

**STRATEGIC MARKET PENETRATION OF PIPED LIQUEFIED
PROPANE GAS (PLPG) IN NIGERIA: BUSINESS PROSPECTS AND
POLICY CONSIDERATIONS.**

By

OWOEYE OPEYEMI ABIDEMI

Abstract

Small businesses play a critical role in driving employment, innovation, and inclusive economic growth across Sub-Saharan Africa. However, their operations are often constrained by volatile economic conditions, including inflationary pressures, exchange rate instability, policy inconsistencies, infrastructural deficits, and fluctuating consumer demand. While existing literature has largely examined these challenges from a quantitative perspective, there remains limited insight into how entrepreneurs interpret and respond to such uncertainty in practice. This study therefore investigates how small business founders navigate economic transitions and identify opportunities within uncertain environments.

Adopting a descriptive narrative research design, the study draws on primary data collected from small business owners operating within Trade Fair Complex, Lagos State, Nigeria. Participants were selected using purposive and convenience sampling techniques, and data were gathered through structured questionnaires and semi-structured interviews. Thematic analysis was employed to examine patterns in entrepreneurial experiences, adaptive strategies, and decision-making processes.

Findings reveal that although entrepreneurs face significant constraints—including rising operational costs, foreign exchange volatility, limited access to finance, and policy unpredictability—they demonstrate notable resilience and adaptability. Key strategies identified include business diversification, adoption of digital sales platforms, cost optimization, alternative sourcing, and enhanced customer engagement. The study also highlights the importance of soft capabilities such as persistence, continuous learning, and strategic flexibility.

The study concludes that uncertainty, while disruptive, can serve as a catalyst for innovation and growth when effectively managed. It recommends that entrepreneurs strengthen adaptive capacities, while policymakers should create a more stable and supportive business environment to foster sustainable enterprise development.

Keywords

Entrepreneurship, Economic Uncertainty, Small Businesses, Resilience, Economic Transition, Business Adaptation, Sub-Saharan Africa

Introduction

The world is undergoing a significant shift in its energy landscape, and both the urgency of energy security and degradation reduction demand the shift. It is in this respect that the switch to cleaner and efficient modern sources of energy, when compared with polluting solid fuel, has become a main issue on the national and international stage of development (Rehfuess et al., 2006). In a nation like Nigeria, which has been blessed with great resources of fossil fuel, but plagued by widespread energy poverty, such a transition is not only an environmental or economic aspect, but a prerequisite to sustainable development. Even though the nation is a large producer of crude oil, natural gas, a substantial proportion of the populace remains not linked to the utilisation of modern power service, as a huge percentage relies on biomass such as firewood and charcoal cooking, heating, and generation of power generation (Oyedepo, 2012). The adverse effects of overreliance on these sources of energy are disastrous in deforestation and indoor air pollution, which leads to respiratory diseases (Kurmi et al., 2012).

Against this complex energy backdrop, Liquefied Propaned Gas (LPG), primarily consisting of propane and butane, has taken the place of a critical transition fuel (Sharma et al., 2025). Its application in home food preparation, especially in urban areas, has been promoted as it uses cleaner instead of kerosene and firewood. High-pressure cylinders are, however, commonly used to distribute LPG in Nigeria (Princewill et al., 2023). Despite this improvement, this model has its own difficulties that prevent its implementation and maximum utilisation in any place. The cost and logistical agony of refilling the cylinders numerous occasions over, grim safety concerns with regard to improper treatment and service of the cylinders, imprecision in supply, and incapacity to apply them to bigger, more energy-intensive operations, such as in commercial enterprises and energy generation.

Piped Liquid Propane Gas (PLPG) emerges as a revolutionary and more strategically preferable choice. PLPG (also known as propane-air systems or distributed gas networks) refers to any type of distribution of propane vaporised by a central storage/vaporisation facility to multiple end-users within a small geographic area, a residential estate, university campus, industrial park or commercial district (Wu et al., 2024). The model is

convenient and reliable, like the natural gas distribution, but on a smaller scale and scalable, which contributes to making the model applicable in areas where the national gas grid is not available. PLPG model offers a paradigm shift of an LPG as a product to an LPG as a utility whereby on-demand service is presented, continuity and enhanced safety, comfort and economic efficiency are provided.

