AKENTEN APPIAH MENKAH UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURSHIP DEVELOPMENT.

FACULTY OF TECHNOLOGY

CONTEXTUALISING THE EMERGENCE OF ENERGY CITIZENSHIP IN GHANA: A CASE STUDY OF NORTHERN GHANA.

(MASTER OF TECHNOLOGY ELECTRICAL AND ELECTRONICS)

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BY

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A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfilment of the requirements for the award of a Master of Technology degree in Electricals and Electronics Engineering.

November, 2023

DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree at this university or elsewhere.

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Supervisor's Declaration

I hereby declare that the preparation and presentation of this dissertation were supervised in accordance with guidelines on supervision of dissertation laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

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ABSTRACT

The factors and drivers along with the role of local communities and institutions in promoting energy citizenship were examined in this study as well as the potential to address energy challenges and foster sustainable development. A comprehensive survey and interviews with key stakeholders were adopted for the study. A stratified random sampling approach was utilised through community engagement and with the aid of questionnaires to gather data from 678 respondents and 5 key informants. The study also examines the perceptions and attitudes of community members towards energy-related issues, their awareness, and the role of local institutions in shaping energy behaviours. The data was analysed using both structural equation modelling (SEM) and descriptive statistics. The results indicate that benefits and motivation support community engagement in energy citizenship. The findings further emphasise the significance of reliable electricity supply and the urgency of community involvement as a critical role in addressing energy-related challenges. The study reveals that majority participants feel empowered to make energy-efficient choices. Notably, education, awareness campaigns, and engaging citizens in decision-making emerge as crucial tools in promoting sustainable energy practices to drive positive change and enhance the effectiveness and acceptability of energy initiatives. This study concludes that energy citizenship has the potential in sustainable development providing actionable insights for policymakers, local institutions, and communities aiming to enhance energy literacy, promote renewable energy, and address pressing energy-related issues. Additionally, the transformative power of active citizen participation and a holistic approach to building resilient and equitable energy systems is emphasised.

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DEDICATION

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LIST OF ABBREVIATION

AMOS	Analysis of Moments Structures
APR	Awareness of Policy
AVE	Average Variance Extracted
BEC	Barriers to Energy Citizenship
CEIs	Community Energy Initiatives
CEM	Community Engagement
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CR	Composite Reliability
DDPP	Deep Decarbonization Pathways Project
EU	European Union
G20	Great 20
GDP	Gross Domestic Product
GridCo	Ghana Grid Company
GSS	Ghana Statistical Service
GWh	Gigawatt hours
ICT	Information and Communication Technology
IFI	Incremental Fit Index
LPG	Liquified Petroleum Gas
MEC	Motivation to Engage
PASD	Potential in Addressing Sustainable Development

PBE	Perceived Benefits
PEC	Perception of Energy Citizenship
PV	Photovoltaic
R^2	Squared Multiple Correlation
RCPE	Role of Local Community Promoting Energy Citizenship
RERs	Renewable Energy Resources
RETs	Renewable Energy Technologies
RMSEA	Root Mean Square Error of Approximation
RTAs	Regional Trade Agreements
SD	Standard Deviation
SDGs	Sustainable Development Goals
SEM	Structural Equation Modelling
SHS	Senior High School
SPSS	Statistical Package for Social Science
TLI	Tucker Lewis Index / Non-Normed Fit Index
UK	United Kingdom
USA	United States of America
USD	United States Dollar

CHAPTER ONE

1.1 Background to the Study.

While the world wants to attain substantial decarbonisation objectives, renewable energy preceded by wind and solar is positioned to become the backbone of the global power supply. However, the growth of renewable energy has repeatedly and dramatically outpaced virtually all projections.

A persistent topic under discussion is the environmental effect of energy transition and how it varies based on current policy decisions according to (IRENA, 2020), the rationale that renewable energy transition and policy should recognize all groups and follow the equity assumption to leave no one behind is crucial.

(Ringholm, 2022), conducted a study on how the evolution to a minimal carbon energy system creates new difficulties for democratic involvement and the potential for institutional innovation and engagement. His research also encompasses the new ways that engagement in policies to reduce fossil fuel use is connected to energy citizen idea innovation, positioning itself in the discussion of participation as an institutionalized democratic virtue.

(Biresselioglu, Demir, Solak, & Turan, 2022), carried out a study to improve awareness of the relationship between energy citizenship, environmental citizenship, and associated phenomena, including its operational mechanisms and conceptual transformation of energy citizenship and environmental citizenship toward the mission of energy transition and global warming.

On the other hand, (Van Wees et al., 2021), analyse the approaches, techniques, and anticipated results for citizen involvement used in six distinct innovations projects and European research in the field of optimistic energy districts to establish a general definition of energy citizenship and investigate the value of public participation for the implementation of an all-inclusive energy perception.

Further research by (Ryghaug, Skjølsvold, & Heidenreich, 2018) on energy citizenship considers public involvement in the transition to low-carbon energy and the theory of material interaction to emphasize how emerging energy technologies may result in new energy practices. It is argued that introducing technological innovations like the smart meter, electric car, and solar panels might be objects of interaction and participation that may promote material participation and energy citizenship.

(Pel et al., 2021) describes the conceptual framework of energy citizenship, which reveals the variety of more and less active energy citizenship forms by highlighting the key contrasts made in sociology, social psychology, geography, political science, energy studies, and critical social theory, that both outlines out the key definitions, theoretical foundations, and preconceived notions of the necessary systematic energy citizenship.

(Lennon et al., 2020) proposed that acknowledging energy citizenship is necessary to provide contexts for action that are more inclusive and collaborative. The traditional ideas of citizenship, particularly those related to its associated rights and obligations, need to be re-evaluated in light of how much energy is consumed in domestic domains for the term to be meaningfully applied to the energy transition. As a result, they contend that the ideas of energy citizens are appropriated to represent prevalent neoliberal discourses and disregard key issues of uneven agency and resource access. Contrarily, official discourses that assign individuals the role of consumers in the energy transition successfully strip citizens of agency, leaving them primarily unconnected and powerless.

(Edomah, Bazilian, & Sovacool, 2020) give an informed socio-technical classification of national energy transitions distinguishing between an interim energy transition when the government adopts green energy measures with no widespread popular backing. Energy transition is when a sustainable energy transition is spurred by a mix of government policy and public action. In contrast, a purposeful energy transition is when consumers initiate alternative energy adjustments even when the authorities do not facilitate transformative measures.

(Osei-Tutu, Boadi, & Kusi-Kyei, 2021) used indicators derived from the literature, such as a diversified energy source type, an adjustment in energy ownership and control, and a transition to eco-friendly vehicular transportation, to determine whether an energy transition has occurred in the electrical energy sector of Ghana. Energy transition is a new research theme, so it is uncertain whether the transformation has happened or not, and if so, in what form it has taken. In Ghana, the decarbonization of energy will be improved as a step toward achieving sustainability through the switch to green energy and the establishment of a participatory energy citizenship conceptual approach. The researcher asserts that existing studies on energy does not contextualize the emergence of energy citizenship in the Ghanaian context. And decarbonization of energy will be crucial to reducing greenhouse gas emissions, reducing the effects of climate change, while accelerating the switch to sustainable energy sources.

1.2 Statement of the Problem.

The convergence of energy consumption and citizenship as fundamental elements of societal progress is progressively attracting more attention from academic researchers. The emergence of energy citizenship in Northern Ghana, within the wider context of Ghana, poses an intricate and diverse challenge. Throughout history, the area has encountered energy disparities characterized by restricted availability of dependable and sustainable energy sources. These obstacles have impeded not only economic progress but also the inhabitants' general welfare. In the pursuit of sustainable and inclusive energy solutions, it is crucial to comprehend the contextual elements that contribute to the development of energy citizenship within the unique socioeconomic and geographical environment of Ghana.

A pivotal element of this matter pertains to the sociopolitical and cultural dynamics prevalent in Northern Ghana. The region has unique historical, cultural, and environmental features that shape its energy landscape. It is imperative to conduct an inquiry into the interplay and impact of these variables on the development of energy citizenship in order to formulate targeted and

effective policies. Furthermore, the absence of a full comprehension of energy citizenship within this context has led to a deficiency in the existing body of literature, therefore requiring a careful investigation to address this gap.

According to (Jack, 2022) Africa, although contributing to less than 4% of global greenhouse gas (GHG) emissions, experiences the adverse impacts of climate change. Confining Africa's engagement in the climate discourse solely to the areas of Loss, Damage, Modification, and Resilience undermines the continent's potential to actively shape the trajectory of global climate affairs. This approach neglects Africa's capacity to significantly contribute to the collective efforts aimed at mitigating the adverse effects of climate change on a global scale. The scientific consensus asserts that in order to mitigate the most severe consequences of climate change, it is imperative to reduce greenhouse gas emissions by approximately 50% by 2030 and achieve a state of net zero emissions by 2050 (United Nations, 2021).

In Davies and Oreszczyn's study (Davies & Oreszczyn, 2012), it was suggested that addressing decarbonization concerns requires an understanding of the potential limitations of existing models and modes of thinking. It is crucial to develop new strategies that encompass the multifaceted nature of the built environment, which is a complex system.

The primary challenge confronting the present climate change regime, as identified by Sun & Yang (2016), is the lack of alignment among various stakeholders. These stakeholders encompass a wide range of actors, such as the scientific community, politicians from different nations, large corporations, small and medium-sized businesses, social activists, consumers, industries, and the media. Furthermore, the present study argues that the issue of global warming and its associated efforts ought to be comprehended from a more intricate and multifaceted perspective, considering social complexities and the disintegration of institutions and sectors. This stands in contrast to the prevailing approach to addressing climate change, which primarily emphasizes the establishment and enforcement of emission limits for greenhouse gases.

Even though there are a lot of scientists and policymakers, initiatives led by citizens, like community renewable electricity initiatives have the potential to support shifting society toward sustainability and carbon neutrality because citizens can work together to co-produce public services, like green energy provision for their communities and themselves. Despite this purported potential, there is still a low level of real citizen participation in climate action ((Mees, 2022).

Furthermore, most of the established associated information was unable to address the precise particular issue of decarbonising energy in Ghana to mitigate the effects of climate change, reduce greenhouse emissions, and speed up the country's transition to sustainable energy sources. This research will make a breakthrough in this field by directly identifying how individual and collective actions contribute to the emergence and consolidation of collaborative energy initiatives and the social and environmental impact of participating in these energy initiatives in Africa.

1.3 Purpose of the Research.

The primary objective of this research is to investigate and provide a comprehensive analysis of the development of energy citizenship within the unique socio-cultural and economic landscape of Northern Ghana. In light of substantial changes occurring in the global energy sector, it is imperative to comprehend the ways in which communities actively participate in and interpret the process of transitioning to alternative energy sources.

The study also seeks is to offer a thorough analysis of the historical, cultural, and economic determinants that have contributed to the development of energy citizenship in the region of Northern Ghana. The research seeks to analyse the historical connection between the region and its energy resources and infrastructure, with the objective of identifying patterns and trends that have influenced the contemporary energy landscape. Moreover, this study will examine the cultural factors that shape energy practices and citizenship, taking into account the influence of local traditions, beliefs, and social structures on the community's energy dynamics.

Furthermore, this research aims to provide a scholarly contribution to the field of energy citizenship by offering valuable perspectives on the unique difficulties and possibilities that are prevalent in the Northern region of Ghana. The primary focus will involve the identification of obstacles to active energy citizenship and the examination of potential ways to surmount these hurdles. The primary objective of this study is to produce valuable insights that can be utilized by politicians, energy professionals, and community leaders to effectively advocate for sustainable energy practices and improve community involvement in energy decision-making procedures.

1.4 Objectives of the Research.

The research aims to create a typology of the energy citizenship concept for diverse communities of citizens by participating and collective engagement in reducing the decarbonisation of energy while accelerating the transition to sustainable energy sources.

The specific objectives of this study include;

1. To examine the factors and drivers contributing to the emergence of energy citizenship.
2. To investigate the role of local communities and institutions in promoting energy citizenship in Northern Ghana.
3. To access the potential of energy citizenship in addressing energy issues and fostering sustainable development in Northern Ghana.

1.5 Research Questions.

1. What are the factors and drivers contributing to the emergence of energy citizenship?
2. What roles do local communities and institutions play to promote energy sustainability and efficiency?
3. What is the potential of energy citizenship in addressing energy issues and fostering sustainable development in Northern Ghana?

1.6 Significance of the Study.

The examination of the contextual factors contributing to the development of energy citizenship in Ghana, particularly in the Northern region, carries substantial significance for multiple reasons. Ghana, just like in many other developing countries, is confronted with the challenges pertaining to energy accessibility and sustainability. This research endeavours to enhance comprehension of the way communities in Northern Ghana actively participate in and contribute to the advancement of sustainable energy practices through an exploration of the notion of energy citizenship. The findings derived from this study possess the potential to provide valuable guidance to policymakers and energy practitioners regarding the use of successful tactics for advancing inclusive and community-oriented approaches to energy development.

Furthermore, the inclusion of Northern Ghana as a special focal point provides a significant regional dimension to the ongoing discussion on energy citizenship. The northern areas frequently encounter distinct obstacles, such as differences in economic conditions and changes in climate. By examining the development of energy citizenship within this framework, it facilitates a more nuanced comprehension of the intricate relationship between socio-economic variables and energy behaviours. Understanding this knowledge is crucial for developing energy policies and interventions that are both tailored to individual regions and culturally sensitive, considering the many socio-cultural dynamics present in Ghana.

Moreover, this study aims to fill the void in current scholarly works by conducting a comprehensive examination of the contextual elements that impact the development of energy citizenship. This study has the potential to enhance theoretical frameworks and empirical evidence by beyond generic models. It aims to provide a more nuanced comprehension of the perceptions, adoption, and participation of local communities in Northern Ghana about sustainable energy efforts. These insights play a crucial role in the creation of interventions that are tailored to the specific situation and align with the socio-cultural values and goals of the population.

Furthermore, the value of the study resides in its potential to enhance community engagement and empowerment. Through an examination of the mechanisms by which individuals in Northern Ghana engage in the energy transition, this research has the potential to offer significant insights into strategies for cultivating a feeling of ownership and accountability within local communities. The process of empowerment has the potential to accelerate the progress of sustainable energy practices, so making a significant contribution to the larger socio-economic development objectives within the region.

1.7 Organization of the Study.

This research is organized into five chapters, and chapter one contains the background of the study, the problem statement, the research objectives, the research purpose, the significance of the research, the thesis organization and research limitations.

Chapter two reviews relevant related literature, while chapter three highlights the research methodology. Furthermore, the discussion and analysis of the findings are also presented in chapter four and finally, chapter five concludes the thesis with the summary and recommendations.

1.8 Limitations of the Study.

The findings from this study may not apply to other parts of Ghana because it focuses on energy citizenship in the context of Northern Ghana. Additionally, since the researcher is not proficient in the native language, language hurdles and the subjective character of the research may present the possibility of bias in the data collection and analysis. Time required for data collection may also have an impact on the reliability of the study.

CHAPTER TWO (2)

LITERATURE REVIEW

The concept of energy citizenship has emerged as an important and timely research topic in the transition towards more sustainable energy systems. Also, according to (Hamann et al., 2023), energy citizenship can be defined as a framework of rights, responsibilities, and identities that shape individual relationships to energy and their participation in the energy system.

(Lennon et al., 2020) highlights that the proactive involvement of citizens in the transition to sustainable energy systems is termed "energy citizenship". This also, requires the engagement of all stakeholders in decision-making processes for energy infrastructure and policy as well as increasing awareness of and educating people about sustainable energy practices. The need for more inclusive and participatory methods of managing the energy sector while emphasizing the role ordinary people can play in determining the direction energy systems take is significant.

(Wahlund & Palm, 2022) assert that the emergence of energy citizenship reflects a growing understanding of the significant influence that citizens can have on energy governance and policy, as well as the necessity of addressing social justice and equity issues in the transition to more sustainable energy systems. Energy citizenship emergence would be particularly pertinent in developing nations, where access to energy is frequently restricted and unevenly distributed.

In Ghana, electricity production is often described as being under government ownership and control, with little or no public input into the decision-making process. Through participation in and engagement with energy systems, citizens can now influence energy policies owing to recent advancements according to the energy business. Identifying key themes and discussions in both theoretical and empirical literature on this issue helps contextualize the establishment of energy citizenship in Ghana. However, in the Ghanaian context the underlying elements that have encouraged development are especially examined in relation to the operationalization and conception of energy citizenship. In addition, this study identifies areas that require more

research alongside the gaps and constraints in the body of existing information. Overall, this literature review aims to contribute to a deeper understanding of the emergence of energy citizenship in Ghana and its potential for promoting sustainable energy systems and social justice.

2.1 Decarbonization and Energy Transition.

Decarbonization and energy transition concepts have recently received recognition as a response to the urgent effort to address climate change and the shift towards a reduced-carbon and more environmentally friendly energy future. Decarbonization intends to eradicate greenhouse gas emissions and minimize global warming to avoid catastrophic climate impacts. The transition to renewable energy systems is regarded as a pertinent aspect of this process, but it presents significant challenges, including infrastructure investment, grid integration, and energy storage. In addition, the Energy transition is likely to impact the labour market and energy sector employment significantly, hence emphasizing the need for policies to support workers and communities affected by the transition. Participation and engagement of stakeholders are also essential to guarantee that the transition is fair and considers the requirements and worries of local communities. This review of related literature summarizes the key themes and findings from research on decarbonization and energy transition, highlighting the challenges, opportunities, and co-benefits of this critical process.

(Araújo et al., 2014) examines the progress, challenges and opportunities presented in the emerging field of energy transitions; in the study, the author discusses various aspects of energy transitions, including definitions, examples, core ideas, global developments, and key information sources also highlights the need for urgent action and innovation in the energy sector to address environmental and security concerns and improve energy access. So far, there is a lack of in-depth analysis and evaluation of the existing literature on energy transitions as

the existing literature review is limited to qualitative analysis, so there is a need for more quantitative studies in the field.

(Osei-Tutu et al., 2021) investigated the electrical energy transition in Ghana, highlighting significant changes in the energy sector that involved a shift from exclusive hydro energy to a hydro-thermal mix. Thermal energy approximately constitutes 69% of the 2020 generation mix. Furthermore, the transition from solely state supply to a mix of state and private supply contributes to around 56% of the present energy supply.

While renewable energy has gained attention in policy, its implementation has been limited, with renewable sources currently accounting for less than 1% of the overall electrical energy mix. Although Ghana has undergone fundamental changes in its electrical energy system, a sustainable transition towards greener energy has not yet been achieved. So far, there is limited understanding of why renewable energy agenda in Ghana has remained primarily a policy agenda with minimal practical implementation. The study emphasizes the importance of conducting further research to identify the challenges and barriers hindering the implementation of renewable energy in Ghana and explore potential solutions to overcome these obstacles.

