International Journal of Social Science and Entrepreneurship ***(IJSSE)*** ***Vol 6, Issue 1***
ISSN (Print): 2790-7716, ISSN (Online): 2790-7724 ***January to March 2026***

Impact of Rooftop Solar Adoption on Employee Performance in Businesses: The Mediating Role of Workplace Sustainability in Pakistan

Muhammad Shehzad
shehzadaewaqt@gmail.com , ***ORCID*** – https://orcid.org/0009-0001-5590-7836

Abstract

Persistent electricity shortages and rapidly rising energy costs have pushed businesses across Pakistan toward rooftop solar photovoltaic systems as a practical alternative to the national grid. While the economic and environmental merits of this transition have received considerable scholarly attention, its implications for employee-level outcomes remain largely unexplored. This study investigates the impact of rooftop solar adoption on employee performance, with workplace sustainability examined as a mediating variable in this relationship. Drawing on Social Exchange Theory, it is argued that organizational investment in renewable energy infrastructure enhances workplace conditions and signals an institutional commitment to sustainability, which employees reciprocate through improved motivation, efficiency, and job satisfaction. A quantitative research design was employed, with primary data gathered from 200 employees working in solar-equipped businesses across major Pakistani cities via a structured, five-point Likert-scale questionnaire distributed through Google Forms. Data were analyzed using SPSS version 24, incorporating reliability analysis, Pearson correlation, and hierarchical regression-based mediation following Baron and Kenny's procedure. The findings confirm that rooftop solar adoption positively and significantly predicts employee performance ($\beta = .671$, $p < .001$) and that workplace sustainability partially mediates this relationship ($R^2 = .612$). All four proposed hypotheses were supported. The study recommends that organizations treat solar adoption as a strategic human capital investment rather than a mere cost-reduction measure, and that policymakers introduce targeted incentives to accelerate uptake among small and medium enterprises. These findings extend the literature on renewable energy, organizational behavior, and sustainable workplaces in the context of energy-constrained developing economies.

Keywords: *Rooftop solar adoption, employee performance, workplace sustainability, renewable energy, Pakistan, Social Exchange Theory*

Introduction

Energy reliability is a critical determinant of organizational productivity and workplace performance. In economies that are in the process of development, unreliable power supply may interfere with the operations of a business, slow down the effectiveness of the workers, and affect the working conditions negatively. Pakistan has been facing a consistent problem of electricity and an escalating energy prices which have posed a major operational problem to businesses operating in different sectors. To counter this, there has been the growing trend by most companies to use rooftop solar photovoltaic (PV) systems as a source of reliable power supply and less reliance on the national power grid. Although the adoption of rooftop solar has mostly been done in economic and environmental perspectives, there has been very little research on its possible effects on employee performance and workplace sustainability. Thus, the research problem is the effect of rooftop solar installation on employee work in companies and the mediating effect of workplace sustainability in the situation of Pakistan.

Pakistan's energy sector has faced chronic structural challenges for decades, including power shortages, infrastructure inefficiencies, and increasing electricity demand. The national electricity deficit is almost 5,800 megawatts in peak summer seasons leading to the introduction of several hours of daily load shedding in urban and rural regions (Ahmadani, 2024). Electricity outages in most areas vary between four and eight hours daily which are crippling and disrupting commercial and industrial activities. Such recurrent energy shortages have demanded high economic prices on the business community. Based on the estimates cited by the World Bank, the cost of power outages to the Pakistani business is estimated at about PKR 570 billion a year in terms of lost production and lost efficiency (Ali, 2024). These disruptions may have direct impacts on the employees in terms of disrupting the working process, lowering the level of productivity, and causing stressful working conditions.

Several studies and industrial surveys highlight the negative impact of unreliable electricity on firm performance and workforce productivity in Pakistan. As an example, a survey by the Pakistan Institute of Development Economics found that 83 percent of engineering companies specified electricity shortages as a key obstacle to achieving production goals, and 78 percent stated that power cuts are a primary hindrance to organizational performance (Haque, 2023). Recurrent outages may stop the work of machines, disorganize digital systems, and minimize the efficiency with which employees can work. These interruptions do not only impact on organizational output but also on the motivation of the employees, job satisfaction and comfort at work. Energy disruptions in labor intensive industries like manufacturing, textiles and small scale businesses may lead to low working hours and job stress among employees. This has seen businesses turn to alternative energy solutions whereby energy would be reliable and at the same time cost less to operate. One of the most viable and the fastest growing renewable energy technologies within the country is the solution referred to as rooftop solar photovoltaic systems.

