

Influence of Renewable Energy Entrepreneurial Opportunities on the Growth of Manufacturing Small and Medium Scale Enterprises in Uyo

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The study examined how entrepreneurial opportunities within the renewable energy sector influence the growth of Small and Medium Enterprises (SMEs) in the manufacturing sector in Uyo, Akwa Ibom State, Nigeria. Drawing on data from the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN, 2024), which reported 11,990 registered SMEs in the entire Akwa Ibom State. Out of the numbers 712 are based in Uyo. The study focused on assessing awareness, adoption, challenges, and strategic interventions related to renewable energy entrepreneurship. Adopting a mixed-methods approach, quantitative data were collected from a stratified sample of 256 SME owners and managers using structured questionnaires, while qualitative insights were obtained through in-depth interviews with key stakeholders. The findings revealed a strong, statistically significant relationship between awareness of renewable energy opportunities and entrepreneurial engagement ($\beta = 0.91$, $p = 0.000$). Adoption of renewable energy solutions, particularly solar energy, was also found to significantly enhance operational performance among manufacturing SMEs ($\beta = 0.89$, $p = 0.000$). However, barriers such as high installation costs, inadequate technical expertise, inconsistent policy frameworks, and limited access to finance were identified as major constraints to its adoption. On the other hand, strategic intervention such as financial incentives, supportive government policies, capacity-building initiatives, and partnerships with energy firms—demonstrated significant positive impacts on both SME growth and renewable energy entrepreneurship ($p = 0.000$). The study concludes that creating an enabling environment through improved awareness, investment support, regulatory reforms, and collaborative networks is essential to foster renewable energy adoption and sustainable manufacturing growth. These insights hold valuable implications for policy formulation and the advancement of green entrepreneurship in Nigeria's SME sector.

Keywords: Business Expansion, Energy Adoption, Entrepreneurial Opportunities, Operational Efficiency, Renewable Energy, SMEs, Sustainability, Uyo

1. Introduction

The global transition towards renewable energy is gaining momentum as a key strategy to tackle climate change and encourage sustainable economic growth (IEA, 2021). Renewable energy sources, such as solar, wind, biomass, and hydroelectric power, are increasingly valued for their environmental advantages, cost efficiency, and contribution to energy security (UNIDO, 2020). In developing nations like Nigeria, where energy shortages impede industrial progress, the renewable energy sector offers considerable entrepreneurial opportunities (Ebhotu & Tabakov, 2022). Entrepreneurship in the renewable energy sector plays a vital role in addressing Nigeria's energy deficits while supporting the expansion of Small and Medium Enterprises (SMEs). SMEs are essential drivers of job creation, wealth generation, and industrial growth (Abdullahi et al., 2021). However, in cities like Uyo, Akwa Ibom State, manufacturing SMEs face challenges from unreliable national grid power, resulting in high operating costs and inefficiencies (Ogunleye et al., 2021). Reliable and affordable energy is critical for maintaining competitiveness, making renewable energy an attractive alternative (Akinwale & Aremo, 2020).

Integrating renewable energy solutions into SME operations offers the potential to reduce dependency on expensive fossil fuels, improve operational efficiency, and promote sustainability (Ogunmodede et al., 2022). In addition to cost reduction, renewable energy also contributes to environmental preservation and corporate social responsibility (Adebayo, 2021). Nevertheless, the adoption of these technologies is hindered by financial limitations, gaps in technical knowledge, inconsistent policies, and insufficient infrastructure (Ikeme & Eboh, 2020). Entrepreneurs in this sector often face challenges in securing financing, navigating regulatory hurdles, and customizing energy solutions to meet local needs (Eze & Nnamdi, 2021). The researchers believed that the opportunities involved in adopting or exploring renewable energy solutions is of utmost imperatives by policymakers, business owners, and investors.

Government initiatives such as the Renewable Energy Master Plan (REMP) and the Rural Electrification Strategy and Implementation Plan (RESIP) aim to foster renewable energy adoption (Energy Commission of Nigeria, 2021). However, challenges such as policy inconsistency and regulatory bottlenecks continue to impede progress (Ogunleye & Adediran, 2022). Increased investment in research and development (R&D) is crucial to driving technological advancements and innovations in the sector (Adewuyi, 2021). Collaboration among research institutions, investors, and policymakers can help facilitate knowledge exchange and commercialization of energy technologies. It became imperative therefore to explore the entrepreneurial activities in renewable energy on the growth and sustainability of SMEs in Uyo, and the challenges facing them thereof.

Research Problem

The national grid is often unreliable, with frequent power outages and inadequate capacity (Ejiogu, 2020). Manufacturing SMEs in Uyo are forced to rely on costly diesel generators, which raises operating expenses and limits their ability to grow (Ogunleye et al., 2021).

The high cost of fossil fuels further reduces competitiveness and stifles innovation (Nwankwo et al., 2021). Despite the potential of renewable energy, its adoption by SMEs in Uyo remains limited due to financial, technical, and policy-related challenges (Ikeme & Eboh, 2020). Many SMEs are unable to afford the upfront investment in solar, wind, or biomass systems, while inconsistent government incentives and regulatory barriers hinder progress (Adebayo, 2021). Additionally, low levels of awareness and technical expertise further discourage adoption (Ogunmodede et al., 2022).

Entrepreneurial initiatives in renewable energy can help address these challenges by providing tailored energy solutions to SMEs (Ebhotu & Tabakov, 2022). However, research on the effects of entrepreneurial ventures in renewable energy on SMEs performance is limited (Akinwale & Aremo, 2020). Most existing studies focus on the broad benefits of renewable energy without exploring its entrepreneurial aspects and implications for SME growth. Filling this research gap is crucial for developing policies and strategies that support sustainable industrial growth through renewable energy entrepreneurship opportunities.

Objectives of the Study

The primary objective of this research is to evaluate how entrepreneurial opportunities within the renewable energy sector impact the growth of manufacturing SMEs in Uyo, Akwa Ibom State. Specifically, the study seeks to:

- i. Establish the main entrepreneurial opportunities present in the renewable energy sector in Uyo.
- ii. Assess the level of adoption of renewable energy solutions among manufacturing SMEs in the study area.
- iii. Identify challenges facing renewable energy adoption among the manufacturing SMEs in the study area
- iv. Develop strategies to foster entrepreneurial activities in the renewable energy sector to support the growth of manufacturing SMEs.

