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Stakeholder Perspectives on Community Energy Contributing to the Use of Renewable Energy Sources and Improving Energy Security in Nigeria

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Abstract: The need for improved energy security in Nigeria cannot be over-emphasized. Currently, energy security is rather poor, while access to energy is fundamental to socio-economic development and poverty alleviation. Renewable energy could potentially contribute to resolving this because renewable sources such as solar radiation are more available and sustainable, and can be set up in small generation units, meaning that it is suitable for community management and ownership. In theory, a community energy approach could well apply. In this paper, the main research question is: In what ways can community energy initiatives contribute to increasing the use of renewable energy sources and improving energy security in Nigeria according to selected stakeholders and households? A mixed methods research approach was used to answer this question, with stakeholder interviews and survey data from 124 residents in two case studies of selected housing estates in Lagos. The results show that 58% of the households and most of the stakeholders express support for community renewable energy as a viable approach for increasing energy access and greening energy supply. The present study shows that there is a need to raise awareness and support projects for effective and supportive renewable energy policy to encourage local renewable energy community formation.

Keywords: renewable energy; community energy; energy security; renewable energy technology; energy policy; microgrid

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1. Introduction

Renewable energy is used in many countries across the world. It can potentially provide reliable and clean power to low-income households in both rural and urban areas. According to UNEP [1] renewable energy can promote energy security by decentralizing energy supply with micro, mini, modular, and rapidly deployable energy projects that are particularly suited to the electrification of rural communities in developing countries. Here, energy security is defined as the uninterrupted availability of energy sources at an affordable price [2].

Over the past four decades, the attention of world leaders has shifted from non-renewable energy sources to clean energy sources that are environmentally sustainable and economically viable [3]. For these reasons diversifying energy sources and adopting a greater share of renewable energy sources is also expected in Nigeria, where it could be part of the national strategy, which indicates the country's commitment to global climate change agreements and could help to remedy the electricity crisis referring to the failure of the Nigerian power sector to provide adequate electricity supply to domestic households and industrial producers despite having a rapidly growing economy.

Currently, Nigeria is the largest producer of crude oil in sub-Saharan Africa. Most of the energy supply in the country comes from fossil fuels. Natural gas is used for thermal

energy production. The majority of Nigeria's electricity supplied via the central electricity grid is generated by using hydropower and natural gas. The enactment of the Electric power reform act in 2005 allowed for renewable energy, such as solar energy, into the energy mix [4].

Although the Nigerian government made a financial commitment to the power sector, in terms of output, no significant improvements were made to increase electricity generation despite vast economic and demographic growth in the country. In some cases, such as Lagos and Ogun State, power supply systems even deteriorated, more particularly with regard to transmission and distribution network cables. The national electricity grid is infamous for experiencing total shutdowns. In February, May, July, and August 2021, and in March 2022, it collapsed, which led to a nationwide blackout, causing a myriad of problems in society [5], such as increased unemployment, poverty, slow economic growth, all related to power failure [6].

Due to the problematic nature of the electricity supply from the central grid, households and industries have become keen to resolve power supply issues themselves by using diesel- or petrol-powered generators for their own energy need [7]. Individual homes remote from the electricity grid use fossil fuels to generate heat and electricity supply (i.e., natural gas or oil). In case of short supply, diesel and petrol generators are used. Fossil-fuel-generated electricity (i.e., using coal, natural gas, or oil) is used in the industry.

1.1. Community Energy

If renewable energy is to be used to a greater extent, it is important that it also resonates at different territorial levels, including the local one. When applied at this level, renewable energy sources can become part of community systems, which comprise technical, social, and institutional components that co-exist and co-evolve. Theoretically, this refers to re-organizing local energy systems, allowing the simultaneous integration of renewable distributed energy resources and involving local communities [8,9]. Here, the concept of community energy is key. Community energy can be defined in different ways [10] but commonly refers to a wide range of citizen initiatives that are concerned with greening (parts of) energy systems, usually but not only on a local or regional scale [11] by collectively organizing decentralized energy actions, with application in the domains of renewable energy, energy efficiency, and energy service provision [12]. Community energy can be viewed as both a bottom-up, grassroots innovation [13] and as a social innovation [14]. Community energy system development can be seen as a potentially important strategy that can be adopted socially and by policymakers to contribute to energy and climate (mitigation) policy goals [14,15]. This does, however, require households, entrepreneurs, industries, and local governments to become motivated to actively participate in or empower community energy systems [16,17].

The drive towards climate change mitigation and the opportunity to empower consumers in the developed and developing worlds points increasingly towards moving away from centralized energy supply models [18]. This would call for the increased use of decentralized models, using distributed generation, which would require allowing community renewable energy projects (including households as energy producers, i.e., 'prosumers') to access and feed excess distributed generated energy into distribution grids [19–21]. This, in turn, would call for institutional change, removing or adapting current legislation that prevents feed-in of distributed generation [22,23] and formulating and implementing economic incentives, regulations, and 'game changers' that encourage and mainstream it [24]. To improve distributed generation and energy access, and empower community energy in Nigeria, theoretically speaking, the central government could initiate and enact this into national and regional legislation.

1.2. Current Electricity Regulatory Framework in Nigeria and Future Plans

Based on experiences with previously failed reforms, the 2010 administration initiated a power sector reform plan, which aimed at generating 40,000 MW of power by 2020 [25]

whilst expanding generation and transmission capacity and improving the electricity market structure. The reform process was successful in handing over the power plants to private sector business companies using tenders and auctions [26,27].

However, transferring the distribution and generation networks to the new owners created a new quasi-monopoly in the electricity sector that eventually even caused the failure of the reform [28]. In hindsight, this was predictable due to the decision-making process that was shrouded in secrecy between the federal authorities and the incumbent electricity companies' networks and without public participation. This led to the failure of the reform, and the government projection of 40,000 MW was unsuccessful. This contrasts with decision-making in some of the developed world countries, having fairly responsive and democratic governance systems in place. Public participation has helped shape reforms in the energy sector, with governments paying attention to ideas from the public while acknowledging key public values [29].

As of 2022, many electricity distribution infrastructures in Nigeria are obsolete. Distributed system operators have failed to invest in revamping these infrastructures, which has hampered consumers' ability to access the grid. The current government recently tried to revamp the power sector by renegotiating the previous government's contract with the generation and distribution companies. However, this failed due to the contractual clause. Another critical point in the contract is that Nigeria's system cannot take more than 4000 MW of electricity to avoid collapse. Critics argue that the national government should have improved the system's capacity before signing a poor contract [30].

In July 2019, the Federal Government of Nigeria set up a Presidential Power Initiative to strategize on how to improve the country's installed capacity and reduce power loss [29]. Currently, Nigeria has a total of 13 GW installed capacity, but only about 3.4 GW is available for distribution to consumers [31].

The current energy regulatory framework in Nigeria is based on the Electrical Power Sector Act (EPSR), which was passed by the National Assembly in 2005 and repealed by the National Electric Power Authority Act (NEPA). The enactment of the EPSR opened the Nigeria electricity sector to private sector investment by breaking the previous monopoly of NEPA. In succession to the EPSRA 2005, the state-owned vertically integrated utility underwent partial unbundling, which led to the creation of six electricity generation companies (i.e., Gencos). This pertained to eleven distribution companies that were privatized in 2013. In the meanwhile, the federal government retained one hundred percent ownership of the national transmission system operator [26].

To further develop the energy sector, the government introduced the Nigerian Renewable Energy and Energy Efficiency Policy in 2015 (NREEEP) intending to inject more hydropower, biomass, solar, wind, and geothermal energy into the energy mix through the distributed energy system, whilst implementing a few economic incentives, such as net-metering, tax credit, and a feed-in tariff that would promote renewable energy production projects in Nigeria's capital, Lagos. The NREEEP was intended to promote national energy security and an efficient energy delivery system that is cost-effective and would work in an environmentally sustainable manner across multiple economic sectors.

NREEP can be viewed as a veritable policy that could promote the energy transition effort of Nigeria and potentially also the development of local community energy initiatives. However, the implementation of NREEP was troublesome because Nigeria did not have an overarching renewable energy regulatory framework in place to enforce compliance with the policy. Moreover, there is a lack of organization to implement it [27,30].