Pakistan has witnessed an unprecedented surge in rooftop solar adoption in recent years. Electricity tariffs in Pakistan increased by more than 150% between 2021 and 2024, making grid electricity increasingly unaffordable for many commercial and industrial users (World Resources Institute, 2025). National Electric Power Regulatory Authority records that the net-metered rooftop solar capacity rose to more than 1,181 megawatts in 2023-2024, and cumulative installations in 2025 had reached 5.3 gigawatts (REN21, 2025). This fast growth is indicative of an overall shift towards decentralized renewable energy networks driven in large part by domestic and commercial demands to have a consistent source of power (Ilyas, 2023). Moreover, already in 2024, Pakistan imported about 17 gigawatts of solar photovoltaic equipment, and this shows that the investment in solar energy technologies has grown significantly (World Economic Forum, 2025). Such a fast adoption demonstrates the increasing significance of renewable energy solutions in enhancing energy reliability and in economic activity support.

Beyond cost savings and energy security, rooftop solar systems may also influence workplace sustainability and employee well-being. Sustainable workplace practices focus on effective energy consumption, environmental awareness and better working conditions of employees. Constant power flow can enhance comfort in the job environment with adequate lighting, fresh air, and working machines that are considered necessary to keep the workers productive. Sustainable energy practices can also help improve the perceptions of employees to their organizations regarding their responsibility and commitment to the environment, which may improve job satisfaction and self-motivation. It is in this regard that workplace sustainability might be a mediating variable that makes the use of rooftop solar have an impact on the performance of employees.

Problem statement

Businesses operating in developing economies increasingly face operational challenges due to unreliable electricity supply and rising energy costs. Power shortages and energy outages interfere with the production processes, lower the working efficiency, and have detrimental effects on the productivity of the employees and working performance. Empirical data have indicated that power limitations have a large negative impact on the productivity of firms, and exposed firms have a productivity level that is likely to be about 11 percent lower than the productivity of firms with stable access to electricity (Zhang et al., 2024). Most organizations are responding to this by considering renewable energy technologies, especially rooftop solar power systems, to guarantee the reliability of energy and the continuation of the business. The use of renewable energy has also been linked with better performance of firms, cost-effectiveness, and sustainability in operations of various industries (Sitompul et al., 2024). In addition, investments in green infrastructure have been identified to enhance the productivity of firms due to better working conditions and efficiency in the activities that take place at their workplaces (Li et al., 2025). In spite of these possible advantages, a lot of businesses, and especially the ones that are in developing countries, still face the challenge of ensuring a sustainable workplace that can facilitate the performance of employees. This underscores the practical importance of knowing how the implementation of renewable

energy sources like rooftop solar systems can impact on workplace sustainability and organizational employee performance.

Although prior research has examined renewable energy adoption and firm performance, the relationship between decentralized solar energy systems and employee-level outcomes remains underexplored. The research that is currently available is mainly concerned with macroeconomic effects, energy efficiency, or productivity of individual firms, and little has been done to examine how renewable energy technologies affect the performance of employees based on the sustainability mechanisms in the workplace (Yin et al., 2024). Moreover, the recent literature underlines that additional empirical studies regarding the association between environmental sustainability practices and micro or employee level labor productivity and organizational performance are needed (Alsulami and Raza, 2025). This absence of empirical data is specially noticeable in the developing economies in which the reliability of the energy is a direct influence on the working conditions. Hence, there is a substantial research gap in the comprehension of whether the use of rooftop solar enhances the performance of employees and the role of sustainability of the workplace in mediating the specified correlation. Filling this gap will be crucial to further research of sustainable business practices and renewable energy adoption and offer practical information to business aimed at enhancing productivity of workforce by identifying sustainable energy solutions.

Research questions

1. Does rooftop solar adoption in businesses significantly influence employee performance in Pakistan?
2. Does workplace sustainability mediate the relationship between rooftop solar adoption and employee performance in businesses?

Research Objectives

1. To examine the impact of rooftop solar adoption on employee performance in businesses in Pakistan.
2. To investigate the mediating role of workplace sustainability in the relationship between rooftop solar adoption and employee performance.

Significance of Study

This study contributes to the growing literature in Energy Economics, Sustainability Science, and Organizational Behavior by examining how renewable energy adoption at the organizational level can influence employee outcomes. While previous research has primarily focused on the economic and environmental benefits of solar energy adoption, limited attention has been given to its potential impact on workplace conditions and employee performance. By investigating the mediating role of workplace sustainability, this research provides a deeper understanding of how sustainable energy practices can improve workplace environments and employee productivity. Practically, the findings of this study will be valuable for business managers, policymakers, and

sustainability practitioners in Pakistan. The results can help organizations understand the broader organizational benefits of investing in rooftop solar systems beyond energy cost savings. Additionally, the study can support policy initiatives aimed at promoting renewable energy adoption within the business sector to enhance sustainable workplaces and improve workforce performance in energy-constrained economies.

Literature Review

This section reviews the existing scholarly literature relevant to the relationship between rooftop solar adoption, workplace sustainability, and employee performance. This review aims at synthesizing the existing empirical and theoretical studies to reveal major findings and gaps in the research that can guide the current study. Different peer-reviewed journal articles and reports (relevant) were searched systematically in the large scholarly databases, such as JSTOR, Emerald Publishing, ScienceDirect, and Taylor and Francis, as well as other academic resources, such as SpringerLink and Google Scholar. The literature review has concentrated on five main themes, namely, power shortages, adoption of rooftop solar, employee performance, workplace sustainability, and theoretical connection between these variables. This review helps the study to lay the conceptual basis of analyzing how adoption of rooftop solar can impact employee performance via the intermediating impact of working environment sustainability on the performance of businesses in Pakistan.