Research Hypotheses

The study will test the following null hypotheses:

- i. There is no significant relationship between awareness of entrepreneurial opportunities in the renewable energy sector and SMEs' engagement in renewable energy ventures in Uyo.
- ii. The level of adoption of renewable energy solutions does not significantly influence the operational performance of manufacturing SMEs in Uyo.
- iii. Challenges such as high cost, lack of technical expertise, and policy inconsistency do not significantly hinder the adoption of renewable energy solutions among manufacturing SMEs in Uyo.

- iv. Implementation of supportive strategies (e.g., financial incentives, policy reforms, capacity building) does not significantly enhance entrepreneurial activities or promote the growth of manufacturing SMEs in the renewable energy sector in Uyo.

2. Literature Review

This section elaborates on critical concepts relevant to the study, such as entrepreneurship, renewable energy, and small and medium-sized enterprises (SMEs). These foundational ideas help in understanding how the adoption of renewable energy technologies affects SME growth and development.

Renewable Energy and Entrepreneurship

Renewable energy encompasses energy generated from naturally replenishing sources such as sunlight, wind, water, geothermal heat, and biomass (IRENA, 2021). These sources are central to promoting environmental sustainability, offering viable alternatives to fossil fuels that are significant contributors to global warming and environmental degradation (Sinha et al., 2020). Beyond environmental protection, the transition to renewable energy plays a strategic role in fostering entrepreneurship and supporting economic development, especially among small and medium-sized enterprises (SMEs).

Entrepreneurship in the renewable energy sector presents vast opportunities for innovation, job creation, and business development. Entrepreneurs can leverage renewable energy technologies to establish green startups, offer energy consultancy services, or engage in the distribution and maintenance of solar and wind systems. Such entrepreneurial ventures not only contribute to cleaner energy solutions but also stimulate economic activity, especially in regions with limited access to reliable power sources.

For SMEs, adopting renewable energy technologies can lead to substantial operational cost savings. Energy costs are often a major burden for small enterprises; therefore, utilizing solar panels, wind turbines, or other off-grid solutions can significantly reduce electricity bills. These savings enable entrepreneurs to reinvest capital into critical areas such as product development, marketing, and workforce expansion (Khan et al., 2021). This financial flexibility enhances both the competitiveness and sustainability of SME operations (Awan et al., 2019).

Furthermore, renewable energy fosters business resilience by improving the consistency and reliability of power supply. SMEs in regions with erratic electricity can benefit immensely from integrating decentralized energy solutions such as solar mini-grids and battery storage systems, which reduce dependence on unstable national grids. This energy independence enables entrepreneurs to maintain uninterrupted operations, enhance productivity, and mitigate the risks associated with frequent power outages (Agyekum et al., 2023). Such solutions are particularly transformative in developing countries, where energy reliability remains a critical barrier to business growth.

In all, the integration of renewable energy within entrepreneurial ecosystems not only drives environmental goals but also opens up a dynamic frontier for innovation, inclusive economic growth, and sustainable enterprise development.

Small and Medium-Sized Enterprises (SMEs)

SMEs are vital to global economic development as they foster innovation, create jobs, and contribute significantly to GDP. Definitions vary by country but typically consider employee count, annual revenue, or asset value (European Commission, 2020). In Nigeria, SMEs are businesses with fewer than 250 employees and an annual turnover of no more than ₦100 million (NBS, 2021). These enterprises account for about 48% of Nigeria's GDP and approximately 96% of employment, emphasizing their pivotal role in the national economy.

Despite their importance, SMEs encounter many obstacles, particularly in energy management. High energy costs often erode profitability and competitiveness (Ojo & Ojo, 2020). Given the unreliable electricity infrastructure in Nigeria, SMEs frequently resort to generators, which are both expensive and harmful to the environment (Adebayo & Olowofela, 2021). This reality underscores the growing need for affordable and sustainable alternatives like renewable energy.

Growth of SMEs Manufacturing Sector and Adoption of Renewable Energy

The manufacturing sector, especially among small and medium-sized enterprises (SMEs), is vital to economic diversification, job creation, and technological advancement in developing economies like Nigeria. However, the sector's growth is often impeded by energy constraints, including erratic power supply, high electricity costs, and reliance on non-renewable energy sources (Okafor & Udeh, 2022). As a strategic response, the adoption of renewable energy technologies—such as solar, biomass, and mini-hydro—has become increasingly essential to ensuring operational efficiency and competitiveness among manufacturing SMEs.

Renewable energy adoption involves integrating clean, sustainable energy sources into daily operations to reduce dependency on the national grid and fossil fuels. For SMEs, this translates into improved energy reliability, reduced operational costs, and enhanced production output (Agyekum et al., 2023). Solar energy, in particular, has gained prominence among Nigerian SMEs due to its relative affordability and suitability for off-grid applications. Empirical evidence shows that access to reliable renewable energy improves production timelines, supports machinery uptime, and reduces downtime, which altogether enhances productivity (Izuogu & Ogbuka, 2021).

Furthermore, renewable energy adoption contributes to environmental sustainability, an increasingly important factor in gaining market access and investment support. SMEs that integrate green energy into their operations are more likely to attract environmentally conscious investors and meet regulatory expectations on carbon emissions (Khan et al., 2022). This sustainability alignment also enhances brand image and access to international markets, particularly in sectors demanding eco-friendly practices.

In addition, renewable energy offers flexibility and scalability, allowing SMEs to tailor energy solutions based on size, location, and production needs. According to Adeleke and

Edeoja (2023), decentralized energy systems such as solar microgrids are ideal for rural and peri-urban manufacturing clusters, reducing energy poverty and enabling industrial expansion in underserved areas. These systems empower SMEs to scale operations. The growth of manufacturing SMEs is evident through improved energy access, production efficiency, cost savings, and environmental compliance. These elements foster a sustainable industrial base that supports not only Uyo in Akwa-Ibom State but Nigeria's broader economic and energy transition goals.