Over the last five years, the federal government of Nigeria has made efforts to improve the grid capacity and reduce the incessant collapse of the power system. The government of Nigeria signed an agreement with Siemens in 2018 to help deliver 25,000 MW by 2025 under the Presidential Power Initiative. The project entailed three phases. The first phase began in 2021 for ten months which would help push the installed capacity to 7000 MW. The second phase would raise the installed capacity to 11,000 MW, and the third phase would increase the installed capacity to 25,000 MW. The phases were designed to cover the

expansion of the transmission and distribution grids, improve access to affordable, efficient, reliable electricity and therefore increase overall increase energy security.

On 24 August 2022, the government of Nigeria launched Nigeria's national Energy Transition Plan (NETP), which covers power, transport, cooking, and industry to reduce emissions and power national economic development. NETP intends to create investment opportunities in solar energy, hydrogen storage, and electric vehicles that would create 330,000 jobs by 2030 and 840,000 jobs by 2060 in the power and transportation sectors. One of the key objectives of NETP was to let go of the diesel and petrol generators, which account for the current bulk of power generation capacity and CO_2 emission in the country. NETP also sought to expand the generation of gas generation capacity to meet the electricity demand and integrate renewable energy.

Facing major problems related to the centralized electricity supply system, one may wonder whether alternative models to electricity supply can be developed and considered for utilization. One of these models refers to community renewable energy initiatives, using distributed generation, giving households and firms opportunities to achieve better access to electricity, and enjoy a higher degree of energy security whilst using energy in a more environmentally friendly supply system. However, currently, there is no incentive to promote community renewable energy initiatives, for it is currently part of any formal policy framework, despite the establishment of the NREEEP [25].

1.3. Community Energy as a Means to Improve Energy Security

The integration of renewable energy into the energy mix has grown over the past two decades to ensure the security of the supply of energy, particularly concerning supplying energy in remote areas and, in the case of solar PV, ensuring electricity supply in times of undersupply by the central electricity grid. However, in the current situation, the central electricity grid does not adequately supply electricity to housing estates. There are lots of blackouts, and the security of the supply cannot be guaranteed. It is fair to state that the centralized nature of the electricity market in Nigeria has created energy insecurity across the country, with problems particularly manifesting in populated areas such as Lagos State, which is especially problematic because it is also the commercial hub of the country.

Community renewable energy could potentially help reduce dependency on the centralized electricity grid. This can be achieved by creating more distributed generation, particularly by using renewable sources, such as solar radiation, and in such a way that end-users have better access to electricity. One way of doing so is by developing community energy systems at the local level [8], which are characterized by community-owned assets, such as distributed generation (e.g., solar PV installations), but also energy storage and energy infrastructure, and can be designed to operate as a microgrid (either connected or disconnected to the central grid), or theoretically even in an islanded mode [31]. In experimental settings and demonstration pilots in remote areas, this concept has already been tested [32,33]. Within a community energy system operating such microgrids, members of a housing estate can theoretically become 'prosumers' of decentralized produced electricity and collaborate within a renewable energy initiative (organization) to control local electricity systems (e.g., as a microgrid).

Renewable energy communities—often organized in the form of a citizen energy cooperative [34]—can address the social, economic, and organizational side of the system by raising awareness of social acceptance, running operations, and controlling the systems (although oftentimes outsourced to an energy service company; 'ESCO') [35]. In this way, housing estates could potentially become more resilient and increase residents' confidence about coping with blackouts, outages, or the undersupply of electricity from the central grid whilst increasing the availability, accessibility, and possibly even the affordability of electricity. In addition, such systems also offer benefits in terms of wellbeing—especially in remote areas—because they replace inferior and health-threatening options, such as kerosene lamps, candles, and in some cases, even darkness [36].

1.4. Research Aim and Question

In the present paper, the focus is on community energy as an alternative model to encourage the production and consumption of renewable energy and, by doing so, help local communities to achieve higher levels of energy security, especially in times of poor electricity supply from the central grid. This is not to encourage or advocate replacing the current centrally-led electricity system in Nigeria but to explore perceptions by stakeholders about developing and running local community energy systems complementing the central system in times of need to overcome supply problems that go along with the former. The locus of this study is two housing estates in Nigeria's capital, Lagos. The main research question of this paper is: In what ways can community renewable energy initiatives contribute to increasing the use of renewable energy sources and improving energy security in Nigeria according to selected stakeholders and households?

This research aims to contribute knowledge towards the possibilities of stimulating local communities to formulate community renewable energy initiatives, even as the government has reiterated its commitment to adding 4000 MW of electricity to the grid every year. If taken seriously, we presume that community renewable energy could contribute considerably to achieving this figure.

This paper is structured as follows. Section 2 presents a literature review. Section 3 presents the research design and methodology. Section 4 presents the results. Finally, in Section 5, the results are discussed on their academic merit, and Section 6 presents the conclusions and limitations, as well as suggestions for future research.

2. Literature Review

2.1. Community Renewable Energy Initiatives

Access to affordable, modern energy is a prerequisite for sustainable development and poverty alleviation and, more specifically, for achieving each of the Sustainable Development Goals (SDGs). The assumption is that social networks and relations are essential determinants of an individual's access to resources, including energy and access to knowledge and skills, funds, energy, and information [37].

Community Renewable Energy Initiatives (CREI) provide such a social structure and express the general notion that cooperation among people for a common purpose yields satisfactory results when compared to doing things only individually [38]. CREIs vary in origin, motives, resources, and approach [14]. Moreover, they are typically found in small towns, villages, or neighborhoods; they are community-driven "grassroots"; they have gone beyond single-issue actions to "managed", multi-stranded programs; and they contribute to reaching sustainability goals [39]. The initiatives are mainly organized by volunteers, who involve community members implementing projects intended to produce sustainability-related outcomes [40]. Examples of community energy projects include household energy conservation initiatives, community-run mini-buses that drive on biogas, collective solar PV plants, and community wind farms, to mention but a few [16].

An important goal CREIs often have is to achieve a just transition to low-carbon economies and societies [41]. They can be seen as a social innovation [15] that aims to disrupt traditional ownership of essential assets and change institutions of energy systems while striving to (re-)gain community ownership and democratic control of energy systems [39,42]. One of the major reasons for the formation of a CREI is to change the structure and institutions of the current centralized, organized energy system from a centralized grid system led by energy market incumbents into a distributed system using renewable energy sources with many benefits, such as improving the general wellbeing of communities, lowering carbon emissions, and contributing to reducing climate change and its effects [15].

Renewable energy production is key to most CREIs and requires having business models in place that are needed to address the ownership and control of renewable energy installations facilitated by supportive national policies and to assure the financial feasibility of the organization. Without the right business model, many CREIs will not last. However,

this depends on the (supportive) policy landscape. Whereas policies that have previously supported the deployment of small-scale renewable projects are withdrawn, others are issued. This requires community energy organizations to innovate and adapt their business models if they want to succeed and survive. Nolden et al. [43] conducted a study on CREI business models in the United Kingdom and discerned three types, all heavily shaped by the policy landscape: (i) community renewable business models based on grant funding (pre-2010); (ii) small community PV projects based on feed-in tariffs (2010–2015); and (iii) large community solar PV projects based on feed-in tariffs and power purchase agreements (after 2013).

CREI projects could either be 100% owned by a community or might be developed under co-ownership arrangements with the private sector. For example, a solar park project in Ameland Island in the Netherlands was co-owned by the municipality and ENECO, an energy-supplying company [39]. Another example pertains to the solar park located in Saerbeck, Germany, with over 24,000 solar PV panels, which are wholly owned by the community [44]. Projects can involve the financing and ownership of distributed generation, with electricity generated fed into the grid rather than in addition to local use. However, this requires using a business model that assumes financial compensation, for example, by using a feed-in tariff or net-metering. To make this possible presumes that the electricity market is regulated in the sense that these instruments are readily available [17,45]. Although CREIs are mostly professed as self-deterministic and bottom-up, the initiatives greatly depend on supportive public policy [17,45–47].

While there are various models of CREIs, the motivations and ideologies behind their formation are often quite similar and may include social needs and the need to create social impact by developing localized solutions, such as educating residents, community members, juveniles, and women, whilst building more capacities [48]. More in general, the various models of community energy include cooperatives, community charity, development trust, and shares held by local organizations (See [37] for a detailed clarification of the different models) and, in most cases, adhere to the seven principles of the International Cooperative Alliance [49].