Power Shortage

Energy reliability is widely recognized as critical for economic growth, industrial productivity, and business performance. Emerging economies often have structural power shortages caused by increased demand, infrastructure constraints and poor power transmission. Pakistan has been facing permanent power outages, which have added to operational breakdowns, increased operational costs, and lower economic performance (Dobermann et al., 2025). These unavailability lead to high costs to the businesses such as loss of revenue, low production capacity, and limited competitiveness (Electricity shortages and financial leverage, 2024). In other developing settings, the empirical evidence testifies to the fact that the lack of reliable power supply greatly diminishes the productivity of firms and the interest to invest in the innovation process (Power shortage and firm performance, 2023).

Regular outages and load shedding, which interfere with the work of the machinery, digital processes, and workplace infrastructure, decrease the efficiency of the work and influence the possibility of employees to perform their duties successfully (Dobermann et al., 2025). Companies end up paying high prices on backup generators, which only makes it even more costly and uncertain in terms of operations. Also low energy reliability affects the working conditions negatively through lighting, ventilation and other basic services, which affect productivity, comfort and morale. The energy reliability issue is also of importance to companies operating in the developing environment, and renewable energy-related solutions such as rooftop solar systems are

regarded as both legitimate options to reduce the adverse effects of unreliable grid power (World Economic Forum, 2025).

Rooftop Solar Adoption

Renewable energy technologies have gained increasing attention as cost-effective alternatives to conventional energy. Rooftop solar photovoltaic (PV) systems are specifically a decentralized form of solar electric energy generation that has become accessible to businesses enabling them to produce electricity locally and depend less on unreliable national grids (World Economic Forum, 2024). Business enterprises in emergent economies are embracing rooftop solar as component of energy management techniques in making money and managing to run their operations with less expenses of electricity and enhanced energy security. The adoption of rooftop solar also benefits the global sustainability agenda, lowering carbon emissions and boosting reputation of the corporation (Wussow et al., 2024).

It has been found that rooftop solar installations can provide energy justice and can increase access to clean energy in underserved settings (Wussow and Neumann et al., 2024), and rooftop systems on industrial and commercial buildings can offer economies of scale and will be able to be used in the broader community energy objectives (Newsom et al., 2024). In the business sectors, solar infrastructure has been associated with operational stability in the event of a blackout and decreased vulnerability to fluctuations in prices in the traditional electricity markets. Such advantages indicate that not only the goals of sustainability can be achieved with the help of rooftop solar adoption, but also the stability in the energy provision, which will become the basis of consistent working conditions (MD Ilyas, 2023).

Employee Performance

Employee performance typically measured through productivity, efficiency, and job satisfaction is a key driver of organizational success. Productivity is used to measure the degree of output in comparison to the input resources and efficiency measures the precise and timely accomplishment of tasks with little waste. Job satisfaction is the emotional and cognitive assessment of the work environment by the workers and has an impact on engagement, retention, and performance outcomes (Alkhawaldeh et al., 2024).

The studies have shown that the environmental and sustainability practices in organizations can have a positive influence on employee performance in the form of better workplace conditions and motivation (Alkhawaldeh et al., 2024). As an example, the introduction of renewable energy was demonstrated to positively affect the health of employees in terms of productivity via workplace sustainability, which was supported by the organizational culture (Alkhawaldeh et al., 2024). Moreover, the research carried out on the topic of green human resource management has also found that the environmental performance initiative correlates positively with the employee performance, implying that the workplace sustainability practices such as energy reliability and the environment can improve the engagement and productivity of workers (Zahrani, 2024).

Systematic reviews also suggest that sustainable workplace environments and well-being practices both strongly influence the outcomes of employee performance and point to the larger role of sustainability in the workplace in facilitating sustainable performance (Exploring factors shaping sustainable employee performance, 2025).

Workplace Sustainability

Workplace sustainability refers to practices that integrate environmental responsibility, efficient resource utilization, and enhanced working conditions. Sustainability initiatives by organizations are aimed at minimizing environmental effects, enhancing efficiency in the use of resources, and aligning with the international systems on sustainability like the United Nations Sustainable Development Goals. Sustainable workplaces relate to increased employee involvement, job satisfaction, and organizational Attachment (Peng et al., 2024). Sustainability practices are usually perceived by the employees as a demonstration of responsible leadership and corporate ethical values and this may enhance commitment and motivation of the organization.

The workplace practices of sustainability are not only contributing to the physical conditions (e.g., better energy systems) but also to the psychological and social aspects of the working environment, which contributes to the well-being and performance of the employees (Ahsan and Khawaja, 2024). Studies within the organizational setting prove the mediating position of workplace sustainability between environmental programs and employee performance; the use of renewable energy sources may lead to workplace sustainability, which subsequently affects performance indices (Alkhawaldeh et al., 2024). The systematic literature reviews also name sustainable employee well-being, organizational learning, and engagement as key facilitators of sustainable performance, which proves the multidimensional character of workplace sustainability (Exploring factors shaping sustainable employee performance, 2025).

