Khulna	54	14.59
Location	Narayanganj	56	15.14

category is senior executives and directors (22.70%), while operations and production managers (21.89%) are the next highest. Managerial sustainability/environmental managers 21.08%. The plant and factory managers are 17.57% percent and human resource managers and officer's 16.76% percent. The allocation comprises various functions pertaining to environmental staff management and energy choices. It does not equate technical knowledge or reporting accuracy of those functions.

The tenure is shared in the four categories. Those that have served over ten years make up 26.2% and those with four-six years make up 25.41%. The one-three-year group is 25.14% and the seven-to-ten-year group is 23.24. These frequencies suggest that the analysis has both relatively new and more long-serving organisational members. Tenure is a descriptive trait, and the structural

coefficients reported do not take into account length of service disparities.

A sample of 51.89% is under domestic private ownership. The state ownership is 20.54%, joint ventures 14.86 % and foreign ownership 12.70%. The highest location share is in Gazipur, with 18.92%, Chattogram, with 18.11% and Dhaka with 17.57%. The rest of the respondents depict Cumilla, Narayanganj and Khulna. These features are the coverage of observed facts analysed. The respondent proportions do not provide any inference about the relative number of manufacturing firms each location and ownership category.

Environmental policy and renewable energy profile

Table 2 indicates that one out of seven respondents give a written environmental policy, that is 272 respondents. The rest 98 do not have a written policy. The respondents

Table 2: Environmental policy and renewable energy profile

Variable	Category	n	%
Environmental Policy	No	98	26.49
Environmental Policy	Yes	272	73.51
Renewable Energy Use	No	74	20.00
Renewable Energy Use	Yes	296	80.00
Renewable Energy Source	Biogas	53	14.32
Renewable Energy Source	Biomass	52	14.05
Renewable Energy Source	None	74	20.00
Renewable Energy Source	Solar electricity	97	26.22
Renewable Energy Source	Solar thermal	41	11.08
Renewable Energy Source	Verified renewable electricity procurement	53	14.32
Renewable Energy Share	0%	74	20.00
Renewable Energy Share	10–24%	91	24.59
Renewable Energy Share	25–49%	55	14.86
Renewable Energy Share	50–74%	24	6.49
Renewable Energy Share	75–100%	12	3.24
Renewable Energy Share	More than 0% but less than 10%	114	30.81

who are currently using renewable energy stand at 296 or 80.00% and those that do not use the renewable energy stand at 74. These findings suggest high levels

of reported adoption in the sample. The percentages are based on the reports of respondents and cannot be viewed as a national rate of adoption in manufacturing

to use renewable energy sources or a proportion of the use of renewable energy that was audited independently. The largest reported category of source is solar electricity with 26.22%. The shares of biogas and certified renewable electricity purchase are 14.32% and 14.05% respectively; the biomass and solar thermal energy shares are 11.08 and 11.08 respectively. There are no overlapping cases between these categories and the total sample (including the none category). Though the questionnaire allows multiple choices, the table used to analyse the answers has mutually exhaustive frequencies of categories. It is thus considered as the reported source classification instead of full inventory of all the energy sources used by any single organisation.

The adoption breadth is different as opposed to adoption intensity. Another 114 respondents indicate that their

renewable share is greater than zero, but less than 10 percent, and 91 report it is 1024%. These groups make up 55.41% of all respondents. Among the respondents, only 36 who report on the renewable shares, which are at least 50% of the total shares, are 9.73% percent of the entire sample. Therefore, the large percentage of indicating some renewable use are accompanied by large numbers of organisations indicating small amounts of renewable energy input in overall energy usage. The difference informs the interpretation of the adoption construct.