2.2. Understanding Formation of Community Renewable Energy Initiatives

An approach to understanding the formation of local community energy initiatives was developed by Boon & Dieperink [50] and later elaborated and empirically assessed by Warbroek et al. [39]. Based on these frameworks, a new one was developed to be applied in the developing country's context (See Figure 1). This framework includes an overview of stakeholders that could potentially contribute to the formation of CREIs, factors that influence the formation processes of CREIs, and various aspects to be considered, such as the three pillars of sustainability, technology, existing regulations, and socio-cultural characteristics and the market for renewable energy technologies.

Stakeholder participation, system efficiency, and the sustainability of the CREIs form the foundation of this framework. Some factors, such as household income level, awareness, and clear understanding of CREIs, can also be considered for renewable energy technology (RET) and CREIs to be developed in developing countries such as Nigeria. However, when reflecting on this, RET diffusion in Nigeria is impossible without also taking into account the regulatory frameworks, technical know-how, socio-economic-, environmental, and socio-cultural factors. These could form potential barriers to local communities initiating energy initiatives.

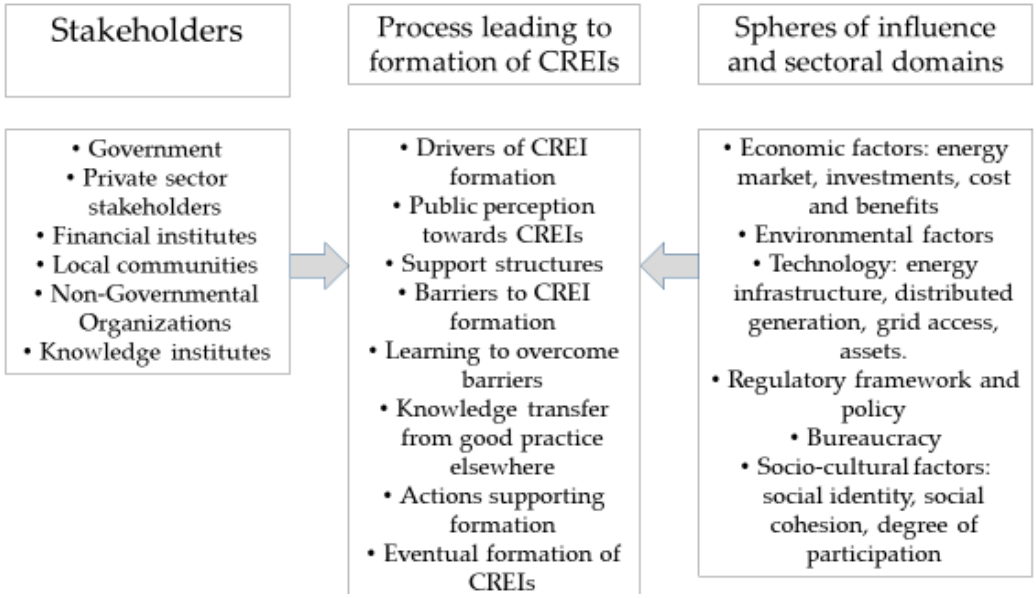

Figure 1. Conceptual framework CREI formation; partly adapted from [50].

As the electricity supply is not secure in Nigeria and people mostly depend on fossil-fuel generators for most of their energy services, this irregular power supply in the country provides a good argument for community renewable energy initiatives in Nigerian communities. Households, local business firms, and public organizations need to control their energy system, reduce the cost of conventional fossil fuels, and reduce the menace of climate change. Therefore, CREIs provide an opportunity to offer individual and collective benefit, mostly in terms of improving energy security and sustainability.

According to the theoretical framework by Boons and Dieperink [50], there are several factors influencing the formation of CREIs. In the paragraphs below, they are described and situated in the Nigerian context.

2.2.1. Awareness Raising and Education

For society to adopt any modern technology or another type of innovation, there is a need to embark on a public enlightenment program on the benefits of renewable energy technology. Proper awareness and education [51] are the first steps in the process toward the adoption of RET or CREI. The use of plain language with less technical terms would help the public to understand how this innovative technology would be beneficial to them. Should they have proper knowledge of RET and its benefits, it will be easier to adopt and diffuse it, which would lead to the success of CREIs in communities. Awareness levels on climate change and local action on energy have increased significantly in recent years due to their potential to reduce CO_2 emissions [52].

2.2.2. Economic Factors

For a developing country such as Nigeria to adopt RET and for CREI, the initial investment cost is one of the significant factors to consider because most of the RET assets and infrastructure are not yet locally manufactured and therefore require import. In addition, there is also a lack of economic policy incentives to encourage the adoption of RET. This is even worse concerning the formation of CREIs. There is also a lack of local skilled labor to operate and maintain renewable energy assets. This could potentially hinder the adoption of RET and, subsequently, CREIs [53].

2.2.3. Regulatory Framework and Policy

Nigeria is a signatory to the Paris 2015 Climate Change Agreement. Still, the non-compliance of implementing this treaty into legislation is considered a big challenge.

Corruption has been the bane of the power sector when the government is committed to implementing some of its policies; the monitoring and enforcement team in the implementing agency jeopardizes the government's efforts with corruption [54]. Regulatory barriers may arise from lengthy bureaucratic procedures and the absence of a long-term and consistent policy framework. One may generate electricity in Nigeria, but one cannot distribute it due to the lack of a sound regulatory framework to access the grid. i.e., there is currently neither a feed- tariff nor a net-metering scheme [55].

2.2.4. Environmental Factors

Nigeria is home to a diversity of natural ecosystems ranging from semi-arid savanna to mountain forests, rich seasonal floodplain environments, rainforests, vast freshwater swamp forests, and diverse coastal vegetation. The country is also conventionally located concerning solar PV electricity generation potential [56]. With tropical temperatures abound, there is high demand for cooling. Nigeria is faced with environmental problems, such as air pollution, water pollution, lead exposure, and poor waste management. This lowers the potential use of bio-energy [57].

2.2.5. Technical Factors

Technical factors encompass a broad range of issues, such as access to the grid and technology availability. Many Nigerians do not have access to the electricity grid. This could also be associated with the structure of the electricity infrastructure and the existing energy policy [56].

2.2.6. Socio-Cultural Factors

Socio-cultural factors include participation, social cohesion, and identity within a community or an estate. An organization or a housing estate consists of people from different backgrounds, cultures, orientations, and understandings of this concept. CREI formation may encounter local opposition if the community members do not understand what they stand to benefit overall [58]. Furthermore, local support and acceptance within a community towards CREI are related to the degree of ownership and expectancy of receiving a fair and equal share of its benefits. When there is an unequal allocation of profits, hostility might set, resulting in poor local support of the projects [50].

One must also stress that the degree of social cohesion and level of trust within the estates under study in this research can influence the local perception, acceptance, support, and formation of CREIs.

2.2.7. Availability of Expertise and High Costs

Renewable energy technology (RET) suppliers and installers play an essential role for communities or people to adopt RET and CREIs in Nigeria. The main barrier concerns the excessive cost of solar PV due to the lack of local manufacturers and incentives for importing agents [30].

Policymakers can pay attention to this aspect to lower the barriers to small-scale generators entering the supply market. Furthermore, the current effort of the Lagos government and Siemens Nigeria in training interested experts in this field is not enough to provide sufficient skilled local installers with this technology soon. The Lagos State Energy Academy has set a target of training 100,000 energy experts, including installers, power engineers, and energy managers, to be reached in 2030 [59].

In other West-African countries, such as Ghana, local microgrids using solar PV have been installed and tested, showing a relatively high levelized cost of electricity. Compared with a common end-user tariff, end-users of this PV-based mini-grid system end up paying more, even under full-grant finance conditions (e.g., for maintenance of the electricity system). This means that solar PV-based systems are comparatively expensive compared to central-grid-supplied electricity. More in general, cost is considered a significant barrier

to the diffusion of renewable energy in African countries, especially with regard to high initial capital costs [33,36].