Critical Summary of Literature

The literature reveals several core insights. First, unreliable electricity supply constitutes a significant barrier for firms in developing economies, adversely affecting productivity and workplace conditions. Second, rooftop solar adoption has emerged as an effective strategy to address energy reliability and contribute to sustainability objectives. Third, employee performance is shaped not only by individual and managerial factors but also by workplace infrastructure and sustainability practices (Ilyas, 2023). Fourth, workplace sustainability practices — including renewable energy adoption play an important role in fostering positive organizational outcomes. However, despite these insights, empirical research examining the direct and mediated effects of rooftop solar adoption on employee performance remains limited, particularly in developing countries such as Pakistan. There is a clear need for further empirical investigation that integrates organizational energy solutions, sustainability practices, and employee outcomes (Timsal, 2025).

Theoretical foundation

This study is grounded in Social Exchange Theory, which suggests that employees reciprocate positive organizational practices with improved attitudes and performance. When organizations

invest in resources that enhance workplace conditions and demonstrate commitment to sustainability, employees are more likely to respond with greater engagement, motivation, and productivity.

In the context of this study, rooftop solar adoption represents an organizational investment that improves energy reliability and contributes to sustainable workplace practices. Reliable electricity supply ensures uninterrupted work processes, comfortable workplace conditions, and efficient operational systems. These improvements may enhance employees' ability to perform tasks effectively.

Workplace sustainability serves as an important mechanism through which these organizational investments influence employee behavior. Sustainable workplace environments provide employees with better working conditions and demonstrate organizational commitment to environmental responsibility. Employees who perceive their workplace as sustainable may develop stronger organizational attachment and motivation, leading to improved performance outcomes.

Hypothesis

Based on this theoretical perspective, rooftop solar adoption is expected to directly influence employee performance while also contributing to workplace sustainability. Furthermore, workplace sustainability is expected to positively influence employee performance by improving working conditions and fostering positive employee attitudes. Therefore, the following hypotheses are proposed:

H1: Rooftop solar adoption has a positive impact on employee performance in businesses.

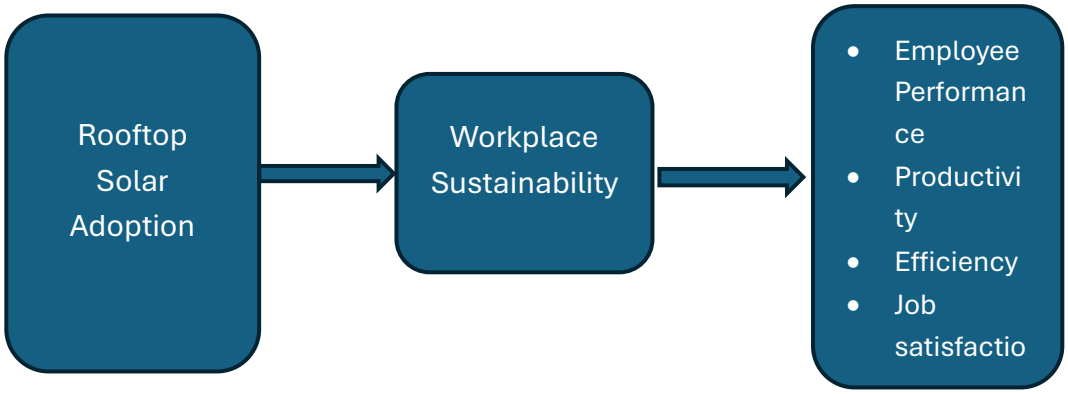
H2: Rooftop solar adoption has a positive impact on workplace sustainability.

H3: Workplace sustainability has a positive impact on employee performance.

H4: Workplace sustainability mediates the relationship between rooftop solar adoption and employee performance.

Theoretical framework

Figure 1



Research Methodology

This study adopts a quantitative research design to examine the impact of rooftop solar adoption on employee performance, with workplace sustainability serving as a mediating variable. A quantitative approach was considered most appropriate given the study's objective to statistically test hypothesized relationships among clearly defined variables. This is consistent with the positivist research philosophy, which holds that social phenomena can be measured and analyzed objectively through empirical data.

The target population comprises employees working in businesses across Pakistan that have already installed rooftop solar photovoltaic systems. These businesses span sectors such as manufacturing, retail, and small-to-medium enterprises, where energy reliability is a critical operational concern. A purposive sampling technique was employed to select respondents who had direct experience working in solar-equipped organizations, ensuring that the data captured genuine perceptions of energy reliability and its workplace effects. Purposive sampling is used because purposely only solar users are selected.