Nigeria has a strong business potential for PLPG (Ihemtuge & Aimikhe, 2020). It is a simple market for the centralised delivery of gas, given the rapid urbanisation of the country, in which the high-density residential and commercial settlements are getting bigger. It has an important entry point in the real estate market that is growing and requires value-added facilities in upscale estates (Hou et al., 2019). Furthermore, the potential market size is in the industries and businesses that wish to apply their processes to the stable and cost-effective and cleaner energy, which will lead to the reduction of the degree of reliance on the expensive and polluting diesel generators (Elkelawy et al., 2025). The benefits of the economy are not just to the service providers but also to the generation of jobs in installation and maintenance, as well as economic productivity in general through improved supply of energy.

However, there is no automatic process of strategic penetration of this potential energy solution. It is linked to an immense number of challenges that demand the implementation of strategic and policy care (Obuseh et al., 2025). The first financial challenge is the one that requires the initial capital to undertake the infrastructure, i.e. bulk storage tanks, vaporisers and the pipeline network itself. A proper system of regulation that controls safety standards, right-of-way of pipelines and tariff systems has yet to be established or not. What is more critical is that consumer confidence and acceptance are a big task to undertake, even within the framework of the market, where the prior experience of using gas has been put in perspective by the cylinder model and the dangers that it involves. Nevertheless, a potential customer may have hidden fears of the piped gas system being unsafe, with the fear of gas leaking and gas explosion and may be sceptical about the clarity of the billing system and reliability of the supply. Therefore, it is essential to observe how the market forces, consumer thinking and the policy that facilitated the factors were necessary to unlock the potential of PLPG in Nigeria.

Purpose of the Study

The proposed study seeks to establish the strategic direction, the business opportunities and policy models that would ensure Piped Liquefied Propane Gas (PLPG) successfully enters the Nigerian market.

Research Questions

This study is guided by the following research questions:

1. What are the business opportunities and main barriers to the adoption of (PLPG) in Nigeria?
2. What is the policy and regulatory action that should be applied to support the development of the (PLPG) market?
3. How do potential end-users perceive and accept (PLPG) systems?

Review of Related Literature

Global Context and Lessons from Established PLPG Markets

The use of Piped Liquefied Propane Gas is not a recent development in the world, but the adoption of the same is grossly imbalanced in the developed and developing worlds. Propane distribution systems are an experimental mode of energy provision in nations like the United States, but also in rural areas where natural gas pipelines are unavailable. An empirical study, such as that by the Propane Education and Research Council (PERC, 2021), focuses on the effectiveness of such systems based on a three-fold basis comprising the strong safety standards of installations and maintenance, an established market with active service **offerors**, and high consumer awareness and confidence in the safety and reliability of the technology. The utility concept is also a power behind the model and has been known to provide a smooth power experience, which is generally preferred because it can easily be used as a form of fuel, which is very convenient and cheap in comparison to other sources of fuel, like heating oil.

As it is implemented in the developing countries, the plot switches to the potential of PLPG as a remedy to energy transition in the cities. In a study on the application of liquefied propane gas to reduce energy poverty (235), Kojima (2017), in particular, points out that one of the models identified to be utilised in the high-density urban settlements is the piped system, claiming that they can overcome the cylinder distribution problems

of cost, safety and logistical ineffectiveness. Empirical evidence on the case of such nations as Brazil and India is transformed into critical insights. The implementation of a GNV and smaller propane-led networks in the business corridors in Brazil indicated that a lot relies on the existence of synergistic relations between the government and companies and the proper zoning and permitting of activities (De Almeida et al., 2019). They found that regulatory clarity was more significant as an enabler than a direct subsidy in the attraction of infrastructure investment by the private entities.

Similarly, the high relevance of the aspects of affordability and consumer behaviour, which is also a valuable lesson to be learnt concerning PLPG, is the key to the study of the Pradhan Mantri Ujjwala Yojana scheme, carried out in India by Sharma and Pal (2020), which primarily addresses the topic of cylinder LPG. In its study, it was found that first-time adoption, despite subsidy, was not followed by long-term use, as many households reverted to traditional biomass, using the repetitive refill cost. This fact indicates that the price and billing model of establishing the free refill logistics of PLPG must be such that it would ensure affordability over the long term. A study conducted by Bhattacharya and Patel (2022) in one of the pilot PLPG projects in the educational campus, Gujarat, India, found that the perceived value of uninterrupted supply and time saved was significant to produce user satisfaction and was more significant than the problems of initial costs. It would mean that the PLPG value proposition must be placed on convenience and reliability instead of the cost only.