3. Research Design and Methodology

This research presents a case study of two housing estates in Lagos State, Nigeria, and uses a mixed methods approach based on both qualitative and quantitative data. The two housing estates—Ojokoro and Sunshine—have a combined 400 housing units, with all of the households having fossil-fuel-powered generators in use when electricity supply from the central electricity grid fails. The adoption of RET and willingness to collaborate and operate an integrated community energy system within the estates would potentially lower the use of fossil fuels from the diesel and petrol generators, the cost of running these generators, and would help increase energy security.

To understand the role of the supporting structure needed for the CREI framework, a deep dive into the role of each stakeholder was taken using a stakeholder mapping method. Stakeholders were analyzed by mapping their positions and functions, their interrelation with other stakeholders, their opinion about CREIs, and barriers they could experience in the formative years and future operations, using a similar approach applied by Viétor et al. [60], combining a stakeholder analysis with an empirical reflective-theoretical approach. Table 1 presents an overview of the stakeholders involved and Table 2 presents an overview of stakeholder characteristics and their views toward CREI. The tables clarify the stakeholders positions and functions, their interrelation with other stakeholders, and to what extent they are influential in supporting the establishment of CREIs in the estates.

Table 1. Overview of stakeholders involved.

Stakeholders	Stakeholder Function	Method of Data Collection	Potential Impact on the Success of CREI
Nigeria electricity regulatory Commission (NERC)	Overarching Regulator	Virtual Interview	Very high
Energy Commission of Nigeria (ECN)	Energy Policy Implementation Agency	Face-to-Face Interview	High
Lagos State Ministry of Energy and Minerals	Policymaker	Face-to-Face Interview	High
Lagos State Electricity Board (LSEB)	Implementing an agency for the power sector in Lagos	Face-to-Face Interview	Medium
Lagos Energy Academy (LEA)	Lagos state funded the renewable energy education academy. They provide technician training and professional certification beyond tertiary education.	Face-to-Face Interview	Low
National Centre for Energy Efficiency and Conservation	Renewable energy research center set up by ECN for the implementation of policy.	Face-to-Face Interview	High
Community Research and Development Centre (CREDC)	Environmental and Renewable Energy NGO	Virtual Interview	Medium
Sunshine Estate Chairman	Coordinates activities in the estate	Face-to-Face Interview	Low
Ecobank Nigeria Limited	One of the commercial banks operating in Nigeria and other West African states. Currently funding renewable energy projects.	Face-to-Face	Medium

Table 1. *Cont.*

Stakeholders	Stakeholder Function	Method of Data Collection	Potential Impact on the Success of CREI
Solar Nigeria	A DFID-sponsored project targeting rural communities that are yet to be connected to the grid.	Virtual Interview	Medium
GIZ	German international organization involved in the Nigeria energy support program on rural electrification. Provide advice on enabling frameworks to encourage energy access and work with the private sector in developing micro- and mini-grids.	Virtual Virtu Face-to-Face Interview	Medium
Eko Electricity distribution company	One of the two distribution companies in Lagos, and recently privatized. It distributes electricity to the Lagos islands and their environs.	Face-to-Face	High
Sunshine Estate and Ojokoro Estate Residents	Community renewable energy initiative adopters	Focus group discussion and Survey Questionnaire	Very High

Table 2. Stakeholders, their main characteristics, and views towards CREIs.

Stakeholders	Position and Function	Interrelation with Other Stakeholders	Opinions towards CREIs	Barriers Identified by Stakeholders for CREIs Formation	How to Support CREIs?
Nigeria Electricity Regulatory Commission (NERC)	Regulate the activities of the Gencos, Disco, and Transco. They also ensured compliance with market rules and operating guidelines, issuing licenses and permits to market participants.	All activities of the electricity market are regulated by NERC.	Positive	Cost of investment	N/A
Energy Commission of Nigeria (ECN)	It is a statutory body established for the strategic planning and coordination of national policies in the field of energy. ECN is the apex government parastatal empowered to carry out overall energy planning and policy implementation.	Policy formulation and implementation in the energy sector	Positive	Lack of awareness about CREIs.	Help draft power purchase agreement, human resources, help raise awareness
Lagos State Ministry of Energy and Minerals	Policy formulation in the state electricity sector	They coordinate all parastatal related to electricity in Lagos State, such as LSEB and LEA	Positive	Lack of awareness about CREIs.	Help draft power purchase agreement, human resources, help raise awareness
Lagos State Electricity Board (LSEB)	This is the implementing agency for the power sector in Lagos. They aim to maximize power supply through independent power projects (IPPs) and improve public lighting for the citizens of Lagos.	They have held several meetings with the Disco and industrialists on how to make the power situation better in the state.	Positive	Technical knowledge, infrastructure, enlightenment of the citizen, lack of incentives.	Advice, Technical knowledge, system design

Table 2. *Cont.*

Stakeholders	Position and Function	Interrelation with Other Stakeholders	Opinions towards CREIs	Barriers Identified by Stakeholders for CREIs Formation	How to Support CREIs?
Lagos Energy Academy (LEA)	This is an academy dedicated to the training of skilled manpower for the Lagos electricity sector. They provide technician training and professional certification beyond tertiary education.	They work hand in hand with the supervising ministry and parastatal. They are in partnership with Siemens, CET power, and other private sector actors.	Positive	Initial Capital cost, lack of skilled, trained technicians, education, and awareness.	Security of investment by providing certified engineers to install the system, that is, if the grant is provided
National Center for Energy Efficiency and Conservation	This is one of the three energy research centers set up by ECN for the implementation of policy. They train personnel, disseminate information on energy use, and develop standards, codes, and policy guidelines.	They are set up by ECN, and they work together with other stakeholders on areas related to their mandate.	Positive	Low awareness, high cost of installation, and lack of social cohesion amongst people.	Help educate the community
Community Research and Development Center (CREDC)	This is an NGO that focuses on environmental issues and advocates renewable energy.	They are always in contact with the policy maker and regulator.	Positive	Low awareness, high cost of solar batteries, technical amateurs.	Technical support, Help seek funds.
Sunshine Estate Chairman	Coordinate all activities in the estate.	They only interact with the Disco supplying the estate.	Positive	Financial barrier, Awareness.	Mobilization of the estate to support the project
Ecobank Nigeria Limited	Ecobank is one of the commercial banks operating in Nigeria and other West African states. They are currently funding renewable energy projects.	They have provided counterpart funding for Disco during the privatization process	Positive	Maintenance cost, pricing, lack of social cohesion, and the poverty level in the society.	Financial support (loan)
Solar Nigeria	This is a DFID-sponsored project targeting rural communities that are yet to be connected to the grid.	They are in constant interaction with the Federal ministry of power, ECN, and GIZ.	Neutral	Awareness, expensive to startup, lack of understanding of the technology.	Financial support (loan)
GIZ	This German international organization is involved in the Nigeria energy support program, rural electrification. They advise on enabling the framework for energy access and work with the private sector in developing micro- and mini-grids.	They work with NERC on establishing regulations and support mechanisms. They also work with the federal ministry of power on an enabling framework to increase energy access.	Positive	The initial capital and maintenance cost, technical know-how, and low awareness level.	Lagos is not part of their jurisdiction. GIZ is currently working in five states in Nigeria.
Eko Electricity distribution company	This is one of the two distribution companies in Lagos and is newly privatized. They distribute electricity to the Lagos islands and their environs.	All their activities are subjected to NERC approval.	Neutral	Lack of social cohesion because Lagos is a multicultural society, unavailability of experts, awareness, funding, and no enabling structure.	Technical support, if affordable, helps to structure it.

3.1. Case Selection

With a population of about 165 million [61] and a GDP of 5.09%, 6.66%, and 7.14% for the years 2011, 2012, and 2013 [62], Nigeria is the most populated and fastest-growing economy in Africa [63], is the largest hydropower producer and has the largest oil reserves in the Economic Community of West African States (ECOWAS). The country also has vast potential for renewable energy, including wind and solar. However, the country's electricity sector is unable to meet the increasing electricity demand. Currently, only half of the installed capacity of 8900 MW is available on the national power grid, which prevents 60% of the population from electricity access [64]. In Nigeria, Lagos is the most populated state, using more energy than any other Nigerian state.

3.2. Data Collection

Research into the formation and implementation of community-led energy initiatives in two housing estates in Lagos was conducted by administering questionnaires to the estates' residents (i.e., households; N = 124). In addition, a series of expert interviews were conducted with stakeholders, including the federal state agencies, international development partners, non-governmental organizations, financial institutes, electricity distribution companies, research institutes, and academic institutes (N = 12).