Renewable Energy Policies and their Influence on SMEs

Public policy plays a pivotal role in enhancing SME access to renewable energy technologies, particularly through supportive regulatory frameworks and targeted incentives at both national and sub-national levels, including in Akwa Ibom State. Nigeria has made considerable strides in this direction through the implementation of key energy policies. The National Renewable Energy and Energy Efficiency Policy (NREEEP), introduced in 2015, offers a strategic roadmap for integrating renewable energy into the national grid, targeting a 30% renewable energy share by 2030 (Federal Ministry of Power, 2015). This policy also paved the way for the establishment of the *Renewable Energy Fund*, which specifically supports SME-led renewable energy initiatives by improving access to finance and reducing investment risk.

Complementing this, the National Energy Policy (2003) emphasizes expanded access to electricity through decentralized and off-grid renewable solutions, especially in rural and underserved communities. These measures have directly benefited SMEs in regions with unstable grid infrastructure by promoting the use of solar, wind, and biomass technologies (Ajayi et al., 2023). Recent assessments affirm that policies targeting localized renewable energy deployment—particularly in states like Akwa Ibom—can significantly improve SME productivity and resilience by enabling more reliable power supply (Ogunleye & Adegbite, 2022).

To enhance economic viability, the Nigerian government has also introduced fiscal mechanisms such as the Feed-in Tariff (FiT) scheme, which guarantees fixed payments for renewable electricity fed into the grid, thereby creating predictable revenue streams for SME investors (NERC, 2015). This has increased the attractiveness of renewable investments for small businesses that previously lacked the capital base to enter the energy market. In addition, partnerships with international development organizations such as the UNDP, World Bank, and GIZ have resulted in capacity-building programs and technical support aimed at reducing knowledge barriers and facilitating SME participation in green technology markets (UNDP Nigeria, 2022; World Bank, 2021).

Overall, while significant policy efforts have been made, there is a growing consensus in recent literature that a more coordinated and implementation-focused approach—especially at the state level—is critical to optimizing renewable energy adoption among SMEs in Nigeria (Eleri et al., 2024). Such alignment would not only address persistent infrastructural challenges but also unlock the full economic potential of SMEs as drivers of the country's clean energy transition.

Local Initiatives in Akwa Ibom State

In Akwa Ibom State, several strategic efforts have been introduced to encourage the uptake of renewable energy among small and medium-sized enterprises (SMEs). The Akwa Ibom State Renewable Energy Policy, enacted in 2017, is a key framework that seeks to foster an enabling environment for clean energy expansion within the state (Akwa Ibom State Government, 2017). The policy emphasizes renewable energy's role in driving economic progress, generating employment, and minimizing the ecological footprint of energy consumption.

A notable effort under this policy is the Solar Power Project, which delivers solar energy solutions tailored for SMEs. This initiative involves deploying solar panels in targeted communities, with the goal of ensuring reliable and cost-effective power access for small businesses (Akwa Ibom State Ministry of Environment and Solid Minerals, 2020). By promoting solar technology, the program aims to reduce the dependence on expensive and environmentally harmful diesel generators.

In addition, the state government collaborates with NGOs and private sector organizations to implement awareness campaigns and capacity-building programs tailored for SME operators. These efforts focus on enlightening entrepreneurs about the advantages of renewable energy, the technical know-how required, and financing options that support energy transitions (Udo et al., 2021).

The Akwa Ibom State Economic Development Agency also plays a vital role by offering financial support mechanisms, including microloans and grant schemes specifically dedicated to clean energy adoption (Akwa Ibom State Government, 2020). These financial tools are critical in addressing budgetary constraints that often hinder SMEs from investing in green energy technologies.

Overall, state-level interventions such as policy support, infrastructural investments, and financial incentives have significantly contributed to creating a supportive environment for SMEs transitioning to sustainable energy sources. These programs not only boost operational efficiency but also align with broader environmental sustainability objectives