Indicator distributions

All 21 indicators have the descriptive statistics in Table 3. The mean of recruitment is between 3.062 and 3.130, training between 3.151 and 3.216 and performance management between 3.024 to 3.119. Environmental

Table 3: Indicator descriptive statistics

Construct	Item	Mean	SD	Skewness	Excess kurtosis
GRS	GRS1	3.062	1.003	-0.092	-0.521
GRS	GRS2	3.076	0.979	0.004	-0.461
GRS	GRS3	3.103	1.028	-0.101	-0.457
GRS	GRS4	3.130	1.004	-0.181	-0.421
GTD	GTD1	3.184	1.003	-0.051	-0.527
GTD	GTD2	3.151	1.011	-0.023	-0.500
GTD	GTD3	3.216	1.005	-0.186	-0.292
GTD	GTD4	3.184	0.968	-0.158	-0.352
GPR	GPR1	3.097	1.034	0.085	-0.627
GPR	GPR2	3.116	1.054	-0.066	-0.599
GPR	GPR3	3.119	1.103	-0.042	-0.675
GPR	GPR4	3.024	1.058	-0.007	-0.568
OEC	OEC1	3.032	1.014	-0.096	-0.354
OEC	OEC2	3.103	1.018	-0.021	-0.493
OEC	OEC3	3.070	1.095	-0.065	-0.624
OEC	OEC4	3.103	0.999	-0.092	-0.339
OEC	OEC5	3.097	1.039	-0.079	-0.577
REA	REA1	2.897	1.249	-0.181	-0.969
REA	REA2	2.938	1.273	-0.192	-1.001
REA	REA3	2.892	1.277	-0.071	-1.062
REA	REA4	2.968	1.302	-0.213	-1.061

Note: $n = 370$ for every indicator; observed responses range from 1 to 5.

commitment means range from 3.032 to 3.103. These values are in the middle range of the agreement scale. They suggest neither a consistently high organisational commitment nor a uniformly strong implementation of green human resource practices nor moderate average endorsement.

The indicators of renewable adoption have smaller means with 2.892 to 2.968 and larger standard deviation with 1.249 to 1.302. This increased dispersion agrees with a large range of implementation reported and routine use. The fact that the descriptive means do not disagree automatically with the 80.00% reporting a renewable

use is some does not imply a contradiction. Binary use and the extent of agreement with statements regarding integration and ongoing reliance are diverse elements of adoption. Minimal installations may be present in conjunction with a reduced perceived integration of operation.

Each of the indicators is within the response scale of one to five. The skewness reported is relatively small in magnitude with a range of about -0.213 to 0.085 and all excess kurtosis values are negative. These statistics characterize relatively wide distributions of responses with no high observed asymmetry. They fail to define

multivariate normality or completely erase all the distributional issues. The structural interpretation is based on the reported estimation and resampling outcomes instead of considering univariate descriptive statistics to be evidence of distributional sufficiency.

Table 4: Measurement reliability and convergent validity

Construct	Loading range	Alpha	rho_A	CR	AVE
GRS	0.804–0.851	0.852	0.854	0.900	0.692
GTD	0.805–0.849	0.852	0.857	0.900	0.692
GPR	0.821–0.864	0.862	0.876	0.905	0.705
OEC	0.785–0.836	0.873	0.875	0.908	0.663
REA	0.906–0.917	0.934	0.934	0.953	0.834

Note: CR = composite reliability; AVE = average variance extracted. Loading ranges include all retained indicators.

commitment loadings is between 0.785 and 0.836. The loading of adoption is between 0.906 and 0.917. All the indicators are positively and significantly loaded on the required construct. The documented findings justify using all the indicators in the given reflective specification, but the magnitude of loading is not sufficient to prove the substantive completeness of a construct alone.

Cronbach's alpha ranges from 0.852 to 0.934, rho_A from 0.854 to 0.934, and composite reliability from 0.900 to 0.953. Mean variance extracted values are in 0.663 (in environmental commitment) to 0.834 (in adoption). The measurement blocks thus demonstrate significant internal consistency and convergent validity in the traditional assessment criteria. The least extracted variance is 0.331 of commitment, which is still higher than the usual 0.50 cutoff. The indicators have a lot of variances in the respective constructs they measure.