3.2.1. Stakeholder Interviews

A semi-structured questionnaire was used to allow the interviewees to give open-ended questions with room for clarification and providing argumentation. This type of interviewing fits well with the explorative nature of the present study. The items on the questionnaire related to how stakeholders perceive CREIs in general and view CREI development in Nigeria, particularly to improving energy security. The questions were drafted by the first author under supervision by the co-authors. The questionnaire used in the interviews can be found in Appendix A. The interviews took between 45 and 60 minutes each. To ensure the quality of the data, the interviews were tape-recorded, and a reporter was hired to take notes during the interview and draft interview transcripts afterward. These stakeholders are relevant to providing the information needed for assessing the support structure, barriers, perception, and willingness to take policy recommendations regarding community renewable energy initiatives and the use of distributed generation renewable energy sources.

3.2.2. Household Survey

For the household survey, the estates targeted were mostly inhabited by educated middle and upper-class residents in Lagos, expecting many of them to be equally financially buoyant, increasing the likelihood that they were willing to adopt the CREI concept locally and start a pilot project at their estate.

Sociodemographic characteristics of the sample pertain to: gender (42% female; 58% male); age (20–30: 16%; 31–40: 38%; 41–50: 32%; >51: 14%); marital status (married: 76%; not married: 24%); religion (religious: 100%; Christian: 74%; Islamic: 26%; Traditional: 0%); education level (postgraduate: 36%; graduate: 48%; secondary school: 16%); occupation (student: 16%; artisan: 28%; trader: 24%; white collar worker: 32%; unemployed: 0%); years of residing in the estate (1–5 y: 26%; 6–10 y: 47%; >10 y: 37%). For the quantitative—statistical—analysis, questionnaire items were based on key concepts from the Boon & Dieperink [50] theoretical framework on the development of local renewable energy organizations. Both open- and closed-ended questions were used in the questionnaire.

3.3. Data Analysis

3.3.1. Stakeholder Analysis

A stakeholder analysis was conducted to generate knowledge about the stakeholders potentially relevant to CREI project development to understand their behavior, intentions,

interrelations, and interests; and to assess the influence and resources they bring to bear on decision-making and implementation of CREIs, in line with [65]. The stakeholder analysis consisted of the identification of stakeholder characteristics, views, and experienced barriers vis-à-vis the uptake and integration of CREIs in Nigeria. For the qualitative analysis, the expert interviews were subjected to transcription and content analysis. Interviews from the various stakeholders were then compared against each other based on selected questionnaire items and by listing the twelve interviewees' answers. Stakeholder mapping and analysis were used to learn about the position, interest, function, power, opinion, interrelation, motivation, information, and resource access of stakeholders, which provides additional meaning to the issues raised and perspectives given by the interviewees. Qualitative data analysis was conducted to assess the position, levels of interest, and influence of CREIs, using the stakeholder analysis approach developed by Schmeer [66]. Stakeholder mapping helped to understand the relationship amongst stakeholders, especially their position, influence, and the resource they bring to CREI. In addition, a stakeholder's analysis worksheet (SAW) was used based on a guideline developed by Eden and Ackerman [67]. The SAW can be found in Appendix B.

This study also included stakeholders in the private sector domain, e.g., electricity companies, DSOs, academic and research institutes such as the Lagos Energy Academy, the National Centre for energy efficiency and conservation, and local NGOs involved in community-based energy and housing estate executives. Based on the interviews with stakeholders, a summary report for each stakeholder was made, after which stakeholder mapping was conducted [60]. To improve understanding of their relationship with other stakeholders, their position, influence, and the resources they bring to the CREIs were surveyed as well. The stakeholders were analyzed per interest, urgency, and attitude [67] about RET uptake and approval of CREI practices.

3.3.2. Analysis of the Survey Data

Data analysis of the residents' survey involved descriptive statistical analysis concerning raw and relative frequencies of selected items to gain understanding of the main features of the respondents' perceptions about CREIs and to indicate the characteristics and trends in the data set.

4. Results

The results show that there is no clear understanding of government efforts about RET, with many Nigerians not aware of existing policies on renewable energy. According to the interview with a CREDC representative, a special workshop, seminar, and publicity of the NREEEP are advised to Nigerians to become aware, educated, and enlightened to have a clear understanding and adoption of RET. Thus far, there are only two bottom-up community energy initiatives in the country; one concerns an NGO funded by a grant, and the other was initiated by a corporate organization for corporate social responsibility.

4.1. Stakeholder Analysis

The results of the stakeholder analysis are summarized in Table 3.

Table 3 shows that all of the government organizations surveyed are considered champions, except the research institute, which has a supportive attitude. NGOs such as Solar Nigeria are neutral to this because they are part of a DFID program (Department for International Development, a UK development organization) that mainly focuses on rural areas not connected to the central electricity grid. At the same time, other stakeholders, such as the electricity distribution company, GIZ, ECO Bank, and the housing estates—are supportive of CREIs formation.

On the **dimension of interest**, all of the government organizations show high interest in CREI formation. In contrast, the private sector stakeholders only show medium interest. However, most NGOs express having a low interest in CREI formation and state that this concept is only feasible in areas that are yet to be connected to the grid.

Table 3. Stakeholder overview and results of stakeholder analysis (with −1 meaning 'low'; 0 meaning 'moderate' or 'neutral'; and 1 meaning 'high').

Name of Stakeholder	Type of Stakeholder	Attitude (Champion, Supporter, Neutral, Critic, and Opponent	Power (1 to −1)	Interest (1 to −1)	Urgency (1 to −1)
ECN	Federal government	Champion	1	1	1
NERC	Federal government	Champion	1	1	1
LSME & M	State government	Champion	1	1	1
LSEB	State government	Champion	1	1	1
LEA	Academic Institute	Supporter	0	1	0
Eko Electricity Distribution Company	Electricity supplier	Supporter	0	0	1
ECOBANK	Private sector	Supporter	−1	0	−1
CREDC	NGO	Supporter	−1	−1	0
GIZ	NGO	Supporter	0	−1	−1
SOLAR NIGERIA	NGO	Neutral	−1	−1	−1
Sunshine Housing Estate	End Users	Supporter	0	1	0
Ojokoro Housing Estate	End Users	Supporter	0	1	0
National Centre for Energy Efficiency and Conservation	Research Institute	Supporter	−1	−1	0

CREIs can access the government funding program to bridge the technical and financial barriers if the private sector can set up solar PV microgrids for the estates and hand them over for maintenance and management. However, this would only be possible if the housing estate allows the private sector to do this in the first place. The estate chairman showed high interest because he views CREI-led solar PV microgrids as a realistic alternative to the current unstable centralized electricity supply system.

On the **dimension of power**, all the government organizations show a strong ability to either encourage or discourage the formation of CREIs. This is important because it is assumed that the formation of CREIs is not likely to become successful in the absence of government incentives and regulatory support. On the other hand, the private sector stakeholders and energy suppliers are considered to have a medium degree of power since they cannot support CREIs without government support because they need regulatory approval by the government. Research institutes and NGOs are also perceived to have the same level of power. Even though they have no direct authority over CREIs, their expertise could significantly influence the government's decision-making process regarding CREIs.

All government stakeholders perceive CREI formation as a step-in-the-right direction with high urgency. Energy suppliers also show high urgency because CREI formation will be beneficial to their business. The private sector stakeholders (i.e., the financial institute) show low urgency as they will only finance CREIs that show business cases with a high internal rate of return and short payback period. Research institutes are considered to have medium urgency since they will be valuable in advising on CREIs formation. The Estate chairman showed medium urgency because CREI-led microgrids would require alternative energy sources. All NGOs except (the local) CREDC show a low degree of urgency; Lagos is not part of its jurisdiction due to its metropolitan nature.

4.2. Estate Household Survey Results

The results show the perception of the inhabitants of the estates on CREI formation and operation; of the 124 respondents, 58% expressed a positive perception, whereas 42% expressed a negative one. With proper sensitization and enlightenment on CREI in the estates, the estates' members could potentially collaborate and adopt this concept. The estates are already practicing a few community-owned projects, though not in the energy domain; for example, a community-funded borehole that ensures constant water supply. For the estate members to cooperate in funding the estate-owned water project, they can similarly fund the estate-owned energy system that would guarantee continuous power supply. However, this would only work when supported by the government and experts.