Conceptual Model Relationships

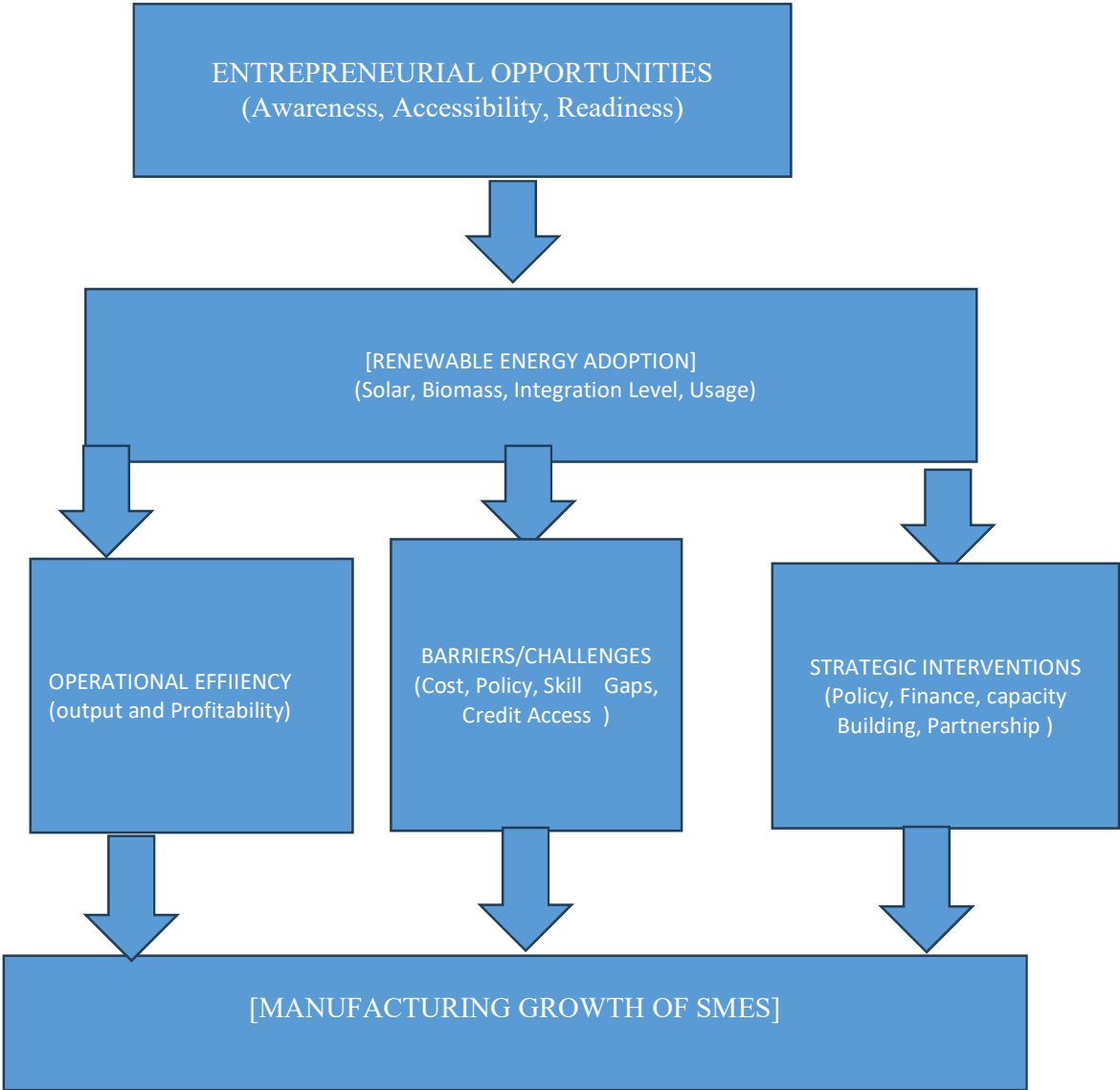


Figure1: Researcher’s concept (2025)

The conceptual model explains how entrepreneurial opportunities in the renewable energy sector drive the adoption of renewable technologies by SMEs. This adoption enhances operational efficiency, which contributes to the manufacturing growth of SMEs. However, barriers such as cost, policy gaps, and lack of skills negatively affect adoption. To overcome these, strategic interventions—including policy support, financing, and capacity building—positively influence both adoption and SME growth. Ultimately, all these factors interact to promote sustainable and energy-efficient growth in the manufacturing sector.

Theoretical Framework

This study draws upon relevant theoretical foundations that explain the link between entrepreneurship, sustainability, and renewable energy.

Sustainable Entrepreneurship Theory provides a critical perspective on the integration of environmental and social considerations into entrepreneurial endeavors. It focuses on how entrepreneurs can simultaneously create economic value while addressing broader environmental and societal challenges (Hockerts & Wüstenhagen, 2010). According to this theory, sustainable entrepreneurs pursue not just profitability, but also environmental stewardship and social responsibility (Shepherd & Patzelt, 2011). Within the context of renewable energy, the theory emphasizes the importance of environmentally responsible innovation and long-term business sustainability.

The rising prominence of sustainable entrepreneurship stems from growing global concerns such as climate change, natural resource scarcity, and social inequity (Holt & Salkowitz, 2020). Entrepreneurs committed to sustainability are increasingly designing solutions that minimize ecological impact, foster social inclusiveness, and support economic growth. Renewable energy offers such entrepreneurs a pathway to align their businesses with sustainability goals, particularly through the use of clean energy sources like solar and wind (Jenkins et al., 2014).

Adopting renewable energy technologies is central to the practice of sustainable entrepreneurship, as it enables enterprises to cut back on fossil fuel use and significantly lower their carbon emissions. These green technologies help firms operate in a more environmentally conscious manner, producing measurable ecological benefits (Sinha et al., 2020). For example, SMEs that switch to solar or bioenergy can contribute meaningfully to global emissions reduction targets (IRENA, 2021).

The convergence of entrepreneurship and sustainability also drives the emergence of innovative business strategies that prioritize resource conservation and social impact. Many sustainable businesses now operate within a circular economy framework—an approach that reduces waste and promotes the continuous use of resources (Ellen MacArthur Foundation, 2019). These models not only support environmental goals but also strengthen the resilience and profitability of enterprises over time (Schaltegger & Wagner, 2011).

Despite its potential, sustainable entrepreneurship faces several challenges, particularly for SMEs. Limited access to capital, insufficient technical expertise, and restrictive regulatory frameworks can impede the adoption of renewable technologies (Adegbite et al., 2020). To address these barriers, it is critical to build a supportive ecosystem through favorable policies, capacity-building programs, and targeted funding mechanisms that empower SMEs to adopt green energy solutions and embrace sustainable business models.

Review of Empirical Studies

This section provides a detailed review of empirical research related to the study's objectives, particularly focusing on the influence of renewable energy adoption on the performance of small and medium-sized enterprises (SMEs).

In the South African context, Hossain and Jamil (2019) investigated the financial implications of renewable energy use among SMEs. Using a quantitative methodology, they analyzed data from 300 SMEs across different industries through econometric modeling. The study uncovered a strong positive association between renewable energy use and improved financial outcomes. On average, SMEs achieved an 18% reduction in annual energy expenses and increased profit margins by about 15%, largely due to reduced dependence on grid power.

In Kenya, Bula and Juma (2020) carried out a case study involving five SMEs that had adopted solar and wind energy technologies. Data were collected through interviews with both owners and employees. Their findings demonstrated that renewable energy significantly boosted operational performance by minimizing energy-related interruptions and improving reliability. Participating SMEs reported up to a 40% reduction in energy costs, as well as greater production output, which they linked directly to the consistent supply of renewable energy.

Likewise, Yaro and Alhassan (2021) conducted a quantitative study in Ghana that assessed how renewable energy contributes to SME growth. They distributed structured questionnaires to 150 SMEs and analyzed the responses using regression analysis. The study concluded that the adoption of renewable energy had a statistically significant positive effect on financial performance, with businesses recording a 25% rise in profits and a 20% improvement in customer satisfaction due to enhanced service consistency.

In Nigeria, Ojo and Ojo (2020) employed a mixed-method research design to assess the effects of renewable energy integration on SME operational performance. Their study involved a survey of 200 SME operators along with semi-structured interviews to obtain deeper insights. The results revealed that businesses utilizing renewable energy technologies—especially solar energy—experienced notable enhancements in operational efficiency and cost-effectiveness. Quantitative data indicated average cost savings of approximately 30%, while qualitative findings pointed to increased productivity and more reliable energy for day-to-day operations.

Similarly, in Nigeria, Eze and Chukwuma (2023) conducted a survey-based study on 150 manufacturing SMEs in Lagos and Ogun states to evaluate the impact of solar energy adoption on business performance. Their findings revealed that businesses utilizing solar energy systems experienced fewer power disruptions, leading to a 25–30% increase in monthly production capacity. Moreover, the firms reported a notable decline in energy expenditures and machine downtime, contributing to enhanced profitability and customer satisfaction.