However, this global review creates an important research gap. Unlike the success factors in the mature market and the benefits that may be achieved in the emerging setting, there are few empirical and qualitative researchers that examine the Strategy process of launching and developing the PLPG in a challenging, price-conscious and complex market, like the case of the Nigerian one. The literature available only prescribes what is to be done, but does not present much context-specific information on how to deal with the specifics of the financial, regulatory, and socio-cultural environment of the Nigerian energy sector.

The Nigerian Energy Landscape and the LPG Transition

Nigeria has witnessed a high dependency on traditional biomass and fossil fuels despite the presence of massive reserves of natural gas in the country, as the energy sector in the country has been widely reported in the literature, where it has been noted that the country is beset by an acute energy crisis. According to both Ogunleye (2021) and Eleri et al. (2022) studies, energy poverty is tripled as a lack of access, a lack of supply, and a high cost of alternatives. The Nigerian Energy Transition Plan (2022) actually says that LPG is among the transition fuels, which are extremely significant to clean cooking, in an attempt to reduce the health risk of indoor air pollution by firewood and kerosene.

Empirical research has been carried out on the market of cylinder-based LPG in Nigeria. The Journal of Energy in Southern Africa proposed by Nnaji et al. (2020) implied that the expensive initial cost of the cylinders and burners, the risk of explosions, and unpredictable supply leading to stock-outs occur frequently are the challenges that restrict the implementation of cylinder LPG. Another investigation made by Adelekan and Itepo (2021) on consumer perceptions in Lagos has found that the fact that was the most discouraging factor among non-users was the safety issue, and the second most harmful factor was the inconvenience of filling and carrying around the cylinders. This literature also comes in handy when determining the limitations of the current model of LPG distribution, and also forms a concrete case of why it is necessary to reflect on a superior alternative like PLPG.

However, scholarship of PLPG specifically in Nigeria is incredibly less and largely speculative. In Nigeria, most piped gas is referred to the national natural gas grid that is limited in scope and has its own issues with infrastructure and vandalism (Okon, 2023). The idea of the distributed gas systems has been hinted at in a small number of policy briefs, e.g. the Nigerian Gas Association (NGA, 2022), and mentioned as a possible solution, but without empirical evidence and detailed exposition on how to do it. An example of such an exception is a feasibility study conducted by the Lagos State Government, along with a private business, of a pilot project of PLPG in a state-owned housing estate (referenced in a business report by PwC Nigeria, 2023). The report has described briefly the large capital outlay and the lack of a specific regulatory framework

to be the key challenges, but the deeper nature of a rooted attitude of the end-users or the more detailed strategic planning of the individual investors is not explored.

The loophole in this review is that issues of the current energy system and the one in the cylinder LPG model are well-written conscientiously, but practically, there is near-zero literature of a specific study of the PLPG as a specific viable solution in the Nigerian context in a mechanical manner. The literature available does not answer the critical questions of the potential business models, the precision of risk perception of the Nigerian consumers and the precise alterations in the regulation that ought to be enacted to offer an enabling environment. The purpose of this research is to fill this gap directly, as the study goes beyond the general concessions of the viability of PLPG to an actual empirical analysis of its viable mode of entry.

Market Penetration Strategies and Policy Frameworks for Clean Energy

To theorise the penetration of PLPG, it is convenient to turn to the literature on the diffusion of innovations and entry ways to the market of new energy technologies. The theory of Diffusion of Innovations put forward by Rogers (2003) is specifically applicable since it seeks to assumes that the perception of relative advantage of a new technology, compatibility, complexity, trialability, and observability are what determine the adoption of new technologies. When imposed on PLPG, it would mean that its penetration into the market will depend on the possibility of explaining the merits of the technology in comparison to the cylinders (convenience, safety), compatibility with the local cooking style and appliances, demystification of the technology complexity, and access to pilot projects (trial).

This is important because the penetration of the market in other similar industries has been investigated empirically. In a study by Adedaja et al. (2020) on the adoption of solar home systems in Nigeria, models that were employed in financing the systems turned out to be as important as the technology itself. Their analysis has proved that pay-as-you-go and other flexible payment schemes play a key role in enhancing the adoption. It implies that the new financing and billing schemes, i.e. connection fees amortisation or energy-as-a-service subscriptions, can be a determining success factor in the case of the capital-intensive technology such as the PLPG.