The examination of the knowledge dynamics of the residents of the estates on CREIs and RET showed that 47% viewed CREIs as making energy services accessible for all; 28%

believed that it would help to bridge the energy poverty gap, while 25% were indifferent. Respondents view CREI as not only helping drive sustainable energy transitions but also improving energy security. Over three-quarters of the respondents (79%) hold that CREI can potentially be seen as a solution to Nigeria's energy security problems, while only 12% felt otherwise, and 9% of the respondents were indifferent. The respondents express concerns about the centralized structure of the electricity grid and the lack of regulatory support to CREIs, citizens, and private investment in the electricity sector. Trust is another concern mentioned. This also relates to potential collaboration with other estate residents. About 80% of the respondents expressed concerns about trust in those that would lead the CREI organization in the estate. They expressed that they would only collaborate when trusted persons would oversee the project's operation.

The success of CREI formation in Nigeria would, to some extent, depend on local and government support. The introduction of a new system or concept in society often faces social resistance and opposition. The level of acceptance of CREIs and RET by the residents of the estate is of fundamental importance. However, it requires a support structure as opposition may pose a serious hindrance to CREI formation. Given this premise, the resident's willingness to collaborate to crowdfund a CREI project in the estate showed that 73% of the respondents were open to having the CREIs in their estate, while 16% of the respondents were not interested, and 11% were neutral.

When asked what could potentially motivate households to potentially participate in a CREI with other residents, 12% stated government support, 17% stated it might guarantee constant electricity supply they are willing to collaborate, while 26% stated that it depends on the level of support or cooperation from neighbors because they expect free riders to unjust benefit from collective action (See also Figure 2). The level of social cohesion in the estate can influence CREI formation or project outcome, but that outcome can influence stakeholders. For example, the support of stakeholders in the estate would positively influence the decision of setting up CREI in the estate, and any pushback from the stakeholders would negatively impact the formation of CREI.

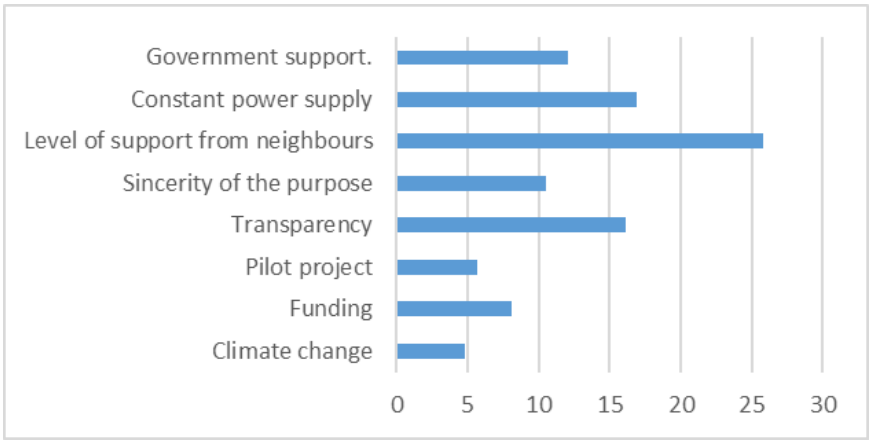

Figure 2. Residents' motivation to cooperate with neighbors in a CREI (in percentages).

However, 10% of the respondents stated that it depends on the sincerity of the purpose among those in charge of the project, citing that, in a project such as this; people responsible are liable to give in to corruption, and 16% of the opinion was transparency, the respondents expressed wanting people in charge of the local energy system that can be trusted and held accountable and who can provide regular feedback. Overall, 7% of the respondents stated that they would rather be late adopters because they will only join when CREIs is considered a proven principle that works correctly, and 8% stated they would only cooperate if the government, a philanthropist organization, or a corporate organization can provide the initial investment cost this can motivate them to cooperate while only 5% stated they are willing to cooperate because of climate change.

The type of support needed to empower CREIs is presented in Figure 3. Following a question about an opinion, these stakeholders mentioned various support structures, such as awareness raising (e.g., via campaigns) and education to be the most important (with 24% of the respondents). Not surprisingly, educating people on how the CREI concept works, especially in an overcentralized electricity market. The first step towards CREI formation in a country that is yet to liberalize its electricity market is to educate, sensitize them to the concept, and provide a full understanding of the idea and its benefits will influence their decision on the adoption of CREI.

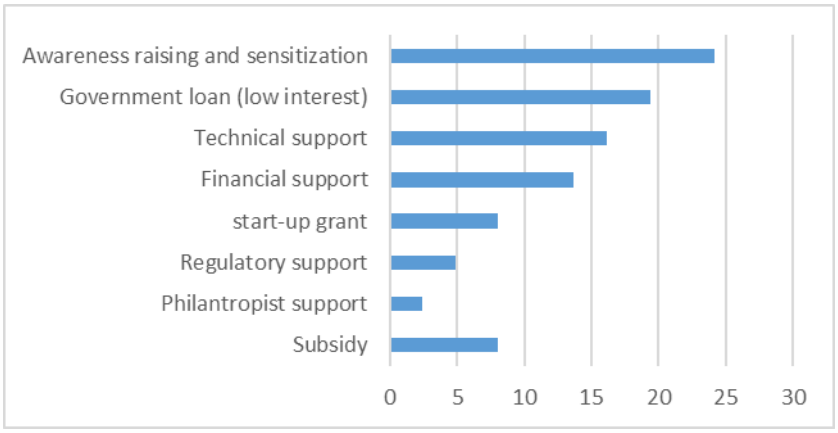

Figure 3. Perceived type of support to empower CREIs (in percentages).

Figure 4 shows the challenges and obstacles that may hinder CREI formation in Nigeria, as stated by the respondents. These pertain to the initial cost of installation (32% of the respondents), lack of social cohesion (20% of the respondents), poor government policy (11% of the respondents), lack of understanding, trust issues, and skepticism (8% of the respondents each), 4% said resistant to change, 10% stated cost of maintenance, while 5% indicated licenses and permits, and just 2% argued that social opposition might post a challenge.

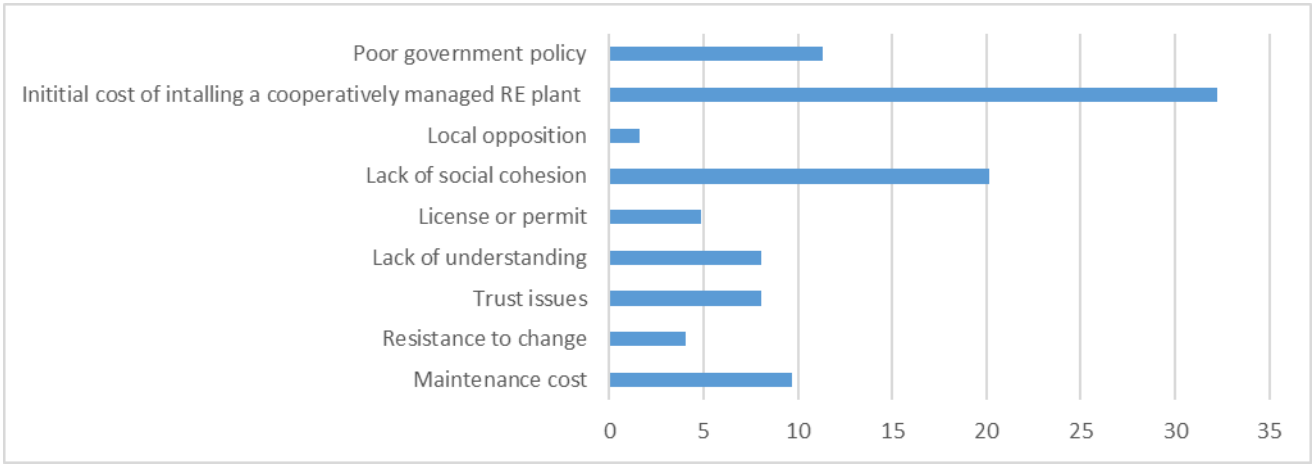

Figure 4. Perceived barriers to the formation of CREIs (in percentages).