The composite reliability of adoption has a value of 0.953, which should be paid attention to the similarity

Measurement reliability and convergent validity

Table 4 provides indicators and quality of measurement retained. Recruitment loadings range from 0.804 to 0.851, training from 0.805 to 0.849, and performance management from 0.821 to 0.864. The range of

of items. Its indicators are all related to installed, regular, combined renewable utilization and might thus give very similar information. The high internal consistency facilitates reliable measurement in this sample, but it may also indicate limited content coverage (Wiredu *et al.*, 2023). The development of future instruments may explore the idea of whether adoption should further differentiate the technical scope, procurement arrangements, or validated consumption intensity. This extension would need new conceptual plumbing as opposed to mere addition of indicators to further broaden measurements.

Discriminant validity

Table 5 shows heterotrait-monotrait ratios and bootstrap intervals they report. Ratios go as low as 0.102 in recruitment and performance management to 0.570 in commitment and adoption. All the ratios are below the conservative 0.85 level. The upper confidence bound of commitment and adoption is the largest at 0.648, below

Table 5: Discriminant validity

Construct pair	HTMT	Lower bound	Upper bound
GRS–GTD	0.148	0.071	0.268
GRS–GPR	0.102	0.047	0.215
GRS–OEC	0.307	0.199	0.409
GRS–REA	0.311	0.196	0.416
GTD–GPR	0.149	0.074	0.262
GTD–OEC	0.505	0.413	0.587
GTD–REA	0.300	0.193	0.403
GPR–OEC	0.314	0.204	0.421
GPR–REA	0.224	0.117	0.327
OEC–REA	0.570	0.485	0.648

Note: Intervals reproduce the reported bootstrap bounds. The supplied outputs do not specify the nominal confidence level or interval method.

this mark too. The findings justify empirical difference between the five measurement blocks and alleviate the worry that the mediator and outcome are statistically identical within the analysed sample.

The ratio of recruitment to training is 0.148, and the training to performance management is 0.149. Such low

correlations suggest that the three green human resource dimensions cannot be considered to be interchangeable without the need to consider. Training and commitment are more closely related with 0.505 ratio, which is the one with a stronger structural relationship. Discriminant validity however deals with the isolation of constructed

constructs. It does not show the direction of causality of their relationships and the questionnaire does not establish that it measures all the relevant organisational processes.

Structural collinearity

The inflated factors of inner variance in the structural

model are low in Table 6. The commitment equation has a range of values between 1.021 and 1.031. The range of values of the adoption equation is 1.077 to 1.388. These values show minimal indication of significant redundancy of predictors in either equation. Adding the commitment to the three green human resource dimensions do not cause problematic collinearity in the reported assessment.

Table 6: Structural collinearity

Outcome	Predictor	Inner VIF
OEC	GRS	1.021
OEC	GTD	1.031
OEC	GPR	1.023
REA	GRS	1.077
REA	GTD	1.237
REA	GPR	1.084
REA	OEC	1.388

This leads to the fact that high measured overlap between the given predictors does not predominate in the interpretation of coefficients.

Direct relationships

Table 7 supports H1, H2, H3, and H4. The correlation between recruitment and commitment is positively

correlated with a coefficient of 0.200 with a range of 0.112 to 0.287. The commitment coefficient with the largest value is training (0.385), with a range of 0.308 to 0.462. The coefficient of performance management is 0.209 with a range between 0.125 and 0.298. The three reported p values are less than 0.001. Their intervals are non-zero and in accordance with the hypothesised

Table 7: Direct structural relationships

Path	β	SE	t	p	Interval
GRS $\rightarrow$ OEC	0.200	0.045	4.417	<0.001	[0.112, 0.287]
GTD $\rightarrow$ OEC	0.385	0.039	9.810	<0.001	[0.308, 0.462]
GPR $\rightarrow$ OEC	0.209	0.044	4.728	<0.001	[0.125, 0.298]
OEC $\rightarrow$ REA	0.434	0.049	8.934	<0.001	[0.336, 0.529]
GRS $\rightarrow$ REA	0.151	0.049	3.071	0.002	[0.053, 0.246]
GTD $\rightarrow$ REA	0.054	0.052	1.046	0.296	[-0.046, 0.156]
GPR $\rightarrow$ REA	0.065	0.044	1.460	0.144	[-0.020, 0.152]

Note: Intervals reproduce the reported bootstrap bounds. The supplied outputs do not specify the nominal confidence level or interval method.