In addition, the literature on the problem of policy frameworks will continuously emphasise the need to have a multi-pronged approach. According to a review of the energy transition policies provided by Mundaca et al. (2018), various tools are critical: (1) Regulatory Instruments: the mandatory building codes that require gas pipeline products to be established in newly-created estates and enforced safety standards; (2) Fiscal and Financial Incentives: tax holiday on the investment in PLPG infrastructure, tax-free import of large equipment, and soft loans from the development finance institutions; (3) Information-Based Instruments: This will involve the public awareness campaigns, which will demystify the technology and build trust.

Lack of research is evident as one attempts to directly apply these broad strategic and policy guidelines to PLPG in Nigeria. Though there is an easy checklist of potential measures that is presented in the literature, it has no clear, prioritised and contextual approach. For instance, which policy instrument will be the most catalytic in the case of Nigeria, a tax incentive or a safety regulation? What are the distinct perceptions by the Nigerian consumers towards the piped gas, and how do they need to be addressed in the best way possible? The existing literature is also not qualitative and stakeholder-driven to render the strategy of these extensive generalisations into a specific and operative plan of action in Nigeria.

Synthesis and Establishment of Research Gap

This review has established that PLPG is a technologically tested model, which has proven to work in other markets. It has been further determined that the desire to change the present energy situation in Nigeria, and that the possibilities of the cylinder LPG model are a loud appeal to find an alternative. Besides, a broad strategic toolkit on clean energy diffusion is available in general theories and policies.

However, an urgent knowledge gap in the meeting of the three aspects has not been eliminated: A consistent empirical study that explicitly addresses the strategic, market-based, and policy-driven paths towards successful introduction and scaling of PLPG within the particular socio-economic and regulatory context of Nigeria is not present. The above questions have been explored in the past either directly in the issues (energy poverty, cylinder LPG barriers) or generally, but never in the concrete players, namely investors,

policymakers and end-users, building a solid conceptualisation of the viable business opportunities, practical policy demands and the factors of willingness to accept PLPG. The proposed research will fill this gap by giving a qualitative and in-depth analysis that can be adopted as a strategic roadmap in transforming the energy environment in Nigeria through the use of Piped Liquefied Propane Gas.

Methodology

The study adopted a qualitative research design wherein it sought to investigate the strategic direction, business prospects and policy guidelines in the exploration of Piped Liquefied Propane Gas (PLPG) in Nigeria. The decision of the approach was to acquire deep contextual rather than numerical knowledge and be relevant in an emerging energy market. The study was completely dependent on secondary sources since it was carried out in a systematic review of the existing literature and policy documents published in the past, since the year 2018 to 2025, so that it can be relevant not only in the past, but also in the present.

Approximately ten high-quality materials (peer-reviewed articles, feasibility studies, and official reports of national and international organisations) were chosen with the assistance of the purposive sampling technique. These sources were chosen based on the fact that they have a direct connection to business opportunities, regulatory issues and user perceptions of PLPG or other clean energy technologies.

The data mining structure employed to obtain the data was a systematic procedure, with the help of which the information about the study topic, the central findings, policy implications, and consumer feedback was obtained. The data were analysed by qualitative content analysis that was defined through the process of coding, categorising, and analysing recurring themes and patterns. This process enabled the inclusion of different findings in one narrative; thus, conclusions were drawn on the basis of systematic and critical analysis of reliable sources.

Results and Findings

This work was a compilation of the findings on ten recent and reputable sources published between 2018-2025 that used Liquefied Propaned Gas (LPG) and distributed gas systems (PLPG) as the subject of research. These materials were divided into themes, which, with the assistance of the qualitative content analysis, would answer the three research questions: (1) business opportunities and barriers to the adoption of PLPG; (2) necessary policy and regulatory responses; and (3) user perceptions and acceptance factors.

Exdc for PLPG Adoption in Nigeria

The literature reviewed provides consistent evidence that Nigeria has a potential for a piped LPG system that remains untapped with the growth in urbanisation, proliferation of housing estates and the need to use cleaner energy even more. Adegbola, Ozigis, and Muhammad (2018) demonstrated by simulation in the Nigerian Journal of Technology that, technically, it is feasible to use gas pipeline networks in residential estates that will reduce the use of single cylinders significantly. Equally on the same spot, Onwukwe, Duru, and Ikpeka (2024) in the Journal of Advanced Research in Petroleum Technology and Management stated that the localised gas distribution systems would not only limit the occurrence of supply disruptions but also minimise the chances of refilling-related accidents.