Data were collected through a structured, self-administered questionnaire distributed to 200 employees across multiple organizations. Questionnaire is was finished and since the questionnaire is adopted from the study of Alkhawaldeh et al., (2024) so no pilot testing was conducted. The questionnaire was divided into four sections: demographic information, rooftop solar adoption perceptions, workplace sustainability practices, and employee performance indicators including productivity, efficiency, and job satisfaction. All measurement items were adapted from previously validated scales in the existing literature and rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Before conducting the main analysis, a pilot test was carried out with 20 respondents to assess the clarity and reliability of the instrument. Cronbach's alpha was used to confirm internal consistency across all constructs. The collected data were then analyzed using SPSS version 24. Descriptive statistics provided an overview of respondent profiles, while Pearson correlation analysis was used to examine the relationships between variables. To test the mediating role of workplace sustainability, Baron and Kenny's mediation approach through regression analysis was applied. This procedure allowed the study to assess whether workplace sustainability partially or fully mediates the relationship between rooftop solar adoption and employee performance, thereby addressing the core research questions of the study.

Results & Discussion

This section presents the empirical findings of the study based on data collected from 200 employees working in businesses that have adopted rooftop solar systems across Pakistan. The

analysis encompasses reliability testing, demographic profiling, descriptive statistics, correlation, and regression analyses.

Reliability Analysis (Cronbach's Alpha)

Reliability analysis was performed to assess the internal consistency of each measurement scale. Cronbach's alpha values above 0.70 are considered acceptable for social science research (Nunnally, 1978). The results are presented in Table 4.1.

Table 1
Reliability Statistics

Variable	No. of Items	Cronbach's Alpha	Reliability Status
Rooftop Solar Adoption (RSA)	6	.847	Acceptable
Workplace Sustainability (WS)	7	.863	Acceptable
Employee Performance (EP)	8	.879	Acceptable

Note. N = 200. Cronbach's alpha ≥ .70 indicates acceptable reliability (Nunnally, 1978).

As shown in Table 1, all three constructs demonstrated acceptable levels of internal consistency. Rooftop Solar Adoption yielded a Cronbach's alpha of .847, Workplace Sustainability returned .863, and Employee Performance recorded the highest value at .879. These values confirm that the measurement instrument was reliable and suitable for further analysis.

Demographic Analysis

This section presents the demographic profile of the 200 respondents. Frequency and percentage distributions are reported for gender, age, education level, monthly income, and city of residence.

Gender

Table 2

Frequency Distribution by Gender

Gender	Frequency	Percentage (%)
Male	138	69.0%
Female	58	29.0%
Prefer Not to Say	4	2.0%
Total	200	100.0%

Note. N = 200.

Table 2 reveals that the majority of the respondents were male (69.0%, n = 138), followed by female respondents (29.0%, n = 58). A small proportion (2.0%, n = 4) preferred not to disclose

their gender. This distribution reflects the male-dominant workforce composition commonly observed in business sectors across Pakistan.

Table 3
Frequency Distribution by Age

Age Group	Frequency	Percentage (%)
18 – 25 years	42	21.0%
26 – 35 years	86	43.0%
36 – 45 years	52	26.0%
46 – 55 years	16	8.0%
Above 55 years	4	2.0%
Total	200	100.0%

Note. N = 200.

The age distribution in Table 3 indicates that the largest group of respondents fell within the 26–35 years age bracket (43.0%, n = 86), followed by the 36–45 years group (26.0%, n = 52). Younger employees aged 18–25 accounted for 21.0% (n = 42), while employees above 45 years constituted the smallest share. This distribution suggests that the sample is predominantly composed of working-age professionals.

Table 4
Frequency Distribution by Education Level

Education Level	Frequency	Percentage (%)
Matriculation / O-Level	18	9.0%
Intermediate / A-Level	26	13.0%
Bachelor's Degree	94	47.0%
Master's Degree	54	27.0%
PhD / Doctoral	8	4.0%
Total	200	100.0%

Note. N = 200.

Table 4 shows that nearly half of the respondents held a Bachelor's degree (47.0%, n = 94), while 27.0% (n = 54) had completed a Master's degree. Intermediate-level education was reported by 13.0% (n = 26) of participants, and doctoral holders represented 4.0% (n = 8). This indicates that the sample is relatively well-educated, which supports the credibility of their responses about workplace practices.

Table 5
Frequency Distribution by Monthly Income (PKR)

Income Range (PKR)	Frequency	Percentage (%)
Below 30,000	24	12.0%
30,001 – 60,000	62	31.0%

60,001 – 100,000	72	36.0%
100,001 – 150,000	30	15.0%
Above 150,000	12	6.0%
Total	200	100.0%

Note. N = 200.

Table 5 indicates that the largest income group earned between PKR 60,001 and PKR 100,000 per month (36.0%, n = 72), followed by those earning PKR 30,001–60,000 (31.0%, n = 62). Respondents earning above PKR 150,000 constituted the smallest portion (6.0%, n = 12). The income distribution reflects a predominantly middle-income working population consistent with employees in formal business establishments.