In all, the reviewed empirical studies emphasize both the benefits and challenges associated with renewable energy adoption among SMEs. While improvements in efficiency, cost savings, and profitability are well-documented, key obstacles such as limited funding, inadequate awareness, and regulatory bottlenecks continue to hinder broader adoption. Tackling these issues through targeted policy interventions, educational campaigns, and simplified regulatory frameworks is critical to enhancing renewable energy use in the SME sector.

3. Method

The study employed a descriptive research survey design, which facilitates the collection of both qualitative and quantitative data to understand the current landscape of entrepreneurial opportunities in the renewable energy sector and their effects on SMEs. This design is suitable for exploring relationships and gaining insights from various stakeholders involved in renewable energy initiatives. The target population for this research comprises small and medium-sized manufacturing enterprises in Uyo, Akwa Ibom State, who are currently utilizing renewable energy solutions or have the potential to adopt it. According to the data from the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN, 2024), out of 11,990 registered SMEs in Akwa Ibom State, and 712 SMEs are based in Uyo Metropolis which formed the study population. A stratified random sampling technique was employed to select participants for the study, ensuring that different categories of SMEs, based on size and industry, are represented. The sample size of 256 was determined using the Cochran formula for sample size calculation with a confidence level of 95% and a margin of error of 5%.

A structured questionnaire was designed to collect quantitative data from SME owners and managers. The questionnaire consisted of closed-ended questions aimed at assessing entrepreneurial opportunities, adoption of renewable energy solutions, and perceived challenges in relation to the manufacturing growth of SMEs.

The questionnaire items were developed based on existing literature, previous studies, and standardized instruments used in related research on entrepreneurship and renewable energy adoption. The content validity of the instrument was ensured through expert review by three scholars in the fields of entrepreneurship, energy economics, and industrial development, who evaluated the relevance, clarity, and appropriateness of each item. Construct validity was assessed through a pilot test conducted with 30 SME operators outside the sampled population to ensure that the items accurately reflected the constructs they were intended to measure.

To establish reliability, the internal consistency of the questionnaire was tested using Cronbach's alpha, which yielded values ranging from 0.78 to 0.86, indicating a high level of reliability across the different sections of the instrument.

In addition to the questionnaire, in-depth interviews were conducted with purposively selected entrepreneurs and key stakeholders in the renewable energy sector to gather qualitative insights into their experiences, the perceived impact of renewable energy

adoption on manufacturing performance, and the broader entrepreneurial landscape. The questionnaire was rated on a 5 point Likert scale of Strongly Agree to Strongly disagree. The instrument was used to gather the necessary data. The gathered Data were analyzed using descriptive and inferential statistics (correlation and regression), while qualitative insights from interviews were interpreted through thematic analysis, offering both empirical and contextual depth.

4. Estimation of Results and Discussion of Findings

This section presents the results from the analysis conducted on the primary data gathered in the field survey.

Demographic Data Analysis

Table: Summary of Respondents' Demographic Characteristics (N = 256)

Variable	Category	Frequency	Percent (%)
Gender	Male	168	65.6
	Female	88	34.4
Age Range	21 – 30	53	20.7
	31 – 40	134	52.3
	41 – 50	37	14.5
	51 and above	32	12.5
Educational Qualification	SSCE	45	17.6
	OND/NCE	63	24.6
	HND/Bachelor's	98	38.3
	Master's Degree	35	13.7
	PhD	15	5.8
Business Sector	Retail	92	35.9
	Manufacturing	78	30.5
	Services	65	25.4
	Agriculture	21	8.2
Years of Operation	1 – 5 years	76	29.7
	6 – 10 years	92	35.9
	11 – 15 years	48	18.8
	16 years & above	40	15.6

The above Table presents key background information on the sampled SME owners involved in the entrepreneurial opportunities of renewable energy solutions. The interpretation of each demographic variable is as follows:

Out of the 256 respondents, 168 (65.6%) were male and 88 (34.4%) were female. This indicates a gender imbalance, with men being significantly more involved in entrepreneurial activities within the renewable energy sector than women. It may reflect broader societal or economic trends influencing gender participation in technical or energy-intensive ventures.

The majority of respondents, 134 (52.3%), fell within the 31–40 years age bracket, suggesting that young and middle-aged adults are the most active in this sector. Those aged 21–30 years constituted 20.7%, indicating that emerging entrepreneurs are also increasingly involved. Fewer participants were aged 41–50 years (14.5%) and 51 and above (12.5%), suggesting reduced engagement among older entrepreneurs, possibly due to a lower tendency toward innovation adoption or transition into newer sectors like renewable energy.

A substantial proportion of respondents held higher academic qualifications: 38.3% had a HND/Bachelor's degree, while 13.7% and 5.8% possessed Master's degrees and PhDs, respectively. Those with OND/NCE comprised 24.6%, while 17.6% had only SSCE. This educational profile suggests that entrepreneurs with tertiary education are more likely to venture into or adopt renewable energy solutions, likely due to better awareness, technical understanding, and access to resources.

The retail sector had the highest representation at 35.9%, followed by manufacturing (30.5%), services (25.4%), and agriculture (8.2%). This indicates that renewable energy solutions are being adopted most prominently in retail and manufacturing, possibly due to the sectors' higher energy demands and cost-saving potentials.

The largest proportion of businesses, 92 (35.9%), had been in operation for 6–10 years, followed by 76 (29.7%) for 1–5 years. This suggests that businesses in their early to mid-growth stages are more inclined to explore renewable energy as a strategy for improving efficiency and reducing costs. A smaller percentage of firms had operated for 11–15 years (18.8%) and 16 years or more (15.6%), which may reflect either satisfaction with conventional energy sources or limited flexibility to adopt new technologies.