Economic opportunities are also very good. The domestic LPG distribution analysed by Uneh, Ene and Onwa (2023) showed that the centralised gas structures would be attractive to the investors and would lower the cost per household by approximately 30 per cent, compared to traditional cylinder delivery. However, the same research also named capital expenditure and funding infrastructure as the largest barriers to entry, which the same study also found, since, according to the report by Nigerian Liquefied Natural Gas (NLNG) Delivery (Nairametrics, 2023), only 40 per cent of the LPG demand was met domestically, hence, the need to import and high retail prices.

Environmental and energy security issues also improve the business case. As Chikezie et al. (2020) noted, the increase in the utilisation of LPG was associated with reduced deforestation and air quality in Imo State, and thus, gas systems can provide the delivered gas as a useful component of the climate targets in Nigeria. Similarly, Laska and Ige

(2023) in Energies added that the rural-urban transition zones could be made of piped LPG, which will reduce the use of unsustainable solid fuels to prepare domestic energy. Nevertheless, some grave barriers remain. Cost of infrastructure, regulatory uncertainty, and insufficient technical expertise were taken as the key challenges (Onwukwe et al., 2024; Adegbola et al., 2018). As in the GPH International Journal of Business Management research conducted by Obele (2025), affordability and consistency in supply were also found to be influential factors affecting the adoption of LPG by Nigerian households, so new large-scale PLPG networks need to consider flexible billing and financing schemes by paying a per-installment connection fee or adopting a prepaid scheme.

Policy and Regulatory Measures for PLPG Market Growth

The findings of academic and policy-based sources lead to the conclusion that policy coherence and regulation of safety are the most significant facilitators of PLPG development in Nigeria. The deficit of a national policy of gas distribution to urban buildings, which would be able to result in the engagement of the sector in the case of a private intervention, is also noted according to the Energy Commission of Nigeria (2023) and the Federal Government Technical Committee on Urban Gas Distribution (Nairametrics, 2024).

According to Adegbola et al. (2018), the gas pipeline ducts must become a part of the code of national buildings, which will allow retrofitting and additional extension. This is justifiable by Onwukwe et al. (2024), which encourages a distinct licensed distributed energy permit as an alternative to the existing gas transportation permits in order to encourage the use of local operators. Moreover, clear tariff regulations and laws that protect consumers should be used to avoid market monopolisation and unfair pricing, as stated by Obele (2025) and Aminu (2025).

The worth of fiscal incentives is provided by the comparative information of the global and regional policies. In their example, the International Energy Agency (IEA, 2024) has reported that in emerging economies, such as Brazil and India, the stimulus of accelerated growth was the low-interest funding of gas infrastructure and the reduction of the importation duty on LPG equipment. Application of the same mechanisms in Nigeria would

rectify the capital intensity and would provide a better opportunity for return on investment.

In January 2025, AllAfrica News noted that the Ministry of Petroleum Resources in Nigeria began to provide new gas distribution licences to the private operators, which means that the strategy of decentralised systems has changed. However, the regulatory structure remains incomplete as of mid-2025. The majority of the reviewed sources propose a National Distributed Gas Framework that would assist in facilitating growth, that is a synthesised document that establishes the standards of operations, safety codes, fiscal stimuli and duties between the federal, state and local agencies.

Perceptions and Acceptance Factors of Potential End-Users

Perception and behavioural problems on the part of the consumer were found to be determinants of the PLPG adoption. As it is ever observed in the study, the motivation to experience the benefits of LPG is on the rise, yet the assumptions of the safety and affordability of gas prove to be the obstacles to the general uptake of gas (Hammeed et al., 2019; Obele, 2025).

Hammeed et al. (2019) in their article about rural households (Badagry, Lagos) have concluded that 65 per cent of households they studied used LPG because it produces low smoke and is not inconvenient, but 47 per cent were scared of the possibility of an explosion. This two-sidedness implies that the importance of infrastructure investment is rivalled by both sensitisation and safety education. Likewise, Uneh et al. (2023) found that the implementation of the community gas networks in the Choba area of Rivers state was less promising in situations when community gas networks were guaranteed to be sustained and the safety was provided by reputable contractors.

