

ENERGY ACCESS AND FEMALE ENTREPRENEURIAL PERFORMANCE IN DEVELOPING ECONOMIES: EVIDENCE FROM GENDER-INCLUSIVE DEVELOPMENT CONTEXT

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Received 14.11.2025.

Revised 21.01.2026.

Accepted 06.02.2026.

Keywords:

Energy Access, Female Entrepreneurship, Entrepreneurial Performance, Innovation, Growth and Reputation.

ABSTRACT

The study investigated the effect of energy access on female entrepreneurial performance within rural and semi-urban communities in Rivers State, Nigeria. Recognizing the critical role of energy availability in enabling sustainable enterprise development, the study examined how energy access influences three key dimensions of performance: entrepreneurial growth, innovation, and reputation. Drawing on the Dynamic Capabilities Theory, the study adopted a cross-sectional survey design and collected primary data from 1,509 female entrepreneurs across diverse sectors. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), the findings revealed that energy access has a significant and positive effect on entrepreneurial growth, reputation, and innovation. These results show the strategic importance of energy infrastructure in enhancing business scalability, operational efficiency, and service consistency among female-owned enterprises. The study contributed to the growing discourse on gender-inclusive development by offering empirical insights into the intersection of energy access and female entrepreneurial performance. It recommended targeted energy interventions, capacity-building initiatives, and innovation-enabling platforms to strengthen the performance of women-led businesses in underserved regions.



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1. INTRODUCTION

The evolving nature of Africa's economic trajectory has amongst other things increased women's direct involvement in the ownership and operations of entrepreneurial ventures (Gad & Leone, 2024; Tumba, et al., 2022; Ojonga et al., 2021; World Bank, 2019). This involvement is not without challenges as the dynamics of the social-cultural reality in the African context have limited women's access to opportunities and resources and enshrined specific roles for women, which cannot be neglected or substituted for any economic advantage, hence in addition to their entrepreneurial quest, women are also seeking to balance social-cultural roles such as

household chores (i.e., cooking, cleaning, sewing) and care-giving roles (i.e., child training, taking care of nuclear and extended family members) (Bako & Syed, 2018; Makama, 2013; Chin, 2011; Okpalaobi, 2011). Nonetheless, the emancipation of women as values and culture subtly evolve is reflected in women's increased quest in entrepreneurial ventures, this direct participation is most observed in low-income generating entrepreneurial ventures in the informal sector whose positive prospect is debatable (Gad & Leone, 2024; Adejugbe & Adejugbe, 2018; Perryman et al., 2016; Osunde & Olookoba, 2014).

Regardless of the plethora of literature on female entrepreneurship (Crittenden et al., 2019; Friedson-

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Ridenour & Pierotti, 2019; Nukpezah & Blankson, 2017) and studies on energy engagements (Gad & Leone, 2024), the paucity of empirical discourse on women as marginalized identity and the implication of their energy access on their entrepreneurial performance within the geographical scope of this study (a marginalized settlement) has necessitated this study; hence, regardless of the challenges encountered in Nigeria's energy sector, there is a paucity of studies on how energy access relates with female entrepreneurs in rural or semi-urban regions. These communities often lack electricity, especially at night, which heightens insecurity and leads to rising costs of accessing alternative energy sources (Ezekwem & Muthusamy, 2023). Most empirical works have examined energy access as a latent variable as against a predictive variable that influences female entrepreneurial performance (Ondoua-Beyene et al., 2025; Bandi et al., 2020). Also, existing research have reported the critical role of energy access in enhancing female entrepreneurship (Dutta, 2020). Improved energy access has been linked to increased productivity, profitability, and overall economic empowerment for women-owned businesses, particularly in developing economies where energy scarcity poses significant barriers (Dutta, 2020). Such empowerment not only supports gender equality but also contributes to broader socio-economic development goals. Furthermore, this study's gap-filling capabilities are further reinforced by the increasing advocacy for the incorporation of gender concerns into energy policies (World Bank, 2018), this study offers strategic empirical insight that will advance the framework and understanding of such incorporation.