Note: p values use the normal approximation reported in the workbook; every path has 10,000 valid bootstrap replications

direction.

There is a positive association between adoption and commitment with a coefficient of 0.434, ranging between 0.336 to 0.529. This association favors H4 and is greater than the extra direct coefficients of the human resource dimensions to adoption. Recruitment has a positive direct coefficient of 0.151, $p = 0.002$ and an interval that does not contain zero. The other direct coefficient of training comes out as 0.054 and that of performance management is 0.065. Their intervals are zero and neither of the extra direct relations are supported with inferential support.

The coefficients also show the differences in the estimated model, but fail to provide statistically significant differences in coefficients. The commitment coefficient of training is numerically bigger than the recruitment and performance management coefficients. No formal coefficient comparison or bootstrap contrast are reported

(Alenzi *et al.*, 2023). It is reported that appropriately, training yields the largest coefficient of commitment and not that its relationship is absolutely strong in the population. Such difference makes descriptive ranking not to be an unjustified comparative inference.

Specific indirect relationships

The three hypotheses of mediation are supported by Table 8. The indirect coefficient of recruitment by commitment is 0.087 with a range of 0.046 to 0.132. The indirect coefficient of training is 0.167 with a range of 0.118 to 0.222. The indirect coefficient of performance management is 0.091 with a range of 0.051 to 0.137. Both intervals contain no 0s and all reported p values of normal-approximation are less than 0.001. Dedication hence constitutes a reinforced positive indirect relationship in all human resource dimensions in the indicated model.

Table 8: Specific indirect relationships

Hypothesis and pathway	Indirect β	Interval	Mediation type
H5 GRS $\rightarrow$ OEC $\rightarrow$ REA	0.087	[0.046, 0.132]	Complementary mediation
H6 GTD $\rightarrow$ OEC $\rightarrow$ REA	0.167	[0.118, 0.222]	Indirect-only mediation
H7 GPR $\rightarrow$ OEC $\rightarrow$ REA	0.091	[0.051, 0.137]	Indirect-only mediation

Note: Intervals reproduce the reported bootstrap bounds. The supplied outputs do not specify the nominal confidence level or interval method

The mediation of recruitment is complementary since the indirect and additional direct relations between it are both positive and supported. Training and performance management are indirectly mediated because the indirect relationships are supported, and the intervals between the variables have the zero (Dian *et al.*, 2022). These categories characterize the statistical pattern given the model and sample. Instead, they do not develop a full causal process and negate other intermediaries. Commitment is an empirically valid intervening construct and its temporal location needs more analysis with designs that follow practices and adoption across time.

Total relationships

Table 9 is a combination of all direct and specific indirect relationships with adoption. The total coefficient of recruitment is 0.237, training 0.221 and performance management 0.155. Any reported intervals are non-zero. The total relationships indicate that a dimension may have an overall supported association despite the unsupported additional direct coefficient to the dimension. This trend can be demonstrated through training: the overall coefficient of training is positive since the size of the mediated component is affecting the overall correlation with adoption.

Table 9: Total relationships with adoption

Predictor	Direct β	Indirect β	Total β	Total interval
GRS	0.151	0.087	0.237	[0.139, 0.335]
GTD	0.054	0.167	0.221	[0.129, 0.314]
GPR	0.065	0.091	0.155	[0.065, 0.249]

Note: Intervals reproduce the reported bootstrap bounds. The supplied outputs do not specify the nominal confidence level or interval method

The total coefficient of recruitment is numerically the highest but as far as training is concerned, it has the greatest indirect coefficient. This disparity shows the retained direct attribute of recruitment. The outcome illustrates why one ranking of human resource practices would muddle their respective model paths. There is no statistical test made to determine whether the overall recruitment and training coefficients are different or not. Managerial interpretation must thus also lay stress on the varying constitution of their relationships instead of marking a conclusive ranking of investment priorities based on tiny variations in numbers.