According to the World Energy Transitions Outlook (IRENA, 2021), the future of energy will be dominated by modern bioenergy, green hydrogen and renewable energy. A combination of technologies is required to achieve the 1.5°C climate pathway, as financial markets and investors are already directing capital towards renewable energy technologies.

Nevertheless, national social and economic policies will be pertinent in delivering the energy transition required to restrict global warming to 1.5°C. Despite the need for increased investment in the energy transition by 30% over planned investment, to a total of USD 131 trillion between now and 2050. However, it is important to note that stakeholders are not explicitly included in the energy transition process, which may affect the equitable distribution of benefits and the overall success of the transition.

(Kingsbury, 2020) studies unequal and coupled energy transitions to reactive decarbonization in Venezuela and Cuba, highlighting that energy transitions towards post-carbon futures often rely solely on technological or legislative measures, ignoring the underlying political and social issues related to climate change. The uneven global distribution of risk, safety, and power must be considered when considering energy transitions, as the experiences of Cuba and Venezuela during their respective crises demonstrate the difficulties and complexities of such transitions and the potential for incomplete or reversible outcomes.

According to Kingsbury's assertion, energy transitions are inherently social processes that require meticulous attention to matters of justice and equity as energy transition's political and societal aspects comprehensively utilize secondary data sources. A detailed analysis of both political and social perspectives of energy transitions is provided through secondary information sources. However, more study is required to explore the conceivable remedies to address the active participation of citizens in the decisions making processes concerning energy.

To ascertain the duration required for conceptualizing the temporal dynamics of energy transformations, (Sovacool, 2016) emphasizes the relevance of understanding the acceleration and direction of energy transition by providing a framework.

The research establishes that energy transitions encompass social and cultural values and norms including economic and technical processes, thereby requiring an all-inclusive dynamics awareness of devising efficient energy policies and strategies. However, the study does not offer a comprehensive diversity of energy transitions and examination of how energy citizenship can support the achievement of social equity and ecological sustainability in energy transitions.

2.1.2 Overview of Global Decarbonization Efforts.

(Meckling, Sterner, & Wagner, 2017) discuss the significance of policy sequencing in decarbonizing energy systems, noting that carbon pricing is the most cost-effective approach.

They argue that combining and sequencing policies are necessary to avoid dead ends in decarbonization.

While their theoretical framework has limited empirical testing, the authors call for further research on the political economy of policy sequencing, including the role of interest groups and political institutions. They also suggest more analysis of context-specific factors affecting policy implementation and studies on potential trade-offs between policy sequencing and other objectives such as equity and economic growth.

(Mitrova & Melnikov, 2019) conducted a study on Energy Transition in Russia, highlighting the lack of reflection on the global transition towards renewable energy sources in Russia's energy policy and the country's reliance on fossil fuels and scepticism towards climate change. So far, challenges such as expanding technological isolation, increasing global competition, and financial constraints that Russia's energy sector faces have been identified. One of the key findings is the absence of a clear strategy for development and renewable energy transition. Little is known to explore the localization of equipment and the redesign of electricity networks.

(Susskind et al., 2020) explore Malaysia's journey towards decarbonization and the challenges it faces. This study identified key factors that have facilitated Malaysia's transition, including behavioural changes, institutional shifts, and collaboration among various stakeholders. However, they also highlight several barriers, including federal-state tensions, limited government capacity, and insufficient funding for renewable energy. To support Malaysia's decarbonization, the researcher makes a case for the necessity of empirical research to comprehend the unique difficulties and opportunities for decarbonization in Malaysia, a thorough examination of potential social and environmental effects, and a focus on the role of international actors and climate governance frameworks. The study emphasizes the significance of a multi-stakeholder, coordinated strategy for escaping carbon lock-in and achieving a sustainable, low-carbon future.

(Sonnenschein & Mundaca, 2016) reviewed how well South Korea's green growth programs worked to meet its decarbonization goals as a majority of factors influencing carbon emissions from fuel combustion had an effect that increased emissions in the nearest, whereas GDP per capita had the greatest long-term influence on carbon emissions, the little government assistance for low-carbon energy technology in Korea and the absence of matching pricing measures did not result in a reduction in the desired emissions.

However, the analysis of South Korea's green growth strategies lacked empirical analysis, and there was little discussion of the political and societal variables that might help or impede its implementation. Last but not least, the assessment skipped over the significance of international accords and collaboration in aiding South Korea's decarbonization efforts.

(Bataille et al., 2016) emphasises the importance of national deep decarbonization pathways for effective climate policy. The Deep Decarbonization Pathways Project (DDPP) offers a methodology for developing country-specific pathways to achieve the 2°C target while balancing advance ambitions and general circumstances.

The paper identifies enabling conditions for transformation, including technology research and development, investment, trade, and global and national policies. However, the article lacks empirical evidence on the effectiveness of national deep decarbonization pathways in different contexts. Moreover, it does not address the potential challenges associated with implementing these pathways or consider the role of other sectors beyond energy in achieving deep decarbonization. Finally, the paper does not discuss the potential interactions between national and global climate action.

(Rockström et al., 2017) provide a strategy for rapid decarbonization, highlighting the feasibility of the Paris Agreement's goals and proposing a carbon law to halve gross anthropogenic carbon emissions every decade. The researcher asserts that inconsistencies between science-based targets and national commitments in the Paris Agreement on carbon

removal efforts to ramp down land-use carbon emissions must be immediately implemented and scaled up to limit warming to well below 2°C.

While the paper builds on prior research, it does not provide new empirical data. The study highlights the need for transformative change across several sectors and the significance of global coordination and cooperation. Further study is, however, necessary for more precise and targeted policy recommendations for the roadmap to be implemented practically and to understand the barriers and opportunities for political action.

2.1.3 Role of Green Energy in Energy Transformations and Decarbonization.

(Gielen et al., 2019) discuss the growing importance of clean energy in the global energy transformation, highlighting its potential to cut the emission of greenhouse gas, combat climate change, and improve energy security. Their study indicates that conventional sources are becoming more cost-competitive.

However, more encouraging policies and regulatory frameworks are required for the implementation of renewable energy adoption varies. Although the paper acknowledges that integrating renewable energy into current energy systems poses technical and financial challenges, it contends that these can be overcome with the right planning, investment, and innovation. The authors stress the need for significant infrastructure investments to switch to renewable energy and international cooperation to address opportunities and challenges. They demand more research on the effects of renewable energy on the economy, society, and environment in various nations and regions, as well as comparative analyses of legislative and policy frameworks to find best practices and lessons learned. The study emphasises the importance of evaluating renewable energy's potential to promote sustainable development and eradicate poverty, particularly in developing nations.

(Nguyen et al., 2021) proposed a mini-review on the potential role of alternative energy sources in decarbonization efforts. The study finds that solar and wind energy are rapidly growing and becoming increasingly cost-competitive. At the same time, biomass can provide reliable energy but requires careful sustainability management also, Hydropower is a mature technology with limited potential for further expansion. In contrast, geothermal energy has significant potential but faces technical and economic challenges on the other hand, Ocean energy, such as wave and tidal power has potential but still in its early stages of development and faces challenges. The study, however emphasises the importance of supportive policies and regulatory frameworks to accelerate the adoption of alternative energy sources and address the challenges of integrating them into existing energy systems. In contrast, very little is known to understand the environmental and social impacts of alternative energy sources, biomass energy sustainability, integration challenges, and emerging alternative energy sources.

2.1.4 Impacts of Decarbonization and Energy Transitions.

(Bridge et al., 2018) critically emphasise the intricate connection between society and energy. The book provides a comprehensive introduction to important ideas like the politics of energy transitions, the social construction of energy, energy justice, energy citizenship, and the difficulties of decarbonization. Its interdisciplinary approach aims to offer suggestions and plans for a future with more sustainable energy sources. However, the book does not offer any empirical research or data, and more study is required to comprehend the social and political aspects of energy transitions.

(Leicester, 2016) proposes the development of object-oriented Bayesian network models to evaluate the economic, environmental, and social effects of solar PV, taking into account uncertainties. The study's findings show that these models can provide substantial outputs in response to variable inputs and that the unpredictability in the percentage of indicators such as

carbon emission reduction discounted cash flow and fuel affordability is responsive to the orientation, age, built form, and socio-economic factors of dwellings in the UK.

However, the lack of empirical application and validation of the proposed model, as well as the need for comparison with other methods of impact evaluation, limit the study's conclusions highlighting the need for future research to investigate the scalability of the model for larger and more complex projects and the potential limitations and challenges of implementing this approach in real-world decision-making contexts.

(Kumar, 2020) identifies the Environmental, social, and economic implications of clean to conventional energy sources. The paper highlights that energy from renewable sources is environmentally friendly and can decrease global warming by limiting greenhouse gas emissions.

Additionally, they can create job opportunities, improve local employment, health, and income development, and contribute to community development. However, the study acknowledges that renewable energy sources have drawbacks, such as seasonal variations in output, which call for particular planning and consideration. So far, too little empirical evidence and comprehensive discussion are available on the challenges, limitations, negative impacts, policies, and economic viability of renewable energy sources.

(Hendriks, Kuenen, Kranenburg, Scholz, & Schaap, 2015) conducted a study on the influence of energy evolutions on source receptor matrices for air quality. The study highlights that the way emissions are distributed over the year significantly affects the efficacy of emission reduction in the power sector, particularly when accounting for the switch in emission time profiles. Also, both primary and secondary pollutants affected the shift in emission timing, which changed source-receptor relationships significantly, emphasizing the importance of considering emission timing when evaluating how system modifications will affect greenhouse gas emissions from temporary substances and air quality. So far, the scope of the study is limited

to the European power sector, and its findings may not be generalizable to other regions with different energy systems or meteorological conditions. In addition, the impact of changes in emissions on human health or ecosystems is also not considered.

2.1.5 Challenges of Implementing Renewable Energy Policies.

(Papadis & Tsatsaronis, 2020) investigate the challenges of decarbonization in the energy sector by categorizing carbon emission reduction options into the generation of secondary energy carriers, sectors interdependencies and end-use energy sectors. In addition, highlighting the challenges faced in decarbonizing the energy sector, such as environmental sustainability, energy security, social aspects and economic stability, The study proposes a global carbon tax as the most promising instrument to accelerate decarbonization but also points out the challenges associated with competition among energy sectors for decarbonization options, high capital requirements, public acceptance of changes in energy use and inconsistent environmental policies.

However, the study emphasizes the need for more empirical data and case studies to support the proposed strategies and the lack of attention paid to decarbonization's social and political dimensions, including potential conflicts and trade-offs between stakeholders. Despite the emphasis on the need for further research to investigate how the shift to renewable energy sources and the phase-out of fossil fuels can impact energy security, access, and affordability in different contexts and how these impacts can be managed.

(Marquardt, 2017) investigates the central-local relations and the implementation of clean energy policies in developing countries, establishing that policy implementation has significant impacts and can either hinder or facilitate the participation of stakeholders and local governments in policy implementation and design to enhance the sustainability and effectiveness of clean energy policies.

The researcher argues that a lack of coordination and cooperation between local and central governments can create obstacles and emphasizes the significance of technical and financial support from central governments and international organizations for successful policy implementation at the local level. While the study focuses on China, its findings may not be generalizable to other African contexts. So far, the study does not explicitly address the potential economic, environmental and social implications of green energy policy implementation, nor does it explore the role of other factors such as technology, finance, and public acceptance.

(Kim, 2021) assesses Korea's renewable energy policies, including implementation plans, effects, and obstacles. The study observed that in recent years, Korea has made significant progress in adopting renewable energy sources in the solar and wind sectors through implementing various policies and programs to promote renewable energy, which has contributed to positive impacts on energy security, economic and environment development. The expansion of renewable energy in Korea continues to confront noteworthy impediments, including exorbitant expenses, deficient power grid infrastructure, and regulatory hindrances. The limited investigation on social and public acceptance and attitude towards renewable energy policies and strategies in Korea acknowledges the environmental and economic consequences. There is, however, little comparative analysis of policies between other countries and Korea's renewable energy programs.

2.1.6 The Potential of Energy Citizenship to Promote Energy Transition.

Revisiting the notions of energy citizenship, Lennon (2020) examines participation towards a sustainable energy system from the perspective of either citizen or consumer, highlighting the relevance of diverse, active engagements from different levels while understanding the various degrees of participation.

Nonetheless, the impact of social values and norms on shaping citizen involvement and the need for effective engagement approach and communication to foster participation. Insight into

the complex nature of citizen participation in the context of sustainable energy transitions, however, calls for empirical research to evaluate the effectiveness of different forms of citizen participation. Although the potential of new technologies and digital platforms to enhance citizen participation in sustainable energy transitions is also discussed, more research is required on the social and cultural factors that influence citizen participation in different contexts and how to design effective engagement strategies that take these factors into account. (Hamann et al., 2023) adopt a citizen-centred perspective to integrate psychological, legal, and economic aspects into an interdisciplinary understanding of energy citizenship as responsibilities and individual rights for a sustainable and just energy transformation.

The study identifies energy citizenship as an EU citizenship that includes individual duties and rights in a committed, sustainable and just energy evolution, with the potential of energy citizenship to shape new economic models that are more collectivist and community-based. However, empirical research on the psychological factors that motivate people to participate in the energy transition, more legal research on the implications of energy citizenship for EU citizenship and legal frameworks, and more economic research on the potential of energy citizenship to shape new economic models.

(Wahlund & Palm, 2022) conducted a comprehensive review of the role of energy citizenship and energy democracy in participatory energy transformations and their potential roles in creating more equitable, inclusive, and sustainable energy systems. The study emphasizes the importance of empowering communities and individuals to participate in decision-making processes. It identifies various initiatives and policies that aim to promote energy citizenship and energy democracy at national, regional and local levels.

However, empirical studies are required on the impacts and concepts of energy citizenship and energy democracy to better understand their implementation in different contexts. While considering potential implications for privacy, security, and social inclusion, little is known

about the role of emerging technologies in supporting and enhancing energy democracy and energy citizenship.

(Ryghaug et al., 2018) investigate the role of energy technologies in creating energy citizenship and material participation, highlighting how the introduction of new energy technologies, such as smart meters, electric cars and photovoltaic panels, can foster energy citizenship and material participation. The study emphasizes the importance of policies for low-carbon energy transitions in creating energy citizenship. However, there are limits to introducing a materially based energy citizenship due to limited resources and expertise among citizens. In addition, a lack of effective communication and collaboration between different stakeholders and the potential of emerging technologies and innovations to support and enhance material participation in energy-related decision-making.

2.2 Participation and Democracy.

(Burke & Stephens, 2017) discuss the energy democracy movement and its goals of advancing renewable energy transitions while resisting fossil fuel dominance and restructuring energy regimes. They contend that this movement connects equity and social justice with energy innovation, integrating technological development with possible socio-economic and political transformation by analyzing 22 policy instruments put out by advocates of energy democracy in the US and contrasting them with 26 goals of energy democracy. They, however discover that the combination of policy instruments offers the ability to speed up the transition to renewable energy, but that the relationship between current policies and the anticipated outcomes is not uniform. To advance the energy democracy agenda, new policies must be created, current ones must be strengthened, and attempts to oppose dominant energy systems while encouraging their democratic and open-minded replacement must be combined. However, the need for empirical studies on the topic of energy democracy and participation, as well as the differences in framing and emphasis within the energy democracy movement that

may lead to divergent policy proposals as the underrepresentation of community-based approaches in the engineering literature on agent-based energy management, despite being an active topic of investigation in neighbouring fields of energy research.

(Welton, 2018) discusses grasping energy democracy by exploring three conceptions in the context of energy law reform, including local control, consumer choice, and access to the process. Each of these visions suggests different regulatory reforms, but pursuing them simultaneously may not be feasible. The study raises concerns about the potential risks associated with hastily embracing consumer choice or local control, as these approaches could undermine existing participatory processes in energy law without offering suitable alternatives. However, the lack of clarity surrounding the meaning of energy democracy and its implications for legal reforms poses a significant challenge to the goal of democratizing energy law. Also, the need for empirical research to assess the implementation and outcomes of energy democracy initiatives and the importance of stakeholders carefully considering and selecting among different conceptions of energy democracy.

2.2.1 Conceptualization and Evolution of Energy Democracy.

(Szulecki, 2018) provides a critical examination of the conceptualization of energy democracy while highlighting the absence of a clear definition, a solid grounding in political theory and normative discussions of energy and sustainability; the researcher proposes an analytical approach to the operationalization and conceptualization of energy democracy through measurable indicators to facilitates and inform comparative policy decisions.

Furthermore, existing definitions of energy democracy incorporate essential elements and lack an explicit connection and coherence to normative debates on political theory on energy and sustainability. However, more coherent definition of the concept and a stronger foundation in political theory and normative considerations are necessary emphasizing the importance of addressing the practical and ethical implications of energy democracy and calls for more

empirical research on its implementation and outcomes. In addition, limited studies across different regions and contexts highlight the need for broader understanding and insights.

(van Veelen & van der Horst, 2018) focus on four key concepts of energy democracy to explore the rationale behind stakeholder exclusion and inclusion, the material and geographical focus and its roots in social movements. By highlighting the intersections between social science energy research, political theory, and energy democracy, the researcher contends that energy democracy has primarily developed from social movements, leading to a body of literature with few connections to established academic theories and debates outlining a research agenda for the future.

However, little has been studied about the critical and complicated comprehension of the idea, its connections to other types of material democracy, and the function of inequality and power within energy democracy. Empirical studies are also required on the practical application of energy democracy, including creating new governance frameworks and the function of technology in enabling democratic energy systems.

A conceptual review of the newly growing area of energy justice, which applies justice ideas to many elements of energy production, consumption, and policy, is presented by (Jenkins, McCauley, Heffron, Stephan, & Rehner, 2016) distributional, recognitional, and procedural justice are the fundamental principles of energy justice. Energy justice provides a framework for identifying and addressing inequalities in the energy system and for directing upcoming studies on energy consumption and production. Investigating the non-activist roots of energy justice is crucial, including economic viewpoints and integrating production and consumption systems. More empirical research is required to investigate how energy justice concepts might be used practically in various circumstances. Research is also important to comprehend the connections between energy justice and other related ideas and the effects and results of energy justice initiatives and policies.

2.2.2 Citizens Role in Shaping Energy Policy.

(Mejía-Montero, Alonso-Serna, & Altamirano-Allende, 2020) present the role of social resistance in shaping energy transition policy in Mexico, focusing on the case of wind power in Oaxaca, and examine the regulatory policy in Mexico that has recognized the importance of incorporating community participation and benefit-sharing in energy transition processes through grassroots movements in the Isthmus of Tehuantepec that have been instrumental in influencing public policies and emphasizing the inclusion of local populations in energy transition initiatives. The study highlights that integration of social aspects into energy transition policies is crucial for fostering just and sustainable energy transitions that take into account the perspectives and needs of all stakeholders involved emphasizing the significance of policymakers prioritizing social considerations in energy transition policies and actively engaging with local communities to ensure their participation and equitable distribution of benefits.