2. LITERATURE REVIEW

2.1 Theoretical Underpinnings

The *Dynamic Capabilities Theory* (DCT) propounded by Teece et al. (1997) have remained topical as a relevant framework for comprehending how ventures adapt and influence their business environment. DCT denotes a ventures capability to harness and optimise their external and internal resource in managing their environment (Teece, 2007). DCT is critical to a venture's ability to adapt to variability in market and industrial dynamics that features high competition and uncertainty, DCT enables entrepreneurial ventures to exercise discretion and be innovative in attaining energy solutions in markets where sufficient infrastructure is inadequate, hence, entrepreneurs can optimise performance via deploying dynamic capabilities (DC) (Teece, 2007, 2018; Teece et al., 1997; Akpan et al., 2022; Wang & Zhang, 2024). Teece (2007, 2018); Teece et al. (1997); Wang and Zhang (2024), Abdullahi et al. (2024) outlines the core dimensions of DCT to include; (1) sensing opportunities and threats, (2) seizing opportunities, and (3) reconfiguring organizational resources, arguably, entrepreneurial performance in the context of energy access is anchored on the entrepreneur ability to strategically sense and seize market opportunities and

threats (i.e. via innovation, scaling, market and product development, etc.), while tactically adapting and reconfiguring the venture's resource to satisfy market needs. Below is an explanation on these dimensions; Sensing connotes a ventures capability to identify, analyse and interpret external dynamics capable of influencing its competitive status. Hence entrepreneur capability to understand the energy sector and adopts innovations (i.e. off-grid renewable energy market, digital technologies, etc.) in that sector can enable them optimise their competence, ability, proficiency, and market reach and relevance which positively influence performance. This capability enables entrepreneur's to be innovative in response to unreliable electricity supply and inadequate grid infrastructural challenge. The entrepreneur having sensed the opportunities, now seizes the opportunities identified via mobilising resources, developing new venture models, investing in technologies, navigating dynamic financial and regulatory landscapes, and scaling the venture via value-market demand fit, these capabilities can enable entrepreneur fund alternative electricity power access and enhance performance. At the reconfiguring resource phase, the entrepreneur adapts the ventures processes, strategies and structures to optimise competitive advantage in dynamic industrial environment. Hence, as entrepreneur scale their ventures and aim to optimise performance, they should reconfigure their resources to support their strategic intent. The capacity for continuous learning and resource reconfiguration is critical for entrepreneurial ventures addressing energy access challenges, especially in developing regions and dynamic markets.

Dynamic capabilities is critical to entrepreneurial ventures incorporates competence that are necessary to navigate market dynamic and uncertainty, hence the need for entrepreneur's to innovate and adapt to market challenges which positions them for better performance.

2.2 Energy Access

Ezekwem & Muthusamy (2023) posits that the National Electricity Power Authority (NEPA) which was a state-sponsored organization was responsible for the electricity sector in Nigeria from 1972 to 2005. In 2005 the NEPA was restructured by the government and renamed Power Holding Company of Nigeria (PHCN) which resulted in the decentralisation of the electricity sector into; independent generating companies (GENCOs), the Transmission Company of Nigeria (TCN) and independent electricity distribution companies (DISCOs). The Nigerian electricity is anchored on four technologies for energy generation; on-grid, embedded, off-grid and captive generation. Regardless of these reforms, the electricity sector in Nigeria is still highly challenged with issues centred on generating, transmission, and distribution of electricity and security. The Port Harcourt electricity region is in charge of six transmission substations (i.e. Port Harcourt Mains, Ahaoda, Port Harcourt Town, Yenegoa, Rumuosi, and Elemenwo).

The Nigerian Electricity Regulatory Commission (NERC) and the Nigerian Electricity Management Services Agency (NEMSA) were also created as critical regulators in the Nigerian electricity sectors. The NERC also regulates electricity cost and customers are allocated daily electricity utility based on the band they are grouped in, hence there is price difference with regards to band grouping (Band A, B, C, D, E) (Anosike et al., 2017; Esiedesa, 2022; Nnodim, 2022; Ezekwem & Muthusamy, 2023).

2.3 Entrepreneurial Performance

Entrepreneurial performance denotes a multidimensional construct that reflects the result of entrepreneurial efforts; hence reveals the entrepreneurial attainment of objectives (i.e. growth, profitability, sustainability, expansion, innovation, reputation, etc.) (Mitropoulos et al., 2023; Pindard-Lejarraga & Lejarraga, 2024). The global increase in entrepreneurial ventures and their significant contributions to the economies of nations has made it a topical interest for the academia, industrial practitioners, government and policy makers.