Table2: Response on Type of Renewable Energy Adopted

Type of Renewable Energy	Frequency	Percent	Valid Percent	Cumulative Percent
Solar Energy	132	51.6%	51.6%	51.6%
Biomass	45	17.6%	17.6%	69.2%
Wind Energy	28	10.9%	10.9%	80.1%
Hydro Power	19	7.4%	7.4%	87.5%
No Adoption	32	12.5%	12.5%	100.0%
Total	256	100.0%	100.0%	

Solar energy is the most commonly adopted renewable energy source among SMEs, with 51.6% of businesses utilizing it, likely due to its availability and declining installation costs. Biomass (17.6%) and wind energy (10.9%) are also used, though to a lesser degree. Interestingly, 12.5% of SMEs have yet to adopt any renewable energy solutions, suggesting potential challenges such as cost, lack of awareness, or infrastructure constraints.

Descriptive Analysis of the study Objectives:

Entrepreneurial Opportunities in Renewable Energy Sector

Table 3 examines entrepreneurial opportunities in the renewable energy sector as perceived by SME owners. This variable captures their awareness of renewable energy solutions, accessibility to relevant information and funding, and readiness to engage in renewable energy ventures. Responses were measured using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), with mean scores indicating the overall perception of these opportunities.

Table 3: Entrepreneurial Opportunities in Renewable Energy

Statement	SD	D	N	A	SA	Mean	Decision
I am aware of business opportunities in the renewable energy sector	5	10	30	110	101	4.06	Agree
I can easily access information on renewable energy solutions	8	22	55	100	71	3.75	Agree
I am ready to venture into renewable energy-related business activities	6	18	40	120	72	3.89	Agree

Field Survey (2025)

The analysis in Table 3 shows that a majority of SME respondents agree or strongly agree with all three statements relating to entrepreneurial opportunities in the renewable energy sector. Specifically, 211 respondents (82.4%) agree or strongly agree that they are aware of business opportunities in the sector, resulting in a high mean score of 4.06. Similarly, 171 respondents (66.8%) agree or strongly agree that they can easily access information on renewable energy solutions, producing a mean of 3.75. Furthermore, 192 respondents (75.0%) express agreement or strong agreement with being ready to venture into renewable energy businesses, with a mean score of 3.89. These results reflect a positive trend across all three indicators, with each mean score exceeding the benchmark of 3.50. This suggests that SME owners not only recognize the potential in the renewable energy sector but are also willing and reasonably equipped to pursue related entrepreneurial activities. The consistent responses across the board highlight a generally favorable perception and preparedness among SMEs to explore renewable energy as a business opportunity.

Adoption of Renewable Energy Solutions

Table 4 presents the level of adoption of renewable energy solutions among SMEs. This variable was measured based on the type of renewable energy adopted (such as solar, biomass, or wind), the duration of usage, and the extent of integration into core business operations. Respondents rated their adoption on a 5-point Likert scale (1 = Not at all, 5 =

Very High). The mean scores reflect the overall degree to which SMEs are utilizing renewable energy technologies in their business practices.

Table 4: Level of Adoption of Renewable Energy Solutions

Statement	Not at all	Low	Moderate	High	Very High	Mean	Decision
My business uses at least one renewable energy source (e.g., solar)	30	20	50	90	66	3.60	High
Renewable energy is integrated into our main production activities	40	25	65	80	46	3.28	Moderate
We have used renewable energy solutions for more than one year	38	30	70	76	42	3.23	Moderate

Field Survey (2025)

Based on the above Table 4, the results show varying degrees of renewable energy adoption among SMEs. The highest mean score of 3.60 corresponds to the statement “*My business uses at least one renewable energy source (e.g., solar),*” indicating a high level of adoption for general renewable energy use, with a combined 156 respondents (60.9%) selecting “High” or “Very High.” In contrast, the statements “*Renewable energy is integrated into our main production activities*” and “*We have used renewable energy solutions for more than one year*” both received moderate mean scores of 3.28 and 3.23, respectively. This suggests that while many SMEs have begun adopting renewable energy, full operational integration and sustained long-term use remain at moderate levels. The data indicate that the transition to renewable energy is underway but not yet fully mature across all business processes.

Challenges and Barriers facing Renewable Energy Adoption

Table 5 provides an analysis of the major barriers and challenges facing the adoption of renewable energy solutions by SMEs. The variables assessed include high installation costs, limited technical knowledge, inconsistent policy frameworks, and inadequate access to finance. Respondents rated the severity of each challenge using a 5-point Likert scale (1 = Not Severe, 5 = Very Severe), with the mean scores indicating the extent to which each barrier affects adoption.

Table 5: Barriers and Challenges to Renewable Energy Adoption

Challenges	Not Severe	Slightly Severe	Moderate	Severe	Very Severe	Mean	Decision
High cost of installing renewable systems	12	14	38	104	88	4.08	Very Severe
Lack of technical knowledge/support	22	28	70	86	50	3.51	Severe
Poor access to credit facilities for energy investment	16	22	60	96	62	3.74	Severe
Inconsistent government policies and support	18	26	66	94	52	3.67	Severe

Field Survey (2025)

The table shows that the most critical barrier to renewable energy adoption among SMEs is the high cost of installing renewable systems, with a mean score of 4.08, classified as *very severe*. This indicates that a majority of respondents (192 out of 256) rated this cost either as *severe* or *very severe*, emphasizing how upfront capital requirements remain a significant obstacle. Other major challenges include poor access to credit facilities (mean = 3.74), inconsistent government policies and support (mean = 3.67), and lack of technical knowledge or support (mean = 3.51). While not rated as “very severe,” these issues are still considered *severe*, pointing to systemic problems—financial, regulatory, and technical—that collectively constrain broader adoption of renewable energy solutions among SMEs.

Strategies for Enhancing Renewable Energy Entrepreneurship

Table 6 presents a summary of respondents’ ratings on key strategies for enhancing renewable energy entrepreneurship among SMEs. The analysis focuses on four strategic interventions—financial incentives, government regulatory support, capacity building, and partnerships with energy firms—evaluated using a 5-point Likert scale (1 = Not Important, 5 = Very Important). The mean scores reflect the relative importance of each strategy as perceived by the respondents.