However, little is known to assess the effectiveness of Mexico's regulatory policy in achieving just and sustainable energy transitions, as well as to explore the role of grassroots movements in shaping energy transition policies in other contexts. At the same time, there is a need to address the challenges and opportunities associated with incorporating social aspects in energy transition policies, particularly in developing countries. So far, it is also important to analyze the impact of energy transition policies on different social groups and their level of participation and benefit-sharing throughout the energy transition process.

(Defila, Di Giulio, & Ruesch Schweizer, 2018) investigate how individuals perceive future energy policies in their dual role as consumer-citizens. Recognizing that individuals have distinct roles as consumers and citizens, the study highlights the importance of considering both energy policy design and decision-making perspectives.

Emphasizing individual values for life quality and justice in both roles. The "Futures Wheel" approach is recognized as a valuable tool for examining the potential implications of different energy policy options and fostering public discussions on the future of energy. The literature analysis highlights the necessity of evaluating the efficacy of techniques for exposing presumptions and views on upcoming energy policy initiatives. It, however emphasises how important it is to consider stakeholder values and concerns when designing policies and making decisions to increase support for those policies. The review also highlights the function of societal consensus-building processes and their impact on how energy policy measures are perceived and assessed.

2.2.3 Models of Democratic Energy Participation and Deliberation.

(Campos & Marín-González, 2020) shed light on the idea of prosumerism as a grassroots initiative that promotes decentralized renewable energy production and consumption by demonstrating a replicable energy model with potential for global adoption and highlighting the convergence of prosumer initiatives towards a transformative social movement, encouraging energy justice, energy democracy, global warming action, while and an energy-efficient society. Consumption is seen as a group effort to create a decentralized democratic energy model. However, the paper calls for an examination of the role of prosumerism in addressing energy poverty and gender inequality, which are critical aspects of energy justice. Additionally, they emphasize the need to investigate how prosumerism can contribute to the development of decentralized democratic energy models in different regions worldwide. Furthermore, exploring the relationship between prosumerism and other social movements is identified as an important area for research, recognizing the interconnectedness and shared goals among these movements.

(Szulecki & Overland, 2020) conducted a conceptual review on energy democracy as a process, an outcome, and a goal exploring the multifaceted nature of energy democracy, and we highlight

that it can be understood as a process shaped by popular movements, an outcome of decarbonization efforts, and a goal that stakeholders aspire to achieve. The researcher argues that the literature on energy democracy exhibits weaknesses, including fragmentation between perspectives from Europe and America, ambiguity on government functions, private enterprise, and communities, and insufficient focus on the dangers posed by energy populism.

Cautions that proponents of energy democracy should not assume that increased democracy will automatically lead to accelerated decarbonization, improved energy access, or enhanced social well-being. However, the need to provide empirical evidence and grounding for energy democracy discussions. This includes conducting studies to assess the impact of energy democracy, examining the roles of different stakeholders, and engaging with practitioners to ensure that energy democracy is rooted in real-world experiences and addresses practical needs.

(Sorman, Turhan, & Rosas-Casals, 2020) conducted a thought-provoking study on the Central Dimensions Surfacing in the Debates of Democratizing Energy and Energizing Democracy, highlighting the critical role of humanities and social science research in addressing energy democracy initiatives and transitions amidst the climate crisis while the political, normative, and embodied research and praxis play a vital role in democratizing the energy sector and empowering community-led initiatives from the bottom up, stressing the significance of broadening the energy transition discourse to encompass diverse perspectives and cautioning against the possibility of post-truth energy politics. While the research lacks specific empirical findings or statistical analyses, it highlights the importance of stakeholder engagement in diversifying the energy transformation debate and invigorating community-led initiatives to democratize the energy landscape.

2.2.4 Energy Citizenship Initiatives that Promote Democratic Participation

(Berthod et al., 2023) shed light on the dynamics of energy democracy in their study titled “The Rise and Fall of Energy Democracy: 5 Cases of Collaborative Governance in Energy Systems.”

The research reveals that while energy democracy principles play a crucial role in the initial phases of collaborative energy evolution governance, they often become more constrained as the collaborative processes progress. To uphold energy democracy throughout the transition, emphasizing the importance of institutionalizing participatory consensus building and facilitation. Among the case studies examined, the Kalmar case is a successful example, demonstrating that a more intermediate and service-oriented approach to energy provision can create a viable business case for democratizing energy through collaborative governance. However, further case studies are required to explore the diverse range of challengers and bottom-up actors involved in energy democratization and identify effective strategies for democratizing energy provision through collaborative governance. Ultimately, the research indicates the significance of the institutional embedding of participatory facilitation and consensus building to uphold energy democracy principles throughout the energy transition.

(Stephens, Burke, Gibian, Jordi, & Watts, 2018) studied opportunities and challenges in clean energy transformation and how to operationalize energy democracy in Vermont, focusing on the comprehensive energy plan, which aims to achieve 90% sustainable energy across all sectors by 2050, engaging the diverse range of stakeholders who are aligned in their commitment to accomplishing this objective, and an innovative, networked effort has been established to foster an all-inclusive and creative atmosphere for communities, individuals, and organisations to profit from the sustainable energy transition highlighting the emergence of controversy within both collaborative and experimental culture, particularly concerning the siting of wind and solar projects, which has faced strong community opposition.

The study also sheds light on the challenges and opportunities associated with operationalizing energy democracy, emphasizing the crucial role of local community involvement and public ownership in ensuring the equitable distribution of political and economic power associated with renewable energy. However, with a limited focus on distributed ownership and labour organization in the energy sector, the study indicates the challenges and opportunities of

operationalizing energy democracy, but further research could explore the specific mechanisms and strategies that are most effective in achieving energy democracy goals. The paper focuses on the state of Vermont, but further research could explore how energy democracy principles are operationalized in other contexts.

2.3 Communities and Energy Citizenship.

(Cantoni, Lis, & Stasik, 2018) explore the concept of energy citizenship and its relevance in understanding the intricate connections between energy, society, and politics by serving as a valuable framework for promoting democratic and sustainable energy systems and acknowledging that individuals and communities engage with energy systems and participate in decision-making processes in diverse ways, influenced by factors such as culture, gender, and socio-economic status.

Also, different interpretations of energy citizenship exist, leading to debates and disagreements. However, to deepen our understanding, investigation is required into how cultural, gender and socio-economic factors alter individuals' and communities' involvement with energy systems and decision-making processes. Additionally, more studies are required to explore the potential of energy citizenship as a tool for advancing democratic and sustainable energy systems, including the challenges and limitations associated with its implementation. Reconciling and addressing the diverse perspectives on energy citizenship in practice should also be explored. Moreover, the role of energy citizenship in global energy transitions and the obstacles to attaining a sustainable and just energy future deserve further investigation.

(Van Wees et al., 2021) examine the new energy concept of energy citizenship and the significance of citizen participation in the effective implementation of positive energy districts in European cities, highlighting the absence of a standardized methodology for evaluating the effect of energy citizenship, which hampers the direct comparison of citizen engagement strategies across different projects and cities.

Also, emphasizing the challenges associated with measuring the contribution of citizen engagement to the success of new energy concepts, considering the transdisciplinary nature and context-dependent solutions of these projects. Lack of comparability makes it to assess citizen engagement strategies' efficiency. However, further investigation into the role of social innovation in promoting energy citizenship and the deployment of positive energy districts prioritizes the scalability and replicability of citizen engagement strategies and methods.

(Bridge et al., 2018) present a critical perspective on energy and society from a distinctive social science perception of energy issues, providing a critical examination of energy systems, emphasizing the social implication of energy systems globally, spanning the South and North establishing relations with energy and crucial political and socio-economic processes such as urbanization, globalization, social justice and international development by employing contemporary geographical concepts and approaches, the authors address key issues such as energy access, energy security, resource availability, and the transition to carbon-free systems. Also, including activities, discussion questions, case studies recommended reading and examples enhances the usability of the work in teaching contexts. Despite the importance of a comprehensive understanding that critically assesses energy issues from a social science perspective, however, research on energy matters from an African standpoint. In addition, it emphasises the significance of stakeholder engagement to ensure comprehensive coverage of all aspects related to energy issues and to address future research needs.

2.3.1 The Role of Communities in Energy Citizenship.

(Silvast & Valkenburg, 2023) provide a critical perspective on energy citizenship, emphasizing three major perspectives regarded as necessary for opening up discussions regarding who counts as a citizen, a crucial aspect that the existing literature fails to address systematically. Also, the arguments for more attention to be given to the interrelations between democratic cultures and citizenship when examining the intersection of energy and citizenship. To sum up,

the researcher suggests further exploration of the diverse forms of citizenship that emerge concerning different types of energy infrastructure.

However, the study indicates the need for a more systematic discussion on the inclusivity of citizens in energy citizenship initiatives, the examination of democratic cultures and their relationship to citizenship, and the investigation of the various manifestations of citizenship across different energy contexts. in addition, limited scope, urging a broader exploration of social science insights on energy governance and citizenship that remain unaddressed.

(Lennon, Dunphy, & Sanvicente, 2019) investigate community acceptability in the energy transformation, focusing on citizens' perspectives. The study indicated that local opposition to renewable energy technologies is higher than expected due to perceived disempowerment and exclusion from decision-making processes, advocating for participatory and inclusive governance structures that consider the experiences of local communities. Similarly, an integrated approach involving co-design and participatory action research to incorporate citizen perspectives into a business model and characterization tool to assess citizen participation and energy democracy potential However, the authors emphasise the need to restructure socio-economic frameworks to engage citizens in decision-making for a sustainable transition.

Although the study acknowledges the importance of social innovations and technical aspects, there is little participatory research in other sectors considering region-specific contexts. (Goedkoop et al., 2022) explore the role of the community in understanding engagement in community energy initiatives (CEIs). The study highlights that interpersonal and community identification contact with other community members play crucial roles in motivating individuals to engage in CEIs, in addition to their motivation for sustainable energy, while, the perception of community-wide sustainable energy motivation was not found to be uniquely associated with initiative involvement.

However, to gain further insights, the examination of community identification and interpersonal contact at both individual and community levels. However, further research is required on the importance of community-level embeddedness. Also, additional research is required to evaluate the extent of individual communication with different members within community social networks considering a more comprehensive understanding of the factors influencing involvement in CEIs can be achieved.

2.3.2 Case Studies on Community-Led Renewable Energy Projects.

(Oteman, Wiering, & Helderman, 2014) conducted a comparative case study of the Germany, Netherlands and Denmark to examine the institutional space for community initiatives in clean energy. Concluding that the institutional arrangement of the energy policy subsystem plays a crucial role in determining the opportunities for community initiative development.

Denmark, known for its civil society-friendly energy sector, has seen a decrease in opportunities for communities due to increased production facilities. With a predominantly market-oriented institutional arrangement, the Netherlands initially provided limited space for communities. Still, there is increasing recognition of the potential for community-based energy.

The state-driven Energiewende policy in Germany fosters favorable conditions for grassroots efforts that support state policies. The institutional space for regional stakeholders, including communities, is improved by decentralization, recognized as a crucial quality. The synchronization of ideologies among government actors and levels is also essential since it gives the energy system predictability and stability while making it possible for citizens to participate in renewable energy initiatives.

However, there is a demand for in-depth research on successful and unsuccessful local projects in many nations and areas and an analysis of the social and cultural elements affecting their growth. In addition, the role of technology and innovation in supporting community initiatives, the potential for collaboration and partnerships among various energy sector actors, and the

possibilities for scaling up and integrating community initiatives into national energy systems are all areas that require further investigation.

(Walker & Devine-Wright, 2008) examine the concept of "community" in renewable energy projects in the UK, emphasizing the lack of a standardized definition for what constitutes a "community" project. The study highlights the significance of meaningful and substantial local involvement in project development to unlock community renewable energy initiatives' catalytic and learning effects. Policymakers and practitioners are urged to prioritize the process of project development to ensure that community renewable energy projects are genuinely community-led and yield positive outcomes for local communities.

However, further research is needed on the social and economic impacts of community renewable energy projects on local communities and exploring strategies for scaling up and integrating these projects into mainstream energy systems. Furthermore, empirical research on the policy frameworks and support mechanisms that can facilitate and promote community-led renewable energy initiatives is identified as an area requiring attention.

(Devarajan et al., 2021) examine renewable energy resources (RERs) through a series of case studies, acknowledging that while RERs are valuable natural resources, they have limitations in terms of their energy production capacity. The study highlights the effective utilization of RERs in households and small industries with low power requirements. However, they also address the limitations of RERs, including seasonality, insufficient equipment, and storage capabilities, emphasizing the need to explore the potential and boundaries of RERs given these limitations.

However, research into enhancing the efficiency of renewable energy technologies to increase their energy production capacity emphasises the importance of assessing the economic feasibility of utilizing RERs in larger-scale industrial applications. So far, investigating the

environmental influences of clean energy technologies and identifying strategies to mitigate any adverse effects is pertinent.

(Simcock, Willis, & Capener, 2016) utilize global case studies to examine the value of community participation in clean energy projects, that emphasize the influence of social and cultural elements on grassroots energy cultures. The research indicates the need for a greater understanding of all the factors driving the success or failure of community energy programs. Further illustrations on the possibilities to quicken the transition from community-based energy cultures to clean energy sources and advance sustainable development emphasise the significance of policy and regulation frameworks that promote community energy initiatives and guarantee their long-term viability.

However, further research is needed on the social and cultural elements that influence grassroots cultures, including their sustainability over time highlighting the requirement for comparative studies across various contexts and regions. The review points out the lack of quantitative data to complement the qualitative analysis presented in the paper.

2.3.3 Factors Influencing Community Participation in Energy Transitions.

(Zoellner, Schweizer-Ries, & Wemheuer, 2008) present findings on public acceptance of clean energies based on case studies in Germany. The study identifies economic considerations, such as a positive cost-benefit calculation, as the primary predictor for reported acceptance of renewable energy systems.

Additionally, landscape evaluation and including transparency, procedural justice criteria, early and accurate information, and public participation opportunities are crucial factors influencing public acceptance. The commitment of the operating company at the local level, public participation, and the choice of location for the plant are also significant aspects of the implementation process.

Also, to achieve local acceptance, the study recommends involving residents in the decision-making and planning process while considering specific regional distinctions and needs. However, it notes that self-reported acceptance measures may not always accurately reflect actual behaviour or attitudes. The review emphasises the importance of active stakeholder engagement in the decision-making process.

In Addition, further studies to replicate the findings in other countries like Ghana. (Mori & Tasaki, 2019) explore the factors influencing collective pro-environmental behaviours towards sustainability transition, specifically in the context of clean energy, highlighting the significant impact of social norms, values, and beliefs on the adoption of such behaviours among young individuals. The research emphasises the role of education and communication strategies in promoting collective pro-environmental behaviours.

Also, active participation in activities related to renewable energy systems is identified as an effective means of fostering these behaviours, suggesting that researchers and environmental educators should emphasize on enlarging tailored education and communication strategies that consider young people's social and cultural context. However, it is important to note that the study solely focused on young people in Taiwan, raising questions about the generalizability of the findings to other populations or contexts. In contrast, stakeholder engagement in energy systems requires observational studies and experiments to validate the findings. Additionally, it acknowledges that the study had limitations in terms of the number of observed variables due to respondent burden, suggesting the potential for future research to employ more comprehensive measures to capture the complexity of the underlying constructs.

(Van Der Schoor & Scholtens, 2015) conducted a study on local community energy initiatives and their role in the transition to sustainable energy. The results imply that neighbourhood energy projects can help create a decentralized, sustainable energy system through

the emergence of a common vision, the nature of the organization and the volume of activity have an impact on the strength of the local networks.

Similarly, the impediments to the success of regional community energy initiatives, such as a lack of money and legislative challenges are identified. The gender aspect of these projects, however, is not fully covered in the present literature on energy initiatives. Also, the limited sample size further restricts the generality of the outcomes therefore, research with a bigger sample size is required to give a more thorough grasp of the concept.

2.4 Climate Change and Energy Sustainability.

(Batruch, 2017) analyzes the connection between environmental sustainability, the energy industry, and climate change highlighting the transformation in social attitudes toward climate change and the environment, which has spurred both businesses and governments to take more action.

Emphasizing that community engagement and corporate support for sustainability have played a critical role in promoting the transition to a low-carbon society, including several strategies the oil and gas industry uses to combat climate change. However, research on the efficiency of low-carbon techniques and their effect on creating a low-carbon society is lacking and the function of stakeholder advocacy and sustainability endorsement in industries other than energy.

(Leal-Arcas, 2020) carried out research on the sustainability of trade, energy, and climate to promote sustainable energy practices and address climate change through trade law.

The study promotes a radical change in how trade is perceived, emphasizing the ability of mega-regional trade agreements (RTAs) to encourage environmental protection in achieving the Sustainable Development Goals (SDGs), it is important to emphasize the need for a bottom-up governance approach. Currently, available policy instruments and the potential of trade law

to support sustainable energy and environmental protection require additional research to look at how trade law and policy tools may be used to support sustainable energy and environmental protection. There is a need to explore the role of citizens' participation in achieving the SDGs and investigate the effectiveness of bottom-up governance approaches.

(Tsosie, 2009) researched indigenous communities' ability to impact climate change and globalization and exercise their right to self-determination. She found that climate change and globalization are posing significant challenges to indigenous communities.

Highlighting the importance of indigenous peoples' perspectives on climate change and their efforts to assert their rights and control over their energy resources to protect their communities from the effects of global warming, as well as the present context of tribal energy development, particularly within the Navajo Nation, to shed light on contemporary expressions of environmental self-determination. However, the existing literature on sustainability, intercultural norms of value, and justice underlying tensions over development are limited in scope and depth. Empirical research on the politics of global worming within domestic and international governance structures is needed.

Additionally, a more in-depth study of the history and current context of tribal energy development and its implications for environmental self-determination among Indian nations in the United States is warranted.

(Kung & McCarl, 2018) examine sustainable energy development under climate change, highlighting the significance of sustainable energy development in mitigating future climate change and fostering sustainable economic growth. The study draws on eleven research papers to explore diverse topics related to renewable energy, industrial innovation, and climate change mitigation to offer valuable insights for decision-making and policy formulation. The research further exemplifies the multifaceted applications of clean energy and responses to global warming, highlighting the essential role of an interdisciplinary approach in sustainable energy

development. However, further study on renewable energy technologies' environmental and social effects and the effectiveness of stakeholder awareness and education programmes for sustainable energy practices is required. Additionally, more research on interdisciplinary collaboration and the inclusion of green energy into existing energy systems.