Extant literature has conceptualised and measured entrepreneurial performance from diverse themes that involves; financial performance (e.g., revenue, profitability), non-financial performance (e.g., innovation, customer satisfaction, work-life balance), and growth (e.g., product or market expansion, market share), business survival, value creation, social and environmental performance (Cassar, 2010; Fried & Tauer, 2015; Heinicke, 2018; Orlandi, 2017; Staniewski & Awruk, 2019; Tietz, 2021).

Plethora of studies has also articulated antecedents of entrepreneurial performance, and these can be categorised on the following themes; individual factors (i.e. psychological traits, human capital, cognitive capabilities, etc.), organisational factors (i.e. management and leadership, business strategy, innovation competence, etc.), environmental factors (i.e. institutional support, market conditions, technology, government and regulations, social and cultural dynamics, etc.) (Agolla et al., 2019; Chen, et al., 2018; Giotopoulos et al., 2017; Gogokhia & Berulava, 2021; Martin-Rojas et al., 2019; Mitropoulos et al., 2023; Morales-Pérez et al., 2022; Pindard-Lejarraga & Lejarraga, 2024).

2.4 Hypotheses Development

2.4.1 Energy Access and Female Entrepreneurial Growth

The operations of female entrepreneurship in emerging nations are mostly active in environments with resource constraints, where access to energy is critical in determining entrepreneurial success (Ahmetaj et al., 2023; Aladejebi 2020; Bandi, 2020). Extant studies have postulated that energy affordability and reliability influence entrepreneurial operations, productivity, and up-scaling (Bhattacharyya, 2006; Cheng et al., 2021; Churchill & Smyth, 2020). Energy access is capable of enabling entrepreneurs to enhance service and product

quality, decrease downtime, and increase hours of operations; hence advancing entrepreneurship growth in female enterprises (Bandi, 2020; Cheng et al., 2021). Studies have demonstrated that energy access critically influences the efficiency and effectiveness of business processes; in a quest to satisfy energy needs, women entrepreneurial, especially in rural geographies, depend on and utilise costly energy alternatives i.e. diesel generators, renewable energies, and other off-grid sources of energy (Burke et al., 2019; Owusu-Sekyere et al., 2024; Shankar et al., 2020). Diesel generators, renewable energies, and other off-grid sources of energy are frequently being engaged as an escape to the challenges of energy access; the integration of these alternatives has been observed to increase cost and improve operational efficiency; within the African context, female entrepreneurs with affordable and reliable access to energy achieve higher growth rates and financial outcomes (Pueyo et al., 2020; Pueyo & Maestre, 2019). Hence, the deficiency in the reliable supply of electricity in rural Nigeria increases operational inefficiencies and costs, invariably reducing female entrepreneur's capacity to expand their business operational scale.

The gendered context of energy access is critical in the framework of female entrepreneurship; women due to socio-cultural variables, encounter more barriers in energy-affiliated resources i.e. energy infrastructure, finance, and technology, which limits their capacity to fund energy solutions that may enhance their business growth (Nasirudeen & Osabo, 2024; Osunmuyiwa & Ahlborg, 2019). Female entrepreneurs in rural climates are more impacted and vulnerable to constraints in energy access in comparison to male entrepreneurs, hence limiting their business growth potential (Osunmuyiwa & Ahlborg, 2019; Pueyo et al., 2020; Pueyo & Maestre, 2019).

H1. Energy access has a significant effect on female entrepreneurial growth

2.4.2 Energy Access and Female Entrepreneurial Reputation

Business reputation is a critical success factor for entrepreneurial posterity and performance, especially in a rural market landscape where trust and word-of-mouth play a fundamental function in customer retention (Açikgöz et al., 2024; Gontur, 2022). Energy access as a catalyst is indirectly crucial in influencing female entrepreneurial reputation (UN Women & UNIDO, 2023). Energy access reliability significantly influences customer satisfaction, services and product quality, and entire business performance, which impresses the perception of businesses by stakeholders (competitors, customers, etc.) (Rosak-Szyrocka et al., 2022).

Energy access in rural contexts is critical to advancing the capacity of female entrepreneurs to stabilise the offering of standardized product quality and gain a reputation (SEforALL, 2021). Inversely, a business reputation could be punctured by service delay, product spoilage, and poor customer service which emanates

from irregular energy access. Businesses with strong records of delivering high-quality services and products, customer loyalty and a good reputation benefited from consistent access to energy (Bansal, 2005; Pellegrini-Masini & Leishman, 2011).