Explanatory performance and effect sizes

Table 10 provides an R squared of 0.280 and 0.293 of commitment and adoption respectively. The adjusted values are 0.274 and 0.286 respectively. It explains about 27.96 and 29.35 of the variance in commitment and adoption respectively in the observations analysed by the model. These values represent significant though unsatisfactory explanations. There is still a lot of variation beyond the outlined human resource and commitment pathways. The adjustment only leads to minor decreases, suggesting that the claimed explanatory value is not purely due to the inclusion of multiple predictors.

Table 10: Explained variance

Outcome	Predictors	n	R ²	Adjusted R ²
OEC	3	370	0.280	0.274
REA	4	370	0.293	0.286

According to Table 11, the effect size of training in the commitment equation is medium with a value of 0.199, and the commitment equation has a medium effect with a value of 0.191. The smaller commitment effects of 0.054 and 0.059 are brought by recruitment and performance management. The adoption effect size of recruitment

is 0.030. The effect of training and performance management has a direct adoption effect value, which is less than 0.01. The findings are consistent with the mediation pattern, which puts the greatest incremental explanatory effects in the training-to-commitment and the commitment-to-adoption relationships.

Table 11: Incremental effect sizes

Path	f ²	Interpretation
GRS $\rightarrow$ OEC	0.054	Small
GTD $\rightarrow$ OEC	0.199	Medium
GPR $\rightarrow$ OEC	0.059	Small

OEI → REA	0.191	Medium
GRS → REA	0.030	Small
GTD → REA	0.003	Below small benchmark
GPR → REA	0.005	Below small benchmark

Predictive assessment

LM = linear model benchmark Table 12 shows the repeat cross-validation findings of the nine endogenous indicators. The predicted values of Q squared are between 0.148 and 0.207 with regard to commitment and between 0.094 and 0.124 with regard to adoption. Each of the values is positive, which is an improvement compared to the mean

prediction benchmark within the given procedure. PLS model has also low root mean squared error compared to the linear benchmark of each indicator. Mean absolute errors are on a downward trend. The test thus gives an indication of predictive usefulness in repeated sample-based validation.

The benchmark advantage is stable, yet small. The

Table 12: Repeated cross validation prediction

Item	Q ² predict	PLS RMSE	LM RMSE	PLS MAE	LM MAE
OEI1	0.148	0.937	0.959	0.741	0.757
OEI2	0.156	0.935	0.950	0.766	0.771
OEI3	0.207	0.976	0.998	0.795	0.811
OEI4	0.186	0.902	0.917	0.723	0.726
OEI5	0.170	0.948	0.964	0.778	0.788
REA1	0.094	1.191	1.211	0.989	1.004
REA2	0.123	1.194	1.211	0.994	1.005
REA3	0.124	1.196	1.215	0.994	1.006
REA4	0.112	1.229	1.248	1.028	1.038

Note: Ten folds, five repeats, and 1,850 prediction records per indicator.

threshold range of root mean squared error differences that favour PLS is approximately 0.014 -0.023 scale units. The errors in the prediction of adoption are still bigger than those in the prediction of commitment, which is in line with the larger indicator dispersion and unexplained variation of adoption. This should not be taken to imply that there is strong prediction of new firms not under the sampling environment (Lee, 2020). It would require external validation and greater documentation of the

inputs to prediction to apply the model to consequential individual organisational forecasts.