2.4.1 The Role of Energy Systems in Promoting Sustainable Development.

(Sarkar, 2012) studied the pathways of adaptation and mitigation to offset the adverse impacts of global warming through sustainable development, emphasizing the criticality of strategic planning and effective implementation measures to address the adverse consequences of climate change sustainably. Concluding that incorporating sustainable development principles into climate change policies is essential, especially in developing and developed countries, because low-carbon economy strategies are a crucial way to combat climate change and its negative effects. So far, an empirical study is required to assess the impact of low-carbon economy strategies on greenhouse gas emissions, economic growth, and other relevant outcomes. Also, studies explore integrating sustainable development principles into climate change policies, such as by setting targets for renewable energy and energy efficiency.

(Türkoğlu & Ozturk Kardogan, 2018) examine the significant role of energy efficiency in fostering a sustainable development of a country, highlighting that effective utilization of energy resources results in economic success and a prominent position in the competitive landscape. The research thoroughly identified the concept of energy efficiency and its significance in achieving sustainable development objectives. It also explored the identification of the most effective policies and strategies for promoting energy efficiency across various countries and sectors. However, there is limited research on identifying potential barriers to implementing energy efficiency measures and developing strategies for overcoming them. While the paper relies on existing literature to develop its arguments and conclusions, there is a lack of empirical research to support and expand upon the discussed concepts and findings.

(Salehabadi, Ahmad, Ismail, Morad, & Enhessari, 2020) provide an overview highlighting the interplay among energy, society, and the environment in the context of sustainable development, identifying energy as a crucial element in achieving sustainable development objectives, and emphasizing the alignment of established sustainable development goals with holistic actions in the energy system.

Suggesting that future research should prioritize developing and implementing sustainable energy policies and technologies while focusing on energy efficiency, conservation, and equitable access to clean and affordable energy for all. So far, there has been too little investigation into the social and economic impacts of sustainable energy policies and technologies, including the role of stakeholder education and awareness-raising in promoting sustainable energy practices and behaviours. While the paper presents the main findings and recommendations based on existing literature, it emphasises the importance of conducting empirical studies to substantiate and expand upon these concepts in practice.

2.4.2 Energy Citizenship Initiatives that Promote Sustainability and Address Climate Change.

(Mattijssen et al., 2019) explore the transformative potential of active citizenship in local governance practices, particularly in the context of green space governance, and how active citizenship can lead to a shift from contestation to collaboration, fostering citizen-driven discourses and activities in spatial planning. This concept of a co-creative shift in governance procedures may aid in more extensive societal changes while highlighting successful cases that might serve as an example to others and emphasizing the significance of social connectedness amongst governance methods. An enabling policy framework is necessary for the transformative process, even though it is slow and path-dependent, it is also challenging to establish and keep up successful relationships between citizens and decision-makers. However,

to fully comprehend the function of an enabling policy environment in promoting citizen-led reforms, more research into the difficulties and chances presented is required.

Additionally, it is crucial to continue investigating the possibilities of citizen-driven discourses and actions in spatial planning and their influence on governance practices. (Bauwens & Devine-Wright, 2018) describe an empirical study that focuses on perceptions regarding renewable energy and community energy engagement. According to the study, those who participate in community energy initiatives have more favourable attitudes toward renewable energy than those who do not proactively and openly oppose renewable energy. Non-members typically exhibit greater disorientation, revealing notable differences among collective participants, emphasizing the discrepancy between community of location and communities of interest.

However, more investigation into the fundamental linkages is required to understand better the connection between attitudes and community energy membership toward renewable energy. In addition, it is critical to look at the possibilities of community energy efforts to address scepticism or indifference toward renewable energy among non-members. Delving into the differences among cooperative members and identifying the influencing factors shaping their attitudes towards renewable energy would contribute to a more comprehensive understanding of community energy dynamics.

2.5 Technological Innovation

(K. Khan & Su, 2023) investigate the relationship between technological innovation and the transition to renewable energy. Their study focuses on countries such as the Netherlands, Germany, Sweden, the USA, and the UK, known for their fervent innovative capacities and substantial research and development investments in renewable energy. While there is no connection between renewable energy and technological innovations in countries other than

Germany, the Netherlands, and the USA that are influenced by technological innovation, factors beyond technological innovation drive the expansion of clean energy.

Notably, sustainable energy can stimulate technological innovation in the Netherlands, Germany, and the USA. Also, the potential challenges posed by a continued reliance on fossil fuels and nuclear energy may hinder the progress of renewables and impede the diffusion of renewable technologies.

However, to advance our understanding, further research is needed, particularly in areas such as offshore and onshore solar and wind energy, which are variable energy sources expected to play a pivotal role in the future energy supply. In addition, exploring the determinants of renewable energy is crucial for a comprehensive understanding of the factors driving its development. Moreover, emphasis should be placed on implementing clean energy technologies, going beyond research and development investments alone.

(Geng & Ji, 2016) provide evidence-based insights into the relationship between technological innovation and sustainable energy development, emphasising the significant role of technological innovation in driving the advancement of renewable energy while identifying a bidirectional causality between renewable energy consumption and technological innovation in the long run, indicating that they mutually reinforce each other.

Furthermore, the study highlights the influence of external driving factors such as GDP per capita, international crude oil prices and carbon dioxide emissions per capita, which have a unidirectional causality with renewable energy technological innovation. However, limited studies exist on the impact of technological innovation on renewable energy development in developing countries. In addition, research is needed to understand how technological innovation can be used to promote renewable energy development in developing countries and how policy interventions can be used to support this process.

2.5.1 Role of Technology in Enabling Energy Citizenship

(Klein, Kumar, Wolff, & Naqvi, 2023) provide valuable insights into the role of digitalization and social media in fostering energy citizenship by identifying several key takeaways to enhance the delivery of energy-related information to energy citizens and promote energy citizenship. The study highlights the importance of addressing qualitative and subjective constructs such as affections, emotions, and feelings to cultivate energy citizenship by emphasizing the translation of these takeaways into social mechanism principles for designing frontend energy-related digital platforms that facilitate improved interactions and engagement with end-users, thus enhancing energy citizenship while recognizing the need to incentivize energy citizens to utilize social media platforms as a means of accessing energy-related information. Additionally, it highlights the necessity of formulating coordinated and coherent strategies for effectively disseminating energy-related information However, further investigation is warranted to evaluate the effectiveness of different energy-related information and communication strategies in promoting energy citizenship. In addition, little is understood about the influence of emotions, affections, and feelings on shaping energy-related behaviours and actions. Extensive research on the role of social media as a tool for fostering energy citizenship, including an examination of the factors that impact its utilization and effectiveness through the design of front-end energy-related digital platforms that can actively engage energy citizens, promote energy literacy, and facilitate energy citizenship requires further exploration, Finally, the development of coordinated and coherent response strategies for disseminating energy-related information to citizens is an area that merits more research attention.

(Pitì, Verticale, Rottondi, Capone, & Lo Schiavo, 2017) shed light on the crucial role of Smart Meters in facilitating real-time energy services for households, particularly in the context of the Italian energy landscape, highlighting that smart meters serve as essential tools for effectively balancing the demand and supply of energy by enabling more intelligent billing solutions While real-time services for end-users are still in the early stages of development in Europe, the roll-

out phase of the second generation of smart meters in Italy has involved considering various architectural and technological options. Identifying specific use cases and their corresponding requirements for smart meter architectures and communication technologies. However, the limited scalability of the communication infrastructure for smart-grid and smart-home services within the low-voltage network ensures the security and privacy of data transmitted by smart meters and received by customer devices. So far, smart meter interoperability with other devices and systems within the energy ecosystem has been a critical consideration.

2.5.2 Challenges and Opportunities Presented by Emerging Technologies.

(Mutanga, Quitzow, & Steckel, 2018) present various strategies to address energy, climate, and development challenges in Africa, with a particular focus on the role of G20 countries, suggesting four key approaches through which G20 countries can contribute to low-carbon development on the continent, including aligning their agenda with African initiatives and the Sustainable Development Goals (SDGs), providing incentives for low-carbon development, and fostering a level playing field for the adoption of low-carbon technologies. highlighting the importance of African countries having access to infrastructure that meets basic needs and promotes industrialization and value creation, facilitating progress across multiple sustainable development targets. However, limited studies on the economic risks associated with climate change and the potential for low-carbon development in Africa in addition, more comprehensive studies are required to determine the most effective means by which G20 countries can effectively support and facilitate low-carbon development in Africa.

(Ambrose, 2020), presents the use of participatory research as a means to challenge energy invisibility and connect citizens with energy futures by actively involving citizens in the energy landscape and offering them first-hand experiences of energy production, which can foster their interest and active involvement in energy policy and decision-making processes, leading to more informed and effective energy policies and decisions in the future, and the importance of

employing participatory research methods to promote citizen engagement with energy issues. However, little is known about the effectiveness of these methods in enhancing citizen engagement, and more investigation is required to understand the potential of citizen involvement in energy policy and decision-making to bring about lasting changes in attitudes and behaviours. There is much uncertainty about the potential of citizen engagement in promoting energy democracy and empowering the energy public.

Attachie & Amuzuv, (2013) conducted a study focusing on renewable energy technologies (RETs) in Ghana, particularly solar photovoltaics (PV), identifying the adverse policy environment and lack of financing as the primary obstacles hindering the growth of a viable market for RET in the country. Also, to address these challenges, it recommends that the government and stakeholders collaborate with the private sector and establish an electrification fund to support the grid extension using RETs.

However, there is a limited exploration of different financing models to promote the adoption of RETs in Ghana, along with the potential for integrating RETs with other energy generation sources, such as hydropower or wind power, to create more reliable and efficient hybrid systems. So far, there has been little research to assess the impact of RETs on local communities, including job creation, economic development, and improved access to essential services like healthcare and education.

2.5.3 Technological Innovations for Decarbonization and Community Energy citizenship.

(Wilson et al., 2020) present a comprehensive examination of granular energy technologies and their potential to expedite decarbonization efforts, emphasizing the advantages that more granular energy technologies can offer in driving progress towards climate targets and identifying the importance of swift technology deployment, avoiding lock-in, and securing social legitimacy. By synthesizing evidence from various sectors, including homes, transport,

industry, electricity generation, and energy supply, while exploring various aspects, including innovation, investment, deployment, social factors, and equity criteria when assessing the relative advantages of different technologies based on their scale.

However, the study also acknowledges the insufficiency of knowledge about the specific conditions under which granular energy technologies can effectively contribute to accelerating progress towards climate targets. In addition, there is no research to delve into the areas of innovation, investment, deployment, social considerations, and equity criteria in Ghana to better evaluate and compare alternative technologies at different scales.

(Alstone, Gershenson, & Kammen, 2015) present the potential of decentralized energy systems to expand access to clean electricity, challenging the notion that energy access and climate progress are mutually exclusive and proposing a framework for achieving both objectives by establishing a foundation of super-efficiency and carbon-free generation, complemented by the integration of new information and communication technology (ICT) connectivity and applications.

The study emphasises the persistent "energy isolation barriers" experienced by individuals in grid-based electrification, stemming from geographic, economic, and political factors. presently, additional research is required to fully comprehend the economic and social implications of decentralized power systems, especially in developing nations like Ghana while very little is known about how ICT connectivity and applications might help Ghana move toward a decarbonized energy system. Also, examining the particular obstacles to energy availability that various communities, particularly those who live in distant or underserved locations, experience is necessary. There are few studies on the more extensive development objectives that can be accomplished by energy access, going beyond simple electrification.

2.6 Conclusion

When examined from an African perspective, this literature study offers insightful information on energy citizenship principles and significance. The review initially addressed carbon reduction before moving on to other topics while considering the social, economic, and environmental effects highlighting worldwide decarbonization initiatives and recognizing the importance of renewable energy in facilitating energy transformations.

The difficulties in putting renewable energy policies into practice have also been discussed. The review also explored the definition and development of energy democracy and the connection between citizenship in the energy sector and democratic engagement. Several participatory democracy and deliberative process models have been studied and analysed on how citizens might influence energy policy.

Case studies of energy citizenship programs that support democratic involvement have been examined, providing examples of what has been successful. Communities' significance in energy citizenship has been stressed, emphasising their function in accelerating energy transitions. The cultural and social elements encouraging community engagement have been highlighted in case studies on community-led renewable energy initiatives. Energy citizenship Initiatives that consider gender equality and support environmental justice have also been investigated.

The essential elements of energy systems have been covered, including climate change and environmental sustainability. Opportunities for energy citizenship aimed at addressing climate change and advancing sustainability have been considered, alongside the role of energy systems in improving sustainable development. recognizing the difficulties and possibilities by evolving technologies, it has been acknowledged that technological advancement is crucial in enabling energy citizenship.

With an interest in diverse communities' technological advancements and options for decarbonization and energy citizenship were examined and the study acknowledges the funding efforts to facilitate the energy transition are greatly aided by outside donations. However, more investigation can look at the possible risks caused by a reliance on outside money that is too great and might consider ways to improve domestic funding mechanisms. Overall, this literature review emphasizes the significance of energy citizenship in encouraging sustainable energy transitions, addressing democratic involvement, increasing community engagement, assuring environmental justice, creating sustainability, and harnessing technical innovation. The results establish a basis for further study, the creation of relevant policies in the area, and a thorough understanding of energy citizenship.

CHAPTER 3

METHODOLOGY

The research methodology is to attain an organised verification procedure of interpreting and analysing data to ensure the applicability and validity of the research objectives (Davidavičienė, 2018; Osuagwu, 2020; Pruzan, 2016). The methodological procedures employed for this study are described in this chapter. It covers an in-depth process and details used to accomplish the study objectives and the hypothesis tested. The chapter further encompasses the study area approach, research background, research design, population, sampling and sampling techniques, sample size, the pilot test, data collection procedure, measure of the construct, data analysis and ethical considerations to validate the reliability of the study. The justification for using different strategies and methods is explained.

This research will examine the factors and drivers contributing to the emergence of energy citizenship. The study will further investigate the role of local communities and institutions in promoting energy citizenship in Northern Ghana. The research will further assess the potential of energy citizenship in addressing energy issues and fostering sustainable development in Northern Ghana.

3.1 The Study Area.

Navrongo is located in the Kassena-Nankana East District, a farming community in the Upper East region of Ghana with a land size spanning about 1,675 square kilometres along the border of Ghana and Burkina Faso.

Navrongo is situated within latitude 10 degrees of the north equator and 1-degree west longitude of the zero meridians. Approximately 200–400 meters above sea level on relatively flat land about 50 km long and 55 km wide. The district is part of the Guinea Savannah belt with primary wet and dry climatic seasons and Sahelian (hot and dry) natural characteristics with a

predominance of semi-arid grassland dotted with small trees Philomena et al. (2001) however, the mean minimum and maximum monthly temperature range from 20 degrees Celsius to 40 degrees Celsius ('Climate History for Navrongo Local Ghana', 2020.). The presence of a solar PV project in Navrongo makes it a preferred location for this study. The first utility-scale PV plant was commissioned in 2013 with a generation capacity of 2.5 MWp, contributing to about 0.1% of Ghana's peak load and feeding about 3.8 GWh per year into the Ghana power Grid Company (GridCo) network. Due to its demonstrative effect and capacity to replace expensive thermal power generation, the project was approved as a Clean Development Mechanism project in 2012 as part of a multi-country Program of Activities developed by the UK-based Standard Bank, Hille & Reiche (2017).

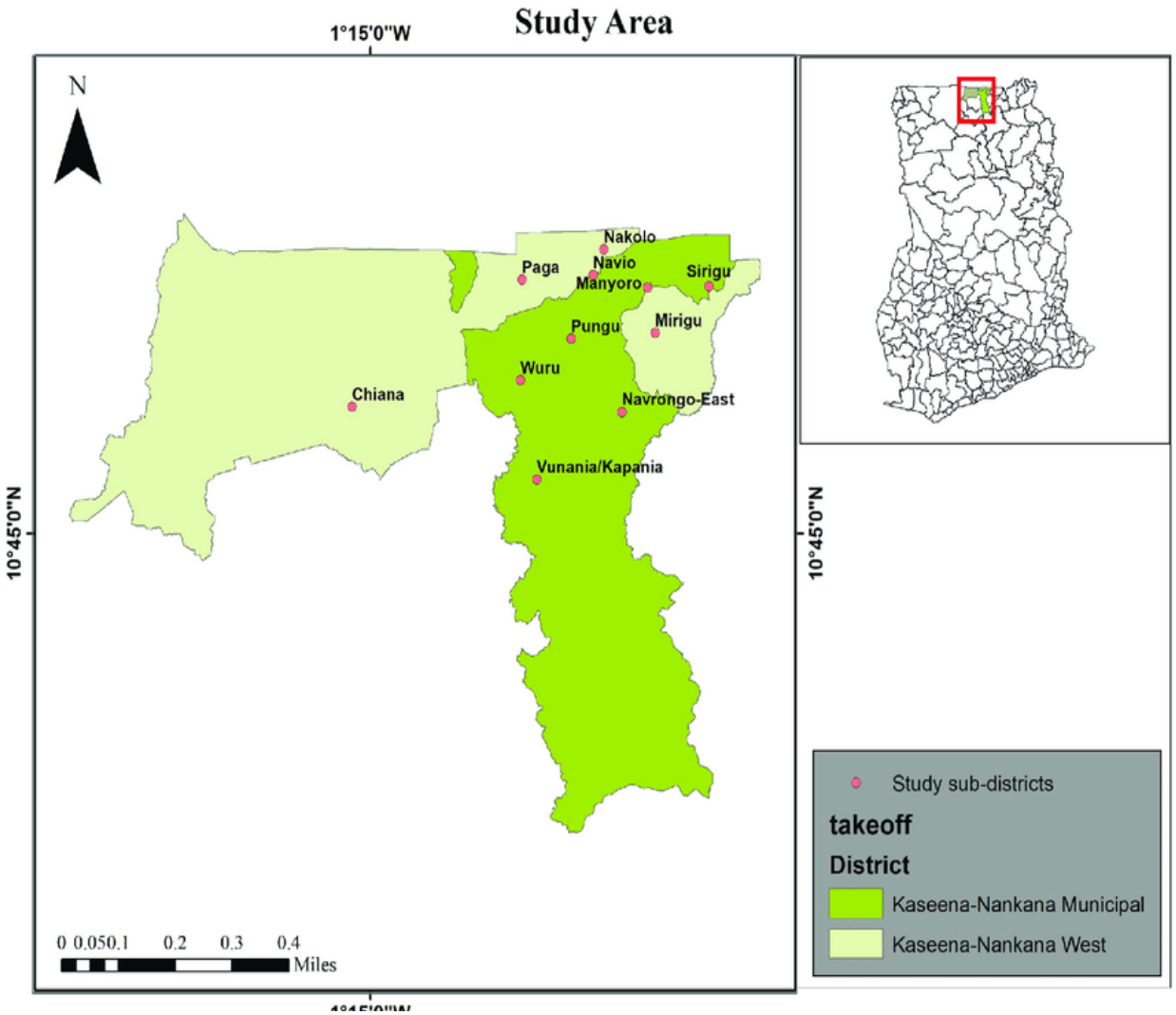


Figure 3. 1 Map of the study area. (Source; Research Gate)

3.2 Research Approach

According to Mulisa, 2022 and Young & Reid (2020) quantitative, qualitative and mixed-method approaches are three fundamental research data collection methods. The mixed-method approach was utilised in this study. A mixed method is an effective approach combining quantitative and qualitative analytical procedures to strengthen empirical analysis for conducting social science research (Mulisa, 2022; Rose & Low-Choy, 2019). Mixed methods research approach helps to explore complex contexts and experiences, which enhances our understanding by integrating both qualitative and quantitative data justified by evaluating complex projects that do not fit standard evaluation protocols (Access et al., 2023; Michael Woolcock, 2019; Wester & McKibben, 2019) A mixed methods approach entails employing both interviews and a survey-based questionnaire to assist the researcher in deciding what strategy will be suitable for the required analysis in the development process to ensure that results can be replicated in different contexts (Kuckartz & Rädiker, 2019; Schönreiter, 2019).