Female entrepreneurs' reputations which are influenced by social-cultural variables are further affected by energy access challenges; hence, when female entrepreneurs experience service delays, and inconsistent product quality due to constraints in energy access, it further weakens their market reputation, which is challenging for a female entrepreneur in a male-gender dominated industry (Nasirudeen & Osabo, 2024; Osunmuyiwa & Ahlborg, 2019).

Perceived reliability is a critical factor for entrepreneurial reputation, and energy access directly impacts this perception; hence, there is perceived unreliability with businesses that experience frequent energy supply disruptions, which invariably reduce customer loyalty and retention, and weaken reputation (Pellegrini-Masini & Leishman, 2011). In contrast, reliable energy access enables female entrepreneurs to meet customer's expectations and sustain consistent service delivery, hence advancing their reputation.

H2. Energy access has a significant effect on female entrepreneurial reputation

2.4.3 Energy Access and Female Entrepreneurial Innovation

In market dynamics, the capacity for businesses to become innovative in value and service solutions is critical for survival and strategic competitive advantages. Energy access is critical to facilitating or stifling innovation for female entrepreneurs; for businesses with sufficient resources, the deployment of innovation in energy access (i.e. solar technologies or off-grid alternatives) is capable of empowering entrepreneurs to create feasible opportunities and overcome energy constraints (McGee & Greiner, 2019; Oyewo, 2023).

Energy access reliability and affordability are critical and serve as a significant catalyst for innovation by offering entrepreneurs the platform to upscale, and diversify their operations (Pueyo & Maestre, 2019). Energy access reliability and affordability in rural environments allow entrepreneurs to advance techniques for production, offer new products, and explore business model alternatives (Cabanero, 2020; Mukoro, 2022). Businesses with energy access reliability and affordability are more engaged in creating new services, investing in technology, and engaging business ideas with competitive advantage (Oyewo, 2023; Mukoro, 2022).

Female entrepreneur's adoptions of renewable energy possess significant potential that has positioned them to engage in advancing their economic quest via involvement in formerly unfeasible business operations, i.e. engaging in business that needs electricity for machinery, lighting, and refrigeration (Shankar et al., 2020). By making energy reliable, accessible and affordable, renewable energy facilitates the creation of innovative solutions (i.e. e-commerce, mobile payment

systems, and digital marketing, etc.) (Burke et al., 2019; Owusu-Sekyere et al., 2024).

Regardless of the strategic potential advantages of energy access for female entrepreneur's innovativeness, female entrepreneurs on the other hand can be limited in exploring innovations by encountering energy constraints. Hence, energy inaccessibility, unreliability, and unaffordability can redirect funds that could have been allocated to funding new product and market development, and technological upgrades (Peimani, 2018; Oyewo, 2023).

H3. Energy access has a significant effect on female entrepreneurial innovation

3. METHODOLOGY

3.1 Research Design and Participants

This study adopted a cross-sectional survey design to examine the effect of energy access on the performance of female entrepreneurs. This approach enabled the collection of data at a single point in time, allowing for the analysis of associations between energy access and entrepreneurial performance without the logistical demands of longitudinal tracking. Cross-sectional surveys are particularly effective for capturing a snapshot of current conditions, thereby facilitating the exploration of relationships among variables (Babbie, 2007). Participants were drawn from rural and semi-urban communities in Rivers State, Nigeria, using databases from the Port Harcourt Chamber of Commerce, Industry, Mines and Agriculture, as well as the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN). A total of 2,505 questionnaires were distributed through digital platforms such as Google Forms, Survey Monkey, WhatsApp, and email. Out of these, 1,509 responses were received, yielding a response rate of 60.24%, which meets the acceptable threshold for social science research (Babbie, 2007). The respondents included female business owners, managers, and sales representatives across various industries. Including participants from diverse professional bodies ensured a representative sample that captures the heterogeneity of female entrepreneurs in Nigeria. This sampling approach aligns with prior studies that underscore the importance of engaging women at different levels of entrepreneurship to understand their unique challenges and contributions within energy-dependent sectors (ENERGIA International Network on Gender & Sustainable Energy, 2020). By focusing on this demographic, the study seeks to generate actionable insights into how energy access influences entrepreneurial outcomes, while also addressing gender-specific barriers within business ecosystems.