The acceptance is also determined by gender and socio-economic conditions. It was also established that women and students registered a larger adoption rate in the presence of LPG, whereby there were organised supply systems, mostly because of the convenience and time saving (Aminu, 2025). These are the same results as the Clean Cooking Initiative by the World Bank (2023), which underlines the importance of energy planning with a gender-sensitive strategy that would help with the sustainability and safety of the clean fuel transitions.

In addition, the aspect of affordability also continues to be a good indicator of consumer behaviour. Obele (2025) and Chikezie et al. (2020) note that such forms of subsidies or instalment payments to receive a connection can become one of the drivers of adoption, especially with the low- and middle-income users. The awareness campaigns on the advantages of PLPG in the long-term, in terms of cost-saving and health, are, therefore, required.

Table 1: Summary of Reviewed Studies (2018–2025)

Author(s) & Year	Study Focus	Key Findings
Adegbola, Ozigis & Muhammad (2018)	Gas network design for estates in Nigeria	Technically feasible; requires strong safety codes.
Chikezie et al. (2020)	LPG use in Imo State	Reduces deforestation and indoor pollution.
Hammeed et al. (2019)	Rural LPG adoption in Lagos	Cost and safety perception affect usage.
Uneh, Ene & Onwa (2023)	Domestic LPG distribution in Rivers State	Centralised systems can cut household costs by 30%.
Obele (2025)	Determinants of LPG adoption in Nigeria	Affordability and reliability drive adoption.
Aminu (2025)	LPG usage among students	Pricing and accessibility determine patronage.
Onwukwe, Duru & Ikpeka (2024)	Domestic gas distribution feasibility	Distributed systems reduce risks and shortages.
Łaska & Ige (2023)	Assessment of domestic solid fuels	LPG is crucial for the energy transition.
Energy Commission of Nigeria (2023)	National energy policy review	Calls for a clear LPG and distributed gas framework.
IEA (2024)	Global LPG transition report	Fiscal incentives and PPPs drive adoption success.

Summary of Findings

The result of the current research indicates that Piped Liquefied Petroleum Gas (PLPG) has great potential in the energy transition of Nigeria, as it is a safer and more efficient replacement of the classical cylinder model. The favourable environment of PLPG uptake is brought about by rapid urbanisation, expansion of estates, and the need to have cleaner household energy. Nevertheless, large-scale implementation is limited by its technical and economic viability due to high infrastructure expenses, the lack of access to funds, and the lack of a specific regulatory framework. Another factor that frustrates investment in the private sector is policy inconsistency and ineffective application of the safety standards.

Another vital factor that affects adoption came out as consumer perception. Though the benefits of LPG are being spread, there is still a consistent fear of explosion and distrust in safety measures, which makes it difficult to be widely accepted. Research indicates that affordability and reliability are the decisive factors, and flexible billing systems and informing consumers can increase the level of trust. It also depends on gender, with women (who are usually the key users of energy in the household) becoming more willing to use PLPG when the safety and convenience are assured.

The findings, in general, prove that PLPG is technically feasible and beneficial to society, yet its implementation requires coordinated policy adjustments, incentives for the investors, and the constant presence of public awareness. Through adequate control and funding processes, PLPG can greatly improve a clean energy transformation in Nigeria.

Discussion

The findings of the current study are comparable to the existing literature on the subject of LPG uptake and energy transformation in Nigeria, along with the expansion of the debate to the novel area of Piped Liquefied Petroleum Gas (PLPG). Similar to Lasisi (2021), who discovered that affordability and access are some of the primary factors that determine LPG adoption, the current paper confirms the idea that costs and availability are the most significant factors that determine consumer behaviour. However, unlike the previous study that focuses mostly on the cylinder-based systems, this study is concerned with other problems associated with the infrastructure financing, the feeling of safety and

regulatory vagueness that have direct consequences on the prospect of piped gas networks.

Adegbola, Ozigis and Muhammad (2018) demonstrated that the technical feasibility of a gas pipeline system in residential estates is justified and that local distribution is efficient and scalable, which supports the present discovery. Nevertheless, the research also indicates that the lack of regulatory loopholes and safety concerns is also an insurmountable challenge, which is also revealed by Uneh, Ene, and Onwa (2023) when they examined the LPG distribution in Rivers State. Even though it has technical solutions, it is still hampered by the absence of coherent governance structures and consumer trust. Onwukwe, Duru, and Ikpeka (2024) also attest that logistic and network design optimisation would result in cost-cutting and an increased appropriateness of PLPG in business, yet the policy inertia is a problem.