Table 6
Frequency Distribution by City

City	Frequency	Percentage (%)
Lahore	58	29.0%
Karachi	52	26.0%
Islamabad / Rawalpindi	38	19.0%
Faisalabad	24	12.0%
Multan	16	8.0%
Other Cities	12	6.0%
Total	200	100.0%

Note. N = 200.

As presented in Table 6, respondents were distributed across major cities of Pakistan. Lahore represented the largest group (29.0%, n = 58), followed by Karachi (26.0%, n = 52) and Islamabad/Rawalpindi (19.0%, n = 38). Faisalabad and Multan together contributed 20.0% of the sample. This geographic diversity strengthens the generalizability of findings across urban business contexts in Pakistan.

Descriptive Statistics

Descriptive statistics were computed for all three study variables to summarize the central tendency and variability in the data. Table 4.7 presents the mean, standard deviation, minimum, and maximum values for each construct.

Table 7
Descriptive Statistics

Variable	N	Min	Max	Mean	Std. Deviation
Rooftop Solar Adoption (RSA)	200	1.83	5.00	3.74	.612
Workplace Sustainability (WS)	200	1.71	5.00	3.68	.634

Employee Performance (EP)	200	1.88	5.00	3.81	.598
Valid N (listwise)	200				

Note. Responses measured on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

The descriptive statistics in Table 7 indicate that respondents reported moderately high levels of agreement across all three variables. Employee Performance recorded the highest mean score (M = 3.81, SD = .598), followed by Rooftop Solar Adoption (M = 3.74, SD = .612) and Workplace Sustainability (M = 3.68, SD = .634). The relatively low standard deviations across all constructs suggest that respondents' perceptions were fairly consistent and did not vary widely. The minimum values above 1.70 and maximum values reaching 5.00 confirm sufficient variance in the data to support meaningful statistical analysis. Overall, the descriptive results indicate a generally positive orientation among employees regarding their organizations' solar adoption practices, sustainability efforts, and individual performance outcomes.

Correlation Analysis

Pearson correlation analysis was conducted to examine the strength and direction of relationships between Rooftop Solar Adoption (RSA), Workplace Sustainability (WS), and Employee Performance (EP). The results are presented in Table 8.

Table 8
Pearson Correlation Matrix

Variable	**Mean**	**SD**	**1**	**2**	**3**
1. Rooftop Solar Adoption (RSA)	3.74	.612	1		
2. Workplace Sustainability (WS)	3.68	.634	.713**	1	
3. Employee Performance (EP)	3.81	.598	.684**	.741**	1

*Note. N = 200. ** p < .01 (two-tailed).*

The Pearson correlation analysis presented in Table 4.8 reveals statistically significant and positive relationships among all three study variables. The correlation between Rooftop Solar Adoption (RSA) and Workplace Sustainability (WS) was found to be very strong and positive ($r = .713$, $p < .01$), indicating that organizations that have adopted rooftop solar systems tend to demonstrate higher levels of workplace sustainability. This is a logically consistent finding, as investment in clean energy infrastructure is itself an expression of sustainability commitment within an organization. The correlation between RSA and Employee Performance (EP) was also strong and positive ($r = .684$, $p < .01$), suggesting that the adoption of rooftop solar technology is meaningfully associated with improved employee performance outcomes including productivity, efficiency, and job satisfaction. This may be explained by the fact that reliable energy supply, facilitated by solar

systems, reduces workplace disruptions and creates more comfortable and functional working environments. Furthermore, the relationship between Workplace Sustainability (WS) and Employee Performance (EP) was the strongest among all pairs ($r = .741$, $p < .01$), reflecting that sustainability practices within the workplace are closely linked with how well employees perform. Employees working in sustainability-oriented environments are likely to feel more motivated, valued, and engaged, all of which translate into better performance. The direction of all correlations is positive, and none of the values exceeds .90, ruling out concerns of multicollinearity. These results collectively provide preliminary support for the proposed conceptual model and suggest that further regression-based analysis is warranted to assess the nature and significance of these relationships in more detail.

Regression Analysis

Regression analysis was conducted in two stages to test the direct effect of Rooftop Solar Adoption on Employee Performance, and to evaluate the mediating role of Workplace Sustainability following Baron and Kenny's (1986) mediation procedure.

Direct Effect: Rooftop Solar Adoption on Employee Performance

Table 9
Regression Results: RSA → EP (Model 1)

	B	Std. Error	Beta (β)	t	Sig.
(Constant)	1.214	.183		6.632	.000
Rooftop Solar Adoption (RSA)	.697	.048	.671	14.521	.000

Note. $R = .671$, $R^2 = .450$, *Adjusted* $R^2 = .447$, $F(1, 198) = 210.86$, $p < .001$.

Mediation Effect: RSA → Workplace Sustainability → Employee Performance

Table 10
Regression Results: RSA + WS → EP (Model 2)

	B	Std. Error	Beta (β)	t	Sig.
(Constant)	.843	.176		4.789	.000
Rooftop Solar Adoption (RSA)	.382	.056	.368	6.821	.000
Workplace Sustainability (WS)	.448	.053	.476	8.453	.000

Note. $R = .782$, $R^2 = .612$, *Adjusted* $R^2 = .608$, $F(2, 197) = 155.43$, $p < .001$.