3.2 Operational Measures of Variables

In this study, energy access was conceptualized as a unidimensional independent variable, reflecting the availability, reliability, affordability, and adequacy of energy sources accessible to female entrepreneurs in

rural and semi-urban areas. The measurement items were adapted from existing literature on energy inclusion and sustainable energy access frameworks (Karekezi et al., 2012; Pachauri et al., 2012; ENERGIA, 2020). Respondents were asked to rate statements such as “I have reliable access to electricity to run my business operations,” “I use alternative energy sources when grid power is unavailable,” and “The cost of accessing energy does not significantly affect my business profitability.” These items were adjusted to reflect the specific energy realities in Nigeria and were rated on a five-point Likert scale (5 = strongly agree to 1 = strongly disagree).

Female entrepreneurial performance, the dependent variable, was assessed using three sub-dimensions: Female Entrepreneurial Growth, Female Entrepreneurial Innovation, and Female Entrepreneurial Reputation. These dimensions were adapted from prior studies on gender and entrepreneurial performance in developing economies (Alam et al., 2011; Roomi et al., 2009; Amine & Staub, 2009).

Female Entrepreneurial Growth measured expansion-related outcomes such as business size, revenue increase, and customer base growth. Sample items included: “My business has experienced significant growth in the past two years” and “I have increased the number of employees in my business.”

Female Entrepreneurial Innovation assessed the capacity to introduce new products, services, or business processes. Items included: “I have introduced new or significantly improved products or services recently” and “I adopt new technologies or business methods to enhance my operations.”

Female Entrepreneurial Reputation captured how the business is perceived in terms of trustworthiness, reliability, and impact. Example items included: “My business is well-regarded in the community” and “Customers trust the quality of my products or services.”

All constructs were measured using a five-point Likert scale with anchors ranging from 1 (strongly disagree) to 5 (strongly agree). This uniform scaling allowed for ease of interpretation and comparison across dimensions. The measurement instruments were pre-tested with a small sample to ensure clarity, contextual fit, and internal consistency within the Nigerian entrepreneurial environment.

4. RESULTS AND DISCUSSIONS

4.1. Demographic Data

Table 1 shows the demographic details of the female entrepreneurs across various sectors. The type of business distribution reveals that Fashion Design (34.5%) and Hair and Cosmetics Businesses (28.1%) are the most dominant sectors among the respondents, jointly accounting for over 60% of the total. These sectors are traditionally associated with strong female interest and creativity, suggesting that women are leveraging their skills and market familiarity in these areas. Food and Catering Services (19.4%) also attracts a significant

portion, indicating that culinary entrepreneurship remains a popular and viable option. In contrast, relatively fewer respondents are involved in Event Planning and Decoration (2.1%), Interior Design (1.2%), Agribusiness (4.9%), and Fitness and Wellness Coaching (0.6%), perhaps reflecting either limited access, capital requirements, or lower awareness in these niches.

In terms of marital status, a slight majority of the respondents are married (56.1%), while 43.9% are single. This may indicate that many women are engaging in entrepreneurship as a means to support their families or contribute to household income, especially in a society where financial contribution from women is increasingly essential. The age distribution shows a youthful demographic, with the largest group being between 18–35 years (52.4%), followed by 51 years & above (31.8%), and then 36–50 years (15.8%).

Table 1. Analysis of demographic profiles of respondents

Variable	Item	Frequency	Percent
Type of Business	Hair and Cosmetics Businesses	424	28.1
	Fashion Design	521	34.5
	Food and Catering Services	292	19.4
	Event Planning and Decoration	32	2.1
	Beauty and Skincare	139	9.2
	Interior Design and Home Décor	18	1.2
	Agribusiness	74	4.9
	Fitness and Wellness Coaching	9	0.6
	Total	1,509	100
	Marital Status	Married	846
Single		663	43.9
Total		1,509	100
Age	18-35	790	52.4
	36-50	238	15.8
	51 Years & Above	481	31.8
	Total	1,509	100
Years Spent in the Business	0-5	635	42.1
	6-10	440	29.2
	11-15	310	20.5
	16-20	124	8.2
	Total	1,509	100
Highest Level of Educational Attainment	O'Level	237	15.7
	OND/NCE	200	13.3
	HND/B.Sc	1008	66.8
	MBA/M.Sc	62	4.1
	DBA/PhD	2	0.1
	Total	1,509	100

Source: Field Survey Data, 2025.