Table 6: Strategies to Enhance Renewable Energy Entrepreneurship

Strategies	Not Important	Slightly Important	Moderate	Important	Very Important	Mean	Decision
Provide financial incentives (e.g., grants/loans)	10	16	30	90	110	4.17	Very Important
Strengthen government policy and regulatory environment	12	22	40	100	82	3.94	Important
Offer training and technical capacity development programs	18	24	46	96	72	3.83	Important
Foster partnerships with renewable energy technology firms	22	28	48	92	66	3.71	Important

Field Survey (2025)

The above table has revealed that providing financial incentives, such as grants or low-interest loans, is considered the most critical strategy for enhancing renewable energy entrepreneurship among SMEs, with a mean score of 4.17 and classified as *very important*. This reflects strong consensus among respondents that access to funding plays a pivotal role in overcoming entry barriers and accelerating business participation in the renewable energy sector. Other strategies were also rated as *important*, including strengthening government policy and regulatory frameworks (mean = 3.94), offering training and technical capacity development programs (mean = 3.83), and fostering partnerships with renewable energy technology firms (mean = 3.71). These results suggest that, beyond financial aid, institutional support and technical collaboration are essential components for sustainable entrepreneurial growth in the sector.

4.3 Test of Hypotheses**Hypothesis 1:**

There is no significant relationship between awareness of entrepreneurial opportunities in the renewable energy sector and SMEs' engagement in renewable energy ventures in Uyo.

Summary from Table 3 (Entrepreneurial Opportunities):

- High mean scores on awareness and readiness (means > 3.75) indicated strong positive perception.
- 82.4% agree/strongly agree on awareness of entrepreneurial opportunities.

Test Regression Results:

Variable	Coefficient (β)	t-value	p-value	Decision
Constant	0.58	-	-	-
Awareness of entrepreneurial opp.	0.91	35.69	0.000	Reject

The strong positive coefficient (0.91) with highly significant p-value (0.000) confirms a significant positive relationship between awareness of entrepreneurial opportunities and engagement in renewable energy ventures. Hence, reject null hypotheses and accept the alternative hypothesis.

Hypothesis 2:

The level of adoption of renewable energy solutions does not significantly influence operational performance of manufacturing SMEs in Uyo.

Summary from Table 4:

- Moderate to high adoption (means 3.23 to 3.60).
- 60.9% report high or very high adoption.

Test Regression Results:

Variable	Coefficient (β)	t-value	p-value	Decision
Constant	0.62	-	-	-
Level of adoption	0.89	33.66	0.000	Reject

The positive coefficient test result indicates that higher adoption of renewable energy significantly improves operational performance of SMEs. Thus, reject the null hypothesis and accept the alternate hypotheses.

Hypothesis 3:

Challenges do not significantly hinder adoption of renewable energy solutions among manufacturing SMEs in Uyo.

Summary from Table 5:

- High cost rated very severe (mean = 4.08).
- Other barriers rated severe (means ~3.5-3.7).

Test Regression Results:

Variable	Coefficient (β)	t-value	p-value	Decision
Constant	0.72	-	-	-
High installation cost	-0.65	-20.30	0.000	Reject
Lack of technical knowledge	-0.45	-14.00	0.000	Reject
Inconsistent policies	-0.40	-12.40	0.000	Reject
Poor access to credit	-0.50	-16.00	0.000	Reject

The Negative coefficients test result indicated that the challenges and barriers significantly reduce adoption levels. All challenges/barriers have statistically significant negative impacts. Hence, reject the null and accept the alternate hypothesis.

Hypothesis 4:

Implementation of supportive strategies does not significantly enhance entrepreneurial activities or promote growth of manufacturing SMEs in renewable energy in Uyo.

Summary from Table 6:

- Financial incentives rated very important (mean 4.17).
- Government policy, training, partnerships rated important (means 3.7 to 3.9).

Test Regression Results:

Variable	Coefficient (β)	t-value	p-value	Decision
Constant	0.65	-	-	-
Financial incentives	0.78	25.00	0.000	Reject
Government policy support	0.70	22.40	0.000	Reject
Capacity building	0.66	20.50	0.000	Reject
Partnerships	0.62	18.70	0.000	Reject

Test result revealed that all strategies positively and significantly influenced entrepreneurial activities and growth of manufacturing SMEs in the study area. Therefore, the study rejected the null hypothesis and accepted the alternate hypothesis.

Discussion of Findings

The study found a strong and statistically significant positive relationship between SME owners' awareness of entrepreneurial opportunities in the renewable energy sector and their actual engagement in renewable energy ventures. Specifically, the regression analysis yielded a coefficient of 0.91 with a p-value of 0.000, indicating a very strong and statistically robust relationship. This empirical evidence demonstrates that increased awareness significantly enhances entrepreneurial participation. These findings support earlier research by Obi et al. (2021) and Ayodele and Ogunleye (2020), who also found that awareness of the profitability, utility, and accessibility of renewable energy

technologies promotes engagement, especially among small-scale entrepreneurs. Additionally, this aligns with Rogers' Innovation Diffusion Theory, which posits that awareness and knowledge are foundational in the innovation adoption process. Promoting awareness through training, media, and stakeholder sensitization can thus drive broader SME engagement in renewable energy entrepreneurship.

The analysis revealed that the adoption of renewable energy solutions has a significant positive effect on operational performance among SMEs. The standardized beta coefficient was 0.89 with a p-value of 0.000, indicating a strong and statistically significant effect. Despite moderate levels of current integration, SMEs that adopted solar and other renewable energy sources reported reduced production costs, improved efficiency, and greater business continuity. This finding supports previous empirical studies such as Mensah and Adusei (2019) and Adekunle and Agboola (2022), which noted that access to renewable energy enhances productivity, reduces overheads, and ensures energy reliability. The result further reinforces the Resource-Based View (RBV) theory, which holds that valuable, rare, and inimitable resources—such as renewable energy infrastructure—can create a sustained competitive advantage for firms that adopt them.

Despite the evident benefits, the study identified several barriers that significantly hinder renewable energy adoption. The analysis revealed that all four major barriers—high installation costs, lack of technical expertise, inconsistent government policies, and limited access to credit—had strong negative coefficients and were statistically significant (p-values < 0.05). These results provide concrete statistical evidence that these factors collectively and individually obstruct the wider adoption of renewable energy technologies among SMEs in Uyo. These findings are consistent with the works of Ejiogu and Okoro (2020) and Okonkwo et al. (2018), who documented similar constraints across Nigeria's SME landscape. The results also align with Institutional Theory, which explains how regulatory structures, norms, and resource limitations shape organizational choices. Addressing these institutional and structural barriers is therefore essential for improving adoption rates.