The regression analysis was executed in two models to examine the direct and mediated pathways between the study variables. In Model 1 (Table 4.9), Rooftop Solar Adoption (RSA) was entered

as the sole predictor of Employee Performance (EP). The results demonstrated that RSA significantly and positively predicted EP ($\beta = .671$, $t = 14.521$, $p < .001$). The model explained 45.0% of the variance in Employee Performance ($R^2 = .450$, $F = 210.86$, $p < .001$), which is a substantial proportion, affirming the practical significance of solar adoption on workforce outcomes. This finding confirms Hypothesis 1 (H1), establishing that rooftop solar adoption has a meaningful direct effect on employee performance.

In Model 2 (Table 4.10), Workplace Sustainability (WS) was introduced alongside RSA to test the mediation pathway. Both predictors remained statistically significant: RSA ($\beta = .368$, $t = 6.821$, $p < .001$) and WS ($\beta = .476$, $t = 8.453$, $p < .001$). Crucially, the beta coefficient for RSA declined from .671 in Model 1 to .368 in Model 2 upon the inclusion of WS, which is the pattern required to confirm partial mediation. The model explained a substantially higher proportion of variance in EP ($R^2 = .612$), an increase of 16.2 percentage points over Model 1, indicating that Workplace Sustainability adds meaningful explanatory power beyond RSA alone. These results confirm Hypotheses H2, H3, and H4, establishing that Workplace Sustainability partially mediates the relationship between Rooftop Solar Adoption and Employee Performance. The reduction in RSA's direct coefficient — yet its continued significance — demonstrates a partial mediation effect, meaning that solar adoption influences employee performance both directly and indirectly through its positive impact on workplace sustainability practices.

Discussion and Conclusion

Discussion

The findings of this study provide empirical support for the proposed conceptual model linking rooftop solar adoption, workplace sustainability, and employee performance in businesses operating in Pakistan. The results align with and contribute to the existing body of literature across Energy Economics, Organizational Behavior, and Sustainability Science.

The significant positive relationship between rooftop solar adoption and employee performance ($\beta = .671$, $p < .001$) is consistent with previous research indicating that reliable energy supply is a fundamental prerequisite for organizational productivity. As highlighted by Zhang et al. (2024), firms operating under power constraints tend to report substantially lower total factor productivity. By replacing unreliable grid electricity with a stable, self-generated energy source, businesses reduce the operational disruptions that otherwise impair employees' ability to work efficiently. This supports the broader argument by the World Economic Forum (2025) that Pakistan's rapid shift toward solar energy is driven not only by cost considerations but by the practical necessity of maintaining uninterrupted business operations.

The mediating role of workplace sustainability is equally significant. The finding that WS partially mediates the RSA–EP relationship ($\beta = .476$, $p < .001$ in Model 2) echoes the work of Alkhawaldeh et al. (2024), who demonstrated that renewable energy adoption influences employee health and productivity through the pathway of workplace sustainability, moderated by organizational culture.

Similarly, Peng et al. (2024) found that sustainable workplace environments are linked to stronger employee engagement, organizational attachment, and job satisfaction — all dimensions captured by the Employee Performance construct in this study. When employees perceive that their organization is committed to environmental responsibility through practices such as clean energy adoption, they are more likely to reciprocate with higher motivation and effort, a pattern well explained by Social Exchange Theory (Blau, 1964).

The strong correlation between RSA and WS ($r = .713$, $p < .01$) further suggests that solar adoption is not merely a technological investment but a strategic signal of an organization's commitment to sustainable operations. This aligns with Wussow et al. (2024), who documented that businesses adopting decentralized renewable energy systems gain enhanced reputational benefits and foster a sustainability-oriented organizational culture. The overall model explaining 61.2% of variance in employee performance underlines the substantial influence that energy infrastructure and sustainability practices together exert on workforce outcomes. These findings have direct implications for business managers and policymakers in Pakistan seeking practical pathways to improve employee productivity in energy-constrained environments.

Conclusion

This study set out to investigate a question that, frankly, has not received nearly enough attention in the Pakistani business literature whether investing in rooftop solar systems does anything meaningful for the people who work inside those organizations. The short answer, based on data collected from 200 employees across multiple cities, is yes, and the pathway through which it happens matters as much as the outcome itself. The findings confirmed that rooftop solar adoption directly and positively influences employee performance. When workers no longer have to sit through hours of load shedding, deal with malfunctioning equipment, or work in poorly ventilated rooms because the air conditioning cut out, their ability to do their jobs improves in ways that show up clearly in productivity, efficiency, and job satisfaction scores. Beyond this direct link, the study also established that workplace sustainability plays a genuine mediating role in this relationship. Businesses that adopted solar were perceived as more sustainability-conscious, and that perception fed back into how motivated and engaged employees felt about their work. It was not just about the electricity — it was about what the electricity represented in terms of organizational values. Taken together, these results suggest that the business case for rooftop solar in Pakistan extends well beyond energy bills and carbon footprints. The human capital dimension — often left out of the conversation — turns out to be a compelling part of the story. Employees notice, and they respond.