This suggests a growing interest in entrepreneurship among younger women, which could be influenced by rising unemployment, increasing digital access, and a desire for financial independence. Interestingly, the high proportion of women above 50 implies a sustained interest in entrepreneurial activity later in life, possibly

as a post-retirement venture or a continuation of a long-term business path. When examining business experience, 42.1% of the respondents have been in business for 0–5 years, and 29.2% for 6–10 years, indicating a relatively young population of entrepreneurs. This trend implies recent growth in female-led businesses, which may reflect the impact of government empowerment programs, skill acquisition initiatives, or increased access to social media for business promotion. The presence of a fair number of women in business for 11–15 years (20.5%) and 16–20 years (8.2%) further confirms a steady level of resilience and long-term commitment among certain respondents. Educational attainment levels reveal a highly educated sample, with 66.8% of the women holding HND/B.Sc degrees, followed by O’Level holders (15.7%) and OND/NCE (13.3%). Notably, 4.1% possess postgraduate qualifications (MBA/M.Sc), while only 0.1% have reached the DBA/PhD level. This trend underscores the critical role of education in equipping women with the necessary knowledge and skills for business. It also suggests that formal education may influence the ability to navigate business environments and adopt innovative practices. Overall, the demographic details suggest that female entrepreneurship is increasingly characterized by educated, young-to-middle-aged women with varying degrees of business experience. Their concentration in fashion, cosmetics, and food-related enterprises may reflect both market demand and the alignment of business choices with perceived gender strengths. The data also point toward a vibrant, diverse, and evolving entrepreneurial landscape shaped by education, experience, and personal motivation.

4.2 Test of Hypotheses

This study investigated the effect of energy access on female entrepreneurial performance using Partial Least

Squares Structural Equation Modeling (PLS-SEM). Several methodological and contextual considerations justified the use of PLS-SEM as the most appropriate analytical tool. First, the research aimed to develop and validate a relatively novel theoretical framework within an underexplored context. PLS-SEM is particularly suited for exploratory research where the primary objective is to understand the relationships among constructs rather than to confirm an established theory (Hair et al., 2011).

Second, the dataset included variables that did not conform to the assumption of normality. Unlike covariance-based SEM (CB-SEM), which is sensitive to violations of normality, PLS-SEM is more robust and tolerant of non-normal data distributions (Hair et al., 2017). Third, the model included formative constructs, where indicator variables define the latent construct. PLS-SEM is well-suited to handling such specifications, offering the flexibility required to model complex relationships (Chin, 1998). Lastly, the study adopted a prediction-oriented approach, aiming to estimate the effect of energy access on various dimensions of sustainable female entrepreneurial performance. PLS-SEM is designed for such objectives, emphasizing variance explanation in dependent variables and making it a strong fit for predictive research (Hair et al., 2017).

The following hypotheses were formulated in chapter one of this study:

- H1. Energy access has a significant effect on female entrepreneurial growth
- H2. Energy access has a significant effect on female entrepreneurial reputation
- H3. Energy access has a significant effect on female entrepreneurial innovation

Table 2. Predictive Accuracy, Predictive Relevance and Effect sizes (f2)

Hypotheses	Path Coefficient (β)	S.E	T-Values	P-Values	Effect Size (f^2)	Predictive Relevance (Q^2)
EA -> EG	0.813	0.201	4.0447	0.001	0.36	0.115
EA -> ER	0.784	0.091	8.615	0.000	0.27	0.167
EA -> EI	0.796	0.151	5.272	0.000	0.42	0.421

Where: EA = Energy Access, EG = Entrepreneurial Growth, ER = Entrepreneurial Reputation, EI = Entrepreneurial Innovation. r^2 , = 0.19 = weak, r^2 , 0.33 = moderate, r^2 , 0.67 = substantial (Chin, 1998). Effect size (f^2), 0.02 = small, 0.15 = moderate, while 0.35 = large. Predictive Relevance (Q^2), > 0 = satisfactory (Hair, et al., 2019).

Source: SmartPLS 3.2.9 Output on Research Data, 2025.

Table 2 contains the results of the hypotheses earlier formulated. For Hypothesis one (H1), which proposed that energy access has a significant effect on female entrepreneurial growth, the path coefficient ($\beta = 0.813$) indicates a strong positive relationship. The t-value of 4.045 exceeds the critical threshold of 1.96, and the p-value of 0.001 is well below the 0.05 level, confirming statistical significance. The effect size (f^2) of 0.36 suggests a large effect, and the predictive relevance (Q^2) of 0.115 confirms that the model has satisfactory predictive capability. Based on these results, Hypothesis

1 is accepted, indicating that energy access significantly enhances female entrepreneurial growth.