To overcome these barriers, households were asked about the factors or intervention strategies needed for CREI and RET's adoption in the estate (See Figure 5). Of the various actions and policies presented, awareness-raising (37%), having a pilot project (16%), provision of finance 13%, flexible regulation to support its formation 13%, government subsidy 10%, grants 6%, and 5% stated provision of technical know-how.

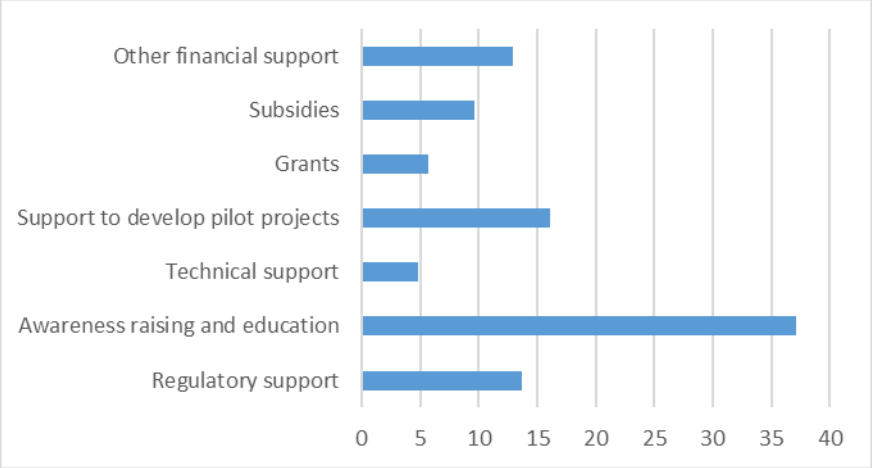

Figure 5. Perceived factors influencing the formation of CREIs (in percentages).

From these findings, it can be deduced that CREIs are considered conditionally capable of increasing access to energy services in Nigeria by the respondents of the two estates and potentially contribute to a sustainable energy future. In addition, the interviewed stakeholders also expressed a favorable opinion about CREIs as a viable approach for increasing energy access, particularly to the rural communities unconnected to the current electricity grid. They argue that CREIs are potentially feasible but will only be sustainable when government regulation supports their development and includes well-trained community members in the formation and maintenance processes. During an interview, a representative of the "Deutsche Gesellschaft fur Internationale Zusammenarbeit" (GIZ)—a German International Development Organization providing tailor-made, cost-efficient, and effective services for sustainable development in developing countries with projects in Nigeria—stated that CREIs could potentially improve energy access, but a dedicated, specialized organization would be needed to drive the process. A representative of the DSO thinks that CREIs could bridge a specific gap in the amount of power available to distribute.

The survey results also show that 79% of the respondents view the development of CREIs as one of the veritable tools for solving the current energy security problems in Nigeria. In addition, 73% of the respondents are willing to cooperate with their neighbors to form a CREI at the estate level. The people's willingness to work with one another to fund CREI shows that if Nigeria's renewable energy policy supports the development of CREI, it will contribute to both a sustainable energy future and energy security.

Currently, DFID and other international organizations have initiated some programs that focus on electrifying rural communities without grid connection, one of which is the solar Nigeria program. The Nigeria Bank of Industries, on 14 October 2015, inaugurated a 24 kW micro-grid solar solution in two communities in Osun State, in Southwest Nigeria. To address the rural-urban migration due to the inadequate electricity supply and improve affordable power through renewable energy technologies [68]. The Lagos State government is building capacity to bridge the gap in a skilled workforce by training and re-training experts in the power sector through the Lagos energy academy. The availability of international electricity companies in Nigeria, such as Schneider Electric, General Electric, and Siemens, might improve technical know-how and may indirectly promote the adoption of RET and the formation of CREIs in Nigeria.

The Energy Commission of Nigeria has already set up platforms to encourage Nigerian citizens to adopt solar energy, such as Nigeria's solar energy society, which is associated with solar energy promotion. Furthermore, the National Electricity Regulatory Commission stated that CREI would allow quicker access to energy, and the rural electrification fund in view will help develop them. The Lagos State Electricity Board believes estates in Lagos State could cooperate to improve energy access.

5. Discussion

The present study provides information on the perceptions that the estate residents have about CREIs as a new perspective for solving energy security challenges in Nigeria. Within the body of literature on community energy, research into how citizen collectives can contribute to improving energy security is a research avenue that has only recently taken off [69]. The present study contributes to this. Whereas the previous study adopted a modeling approach [69], the present study delivers empirical insights from both an in-depth case study and household survey data.

The results from the present study reveal mixed support for CREI formation from both stakeholders and estate residents. Although the latter expressed some benefits, there are also considerable perceived barriers. For example, the constraints of the domestic electricity market on the centralized system of the political structure do not provide the right incentives to support the formation of CREIs. To do so, there is a dire need to have the right policy support incentives and schemes in place. This is also shown in the survey results, with the residents mentioning that interventions such as low-interest government loans (19%), start-up grants (8%), subsidies (8%), regulatory support (5%), and other measures would probably not work without at least some government support, and that awareness raising and education (24%) would be necessary to empower CREIs. Furthermore, they also claimed that the lack thereof (i.e., in terms of 'poor policy') was a key barrier.

Studies have shown that energy policy support schemes and financial–economic incentives, such as the feed-in tariff and net-metering have driven the popularity of CREIs in Western Europe [70]. This is in line with the results of the present study, as a lack of policy support or incentives for CREI formation in Nigeria is perceived as an impediment to its development (as revealed in the stakeholder analysis and the residents' survey). This result can also be viewed in light of renewable energy source adoption, which is in line with more countries in the region [33]. This also applies to the results of the residents' survey, where the upfront cost is considered the main barrier (32%), and reveals the importance of such problems because they have great implications for (future) CREI's business model. Given that solar PV microgrids can still be considered an expensive alternative to common central-grid-supplied electricity [36], along with the other barriers observed, one cannot expect that viable business models can be generated by CREIs that would work in the absence of at least one supportive financial incentive implemented by the government [43]. In the absence of these incentives, viable business cases are not likely to be generated, and CREIs are even less likely to emerge (with initiators not daring to take the risk), let alone private sector investment.

The present study also shows that stakeholders argue that CREIs would be in need of support and empowerment, not just in terms of favorable policy but also in terms of capacity building, as indicated in the GIZ interview. This indicates the importance of intermediaries supporting CREI formation, organizational operation, brokering contracts, and lowering transaction costs [43], as also observed in countries that witnessed the emergence of community energy in recent years [16,71,72]. Another observation indicated the importance of social cohesion and trust, as witnessed in the residents' survey, where the former (20%) and the latter (8%) came across as key barriers to CREI formation. This underlines the importance of these social characteristics of local communities in which a CREI is formed, and is in line with results from other studies [13,73].

Energy transition geared towards generating energy through a decentralized form of governance that empowers local actors is gaining momentum in various countries across the world [45,74]. At the same time, Nigeria still heavily depends on crude oil for energy. The government has promised to unbundle the power sector to include microgeneration. This is contained in a new legislative bill proposed in June 2021 [75]. The form of local action using a CREI model is one of the strategies that the Government of Nigeria can potentially adopt when it is right to unbundle this critical economic sector. Community renewable energy generation and supply that are either wholly owned or managed by the

members who contribute financially to its development or organized in a partnership with utility companies helping to address the country's energy poverty and security issues.

Increasing the production and consumption of energy from renewable energy sources is fundamental to sustainable development. Being a signatory to the SDGs, Nigeria can domesticate these goals, particularly SDG7, by supporting and promoting community renewable energy development in housing estates in Nigeria. SDG7 clearly outlines the UN's ambitions to ensure access to affordable and clean energy [76].

The continuous dependence on unsustainable energy sources and the adverse effects of greenhouse gas emissions means that switching to renewable energy is essential. The service provided by energy is vital to economic growth, progress, development, and the eradication of poverty in any country aspiring to meet the UN's SDG7 [77].

Reforming energy policy while considering the need to transition to a low-carbon economy, energy security, and citizens' participation in democratizing Nigeria's energy systems could contribute to social and environmental justice. Social and environmental justice is related to the equitable distribution of wealth in society [77]. Energy from community-led projects is one approach that can contribute to environmentally and socially just energy transitions and to SDG7 [42].