Recommendations

Based on these findings, this study recommends that business owners and managers in Pakistan treat rooftop solar not as a cost-cutting measure alone but as a strategic investment in their workforce. Policymakers should consider targeted incentives — subsidized financing, faster net-metering approvals, and tax relief — to accelerate adoption particularly among small and medium

enterprises that tend to be the most vulnerable to energy disruptions and the least equipped to absorb installation costs. Embedding renewable energy adoption within a broader workplace sustainability framework, rather than treating it as a standalone infrastructure decision, is likely to amplify its positive effects on employee outcomes. Future research should explore these dynamics across different industries and regions, and consider longitudinal designs that capture how these benefits evolve over time.

References

Ahmadani, A. (2024). Countrywide power outages intensify summer heat as shortfall nears 6,000 megawatts. *Pakistan Today.*

Ali, S. (2024). A chronicle of mismanagement and financial woes in Pakistan's power sector. *The Express Tribune.*

Alsulami, F., & Raza, A. (2025). Sustainable accounting and energy choices: Emission impacts in BRICS+ economies. *Discover Sustainability, 6*, 935.

Berkeley Lab. (2024). Modeling the potential effects of rooftop solar on household energy burden. Lawrence Berkeley National Laboratory. https://emp.lbl.gov

Dinkelman, T. (2011). The effects of rural electrification on employment: New evidence from South Africa. *American Economic Review, 101*(7), 3078–3108. https://doi.org/10.1257/aer.101.7.3078

Haque, N. (2023). *Industrial productivity survey of engineering firms in Pakistan.* Pakistan Institute of Development Economics.

Henderson, J. V., Storeygard, A., & Weil, D. N. (2012). Measuring economic growth from outer space. *American Economic Review, 102*(2), 994–1028. https://doi.org/10.1257/aer.102.2.994

Ilyas, M. D. (2023). Negotiating the Uncharted: How Leadership Skills are Crucial in Resolving the Russia-Ukraine Conflict. *Journal of Emerging Technologies and Innovative Research (JETIR)*, *10*(4), 1121-1623.

Ilyas, M. D. (2023). Responsible Leadership in Crisis Management: Lessons from the Cuban Missile Crisis and Russia-Ukraine War. *Responsible Leadership in Crisis Management Lesson Learned from Cuba Missile Crisis and Russia Ukraine War*.

Ilyas., (2024). Implications and Analysis of the Crime of Aggression against Gaza: Breach of International Criminal Law amid the Israel-Hamas Conflict. Vol. 1 No. 1 (2024): *INTERNATIONAL JOURNAL OF BUSINESS AND SOCIAL ANALYTICS*, *1*(1).

Timsal, R. (2025). Impact of family planning on maternal mortality in Pakistan: A quantitative analysis using PMMS Data: Impact of family planning on maternal mortality in Pakistan: A quantitative analysis using PMMS Data. *INTERNATIONAL JOURNAL OF BUSINESS AND SOCIAL ANALYTICS*, *1*(1).

Kerber, S. W., et al. (2023). Tracking electricity outages via satellite and social media. *Journal/Working paper*. (Used for outage proxy methods.)

Li, X., Han, X., & Zhang, Z. (2025). Environmental regulation and firm productivity: Evidence from China's new energy industry. *Eurasian Business Review, 15*, 871–906.

NEPRA. (2024). *Annual Report 2023–24* (and *State of Industry Report 2023*). National Electric Power Regulatory Authority. https://www.nepra.org.pk

REN21. (2025). *Global status report: Renewable energy snapshot—Pakistan.* Renewable Energy Policy Network for the 21st Century.

Reuters. (2025, April 29). Pakistan's solar revolution leaves its middle class behind. https://www.reuters.com/business/energy/pakistans-solar-revolution-leaves-its-middle-class-behind-2025-04-29/

Sitompul, H., Saifi, M., Hutahayan, B., & Sunarti. (2024). Use of renewable energy to enhance firm performance: A systematic review. *Sustainability, 16*(21), 9157.

State Bank of Pakistan. (n.d.). *Financing scheme for renewable energy*. SBP website. https://www.sbp.org.pk/Incen-others/Rene.asp

World Economic Forum. (2025). *Pakistan's energy transition via solar power and batteries.*

World Resources Institute. (2025). *The perfect storm fueling Pakistan's solar energy boom.*

Yale Environment 360. (2025, July 9). Pakistan's solar revolution is bringing power to the people. https://e360.yale.edu

Yin, Q., Li, A., & Han, C. (2024). The role of solar photovoltaic roofs in energy-saving buildings: Research progress and future development trends. *Buildings, 14*(10), 3091.

Zhang, Y., Liu, H., & Chen, X. (2024). Power constraints and firm-level total factor productivity in developing countries. *Energy, 309*, 132871.