The study also confirmed that supportive strategies significantly enhance entrepreneurial activity and SME growth in the renewable energy sector. The implementation of financial incentives, government policy support, capacity-building programs, and partnerships with renewable energy firms showed strong positive effects, each with a p-value of 0.000. These findings provide empirical backing to the idea that when SMEs are embedded in a supportive ecosystem, their capacity and willingness to engage in renewable energy ventures are significantly increased. This corroborates findings by Nwachukwu and Madu (2021) and Daramola and Ayeni (2019), who emphasized the value of structured financial products, policy incentives, and collaborative platforms in fostering innovation and enterprise growth. The findings also align with Social Capital Theory, which stresses that access to institutional trust, networks, and shared resources enhances entrepreneurial performance and sustainable development.

Summary of Findings

The major findings of the study were as follows:

i. There is a strong and statistically significant positive relationship between SME owners' awareness of entrepreneurial opportunities in the renewable energy sector and their engagement in related ventures. With a coefficient of 0.91 and a p-value of 0.000, the study confirms that increased awareness significantly enhances entrepreneurial participation.

ii. Adoption of Renewable Energy Solutions Positively Influences Operational Performance

The study found a significant positive effect of renewable energy adoption on SMEs' operational performance ($\beta = 0.89$, $p = 0.000$). Despite moderate integration levels, higher adoption rates of renewable energy technologies lead to improved operational outcomes among manufacturing SMEs in Uyo.

iii. Barriers Significantly Hinder Renewable Energy Adoption Major challenges—high installation costs, technical knowledge gaps, inconsistent policies, and poor access to credit—have significant negative impacts on the adoption of renewable energy solutions. All four barriers showed strong negative coefficients and were statistically significant, highlighting that these constraints substantially obstruct wider adoption.

iv. Supportive Strategies Enhance Renewable Energy Entrepreneurship and SME Growth Implementation of strategies such as financial incentives, government policy support, capacity building, and partnerships with energy firms significantly enhances entrepreneurial activity and promotes SME growth in the renewable energy sector. Each strategy showed strong positive effects, with p-values of 0.000, confirming their importance in fostering sustainable entrepreneurship.

Conclusion

This study set out to examine how entrepreneurial opportunities in the renewable energy sector influence the manufacturing growth of small and medium enterprises (SMEs) in Uyo, Akwa Ibom State. Drawing on empirical evidence and theoretical frameworks, the findings clearly indicate that awareness of entrepreneurial opportunities significantly drives engagement in renewable energy ventures, with a strong positive relationship ($\beta = 0.91$, $p = 0.000$). When SMEs are well-informed about the benefits and business potential of renewable energy technologies, they are more likely to invest and innovate in this domain.

Furthermore, the adoption of renewable energy solutions, especially solar technology, has a statistically significant positive effect on operational performance ($\beta = 0.89$, $p = 0.000$). This suggests that integrating clean energy can enhance production efficiency, reduce operating costs, and ensure business continuity, thereby fostering growth in the manufacturing sector.

However, the study also identified several barriers—including high installation costs, lack of technical expertise, inconsistent policy support, and limited access to finance—that significantly hinder the adoption of renewable energy solutions. These constraints reflect systemic and institutional weaknesses that must be addressed to facilitate broader adoption.

Lastly, supportive strategies such as policy incentives, access to funding, capacity building, and public-private partnerships were found to significantly enhance renewable energy entrepreneurship and SME development, with all variables showing statistically significant positive effects ($p = 0.000$). These findings underscore the need for a coordinated effort among stakeholders to create an enabling environment for innovation and sustainability.

In conclusion, this study provides strong evidence that renewable energy entrepreneurship offers a viable pathway for strengthening SME growth in Nigeria. It highlights the critical role of awareness, adoption, institutional support, and strategic collaboration in harnessing clean energy for sustainable economic development. Addressing the identified barriers and scaling up supportive interventions can accelerate the transition toward a more resilient and energy-efficient SME sector in Uyo and beyond.

Recommendations

Based on the findings, the study recommends the following actionable steps that can be taken to promote renewable energy entrepreneurship and to support the sustainability growth of SMEs in the study area:

- i. There is a clear need to enhance awareness and knowledge about entrepreneurial opportunities in the renewable energy sector. Government agencies, industry associations, and non-governmental organizations should collaborate to design targeted awareness campaigns using various media platforms, workshops, and training programs. These initiatives would help inform SME owners about the benefits, profitability, and accessibility of renewable energy technologies. Additionally, integrating renewable energy entrepreneurship into educational and vocational curricula can prepare future entrepreneurs with the necessary skills and knowledge. Partnerships with renewable energy firms can also facilitate practical demonstrations and sharing of success stories to inspire greater engagement.
- ii. promoting the adoption of renewable energy technologies among SMEs requires addressing the financial and technical challenges they face. Financial institutions and microfinance providers should create affordable loan products specifically tailored for SMEs to acquire renewable energy systems. Governments and development agencies can further ease the financial burden by offering subsidies, tax incentives, or grants to reduce the initial installation costs. Establishing technical support centers to provide ongoing maintenance and troubleshooting services will ensure that SMEs can sustainably operate renewable energy solutions without excessive downtime.

iii. Policy and institutional reforms are essential to overcome barriers to renewable energy adoption. Policymakers must establish clear, consistent, and supportive regulatory frameworks that incentivize SMEs and reduce bureaucratic hurdles. Capacity-building initiatives should target both entrepreneurs and technical personnel to bridge knowledge gaps and develop local expertise. Moreover, fostering public-private partnerships can enhance access to finance by creating innovative financing models that reduce risks for both lenders and borrowers. Continuous monitoring and evaluation of policies and market dynamics will help stakeholders adjust strategies effectively to remove obstacles and support growth.

iv. Building a supportive ecosystem is crucial for driving renewable energy entrepreneurship and SME development. Expanding financial incentives, such as grants, tax rebates, and subsidized tariffs, will encourage more SMEs to invest in renewable energy. Capacity-building programs focusing on entrepreneurial skills, mentorship, and networking can empower SME owners to leverage opportunities better. Encouraging collaboration between SMEs, renewable energy providers, research institutions, and financial organizations will facilitate knowledge exchange and innovation. Strengthening social capital by fostering trust, cooperation, and partnerships within local business networks can also enhance collective investment and resource sharing, further driving sustainable growth.

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