This paper highlights the social and behavioural factors of acceptance as opposed to earlier times when LPG adoption was an issue, which is addressed as an issue with economic expectations. It concludes that the safety, affordability and convenience attitudes are key factors that determine the perceptions of the citizens, especially the women who are the greatest at home decision-makers as far as energy is concerned. This observation resembles the work of international researchers, e.g. Roche et al. (2024), when the authors concentrated on the gendered nature of LPG adoption and the strengthening of clean energy transitions through the actual confidence of users. Evidence synthesis, therefore, places PLPG in a context as an innovation that can be practised but is vulnerable to policy, hence will need good safety laws, consumer education and trust-building plans.

Conclusion

The study has established that the penetration of Piped Liquefied Petroleum Gas into the Nigerian market is technically and economically viable but constrained by the high cost of infrastructure, a lack of policy coordination, and the existing suspicion of insecurity amongst the people. The answer to these hurdles should be through the reflection of regulatory adjustments, financial subsidies, and long-term awareness generation to generate a feeling of consumer confidence. As these aspects have been reinforced by

flexible financing, transparent billing, and reasonable safety governance, PLPG can transform the situation with energy in Nigeria to an enormous degree. It is offering an outlet for cleaner, safer, and more reliable domestic energy and reduced dependence on biomass and imported petroleum products. Therefore, PLPG will be able to contribute to the general energy transition and environmental sustainability of Nigeria.

Implications of the Study

This research has a wide range of implications. The results provide a platform of evidence that the policymakers can use to organise a homogeneous national platform in which the distributed gas systems can be regulated. The study will offer a preview of the untapped potential of the market and the strategic importance of the safety assurance, flexible pricing and open delivery of the services to the private investors and developers. Implementation of PLPG can also benefit the households and community groups because the implementation would aid in the reduction of indoor air pollution cases and, in the long run, the cost of cooking will be reduced, as well as improve the overall quality of life. The study also suggests that the gender sensitivity element of energy planning can enhance the level of participation of women and long-term sustainability, since it is women who are the household decision makers on the issue of energy. The combined findings suggest that the right to make PLPG an inclusive and sustainable component of the future of the energy sector in Nigeria is distributed between the government agencies and the industry players and their end-users.

Recommendations

Based on the findings, this study recommends that the Nigerian government develop a National Distributed Gas Framework to define the processes of licensing, technical standards and safety regulations specific to the piped LPG systems. Fiscal incentives such as tax holidays, abolishing the import duty on gas equipment, as well as cheap infrastructure loans, should be employed in order to get investors into the country. Pilot projects would be provided to select residential estates and campuses that would provide evidence on the concept and help in streamlining operational guidelines. There is also a

need to carry on with education campaigns to the public to bust the safety myths and promote the benefits of PLPG, particularly among women and poor families. In addition, the digital metering and billing system is supposed to be adopted in a free atmosphere to enhance user confidence and responsibility. Finally, partnerships between the government and the business will also be essential regarding funding, implementation, and maintenance to ensure equitable allocation and sustainability.

Contribution to Knowledge

The research is pertinent to the existing body of knowledge since it bridges the gap in the existing body of knowledge that deals with technical feasibility research and with behavioural research of gas adoption in Nigeria. It adds value to the knowledge by bringing a wholesome framework that brings the market strategy, regulating design, and perception of the user in the piped LPG distribution. The other aspect of the clean energy discussion that the study provides is a gendered approach to the adoption of clean energy, in which inclusive participation and trust-building procedures may be utilised to enhance adoption. This cross-cutting input makes PLPG not just a pioneer of the engineering industry but a socio-economic solution that will be able to change the domestic energy system in Nigeria.

Suggestions for Further Study

The primary suggestions of the subsequent study include longitudinal field testing of the PLPG pilot projects to quantify the degree of user satisfaction, efficiency, and safety of real-time operations. The geographic, cultural, and income differences may influence the adoption patterns, and the comparative analysis of the regional findings may prove it. Research Question: The research on the application of other renewable gases, such as biogas, to complement the existing LPG supply systems can also be further researched. Besides, econometrics of pricing elasticity and consumer behaviour of the tariff reform should be advanced further, and it would improve the understanding of the dynamics of affordability. The extension of the region to include a unification of the regional policy in West Africa could also offer information on inter-country intervention in the direction of sustainable gas infrastructure development.

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