In order to acquire a comprehensive understanding of the factors, dynamics, and implications driving the emergence of energy citizenship in Northern Ghana, the qualitative case study design is adopted. This strategy is selected based on the understanding that energy citizenship is a complicated and diversified concept that is influenced by social, cultural, economic, and environmental components. This study seeks to explore the distinctive characteristics and contextual variations that influence behaviours and attitudes with regard to energy systems in a particular geographic location in Northern Ghana.

The data collection process utilizes direct observation, semi-structured interviews, and structured surveys. To obtain extensive qualitative insights into significant stakeholder experiences, attitudes, and motivations regarding energy citizenship a structured interviews is conducted with key informants. The awareness of actual activities and relationships is further improved through personal observation of energy engagement programs, meetings, and events.

A structured questionnaire is administered to a sample of the population to collect quantitative information in relation to factors like awareness levels, attitudes, and engagement patterns.

The data gathered using these techniques is carefully analysed. While quantitative data is analysed using statistical methods to determine correlations and trends, qualitative data on the other hand is thematically analysed to examine patterns, themes, and narratives. The integration of both quantitative and qualitative results offer a complete and in-depth awareness of establishing energy citizenship in Northern Ghana. In summary, this research approach seeks to contribute to the overall interaction between energy systems and consumers by offering contextual understanding and implications that might guide future research initiatives, practices, and policies.

3.3 Research Design.

The research design is the overall structure that provides a comprehensive overview of the techniques adopted by the researcher. According to Rodgers & Yee, (2016), an effective research approach examines contemporary global concerns, is innovative and revolutionary, and influences our lives through ethical, sustainable, and meaningful techniques. An effective research design guarantees confidence and effectiveness while minimising research-process errors.

Access et al. (2023) highlight research designs, including experimental, quasi-experimental, survey, case study, correlational, narrative analysis, ethnography, historical research, phenomenology, convergent parallel, grounded theory, exploratory sequential, explanatory sequential, embedded, transformative, and multiphase. This research both a survey and ethnographic approach, to enhance respondents' engagement Duan & Tan, (2020).

The obtained data is then employed to assess characteristics or identify patterns of association. Additionally, data from the mixed method will be used for analysis and studied to provide causes for the relationship between variables to achieve study objectives.

Because of the large population and the potential for information regarding contextualising the emergence of energy citizenship in northern Ghana, both survey questionnaires and ethnographic methods will be used in this study.

3.3.1 Research Framework

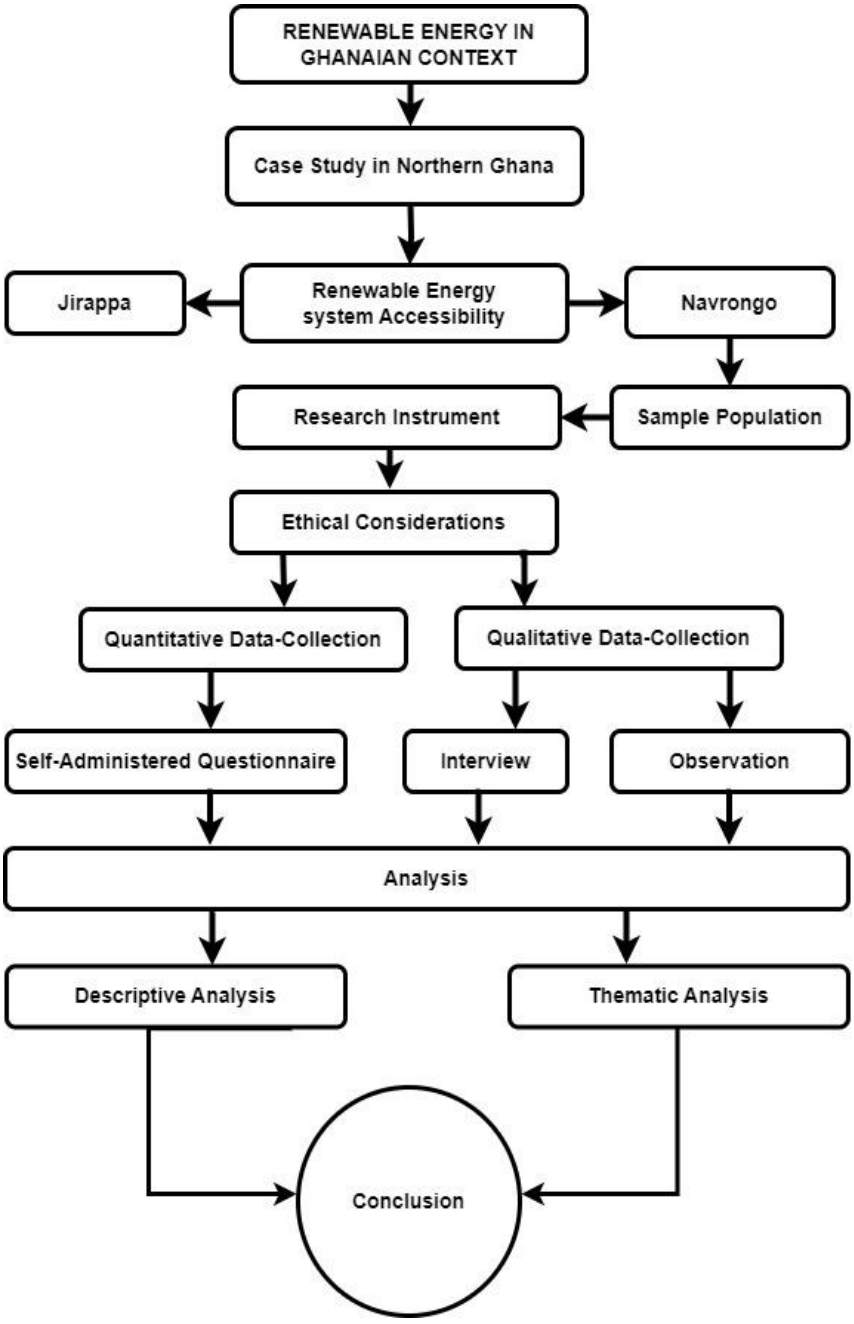


Figure 3. 2 Research Framework. (Author Construct, 2023)

3.4 Population.

A research population includes all participants involved in a study regardless of their exposure, treatment and outcome Kestenbaum (2019), This research seeks to examine the emergence of energy citizenship in the context of Northern Ghana. The population of interest comprises all residents of Navrongo, a suburban community in the Kassena Nankana District, who may have direct or indirect experiences and interactions with the solar power plant.

This research explores the motivations, experiences, and perceived impact of community involvement among these individuals within the Navrongo Community with a population of approximately twenty-eight thousand five hundred (28,500) participants from the 2021 population census conducted by the Ghana Statistical Service (GSS) with about 14-percent men majority, Table 3.1 presents details of the population under study for this research.

Table 3. 1 Details of the population by age categories used for the study.

Ages	0-14	15-29	30-44	45-59	60-74	75-89	90 +
Male	5278	3975	2767	1660	673	104	1
Female	5057	3804	2658	1664	739	134	1
Total	10339	7782	5430	3327	1417	343	3

(Source; Population categories of Navrongo 2021)

3.5 Sampling and Sampling Techniques.

Sampling is considering participants for a research study from a population to be studied Turner, (2020). Non-probability sampling and sampling from a probability distribution are the two basic types of sampling Taherdoost, (2018). Non-probability survey sampling has recently become more prevalent in research techniques and statistical analysis. This approach entails selecting samples pertaining to particular variables, such as convenience or purpose Taherdoost, (2018).

Probability sampling, on the other hand, involves a random selection of variables and establishing predictions regarding the study population, ensuring that each variable within the population has equal selection opportunity Smith & Dawber, (2019). Systematic, random, cluster, and stratified sampling are typical probability sampling techniques Ghojogh et al., (2020).

This study employs the probability sampling technique. Latpate et al., (2021) state that, for large populations, probability sampling is useful since it offers more efficient sampling processes by giving every member of the population an equal opportunity to represent the sample size.

Additionally, probability sampling is the most extensively employed since it provides a more accurate representation of the overall population and allows for the generalization of the research findings Khan, (2020). The stratified random sampling technique was specifically employed to sample the respondents. According to Arnab (2017), dividing the population into homogeneous layers and selecting samples from each group separately can significantly increase efficiency.

3.6 Sample Size

Sample size is an essential consideration after obtaining a sampling technique. A sample size indicates the number of participants chosen from the population to engage in a study Taherdoost, (2018). The features of the sample size can then be used to make conclusions regarding the population Sun, (2019). Andradee, (2020) purported that a larger sample size is preferable for responding to research questions since it improves statistical power and minimises the potential for obtaining misleading or incorrect answers. Similarly, Joshi & Rajarshi, (2018) argued that when employing a large sample, the likelihood of inaccuracy while generalising the sample findings to the entire population is negligible. Furthermore, Larger sets

of data can contribute to improving the accuracy of study results, which is going to have potential consequences for reliability and generalizability Latpate et al., (2021).

Aamir, (2014) recommended that the study population size, confidence level, predicted proportion or standard deviation of the outcome variable, and necessary precision are all significant considerations for estimating sample size. Hence, Miah, (2016) suggested a technique through which the study's sample size was established.

$$E = \sqrt{\frac{Z^2 * P * (1-P)}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

Where E= margin of error

Z= Z-score corresponding to the desired confidence level

P= estimated proportion

n= sample size

z for a 95% confidence level is approximately 1.96

n=678

$$E = \sqrt{\frac{1.96^2 \times 0.5 \times (1-0.5)}{678}} = 0.0376$$

Hence, the margin of error is 3.76%

The total population of Navrongo in 2021 from the 2020 population and housing census was approximately twenty-eight thousand five hundred. A sample size of 678 participants, including potential incomplete responses, is selected for this study using the equation 3.1, considering a confidence level of 95 percent and an error margin of 3.76 percent is identified as sufficient in achieving the statistical significance. Additionally, (Hair et al., 2010) suggested that the model complexity and basic parameters are based on the minimum sample size. Table 3.2 displays the recommended sample size according to Hair et al. (2010) In view of this, the minimum sample size of this study falls within 300 sample sizes. Data was successfully obtained from 678 respondents for this study.

Table 3. 2 Recommendations for sample size.

Model Characteristics (Number of latent constructs and items)	Minimum Sample Required
Five or less latent constructs. Each latent construct has more than three items.	100 sample
Seven or less latent constructs. Each construct has more than three items.	150 sample
Seven or less latent constructs. Some constructs have less than three items.	300 sample
More than seven latent constructs. Some constructs have less than three items	500 sample

3.7 Pilot Test

The pilot test will be conducted at the Akenten Appiah Menka University of Skills Training and Entrepreneurial Development Campus in Kumasi Tanoso with the help of the research supervisor and the electrical laboratory assistant. Fifty questionnaires will be administered to respondents employing stratified random sampling techniques to pilot the data and ensure that the questions were simplified and that the study's aim and objectives will be addressed.

The pilot test demonstrated that the instrument could be acknowledged as valid and reliable while providing room for the research tool to be improved and modified Nurul et al., (2020). A few sections of the questionnaire permitted respondents to state any unclear questions. The questionnaires were collected after three days. Fifteen of the issued questionnaires were not received. Furthermore, there were no remarks on the ambiguity of the questions that indicated a thorough comprehension of the topics.

3.8 Data Collection Procedure

Following the research design, a comprehensive overview of survey questionnaires as a primary data collection instrument will be used Dalati & Marx Gómez, (2018). Also, the review of related literature in Chapter two discovered that the indicators were utilised in most similar studies. Furthermore, the use of both interviews and questionnaires is preferred considering that it has the potential to reach a significant number of respondents within the sample size and produce empirical and accurate information relevant to this study's purposes Latpate

et al., (2021). Additionally, a questionnaire can provide a more accurate representation when used as a data-gathering tool. Furthermore, Questionnaires offer the advantage of presenting a statistical analysis of socio-demographic information in tables, graphs, and charts Madsen, (2016).

The researcher employs a self-administered questionnaire and interviews through stratification, selecting respondents and community representation. As a result, every member of the community had an equal opportunity to be chosen as a participant in the final sample. The data were simultaneously collected along with administering the questionnaires. A total of 700 responses were received, with 678 of them being useful.

The questionnaire structure centred on the research context and includes recommendations regarding scales from existing relevant research (Robb & Shellenbarger, 2020; Robert et al., 2018; Sanda et al., 2021).

The questionnaire comprises 43 items that have been categorised into four sections (A to D) and labelled as general information, factors and drivers, role of local communities and potential of energy citizenship. The measurement was scaled with the Likert-type scale, multiple choice and short response type questions. The Likert-type scale items were measured on seven-point (1 = Strongly disagree, 2 = Slightly disagree, 3 = Disagree, 4 = Neutral, 5 = Agree 6 = Slightly agree, 7 = Strongly agree). The Likert-type scale is essential for demonstrating the degree of responses in accordance with the research objectives. The seven-point scales were employed because it has a middle option (neutral response), which prevents respondents who are unsure of their satisfaction from being pressured to make a decision that does not accurately reflect their feelings. Additionally simple to comprehend, the Likert scale has been widely used in social science research. Appendix I provides a copy of the questionnaire for this study.

A copy of the study's questionnaire is provided in Appendix 1. Section A of the questionnaire sort into the demographic details of participants. Section B, therefore, contains items on perception of energy citizenship (PEC), motivation to engage (MEC), community engagement

(CEM), perceived benefits (PBE), barriers to energy citizenship (BEC) and awareness of policy (APR). While Section C focused on promoting energy citizenship (RCPE), section D focused on the potential in addressing sustainable development (PASD).

3.9 Measurement of the Construct

In this study, contextualising the emergence of energy citizenship is the independent variable, which includes participant awareness, participant knowledge, participant attitudes, energy consumption behaviour, and renewable energy use while the emergence and understanding of energy citizenship is the dependent variable.

A questionnaire containing a combination of the items on participant awareness, participant knowledge, participants' attitudes, consumption behaviour, and renewable energy use, community involvement, energy policy of the respondents, was used for the research with a total of 43 questions to measure energy citizenship orientation.

Measurement of the construct was adapted from (Lőrincz & Torriti, 2021; Van Der Werff & Steg, 2015). The energy behaviour was measured using to validate Lopes et al., (2012).

3.10 Data Analysis

According to Derry et al. (2010), analysing data entails applying logical and analytical reasoning to draw out pertinent information for decision-making. This is further advanced by Werff & Steg, (2015) analysis is the process of inspecting, cleansing, transforming, and modelling data to discover useful information and support decision-making. Zohuri & Moghaddam, (2017) purported that**,** collected data should be analysed to test theory-driven hypotheses in a quantitative study.

The researcher uses a number of data analysis approaches to examine the information gathered from administering the self-survey questionnaires, interviews, and observations.

Structural Equation Modelling (SEM) together with Analysis of Moments Structures (AMOS) software to was adopted for the analysis of the study to determine the relationship between perceptions, motivations, and awareness of policy on perceived benefits, barriers and community engagement.

Confirmatory Factor Analysis (CFA), SEM all fall under inferential statistics. The validation of the indicators was made using CFA, while the Path analysis was adopted to determine the relationship between the constructs. The SEM was used to test the hypothesis.

The Statistical Package for Social Science (SPSS) program is implemented in the study to analyse and summarise the characteristics, actions, and attitudes toward energy citizenship. Frequency distributions, percentages, and figures are also used to present an evaluation of the survey data and examine the connections between demographics and practices relating to energy.

The interview employs a qualitative approach to identify recurring themes and patterns in the transcripts, shedding light on motivations, barriers, and experiences related to energy citizenship.

Observational data uses content and thematic analysis to identify patterns, emerging themes, and insights from the observed energy citizenship behaviors and practices. Event sequencing helps analyse the sequence and flow of observed energy-related events or activities, providing a deeper understanding of patterns, interactions, and dynamics within the context of energy citizenship.

3.10.1 Structural Equation Modelling

Structural equation modelling (SEM) is identified as a statistical approach that examine multiple relations within indicators simultaneously (Collier, 2020). More importantly, the interrelationship between the observed variables and the latent constructs together with different indicators can be simultaneously integrated into the model using SEM, referred to also

as a Second-Generation Approach (Awang, 2012). Multiple regression and SEM are very similar, but SEM is far more flexible and robust (Collier, 2020). This is because SEM enables you to anticipate how indicator variables influence numerous dependent variables at once; secondly, facilitates incorporating measurement error into account as well as estimate error, alongside testing a whole model instead of just specific relationships. Unlike the regression method, which is limited to testing a single dependent variable in a moment, does not consider measurement error, and prioritises individual relationships over the sample as a whole (Collier, 2020).

Additionally, (Saga and Kunimoto, 2016) stated that using path models and SEM, a researcher may develop a conceptual model of the relationships between variables. In other words, it allows the user to investigate the connections between a variety of latent and observed variables. Moreover, structural equation modelling (SEM) represents the conceptual relationships between variables. Considering this, variables and their relationships, including errors, are represented by symbols (Collier, 2020).

In the SEM procedure, unidimensionality, validity, and reliability of the measurement model are assessed initially accessed. Subsequently, the structural model is analysed to verify the relationships that the proposed model hypothesises. (Cheung, 2005).

3.10.2 Evaluating the Model Fit

The model fit test is utilized to examine the extent to which the overall structure model's fits the data. In other words, how perfect does the sample data fits the theoretical model (Collier, 2020). According to Byrne, (2013) the goodness-of-fit indices and coefficient parameter estimations define how well the SEM model fits. Additionally, (Hair et al., 2010) indicated that the three types of fit indices measure in structural equation modelling are the absolute fit indices, incremental fit indices, and parsimonious fit indices. Therefore, (Collier, 2020) further stated that, the most used model fit indices include the chi-square to the degree of freedom

(X^2/df), Comparative Fit Index (CFI), Tucker Lewis Index (also called the Non-Normed Fit Index) (TLI), Incremental Fit Index (IFI) and Root Mean Square Error of Approximation (RMSEA). The Goodness of Fit Statistics in SEM for each category is shown in Table 3.3.