Hypothesis summary

Table 13 summarizes evidence in support of the seven hypotheses put forth. The four hypothesised direct relationships are supported and positive, the three specific indirect are also supported and positive. The abstract is

Table 13: Hypothesis decisions

Hypothesis	Relationship	β	Interval	Decision
H1	GRS → OEI	0.200	[0.112, 0.287]	Supported
H2	GTD → OEI	0.385	[0.308, 0.462]	Supported
H3	GPR → OEI	0.209	[0.125, 0.298]	Supported
H4	OEI → REA	0.434	[0.336, 0.529]	Supported
H5	GRS → OEI → REA	0.087	[0.046, 0.132]	Supported
H6	GTD → OEI → REA	0.167	[0.118, 0.222]	Supported
H7	GPR → OEI → REA	0.091	[0.051, 0.137]	Supported

Note: Intervals reproduce the reported bootstrap bounds. The supplied outputs do not specify the nominal confidence level or interval method.

related to the initial hypothesis. The other direct training and performance management avenues are not supported as demonstrated in Table 7. When combined, the findings give credence to the identified commitment mechanism without excluding a unique direct recruitment relationship and significant variation in the adoption of renewable energy that remains unexplained.

Discussion

Environmental commitment as an organisational mechanism

The results put environmental commitment in the focal point of the interrelationship between green human resource practices and adoption of renewable energy. The three dimensions of practice are all related to

commitment and commitment to adoption is added to the practice relationships after the direct practice relationships are considered (Vázquez-Brust *et al.*, 2023). The indirect coefficients supported show that a pattern of employee management and organisational priorities is linked. The given pattern provides a reason of why environmental human resource activity can be important to an organisational energy outcome which is generally discussed in the technical or financial context.

The measure of commitment is the long-term priorities and concern with the environment when making crucial decisions. Its dependence on adoption is thus in line with a process whereby environmental expectations are sustained by the organization (He *et al.*, 2023). Renewable energy plans need to be coordinated and used regularly once they have been first put in use. An organization might require a workforce that can absorb pertinent processes, managers, who can acknowledge the role played by the environment and decision making that does not overlook the environmental goals. The statistical data confirm this combined explanation without the need to observe each of the given organisational actions separately.

The medium incremental effect size of commitment also suggests that commitment adds some information to the three dimensions of human resource (Ren & Hussain, 2022). Nevertheless, the adoption R^2 is less than a third. Loyalty may thus be construed as a part of an incomplete explanatory model. The circumstances of financing, physical appropriateness, work needs and management plan could also play a role but these were not quantified into the provided specification. The potential significance is due to the unresolved variance and conceptual breadth of adoption, not to the coefficients that have been tested in this study.

The prominent training pathway

The reported coefficient of training on commitment is the highest with the highest indirect coefficient on adoption. This trend is in line with learning activities that assist organisations in converting the environmental goals to perceived roles. Training could help to ease the process of environmental procedures and discuss energy alternatives (N. U. Khan *et al.*, 2021). Due to the fact that the instrument has renewable energy and cleaner technology training, its conceptual association to commitment is directly related to energy choices. The finding justifies the focus on environmental learning in human resource systems at manufacturing.

More direct adoption coefficient of training is not justified when the commitment is included in the equation. This implication implies that the relationship between training and adoption is mainly embodied by the quantifiable commitment pathway in the current framework. This does not mean that implementation is irrelevant to training of technical training or that commitment is the only plausible mechanism (Chreif & Farmanesh, 2022). The construct of the training is whether the practices are generally organisational and the outcome of adoption

relies on the decisions that may go further than the learning of the employees. Future studies may investigate the possibility that specialised energy competence is an intervening pathway.

The results do not support the understanding of training participation as adequate evidence of the willingness to adopt. Knowledge can be enhanced in training without ensuring the power of implementation, access of resources and operational acceptability. The mediated relationship in favour indicates that organisational priorities and decision procedures ought to be linked with environmental learning (Malik *et al.*, 2021). This meaning is useful in practice in that it does not consider the presence of training activities as an evaluation but rather whether the training activities contribute to a sustained attention to the environment. Effectiveness in actual programmes would still need evidence on content, participation, learning outcomes and application to organisation thereafter.

Recruitment and the retained direct relationship

The process of recruitment is not the same as the other practice-dimension since both the mediated and supplementary direct adoption relationships are supported. Complementary mediation is an indication that commitment describes part of the recruitment connection and another aspect is there (Ogbeibu *et al.*, 2024). Environmental selection can offer adoption-relevant skills, like relevant awareness or technical know-how. The questionnaire does not refer to the identified capabilities separately, which means that the direct pathway cannot be attributed to a particular skill. It confirms that there is another such association as opposed to the detailed organisational description.