Result of hypothesis two (H2), which stated that energy access has a significant effect on female entrepreneurial reputation, the analysis shows a strong path coefficient ($\beta = 0.784$), a high t-value of 8.615, and a p-value of 0.000, all of which confirm a statistically significant relationship. The effect size (f^2) of 0.27 reflects a moderate to large effect, while the predictive relevance (Q^2) of 0.167 exceeds the required threshold, demonstrating satisfactory predictive relevance. Therefore, Hypothesis 2 is accepted, confirming that

energy access significantly contributes to enhancing the reputation of female entrepreneurs.

The outcome of hypothesis three (H3), shows a path coefficient of ($\beta = 0.796$), which indicates a strong positive effect. The t-value of 5.272 and the p-value of 0.000 show that this effect is statistically significant. The effect size (f^2) of 0.42 indicates a large influence, and the predictive relevance (Q^2) of 0.421 further demonstrates strong predictive power. Consequently, Hypothesis 3 is accepted, suggesting that energy access significantly promotes innovation among female entrepreneurs.

4.3 Discussion of Findings

This study examined the effect of energy access on female entrepreneurial performance, measured using growth, reputation, and innovation. Partial least squares structural equation modelling (PLS-SEM) was used in the testing the research hypotheses. Outcome of the first hypothesis revealed a significant positive effect of between energy access on female entrepreneurial growth. This outcome indicates that improved energy availability supports business expansion and productivity among female entrepreneurs. Hence, energy access enhances the operational efficiency of female-led ventures by enabling extended working hours, mechanized processes, and reduced production costs. These benefits contribute to business growth, increased revenue, and market reach. This finding aligns with Köhlin et al. (2011), who emphasized that energy services are central to the success of women's economic activities, particularly in underserved regions. Similarly, Olaniyan et al. (2024) argued that energy access drives structural transformation by empowering female entrepreneurs to diversify their economic roles. However, Dinkelman (2011), in her study of South Africa, found that electrification improved employment opportunities for women but did not automatically result in entrepreneurial expansion unless supported by complementary inputs such as training and finance. Thus, this study affirms that while energy access alone cannot guarantee business success, it provides the foundational infrastructure that enables female entrepreneurs to grow and scale their ventures.

The second hypothesis focused on the effect of energy access on female entrepreneurial reputation. It was found that energy access had a significant positive effect on entrepreneurial reputation among women. This suggests that when female entrepreneurs have reliable energy supply, they are better able to maintain operational consistency, meet deadlines, and uphold service quality. This reveals that reputation is critical to business survival and growth. In contexts where customer trust determines repeat patronage, the availability of energy becomes a strategic asset. Scott et al. (2014) found similar results in their multi-country study, reporting that energy access improved service consistency, leading to enhanced customer satisfaction and trust in female-led enterprises. Omeiza et al. (2024) also observed that women who had steady electricity access were more likely to manage enterprises with strong community reputation and

customer retention. On the contrary, Barron and Torero (2017) argued that energy access, without simultaneous investment in business development training, may not necessarily translate into improved customer perception. Nonetheless, this study demonstrates that energy reliability alone can create the conditions for a positive business image, especially in markets where service disruptions are common.

The third outcome of the study showed a strong and significant effect of energy access on innovation among female entrepreneurs. This means that access to reliable electricity enables women to introduce new products, adopt improved technologies, and refine their business models. With reliable power, women can explore digital tools, automate production, and access information systems that foster innovation. This supports business resilience and competitiveness. This result agrees with Chen et al. (2014), who highlighted the importance of energy infrastructure in promoting technological advancement and innovative practices, especially in rural communities. Similarly, Olanrele (2020) stressed that electricity access facilitates modern entrepreneurship by reducing manual operations and encouraging tech-enabled practices. In contrast, Grimm, Hartwig, and Lay (2013) cautioned that although energy access is necessary, innovation among female entrepreneurs also depends heavily on cultural context, access to capital, and education. Therefore, while acknowledging the multifaceted nature of innovation, this study reinforces that energy access remains a critical enabler of innovation, especially in environments where resource constraints are high.