Table 3. 3 Goodness of Fit Statistics in SEM for each category.

	Name of category	Name of Index	Acceptance Level
1	Absolute fit	Chisq	P> 0.05
		RMSEA	< 0.08
		GFI	> 0.90
2	Incremental fit	CFI	> 0.90
		NFI	> 0.90
		TLI	>0.90
		NFI	>0.90
3	Parsimonious fit	Chisq/df	<3.0

Source: Hair et al. (1995, 2010)

3.10.3 Measurement Model (Confirmatory Factor Analysis)

Confirmatory Factor Analysis (CFA) is a statistical approach that examines the extent to which the indicators represent the unobserved constructs and whether the unobserved constructs differ from each other in any way (Collier, 2020). The AMOS software was employed to conduct the CFA to identify arduous construct. The scales were initially tested in to avoid violating the minimum sample size to parameter ratio (Boso, Story and Cadogan, 2013). The subjects included the factors and drives contributing to the emergence of energy citizenship. That is perception (five indicators), motivation (five indicators), community engagement (five indicators), perceived benefits of energy citizenship (five indicators), barriers to energy citizenship (five indicators) and awareness of policy and regulations (five indicators).

The CFA must be performed for all latent constructs in a model by the researcher to ensure unidimensionality. The researcher could separately run the CFA for each measurement model or as part of a pooled CFA. Unidimensionality is attained when the measurement items have adequate factor loadings for the relevant latent construct. To ensure a unidimensionality of measurement model, any indicator with an unsatisfied factor loading (< 0.5) eliminated. The

factor loading for a newly developed item should be 0.5 or higher, and the factor loading for an established item should be 0.6 or higher (Collier, 2020).

The elimination was carried out on indicators with the lowest factor loading and one item at a time and rerunning the model again any time after omitting an indicator. This iteration process was repeated until the unidimensionality requirement was achieved. Indicators that did not pass the CFA test is presented in Table 3.4.

Table 3. 4 Summary of indicators that failed the CFA test.

Variable	Item that did not pass the CFA test
Perception	PEC 5
Motivation	MEC 3
	MEC 4
Community Engagement	CEM 1
	CEM 3
Barriers to Engage	BEC 5
Awareness of Policy and Regulation	APR 2

Figure 3.3 shows the exact model fit assessed and representation of the measurement model.

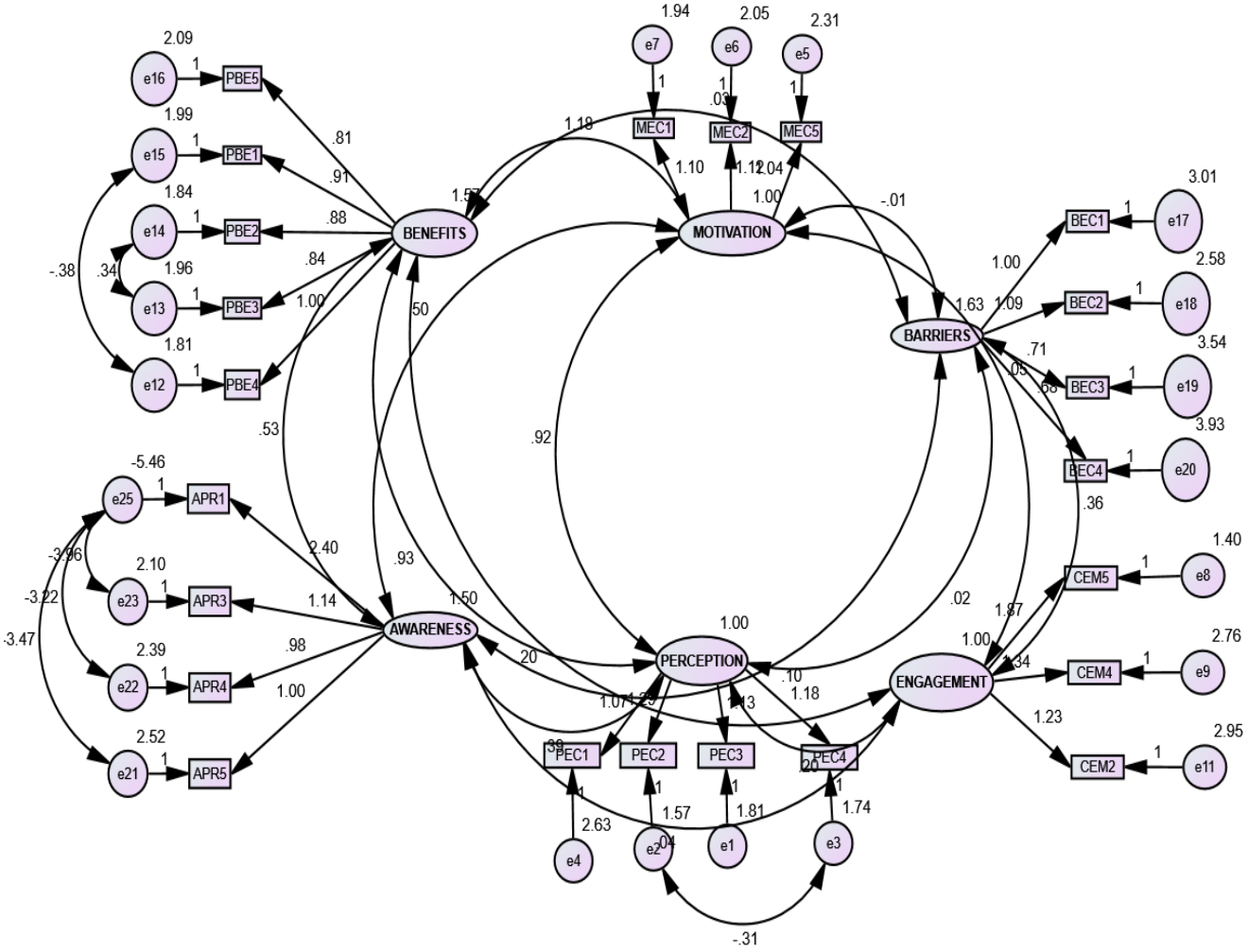


Figure 3. 3 Measurement Model.

Table 3. 5 Summary of fit indices for measurement model.

Name of index	Level of acceptance	Results
Chisq/df	< 3.0	$X^2 = 602.372, d/f = 209\ X^2\ /\ d/f\ =\ 2.882$
CFI	> 0.90	0.902
TLI	> 0.90	0.881
IFI	> 0.90	0.903
RMSEA	< 0.08	0.053

The models' chi-square to the degree of freedom (X^2/df) is 2.882 indicating a good fit. According to (Malhotra, Lopes and Veiga, 2014; Byrne, 2013) a value of X^2 /df less than 3.00 indicates a good fit. Moreover, the Comparative Fit Index (CFI), Incremental Fit Index (IFI) and the Root Mean Square Error of Approximation (RMSEA) were greater than the

recommended value of >= 0.90 (Collier, 2020) except for Tucker Lewis Index (TLI) which was approximately close to the recommended value.

3.10.4 Validity and Reliability

According to (Awang, 2012) validity is the degree to which an instrument accurately produces the characteristics of a concept. There are three types of validity namely Construct validity, Convergent validity and Discriminate validity.

Construct validity otherwise known as content validity or face validity (Collier, 2020). The extent to which the measures precisely produce a concept is referred to as content validity (Bougie and Sekaran, 2019). Validity is attained when the Fitness Indexes for a construct gains its required level (Awang, 2012). Construct validity further ensures that each indicator in a survey appear to measure the specified concept.

The relationship of the scale to other variables and measures of the same construct is referred to as Convergent validity. The validity of convergence can also be verified by calculating the

Average Variance Extracted (AVE) for each configuration. (Fornell and Larker, 1981) stated that the Average Variance Extracted (AVE) for each construct must be calculated to assess convergent validity. An AVE is calculated by adding the R^2 values of each indicator in a construct and dividing by the total number of indicators. The value of the AVE must be 0.5 or higher for the effectiveness of convergence to be achieved (Awang, 2012). This kind of validity determines whether all the indicators in a particular construct measure "the same thing".

Discriminate validity determines whether different construct measurements are unrelated.

These are a set of indicators that are supposed to measure one construct and are different from the other constructs. Discriminant validity observes if your construct is unique and different from other potential constructs of interest (Collier, 2020).

Reliability on the other hand is the ability of an instrument to consistently measure the attributes of a construct or variable (LoBiondo-Wood and Haber, 2014). According to Heale and Twycross, (2015) consistency of measurement is known as reliability. This means that the measurement model should measure the intended latent construct (Awang, 2012). Examining the reliability of a measurement model could be through internal reliability and composite reliability. Internal reliability is achieved when the Cronbach's Alpha coefficient is greater than 0.7 (Awang, 2012). The reliability of a measurement model can also be assessed through the Composite reliability. A value of composite reliability (CR > 0.7) is required in order to attain composite reliability for a construct. Composite reliability is calculated using factor loadings from a confirmatory factor analysis (Collier, 2020).

The instrument for this study was developed based on a thorough review of the literature and pilot tested. This was done to ensure the content's validity (Cao et al., 2015). In determining the reliability of the measures used to measure the relevant construct, Cronbach Alpha was used. The results of the reliability test as well as the Composite Reliability (CR) and Average Variance Extracted (AVE) are presented in Table 3.6.

Cronbach Alpha is employed to measure the reliability of the measured construct, alpha values ranging from 0 to 1 where a greater value indicates satisfactory above the minimum cut-off limit of 0.70 (Bagozzi and Yi, 2012). This demonstrates that the measures used to assess the respective constructs had high internal consistency (Field, 2009). The results from Table 3.6 further indicates a convergent validity in the model. Significant factor loadings achieve convergent validity of Positive (+) values ranged from 0.402 to 1.652.

The discriminant validity was determined using the procedure described by (Fornell and Larker, 1981). This entails comparing the Average Variance Extracted (AVE) to the shared variances (squared correlation).

Table 3. 6 Confirmatory Factor Analysis (CFA) summary for constructs.

3.11 Ethical Consideration

Various stages of renewable, social science and energy transition research raise ethical concerns (Michel, 2020; Sovacool et al., 2016). Ethical issues in research are pertinent and must not be ignored James, B., (2009). The researcher must respect the respondents' needs and rights as a result.

Code	Measures/ indicators	Loading (t-Value)
	Perception **(α = 0.721; CR = ;0.667, AVE= 0.335)**	
PEC1	Energy applies to all aspects of my daily life.	0.551(14.249)
PEC2	Do individuals have a role in shaping their energy decisions?	0.717(18.819)
PEC3	Do you feel a sense of responsibility to participate in energy-related discussions?	0.644(17.195)
PEC4	I am aware of the energy challenges and opportunities.	0.666(17.037)
	Motivation **(α = 0.625; CR = ;0.453, AVE= 0.217)**	
MEC1	I am motivated to reduce my energy consumption and willing to invest in energy-efficient technologies for my home.	0.621(16.627)
MEC2	I am concerned about the environmental impact of traditional energy sources.	0.615(16.444)
MEC5	I am confident that my participation in energy activities can reduce carbon emissions.	0.565(14.972)
	Community Engagement **(α = 0.719; CR = ;0.543, AVE= 0.289)**	
CEM2	I have opportunities to attend community meetings related to energy issues.	0.582(14.102)
CEM4	My community provides educational resources about energy conservation and values the input of citizens in energy planning.	0.628(15.151)
CEM5	My community actively encourages citizen involvement in energy decisions.	0.845(19.590)
	Perceived Benefits **(α = 0.761; CR = ;0.761, AVE= 0.390)**	
PBE1	I believe my engagement with renewable energy can lead to a more sustainable community.	0.631(12.800)
PBE2	I perceive individual engagement with energy systems as a way to improve my community's overall quality of life.	0.631(13.719)
PBE3	I see potential economic benefits for my community through energy innovation.	0.599(13.099)
PBE4	I always perceive changes in my local area that I think are connected to climate change.	0.681(***)
PBE5	I think that participating in energy initiatives can lower energy costs for residents.	0.574(12.776)
	Barriers **(α = 0.596; CR = ;0.542, AVE= 0.237)**	
BEC1	I am concerned that my actions won't make a difference in energy matters.	0.592(***)
BEC2	Lack of time prevents me from engaging in energy-related activities.	0.656(8.552)
BEC3	I don't have access to sufficient information about energy options in my community.	0.434(7.580)
BEC4	I believe that energy decisions are primarily the responsibility of government and industry.	0.402(7.188)
	Awareness **(α = 0.562; CR = ;0.925, AVE= 0.793)**	
APR1	Carbon emissions have implications for the environment and human health.	1.652(6.425)
APR3	I am aware of government policies and incentives related to renewable energy.	0.695(10.301)
APR4	I understand the regulations surrounding energy production and consumption in my area.	0.615(10.274)
APR5	I believe that government policies support the development of renewable energy.	0.611(***)

The following actions were taken to safeguard the rights of the respondents. In order for the respondents to completely and voluntarily participate in the study, their agreement had to be gained. However, participants were educated on the influence and advantages of participating

in the study, such as expanding the body of knowledge and increasing the potential to facilitate the expansion of the already existing solar project. And as well as attract potential investors and funding. The cover letter made a clear statement about the study's goal.

Furthermore, the questionnaire was made such that none of the participants would find it offensive Nortvedt & Sumpter, (2016). Therefore, the questionnaire did not reveal personal information such as names, addresses, or phone numbers.

CHAPTER FOUR (4)

RESULTS AND DISCUSSION

This chapter presents the results along with a detailed discussion of the analysis obtained regarding the objectives of this study. The chapter is categorised into four sections referred to as the Scenarios. The results are presented as tables, graphs and figures with a thorough discussion. Scenario one begins with the presentation of the Socio-Demographic and energy characteristics of respondents including the normality results, while scenario two on the other hand presents the analysis of identified indicators of the factors and drivers contributing to the emergence of energy citizenship in Ghana. Scenario three and four respectively.

4.1 Socio-Demographic and Energy Characteristics of Respondents.

The sociodemographic attributes of respondents and their energy-related behaviours are emphasised in Table 4.1 to uncover the intricate relationship between individuals and their energy consumption patterns. A comprehensive overview of the factors that shape how respondents interact with energy including a range of socio-demographic variables and energy-related features to gain valuable insights into the dynamics that influence energy choices, inform effective policies, and advance sustainable energy practices.

Table 4. 1 Summary of socio-demographic and energy characteristics of respondents.

Characteristic	Variables	Percentage (%)
Gender	Males	54.6
	Females	44.8
	I prefer not to say	0.6
Age Groups	15 - 24	37.6
	25 - 34	35.4
	35 – 44	15.8
	45 - 54	5.8
	55+	5.5
Educational Levels	Basic	28.3
	SHS	14.7
	Tertiary	47.1
	Other	0.4
	None	9.4

Main Occupation	Agriculture	19.9
	Paid Employment	21.5
	Self-employed	14.2
	Retired/Pensioned	0.4
	Unemployed	10.0
	Voluntary Work	1.3
	Full-time student	30.8
	Unavailable to Work	1.8
Household Size	14 years and below	30.46
	15 years and above	69.54
Length of Residence	Less than a year	4.4
	1 – 5 years	19.9
	6 – 10 years	8.4
	More than 10 years	67.3
Cooking Energy	LPG	26.7
	Charcoal	17.3
	Firewood	56.0
Lighting Energy	Solar energy	1.9
	Battery-powered touch	7.4
	National Grid	88.8
	No electricity at all	1.9

This study was carried out in some selected communities under the Kassena Nankana East municipal with Pungu as the main focus area. A total of 678 respondents were involved with 54.6% of the respondents identified as male and 44.8% as female including a small fraction of 0.6% choosing not to disclose their gender. The age distribution of respondents is notably skewed toward the range of 15 years to 34 years, with the majority of respondents falling within this bracket. Respondents between the ages of 15 to 24 years constitute 37.6%, while those between 25 to 34 years contribute 35.4%. The age distribution gradually decreases in older categories, revealing 15.8% of respondents between 35 years to 44 years, whereas 5.8% of respondents fall between 45 years to 54 years, and 5.5% of respondents are above 55 years. This diversity in age range among respondents allows for considering how different age groups may influence energy-related preferences and behaviours.

Further to this, the educational levels of respondents also exhibit a significant variability indicating that 47.1% have acquired a tertiary education whereas 28.3% and 14.7% of respondents have attained a basic education and Senior High School (SHS) education

respectively. Additionally, 9.4% of respondents have no formal education, and 0.4% fall into the "Other" category. These educational differences can significantly impact energy-related knowledge and decision-making. Occupations vary widely as 19.9% of respondents engage in agriculture, paid employed respondents constitute 21.5% whereas 14.2% of respondents were self-employed. Notably, a substantial proportion of 30.8% of respondents are identified as full-time students, while 10% report being unemployed. The diversity of occupations is an important consideration for understanding how different individuals engage with energy resources and consumption patterns.

Our survey also reveals variations between an average of 2 to 5 members in each household amounting to 4320 individuals. 69.54% and 30.46% of the population within a household are above 15 years and less than 14 years respectively. This study also indicates that 67.3% of respondents have lived in their current residence for more than 10 years revealing that they are indigens of the community, while 28.3% have lived between 1 to 10 years. 4.4% on the other hand, have resided for less than a year.

Also, the findings indicate that 56.0% of respondents sort to firewood as their main source of energy for cooking, while 26.7% and 17.3% utilise LPG and charcoal respectively. On the contrary 88.8% of the respondents are connected to the national grid as their most prevalent source of energy for lighting, while 1.9% and 7.4% sort solar energy and battery-powered touch lights for lighting.

4.2 Descriptive Statistics of Perception, Motivation, Community Engagement, Perceived Benefits, Barriers and Awareness of Policy Regulations.

A summary of the dynamics of the descriptive statistics of the perceptions, motivations, and concerns of individuals within a community regarding their energy-related behaviours, the

perceived benefits, barriers and the awareness of policy and regulations surrounding energy citizenship is presented in Table 4.2. the standard deviation (SD) and mean of each indicator along with their corresponding questionnaire construct are presented to provide a nuanced view of the energy citizenship landscape.

The results from Table 4.2 indicate a mean score for individual perception towards energy citizenship. The indicator “I am aware of the energy challenges and opportunities” recorded the highest mean score of 5.42. Whereas the indicator “Do you feel a sense of responsibility to participate in energy-related discussions” scored the lowest mean of 5.17. This highlights the willingness of respondents to actively engage in energy-related discussions. Additionally, to understand how energy significantly impacts various aspects of respondents’ daily lives revealed a mean score of 5.19. Exhibiting a high level of awareness regarding energy challenges and opportunities suggesting an informed proactive attitude towards energy citizenship.