The total coefficient of recruitment is slightly greater than that of training and the indirect coefficient is also less. This combination demonstrates the relative significance of a practice is based on the relationship under consideration. Recruitment can offer a short-term capability connection, and training can be more in line with commitment (Hayyat *et al.*, 2023). These interpretations are conditional as the differences between coefficients have not been formally tested. The results propound joint focus on recruiting and training instead of a preference based on their numeric position.

Performance management and environmental accountability

Commitment shows a positive correlation with performance management and rewards, and there is an indirect relationship between adoption and performance management as well as rewards. The environmental assessment and recognition could be helpful to sustain focus on organisational duties (Kitsis & Chen, 2023). The pattern of indirect-only is in line with accountability of employees encouraging adoption when incorporated in the overall dedication of managers. Individual employee use of appraisal procedures may not be enough when

energy decisions involve the use of resources and power outside the scope of employees. The identified pathway thus bridges the gap between performance systems and the organisational environment in which the decisions on renewable energy are made.

Adoption breadth and integration

The energy profile demonstrates that a large proportion of respondents exhibit renewable usage and the majority of them have renewable shares less than a quarter of their total consumption (Yue *et al.*, 2023). The means of the adoption indicators are also below the midpoint of agreeableness. These findings indicate that presence and organisational integration as reported should be differentiated. A renewable source can be tapped by a firm to only a certain degree, without overstraining it to meet the operational needs of the firm. The construct measures this wider integration aspect, which is why there are different frequencies of binary adoption, and averages of the indicators vary.

The research thus forms part of an organisational consideration of the intensity of adoption but measurements are subjective. Reported energy share categories offer informative context description but do not have an independent validation of the latent construct to real consumption records (Molina-Azorin *et al.*, 2021). Analysis in the future would be able to compare respondent estimates against metered consumption of renewable, recorded procurement and installed capacity. These comparisons would elucidate whether the organisational adoption measure is related well to technical implementation or the managerial perceptions of integration are the main cause.

Implications

Theoretical implications

The model differentiates the organisational roles of recruitment, training, and performance management. Their individual treatment shows various blends of direct and indirect connections that would remain unidentified by a cumulative score in green human resources. The strongest numerically association is between training and commitment and recruitment retains an extra adoption aspect (Ahmad *et al.*, 2023). Environmental commitment is practical because it is a bridging construct, and does not mandate that all practices must be mediated solely. This contribution narrows down the interpretation of the relationship of employee management with the implemented environmental change.

Managerial implications

Decision responsibilities and ongoing organisational priorities should be linked to environmental training by manufacturing managers. The training goals can be defined in terms of how employees implement knowledge to the operational energy needs and discuss technical issues (Aftab *et al.*, 2023). Energy executives should examine how learning processes can provide insights to the real

assessment and execution. These suggestions are based on the endorsed training and dedication route. They do not believe that under all organisational circumstances, a quantifiable growth in renewable energy adoption can be achieved only by additional investment in training.

Environmental competencies pertinent to specific jobs should be recognized in recruitment processes. When necessary, job descriptions can be used to explain environmental assessment responsibility, use of technology, or operating procedures. The criteria used to select should be related to the requirements of the position and not to impose the same criteria of environmental expectations to all applicants (Shoaib *et al.*, 2021). The guiding retained recruitment relationship aids in focusing on workforce capabilities and organisational commitment. A follow-up assessment of whether the chosen competencies are utilized in the eventuality of energy choices as well as whether operational adoption is achieved through those choices should follow.

Performance management ought to set out environmental standards, which employees are able to grasp and impact in a meaningful way. Recognition must be based on the evidence-supported contributions and appraisal should not be based on the employees getting the energy outcomes and lack the corresponding authority (A. H. Khan, 2020). Managerial decisions must also be observable in terms of commitment such as extra effort in cases where environmental goals need greater effort. Such arrangements can enhance congruence between the proclaimed priorities and employee expectations. They need to be evaluated as effective by observable execution and operational performance rather than evaluating them based on formal procedures.