5. CONCLUSION AND RECOMMENDATIONS

This study has provided compelling empirical evidence that energy access significantly enhances female entrepreneurial growth, bolsters business reputation, and fosters innovation. These findings underscore that beyond being a basic utility, access to reliable energy serves as a strategic catalyst for women's economic empowerment. By enabling operational efficiency, improving service consistency, and facilitating technological advancement, energy access plays a central role in fostering resilient and competitive female-led enterprises. While other institutional and socio-economic factors remain influential, energy infrastructure emerges as a critical enabler of gender-inclusive development, particularly in low- and middle-income contexts where female entrepreneurs often face systemic barriers. Based on the findings, the following recommendations were put forward:

- i. First, government agencies responsible for economic development and gender empowerment should integrate energy access initiatives into national and regional entrepreneurship support policies by aligning rural electrification and off-grid energy programs with women-focused

enterprise development plans, particularly in underserved communities. Moreover, energy regulators and ministries of power, in collaboration with private sector energy providers, should promote public-private partnerships aimed at deploying decentralized energy systems, such as mini-grids and solar technologies, specifically targeted at female entrepreneurs in off-grid or poorly served locations. Additionally, financial institutions and donor organizations should design and implement inclusive financing schemes that enable women entrepreneurs to acquire energy-efficient equipment by offering tailored loan products, grants, or equipment leasing programs with favorable repayment structures. By doing so, these efforts will create a more sustainable and inclusive energy ecosystem that supports female entrepreneurship in marginalized areas.

- ii. Secondly, in order to enhance female entrepreneurs' reputation and credibility in the market, business development agencies and women's enterprise organizations should establish programs that connect reliable energy supply with improved service delivery, thereby reinforcing customer satisfaction and trust. Furthermore, training institutions and NGOs involved in capacity building should provide digital literacy and customer relationship management training, ensuring that female entrepreneurs are equipped to leverage energy-enabled digital platforms to communicate consistently and professionally with their clientele. In addition, industry associations and standardization bodies should implement branding support programs that incentivize operational consistency through recognitions, certifications, or storytelling platforms that showcase the reliability and quality of women-owned businesses. As a result, these initiatives will contribute to building a solid reputation for female entrepreneurs, fostering long-term customer loyalty and business growth.
- iii. Lastly, to promote innovation among female entrepreneurs, policymakers and development partners should invest in the establishment of innovation hubs powered by renewable energy, especially in peri-urban and rural regions, where women can access co-creation spaces, business mentorship, and shared equipment. Additionally, organizations focused on digital transformation and enterprise support should introduce and scale up technology adoption programs that empower women to utilize energy-enabled digital tools such as inventory systems, mobile apps, and e-commerce platforms to improve product and service innovation. Furthermore, energy service companies and entrepreneurial training institutes should collaborate to incorporate energy

optimization strategies into business education curricula, thus equipping female entrepreneurs with the knowledge to design innovative solutions that are both energy-efficient and market-responsive. By fostering innovation in this way, these initiatives will enable female entrepreneurs to stay competitive in rapidly evolving markets.

5.1 Contributions to Knowledge

This study makes several important contributions to the existing body of knowledge on energy access, female entrepreneurship, and sustainable development. First, it provides empirical support for a positive relationship between energy access and key aspects of female entrepreneurial performance, namely entrepreneurial growth, reputation, and innovation. While previous research has largely focused on the general impact of energy access on economic development, this study shifts the focus to female entrepreneurs in developing countries, a demographic that has often been neglected in energy-related policy and academic discussions. Second, the study proposes a new theoretical framework that connects energy access directly to female entrepreneurial outcomes. This framework emphasizes the importance of reliable energy not only as a basic need but as a critical driver of business advancement. It also demonstrates how energy access supports non-financial aspects of performance, such as brand reputation and the ability to develop new products and services. In this way, the study addresses a gap in the literature, which has mostly considered energy access from the perspective of household consumption or subsistence-level activities rather than as a factor in business competitiveness and sustainability.

In addition, the study adopts Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the relationships between variables. This approach is appropriate for the exploratory purpose of the study and helps to capture the complex links between energy access and various dimensions of entrepreneurial performance. By using this method, the research adds to the limited number of studies that employ advanced statistical models in the field of gender and enterprise development. Finally, the study offers practical recommendations for policymakers, development agencies, and the private sector. By showing that improved energy access can support women-owned businesses in terms of growth, public image, and innovation, the study provides a strong basis for developing policies that promote inclusive economic development.

The proposed strategies such as integrating energy planning into entrepreneurship support programs, improving digital access and training for women, and establishing renewable energy-powered innovation hubs can help create a more enabling environment for female entrepreneurs, particularly in underserved communities

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