Furthermore, the findings in Table 4.2 reveal the motivation to engage in energy citizenship activities. The mean score ranged from 5.54 to 5.20 with the indicator “I am motivated to reduce my energy consumption and willing to invest in energy-efficient technologies for my home” being the dominant. Similarly, with an average score of 5.47, respondents also show serious worries about how traditional energy sources affect the environment. considering a mean score of 5.20, respondents also demonstrate confidence in their participation in reducing carbon emissions through energy-related activities. The findings imply respondents have an intense desire towards sustainable energy practices demonstrating an outstanding level of environmental awareness.

Table 4. 2 Descriptive Statistics of Perception, Motivation, Community Engagement, Perceived Benefits, Barriers and Awareness of Policy Regulations.

	Indicators	Mean	SD
PEC1	Energy applies to all aspects of my daily life.	5.19	1.944
PEC2	Do individuals have a role in shaping their energy decisions?	5.17	1.797
PEC3	Do you feel a sense of responsibility to participate in energy-related discussions?	5.17	1.759
PEC4	I am aware of the energy challenges and opportunities.	5.42	1.768
MEC1	I am motivated to reduce my energy consumption and willing to invest in energy-efficient technologies for my home.	5.54	1.781
MEC2	I am concerned about the environmental impact of traditional energy sources.	5.47	1.815
MEC5	I am confident that my participation in energy activities can reduce carbon emissions.	5.20	1.843
CEM1	I have opportunities to attend community meetings related to energy issues.	3.41	2.217
CEM2	My community provides educational resources about energy conservation and values the input of citizens in energy planning.	3.68	2.111
CEM5	My community actively encourages citizen involvement in energy decisions.	4.03	2.137
PBE1	I believe my engagement with renewable energy can lead to a more sustainable community.	5.13	1.766
PBE2	I perceive individual engagement with energy systems as a way to improve my community's overall quality of life.	5.14	1.749
PBE3	I see potential economic benefits for my community through energy innovation.	5.19	1.751
PBE4	I always perceive changes in my local area that I think are connected to climate change.	5.08	1.841
PBE5	I think that participating in energy initiatives can lower energy costs for residents.	5.15	1.818
BEC1	I am concerned that my actions won't make a difference in energy matters.	3.53	2.155
BEC2	Lack of time prevents me from engaging in energy-related activities.	3.81	2.127
BEC3	I don't have access to sufficient information about energy options in my community.	4.33	2.090
BEC4	I believe that energy decisions are primarily the responsibility of government and industry.	4.12	2.167
APR1	Carbon emissions have implications for the environment and human health.	5.54	1.772
APR3	I am aware of government policies and incentives related to renewable energy.	4.16	2.018
APR4	I understand the regulations surrounding energy production and consumption in my area.	4.14	1.961
APR5	I believe that government policies support the development of renewable energy.	4.64	2.006

Note; SD= Standard Deviation

Additionally, community engagement had a mean score ranging from 3.41 to 4.03 with respondents indicating a relatively low of availability for attending community meetings on energy-related matters. Despite the significant mean of 3.68 for “My community provides educational resources about energy conservation and values the input of citizens in energy

planning” there is still space for improvement. Nonetheless, the response for “My community actively encourages citizen involvement in energy decisions” recorded a mean score of 4.03.

To ascertain the perceived benefits of energy citizenship a mean score ranging between 5.08 accessing “Any changes in the locality that are perceived to be connected to climate change” to 5.19 “I see potential economic benefits for my community through energy innovation” including the belief of whether engaging with renewable energy can lead to a more sustainable community. These favourable opinions suggest that people think energy citizenship is important for their own and their community's well-being.

Furthermore, the barriers to energy citizenship shows the lowest mean as the indicator "I am concerned that my actions won't make a difference in energy matters" to as 3.53, indicating that people may be doubtful about the results of their efforts. Time restrictions are mentioned as a potential barrier by the mean score of 3.81 for the statement, "Lack of time prevents me from engaging in energy-related activities". A need for more information access is shown by the mean score of 4.33 for the statement, "I don't have access to sufficient information about energy options in my community". "I believe that energy decisions are primarily the responsibility of government and industry" with a mean score of 4.12, which indicates that people believe they have little influence over energy-related issues. The areas that need to be addressed to remove obstacles to energy citizenship are highlighted by these results.

Regarding Awareness of Policy and Regulations, a mean score ranges between 4.14 to 5.54. indicating that respondents see possible support for the development of renewable energy sources. The question “Carbon emissions have implications for the environment and human health” obtained the highest mean whilst “I understand the regulations surrounding energy production and consumption in my area” obtained the lowest mean 4.14. Besides, with a mean score of 4.64, respondents think that policies from the government encourage the growth of renewable energy.

4.3 Descriptive Statistics of the Role of Local Communities.

The role of local communities and institutions as central players in the promotion of energy citizenship and providing a transformative concept to reshaping the approach to energy. Revealing their potential to drive positive change and empower individuals in shaping their energy future.

Table 4. 3 Descriptive Statistics of the Role of Local Communities.

	Indicators	Mean	SD
RCPE1	I have actively participated in energy-related projects and decision-making processes in my local community.	3.50	2.288
RCPE2	The behaviour of members in my community with an energy system is positive.	4.33	1.886
RCPE3	I admit that both my attitude and the behaviour of members of my community towards the renewable energy project are positive.	4.67	1.792
RCPE4	I believe educational institutions can contribute to raising awareness about energy systems among residents.	5.54	1.744
RCPE5	I feel empowered to make energy-efficient choices in my daily life because of the support and information provided by local organizations.	4.73	2.101
RCPE6	I have observed energy-related educational programs conducted in my community's schools.	3.48	2.212
RCPE7	I have witnessed collaborations between local institutions and community members in energy-related projects.	3.47	2.135
RCPE8	I believe technological limitations, resistance to change and regulatory barriers are challenges in effectively promoting energy systems.	4.63	1.868
RCPE9	I believe limited resources and lack of awareness are challenges in effectively promoting energy systems.	5.00	1.830
RCPE10	Local communities provide incentives, such as tax breaks to promote energy-efficient practices and technologies.	4.00	2.014
RCPE11	Local communities and institutions play a vital role in building a sustainable energy future by communicating the benefits.	4.94	1.956

Table 4.3 presents a mixed landscape regarding the role of local communities and institutions in promoting energy citizenship. The indicators ranged from having witnessed collaborations between local institutions and community members in energy-related projects, with a mean score of 3.47 to 5.54 highlighting a strong belief in the potential of educational institutions to raise awareness about energy systems.

4.4 Descriptive Statistics of the Potential of Energy Citizenship in Addressing Energy Issues.

The potential of energy citizenship in addressing energy citizenship issues and fostering sustainable development. The results in Table 4.4 indicate that the mean of respondents towards the potential of energy citizenship in addressing energy issues and fostering sustainable development ranged between 5.0 to 5.79. with “Inadequate infrastructure for renewable energy is my community's most pressing energy-related issue” as the least. while “I believe that education and awareness campaigns can empower individuals to make more sustainable energy choices” dominated the mean score. These results highlight a collective recognition of the transformative potential of energy citizenship in driving sustainable development and addressing pressing energy-related challenges.

Table 4. 4 Descriptive Statistics of the Potential of Energy Citizenship in Fostering Sustainable Development.

	Indicators	Mean	SD
PASD1	Lack of reliable electricity supply is a most pressing energy-related issue.	5.09	2.124
PASD2	Renewable energy systems can significantly contribute to a more sustainable and environmentally friendly future.	5.51	1.704
PASD3	Inadequate infrastructure for renewable energy is my community's most pressing energy-related issue.	5.00	1.916
PASD4	Actively contributing to renewable energy systems can foster sustainable development and greater adoption.	5.42	1.693
PASD5	Involving citizens in decision-making processes related to energy can enhance their effectiveness and acceptability.	5.51	1.700
PASD6	Engaging the public in energy conservation and efficiency efforts is essential for achieving long-term sustainability goals.	5.53	1.615
PASD7	I believe promoting renewable energy has the potential to contribute to economic and environmental concerns.	5.54	1.674
PASD8	I believe that education and awareness campaigns can empower individuals to make more sustainable energy choices.	5.76	1.688

4.5 Normality Test

According to (Bayoud, 2021; Hair, Black, Babin, & Anderson, 2010) normality is a form of data distribution or an individual metric variable and its correspondence to the normal distribution, which is the benchmark for statistical methods. One crucial assumption in SEM is that variables must be normally distributed (Tabachnick and Fidell, 2001). Both skewness and kurtosis are constituents of normality. The skewness represents the distribution's symmetry,

whereas the kurtosis is a measure of the heaviness of the tails in a distribution when compared to the normal distribution (Chandio, Abbasi, and Nizamani, 2013). (Collier, 2020) indicated that data that has its skew values between -2 and +2 and Kurtosis between -10 and +10 is considered normally distributed.

After the measurement model's fitness indices were attained, a normality assessment of the data was conducted. Table 4. 5 displays the normality test results.

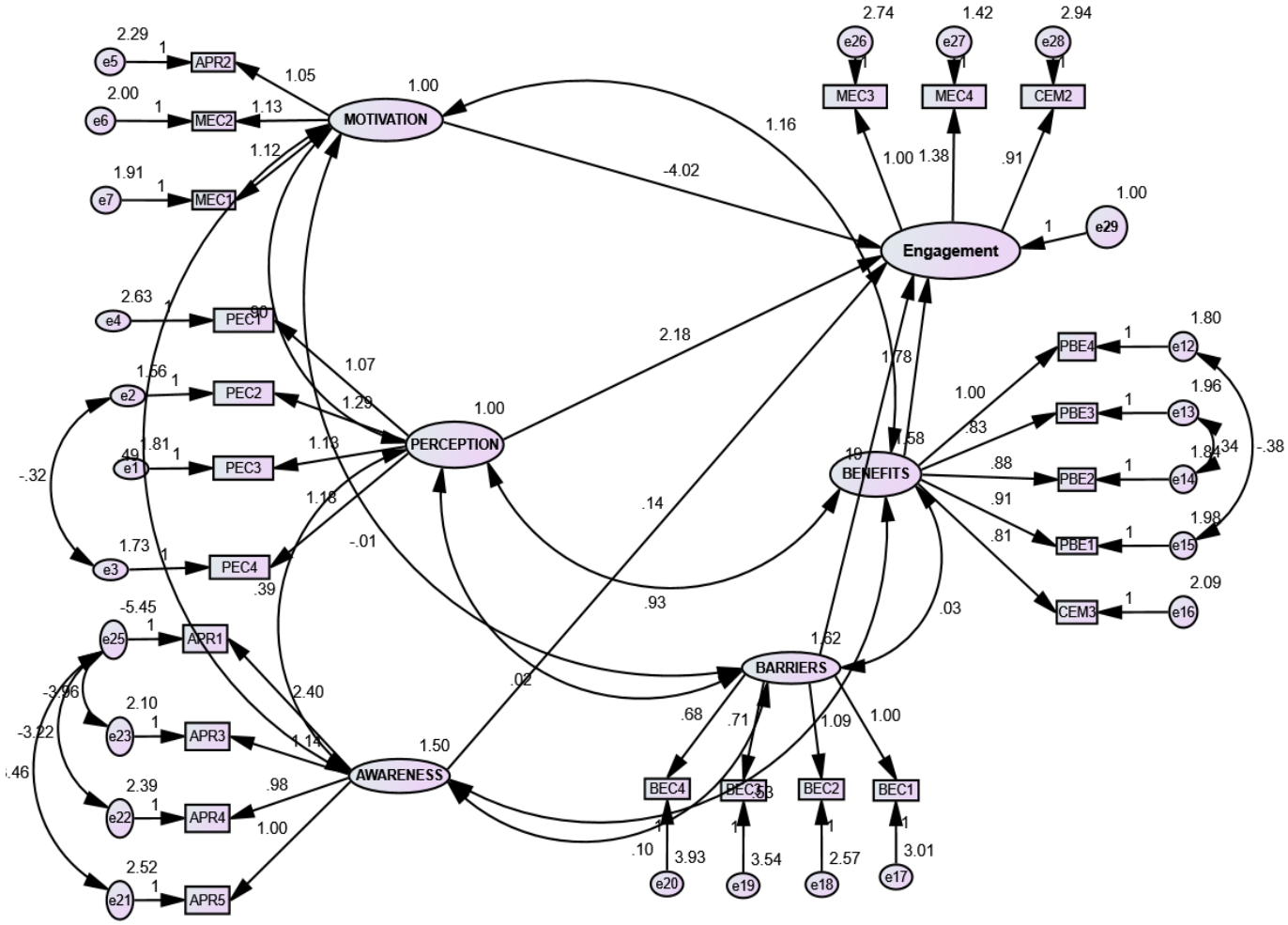
Table 4. 5 Results of the normality test

	Indicators	Skewness	Kurtosis
PEC1	Energy applies to all aspects of my daily life.	-.886	-.332
PEC2	Do individuals have a role in shaping their energy decisions?	-.893	-.039
PEC3	Do you feel a sense of responsibility to participate in energy-related discussions?	-.796	-.173
PEC4	I am aware of the energy challenges and opportunities.	-.987	.054
MEC1	I am motivated to reduce my energy consumption and willing to invest in energy-efficient technologies for my home.	-1.208	.519
MEC2	I am concerned about the environmental impact of traditional energy sources.	-1.127	.330
MEC5	I am confident that my participation in energy activities can reduce carbon emissions.	-.880	-.173
CEM1	I have opportunities to attend community meetings related to energy issues.	.313	-1.357
CEM2	My community provides educational resources about energy conservation and values the input of citizens in energy planning.	.091	-1.315
CEM5	My community actively encourages citizen involvement in energy decisions.	-.172	-1.314
PBE1	I believe my engagement with renewable energy can lead to a more sustainable community.	-.834	-.078
PBE2	I perceive individual engagement with energy systems as a way to improve my community's overall quality of life.	-.807	-.204
PBE3	I see potential economic benefits for my community through energy innovation.	-.840	-.121
PBE4	I always perceive changes in my local area that I think are connected to climate change.	-.775	-.368
PBE5	I think that participating in energy initiatives can lower energy costs for residents.	-.870	-.154
BEC1	I am concerned that my actions won't make a difference in energy matters.	.221	-.1336
BEC2	Lack of time prevents me from engaging in energy-related activities.	.042	-1.323
BEC3	I don't have access to sufficient information about energy options in my community.	-.270	-1.191
BEC4	I believe that energy decisions are primarily the responsibility of government and industry.	-.106	-1.363
APR1	Carbon emissions have implications for the environment and human health.	-1.159	.371
APR3	I am aware of government policies and incentives related to renewable energy.	-.145	-1.145
APR4	I understand the regulations surrounding energy production and consumption in my area.	-.165	-1.105
APR5	I believe that government policies support the development of renewable energy.	-.445	-.976

4.6 Structural model

The structural model was adopted to examine the relationship between perceptions, motivations, community engagement, the perceived benefits, barriers and the awareness of policy and regulations surrounding energy citizenship. The researcher can evaluate construct relationships and take measurement errors in a construct indicator into account with a full structural model (Collier, 2020). The conceptual model was tested using structural equation modelling.

The moderation was further tested using the "interaction term," is created by combining the independent variable and the moderator. The interaction term afterwards will determine whether or not the moderator's presence significantly influences the relation between the independent and dependent variables (Collier, 2020). The interaction term afterwards will determine whether or not the moderator's presence significantly influences the relation between the independent and dependent variables. To test for moderation, the study carefully adhered to recommendations for analysing each variable used in the "interaction term" method in SPSS. In addition, the moderation model is created and tested using the AMOS graphic window. The analysis was completed with a path from the moderator and interaction variables to the dependent variable. The "Estimates" link in the output presents the results for additional interpretation, as indicated in Figure 4.1.



$Model\ Fit\ Statistics: X^2 = 603.384.\ {}^{d}/_{f} = 210.\ {}^{X^2}/_{df} = 2.873\ CFI = .902. TLI = .882. RMSEA = 0.053$

Figure 4. 1 Full Structural Model

Figure 4.1 depicts the connection between perceptions, motivations, community engagement, the perceived benefits, barriers and the awareness of policy and regulations surrounding energy citizenship. Figure 4.1 indicates that the model corresponds to the data. This is an indication that the model fit indices are all within the recommended range (Collier, 2020). The direct effects (Hypothesis 1 to 5) are accessed using the standardized estimates and t values (C.R).

4.7 The Relationship between Perceptions, Motivations, and Awareness of Policy on Perceived Benefits, Barriers and Community Engagement.

This section examines the Hypothetical relationship between Perceptions, Motivations, and Awareness of Policy on Perceived Benefits, Barriers and Community Engagement. The direct relationship of the results is presented in Table 4.6.

Table 4. 6 Structural Model Test Results

Hypothesized Relationships	Estimates	T Value	P-Value	Hypothesis
H1: Benefits → Awareness	-0.091	1.412	0.158	Not Supported
H2: Benefits → Perception	-1.003	-1.525	0.127	Not Supported
H3: Benefits → Motivation	2.139	3.133	0.002	Supported
H4: Barriers → Benefits	0.031	0.599	0.549	Not Supported
H5: Engagements → Benefits	0.156	2.99	0.003	Supported
Squared Multiple Correlation (R^2)	.570			

Table 4.6 shows that the hypothesized (H1) impact of benefits on awareness of policy and regulations (β = -0.091; t- value = 1.412; P = 0.158) is not supported. Also, the study indicates that the hypothesized impact of benefits on perception toward energy citizenship (β = -1.003; t- value = -1.525; P = 0.127) was as well not significant. As such Hypothesis relationship (H2) of this study was not supported. The findings further revealed a positive and significant relationship between the benefits of energy citizenship (β = 2.139; t value = 3.133; P = 0.002) and motivation to engage in energy citizenship. Thus, Hypothesized relationship (H3) which indicates the effect of the benefits and motivation to engage in energy citizenship was accepted. The study on the other hand discovered that barriers to energy citizenship (β = 0.031; t value = 0.599; P = 0.549) do not affect the benefits. Thus, the Hypothesis relationship (H4) which indicates the effect of barriers to energy citizenship on the benefits was not supported. The study further indicates that benefits of energy citizenship was the most powerful predictor of energy citizenship. The findings in addition showed a positive and significant relationship between

community engagement of energy citizenship (β = 0.156; t value = 2.99; P = 0.003) and the perceived benefit of energy citizenship. Thus, Hypothesized relationship (H5) which indicates the effect of community engagement and perceived benefits of energy citizenship was accepted. Furthermore, the structural model explains a 57% variance in the perceived benefits of energy citizenship.

4.8 Roles of Local community and institutions in contributing to the emergence and promotion of energy citizenship.

This section presents an analysis of the role of the local communities and institutions in promoting energy citizenship. A descriptive statistic and normality test is conducted and the results are presented in Table 4.11 along with the supportive graphs and discussion.

The results from Table 4.11 indicate that the mean for the indicators ranges from 3.47 to 5.54 values. The standard deviation values also range from 1.744 to 2.288. the skewness statistics on the other hand fall within -2 and +2. The kurtosis on the other hand range between -10 to +10 which is considered Normally distributed.