Therefore, governments of developing countries are advised to be strategic when addressing energy security issues by using CREIs as one of the possible approaches to green energy systems and improving energy security. For CREIs to be successfully implemented, national governments must ensure that the right people receive the correct information and the proper support at the appropriate time.

6. Conclusions

This paper started with the research question: In which ways and under which conditions can Community Renewable Energy Initiatives (CREI) contribute to the use of renewable energy sources and improve energy security in Nigeria as perceived by selected stakeholders and households? The present study used a mixed method research approach to answer the research question and did so by combining a stakeholder analysis and a household survey.

The former showed that government actors have a fairly positive attitude towards CREI formation. Government actors also acknowledge the high urgency of the situation and are considered to be the most capable of potentially supporting the formation. Most other stakeholders are supportive of CREI formation but see less urgency and were revealed to have less interest. The government is also perceived as having the most powerful role. The private sector depends on it because it requires (legal) approval. Furthermore, CREIs depend on the government because they require a favorable regulatory framework; this is currently not the case in Nigeria.

The household survey revealed how residential sector end-consumers perceived local CREI formation. First, there is a mixed view of CREIs, with 58% of the respondents having a positive view and 42% having a negative view. Nonetheless, 79% expressed that a CREI-led solar PV microgrid could be a possible solution toward achieving increased levels of energy security, and 73% expressed openness to having a CREI present on their estate. The survey also revealed that the estate members are experienced in running community-owned projects, yet not in the energy domain. On those occasions, the housing estate did require technical, financial, as well as government support. Having this perspective, the residents expressed viewing the currently poor regulatory framework as a big challenge to potential CREI formation. An additional barrier would be the lack of trust in other community members, especially concerning staffing, leadership, and running the operations of the CREI organization. Nonetheless, the support of neighbors was seen as an important motivation to participate in a local CREI, as was the wish for a constant electricity supply. When asked about perceived barriers to CREI formation, residents mentioned upfront costs, lack of (social) cohesion in the estate, and poor government policy (unsupportive to RET adoption, microgrid development, and formation of CREIs). Perceived factors to encourage

CREI formation pertain to awareness raising, (financial and technical) project support, and the desire to have a supportive regulatory framework available.

In summary, the estate residents consider CREIs as conditionally capable of increasing access to energy services and improving energy security in Nigeria. However, CREIs are only viewed as a viable option once government regulation is in place to support their development and includes well-trained community members in the formation of its strategic and operational processes. Moreover, the residents also expressed that CREIs will most likely best succeed in remote rural areas.

6.1. Limitations and Suggestions for Future Research

The households and housing estates in the Lagos State of the present study are, to a limited extent, representative of the population of Nigeria. This also holds for a number of the stakeholders consulted. Extrapolating the results of the present study to the general population of Nigeria would be misleading. However, given the explorative nature of the study and the investigation of the openness, perceptions, and potential acceptance of novel energy and social innovation that could potentially alleviate energy security problems, the results are of importance, particularly regarding the social and policy dimensions of energy issues, and about solar PV microgrids, which had previously only been studied from a technical and financial perspective in the West African region (e.g., [36]).

Future research can address the social acceptance of such energy systems and social innovations such as CREIs in more detail or use a citizen sample with greater representativeness of Nigeria. Furthermore, due to logistical constraints, not all of the relevant housing estates and stakeholders in the electricity sector were covered in the present study. This opens a window of opportunity for further research on community energy initiatives in Nigeria that would cover the thirty-six states that were not included in the present study.

An important limitation of the present study concerned the fact that the CREI concept is new to Nigeria, affirming that this is the first study using this concept in Nigeria, according to one of the stakeholders interviewed. This made the process of data collection tedious, as the concept constantly required explanation and illustration to the interviewees and survey respondents. Future researchers are advised to consider replicating the present study a few years from now when CREIs are possibly more present in Nigeria. Another issue pertained to not being able to interview solar PV panel distributors in Nigeria, many of whom believe that the present study was only conducted for market research purposes of their competitors, making them feel uncomfortable divulging information for fear of losing market distribution potential. Future researchers might consider using dedicated tactics to convince solar PV asset suppliers to participate in the study.

Finally, replication of the present study is proposed for future researchers in comparable developing countries where community energy has not yet landed. The present study did not focus on technical and financial-economic details of CREI-managed solar PV microgrids. Future research, taking a more multidisciplinary approach, could complement the research approach central to the present study with technical and economic details, which would also allow for highlighting the importance of business models or presenting and discussing a business case.

6.2. Policy Recommendations

For CREIs to be successful in Nigeria, it is suggested that the government enacts an appropriate renewable energy policy with fiscal incentives, such as feed-in tariffs, to attract investors and communities that are willing to cooperatively fund their independent energy systems, such as the two estates presented in this paper. NGOs and government agencies must also design a robust education and awareness program for communities to adopt this concept and a few pilot projects to demonstrate how CREIs work. Policymakers are also advised to support or set up intermediary support (schemes) to empower CREI initiatives. With the stakeholders performing their functions and all of the necessary factors accounted

for, CREI formation can potentially become successful in Nigeria and help enhance its greening of energy supply and improve the energy security.

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Data Availability Statement: The authors confirmed that the data supporting the findings of this study are primarily collected and analyzed by the authors and are available upon request.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questionnaire Used in Stakeholder Expert Interviews

1. What is your role within this organization?
2. How did your company get involved in the NESP?
3. Have you heard of the Local energy initiative?
4. What is your organization's opinion on the concept of local energy initiatives?
5. Do you think they are feasible and sustainable in Nigeria?
6. Do you know any existing LEIs or community-based energy systems in Nigeria?
7. If yes, could you shed more light on it perhaps give us a contact
8. Do you think the Local energy initiative if adopted could improve energy access in Nigeria?
9. Do you think Nigerians can adopt local energy initiatives? If yes, can you explain further, and if not could you suggest some of the challenges and barriers to the adoption of Local energy initiatives and renewable energy in Nigeria?
10. One of the core objectives of NESP is to promote renewable energy investment in Nigeria, what is the current adoption level of renewable energy technology in Nigeria?
11. In your opinion what are the barriers to renewable energy technology (RET) in Nigeria?
12. In your opinion, what strategy do you think can be put in place as a sort of motivation for Nigerians to adopt the local energy initiative and RET?
13. What support can your organization give to potential volunteers or communities who are willing to form an energy cooperative or local energy initiative?
14. Support in what form?
15. Would you add something that might be considered important for this study?
16. Do you know any other organization that performs the same role as yours?

Appendix B. Stakeholder Analysis Worksheet

Table A1. Stakeholder analysis worksheet.

Attributes Used in the Research					
Level of Attitude					
Definition	Champion	Supporter	Neutral	Critic	Opponent
The level of stakeholder support opposes, or neutral about CREIs	Stakeholders that give significant support to CREIs	Stakeholders that give less significant support for CREIs	Stakeholders that neither oppose nor support CREIs	Stakeholders that criticize the projects and operations of CREIs but do not oppose CREIs.	Stakeholders that oppose the project and operations of CREIs
Level of power, Level of Interest and Level of Urgency					
Definition	High (1)		Medium (0)		Low (−1)
1. Level of Power					
The ability of the stakeholder to affect the CREIs	Stakeholders can make overreaching decisions regarding the formation of CREI in their jurisdiction.		The stakeholder is one of the several authorities that can make decisions on the formation of CREI. The stakeholders also depend to some extent on other stakeholders.		The stakeholders cannot make decisions on the formation of CREIs but depend solely on the decision-making of other stakeholders.
2. Level of Interest					
The stakeholder's interest in the formation of CREIs. The disadvantage and/or advantage of CREI to stakeholders	When the stakeholders have a high interest or advantage through the formation of CREIs		When the stakeholders have a medium interest or benefit from CREIs		The stakeholders have zero or fewer interests or benefits from CREIs
3. Level of Urgency					
The urgency of a stakeholder to successfully form CREIs	The stakeholder's support is very urgent in ensuring the formation of CREIs, and any opposition from stakeholders would mar the successful formation of CREIs		The support of stakeholders is slightly urgent to the formation of CREIs, and the absence of its support will affect the formation of CREIs		The stakeholder's support is less urgent, and a lack of support will not significantly affect the formation of CREIs

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