Institutional and policy implications

Organisational capacity can be part of technical assistance in institutions that facilitate manufacturing energy transitions. Relevant workforce knowledge, environmental responsibilities, and managerial commitment and project feasibility, might be tackled in programme design (Qiao *et al.*, 2022). The results give a reason to study these organisational circumstances, but do not analyse a particular public programme or policy intervention. The support mechanisms thus need to be evaluated on pilot basis and recorded results prior to making generalized conclusions about the cost effectiveness or the sector wide impact.

Limitations and Future Research

The cross-sectional design restricts causal inferences and claims of mediation in time. The measurement of recruitment, training, commitment, and adoption takes place within the same level of analysis (Nureen *et al.*, 2023). Common influences and reverse relationships are still possible. The subsequent research must gather observations in various phases that situate the human resource practices prior to the commitment and the following results of adoption. Re-testing might also be able to differentiate

between long-term organisational commitment and short-term reactions to an energy project. This data would be a better platform to review the suggested order.

There exists the possibility of common-source and reporting biases when using the respondent-based approach. Skilled managers can offer valuable data, yet the image can be different between functions and can express a positive organisational image (Zhao *et al.*, 2020). The provided outputs lack a special common-method evaluation or separate verification of the outcomes. Future designs will need to get human resource information with the help of the relevant managers and energy information based on operational records or individual respondents. Consideration among sources would bolster the interpretation of the organisational association and decrease the dependence on one reporting viewpoint.

The materials provided lack sampling and documentation of fieldwork. The sample under analysis is heterogeneous, and it is not possible to determine the probabilities of its selection, the response rate, and the independence on the level of the firm. Several respondents per firm may form a clustering, which may have to be treated differently analytically (Chen & Wu, 2022). The identification of organisations in the future research study must be kept secret; the sampling frame must be described and non-response and recruitment recorded. Such improvements would help to understand whether respondent-level estimates can be used to draw conclusions at the firm level and to what extent the findings will be generalised outside of the sample.

Interpretation is also confined by the scope of measurement (Parida *et al.*, 2023). The instrument will capture overall green practices, commitment, and integration of adoption without directly quantifying financing, suitability in technology, performance of the project, or even length of renewable use. The composite reliability of adoption is high implying strongly correlated indicators. More effort is still needed to measure content coverage and relate the results to known energy records with perceptual adoption. Measurement invariance assessment would also be needed in the interpretation of the group differences in sector comparison. The current aggregated performances do not prove the fact that the same mechanisms work in all manufacturing industries.

Predictive assessment involves repeated cross-validation based on the available observations. The usefulness under that procedure is supported by positive predictive relevance and reduction of benchmark errors but improvements are not very significant (Mahi Uddin, 2022). Future research must consider organisations that are gathered independently and record the information they have at the time of generating the predictions. The outcome models may need to be varied to predict the status of the implementation, renewable share and the continuous operational use. Improved external prediction and conceptual clarity should be used to judge a broader specification as opposed to an increase in explained variance alone.

CONCLUSION

Renewable energy use (through the organisational environmental commitment) is positively linked with green human resource management in the analysed manufacturing sample. Recruitment, training and performance management are positively related to commitment and commitment is positively related to adoption. Recruitment has complementary mediation and training and performance management have indirect-only mediation. The model describes 27.96% of the variance of commitment and 29.35% of the adoption variance and the endogenous indicators are positively predicted. The results affirm integration of environmental employee management and long-term organisational priorities. Renewable use is still differentiated as opposed to extensive operational integration and only part of the adoption variation has been considered in organisational practices. The relationships suggested in the given model are supported with the evidence, whereas the causal interpretation, independence of firms, and the national generalisation are still not determined. More longitudinal and independently validated studies are needed to determine the development of these organisational relationships in the real implementation of renewable energy.

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