Table 4. 7 Summary of Normality

	Indicators	Skewness	Kurtosis
RCPE1	I have actively participated in energy-related projects and decision-making processes in my local community.	.270	-1.443
RCPE2	The behaviour of members in my community with an energy system is positive.	-.291	-.908
RCPE3	I admit that both my attitude and the behaviour of members of my community towards the renewable energy project are positive.	-.441	-.655
RCPE4	I believe educational institutions can contribute to raising awareness about energy systems among residents.	-1.145	.397
RCPE5	I feel empowered to make energy-efficient choices in my daily life because of the support and information provided by local organizations.	-.575	-.939
RCPE6	I have observed energy-related educational programs conducted in my community's schools.	.290	-1.363
RCPE7	I have witnessed collaborations between local institutions and community members in energy-related projects.	.260	-1.318
RCPE8	I believe technological limitations, resistance to change and regulatory barriers are challenges in effectively promoting energy systems.	-.431	-.852

RCPE9	I believe limited resources and lack of awareness are challenges in effectively promoting energy systems.	-.741	-.411
RCPE10	Local communities provide incentives, such as tax breaks to promote energy-efficient practices and technologies.	-.103	-1.172
RCPE11	Local communities and institutions play a vital role in building a sustainable energy future by communicating the benefits.	-.672	-.686

4.9 Descriptive statistics of the Role of Local communities and institutions contributing to energy citizenship.

In the context of the role of local communities and institutions in promoting energy citizenship, the data obtained suggests that community members have varying degrees of participation in energy-related projects and decision-making processes. Figure 4.2 presents the results and responses to the questions in section C of the questionnaire and the corresponding summary of the frequency table is presented in Appendix I and Appendix II respectively.

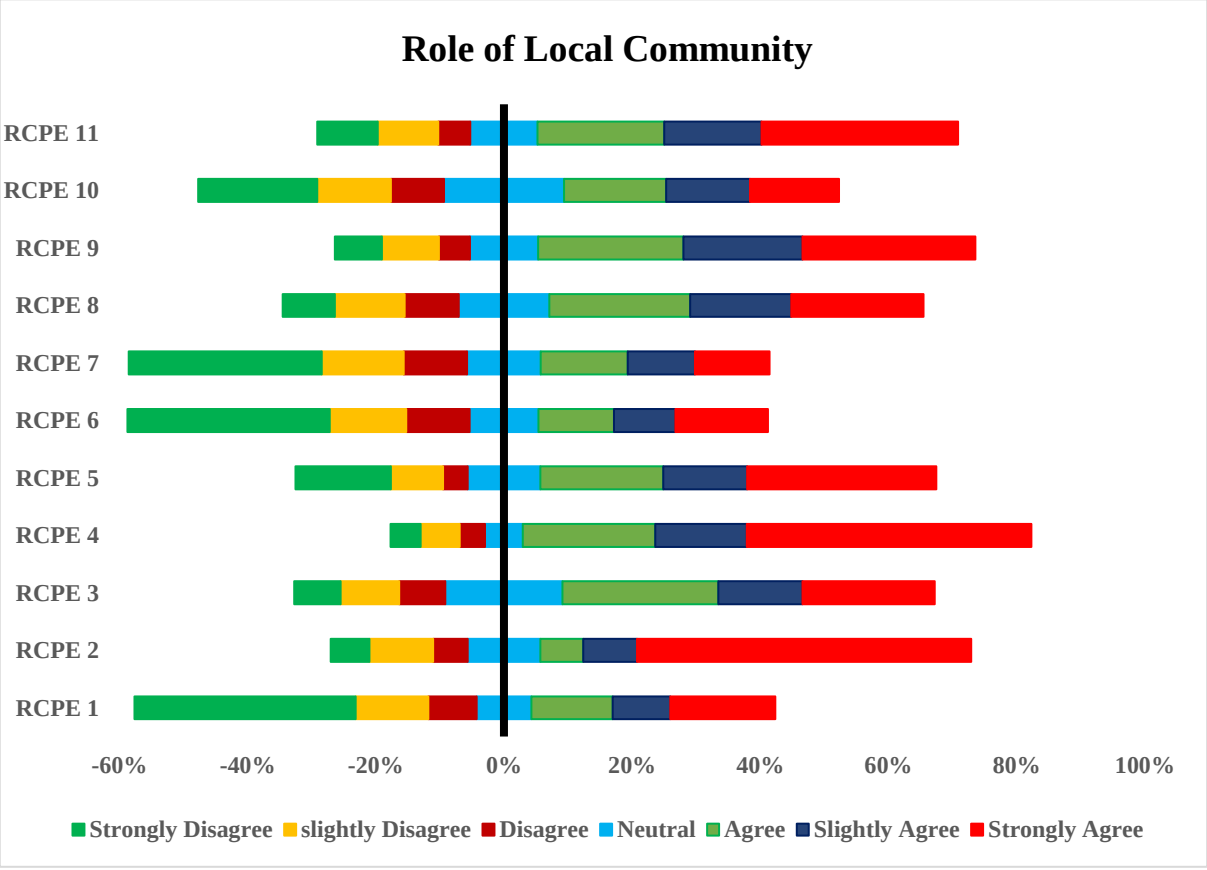


Figure 4. 2 Summary of responses to Section C

The data reveals the current circumstances of community participation in energy-related projects and decision-making processes within the context of promoting energy citizenship. A significant portion of the community indicates a lack of engagement, with about 53.4% of the respondents indicating between the "Strongly Disagree" and "Disagree" categories. Although approximately 38.1% express active participation by agreeing and strongly agreeing. 8.6% also suggests an untapped potential for engagement with the presence of the "Neutral" category. (Hanke, Guyet, & Feenstra, 2022) the fundamental role of local institutions and organizations in bridging the gap and facilitating energy citizenship, (Soares da Silva & Horlings, 2020) explores strategies to promote increased community involvement, considering the barriers and opportunities identified within these responses.

Furthermore, it is noteworthy that a substantial majority of 50.6% of respondents "Agree" and "Strongly Agree" that the members of the community exhibit positive behaviour concerning energy systems, signifying a prevailing sense of community engagement and responsibility. However, 19.4% of respondents express dissenting views indicating a need for further investigation into the factors influencing these perspectives by selecting neutral. (Koirala et al., 2018), it is imperative to explore the underlying reasons for such disparities and recommend strategies to enhance community awareness, participation, and shared responsibility in energy-related initiatives. (A. Kumar, Wolff, & Naqvi, 2023) thereby advancing the concept of energy citizenship within the local community.

Also, the community attitudes and behaviors towards renewable energy projects is essential for understanding the dynamics of local communities and institutions in fostering energy citizenship. 58% substantial majority of respondents holds a positive view of both their own attitudes and members of their community's behavior regarding renewable energy initiatives. This indicates a considerable willingness within these communities to engage with and support renewable energy efforts. 18.3% of respondents however indicates neutrality, highlighting the

importance of addressing concerns and ensuring inclusivity in energy citizenship initiatives. (Van Wees et al., 2022) suggest that local institutions have a significant role to play in leveraging this positivity and crafting tailored strategies that encompass the entire community while promoting the concept of energy citizenship and sustainable energy practices.

Additionally, the perceptions of local community members regarding the role of educational institutions in promoting energy citizenship. A substantial majority of 79.3% strongly agree and firmly believe that educational institutions can contribute significantly among residents regarding increasing awareness about energy systems. This data reinforces (Silvast & Valkenburg, 2023) emphasizing the crucial role of various institutions, particularly educational institutions in cultivating energy citizenship. However, institutions and local communities can collectively provide people with the information and abilities to make informed choices about sustainable energy practices. The result is however necessary to understand the strategies for enhancing the role of educational institutions in energy citizenship initiatives. According to (Price et al., 2021) educational institutions are significant contributors to energy citizenship in local communities.

Fostering energy citizenship within local communities and institutions, the significant role played by local organizations in empowering individuals to make energy-efficient choices in their daily lives is emphasized. A substantial number of the respondents totaling 61.8%, either strongly agree or agree that local organizations have provided essential support and information, leading to their feeling of empowerment in making energy-efficient decisions. This is supported by (Soares da Silva & Horlings, 2020) who highlight the critical importance of local initiatives and educational programs in promoting energy citizenship. Nonetheless, it's essential to address the concerns of the 26.8% of respondents who disagree and strongly disagree. Understanding the reasons behind their lack of empowerment is vital for modifying

future strategies and ensuring that energy citizenship initiatives are inclusive and effective for all community members (DellaValle & Czako, 2022).

The presence of energy-related educational programs in schools plays a pivotal role in promoting energy citizenship. 35.8% of respondents agreed that educational programs exist and provide valuable knowledge, and a substantial 64.2% expressed disagreement and unawareness about the presence of educational programs conducted in schools in the community. This divergence highlights a crucial need for more transparent and accessible energy education initiatives. Recognizing the positive impact of energy-focused education on the 35.9% who acknowledge its presence emphasizes the potential for local schools to play a significant role in promoting energy citizenship. According to (Lennon, Dunphy, & Sanvicente, 2019) awareness and perceptions, facilitate a more inclusive approach to energy education and promote informed, engaged energy citizens.

Moreover, the context of local community engagement in energy-related projects, to ascertain if respondents have witnessed any collaboration between local institutions and community members in energy-related projects to offer valuable insights. A significant proportion, 52.8%, strongly disagree with the existence of such collaborations, indicating a lack of confidence and visibility in energy initiatives, while 11.5% suggest some skepticism. However, a substantial 25.1% either agree and that they have observed collaborations which indicates that a portion of the community does perceive any positive partnerships. (Jansma, Long, & Lee, 2023) indicates the varying responses reflect diverse community perspectives and experiences. (Kalkbrenner & Roosen, 2016) confirm exploring the underlying factors influencing these perceptions and the implications for fostering community participation in energy projects.

Comparatively, perceptions of technological limitations, resistance to change, and regulatory barriers in promoting energy systems within local communities and institutions offer critical insights into the challenges of fostering energy citizenship. 58.4% of respondents agree that

technological constraints possibly relating to limited access and infrastructure are barriers to effectively promoting energy systems including cultural, behavioral factors and regulatory barriers. To effectively promote energy systems and enhance energy citizenship, addressing these challenges comprehensively is essential. Similarly, (Sovacool, 2009) elaborates on the aspects of technology, culture, and regulation that affect energy citizenship and proposes strategies to overcome these barriers.

Simultaneously, 68.3% of respondents strongly agree that lack of awareness is a significant barrier that local communities and institutions require to effectively promote energy citizenship. Moreover, the prevalent perception of insufficient awareness underlines the fundamental role of education and information dissemination in improving energy citizenship. (Wahlund & Palm, 2022) offering a thorough analysis of the impact of energy citizenship in local communities and institutions.

Considering that within the context of local communities and institutions promoting energy citizenship, a significant 38.3% of respondents disagree that local communities provide incentives to inspire energy-efficient practices and technologies whereas, 18.7% of respondents indicate unfamiliarity and unaware of the incentives crafted at the local level in fostering environmentally responsible actions among community members. Moreover, the nature of energy-efficient incentives how they are structured effectively to motivate sustainable energy choices, and their overall influence on the cultivation of energy citizenship within local communities. Analyzing the geographical areas where these policies have proven most effective (Alberini & Bigano, 2015) identifying areas for potential enhancement will be crucial in guiding future energy citizenship initiatives.

Subsequently, local communities and institutions play an essential role in advancing energy citizenship by effectively conveying the benefits of sustainable energy practices and technologies. Given this, a substantial proportion of 65.6% of the respondents strongly agree

and recognize the importance of local institutions and communities in disseminating the advantages of sustainable energy. Local communities and institutions must delve into the specific strategies and initiatives undertaken to communicate the benefits of energy citizenship and a sustainable energy future. Assessing the efficacy and impact of efforts on the attitudes and behaviors of the local community related to energy consumption and sustainability (Soeiro & Ferreira Dias, 2020). In essence, (Olawuyi, 2021) the critical role of local communities and institutions in promoting energy citizenship necessitates an inclusive exploration and contributions.

4.10 Descriptive statistics of the potential of Energy citizenship in Addressing energy issues and fostering sustainable development.

Table 4. 8 Summary of Normality test results.

	Indicator	Skewness	Kurtosis
PASD1	Lack of reliable electricity supply is a most pressing energy-related issue.	-.780	-.758
PASD2	Renewable energy systems can significantly contribute to a more sustainable and environmentally friendly future.	-1.164	.566
PASD3	Inadequate infrastructure for renewable energy is my community's most pressing energy-related issue.	-.738	-.554
PASD4	Actively contributing to renewable energy systems can foster sustainable development and greater adoption.	-1.096	.547
PASD5	Involving citizens in decision-making processes related to energy can enhance their effectiveness and acceptability.	-1.125	.446
PASD6	Engaging the public in energy conservation and efficiency efforts is essential for achieving long-term sustainability goals.	-1.090	.517
PASD7	I believe promoting renewable energy has the potential to contribute to economic and environmental concerns.	-1.149	.529
PASD8	I believe that education and awareness campaigns can empower individuals to make more sustainable energy choices.	-1.434	1.175

The exploration of energy citizenship and its potential to address energy challenges and promote sustainable development regarding the perceived lack of reliable electricity supply is significant.

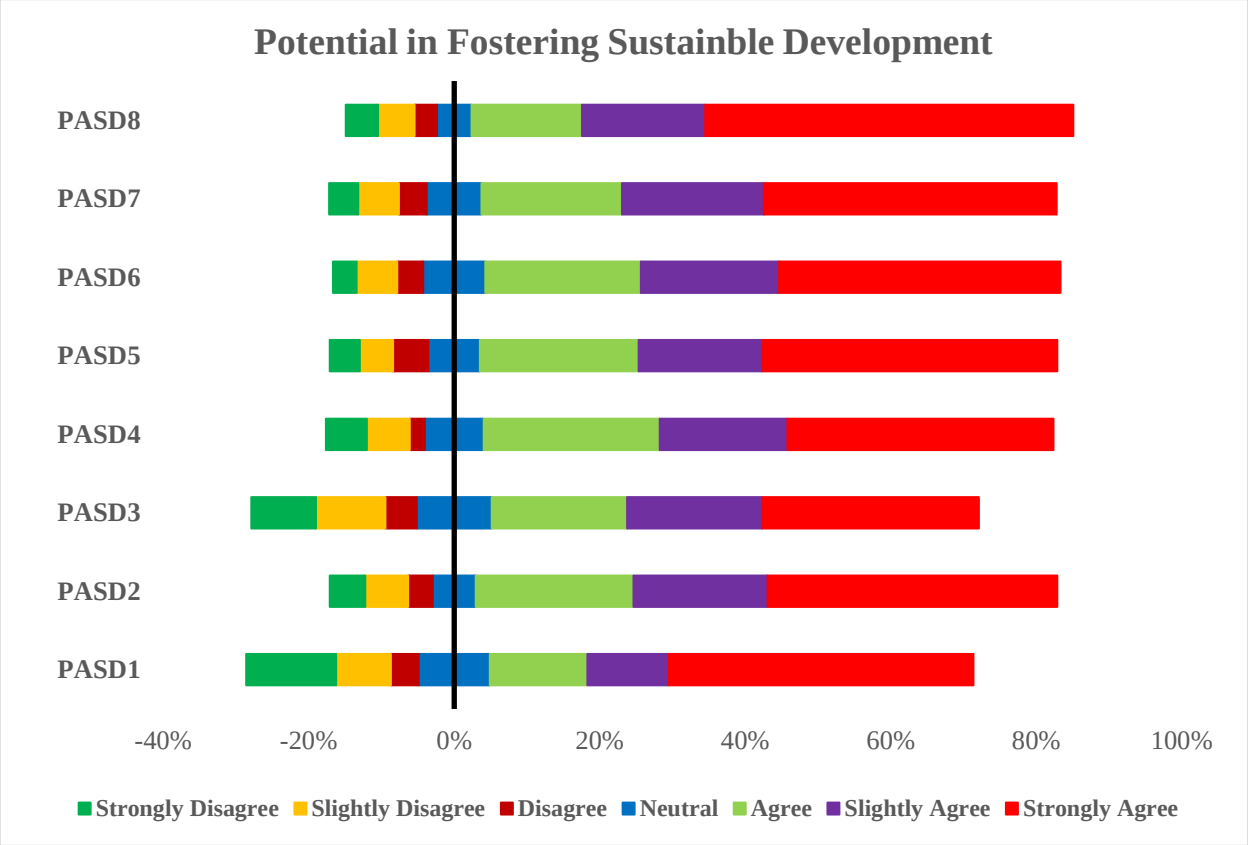


Figure 4. 3 Summary of responses to section D

This result reveals that a substantial majority of respondents approximately 66.5% strongly agree, agree, and slightly agree that the absence of dependable electricity is a pressing issue. The urgency of community involvement and the crucial role of local institutions in tackling energy-related difficulties is highlighted particularly those linked to electricity supply. demonstrating that local organisations and communities are in an ideal position to utilise advocacy, collaboration, and education to have a significant influence. (Mariani, Trivellato, Martini, & Marafioti, 2022) suggest sustainable solutions to enhance electricity supply reliability is necessary for supportive policies and regulatory structures that empower energy citizenship initiatives. (Lennon et al., 2019) local communities and institutions can contribute to improved energy infrastructure and raise awareness about the essential role of dependable electricity supply in driving socioeconomic progress, supporting the importance of energy citizenship in the sustainable development discourse.

Furthermore, the potential of energy citizenship as a driving force in addressing pressing energy issues and advancing sustainable development. The overwhelming majority of respondents, representing 79.9%, feel empowered to make decisions about their daily lives that are energy-efficient. (Oluoch, Lal, Susaeta, & Vedwan, 2020) outlines the essentials of local communities and institutions in nurturing energy-conscious behaviours. The overwhelming consensus that has observed energy-related educational programs conducted in their community's schools signifies the importance of formal education in promoting energy literacy. By contextualizing these findings, (Wahlund & Palm, 2022) underline that energy citizenship, encouraging educational efforts and community involvement hold great potential in addressing energy challenges and driving sustainable development. (Vainio, Pulkka, Paloniemi, Varho, & Tapio, 2020) reinforces the idea that informed and engaged citizens are instrumental in building a more energy-efficient and sustainable future.

Interestingly, statistics concerning the role of energy citizenship in addressing pressing energy issues and advancing sustainable development, suggest that 67% of respondents agree that inadequate infrastructure for renewable energy is the most critical energy-related concern in the community. However, a growing awareness among community members regarding the significance of robust infrastructure to support renewable energy systems. (Jansma et al., 2023) highlights the pivotal role that informed and engaged citizens play in recognizing energy issues toward addressing them. (Kabeyi & Olanrewaju, 2022) indicates energy citizenship can catalyze action, prompting the development of necessary infrastructure to facilitate renewable energy, ultimately fostering a more sustainable and environmentally friendly future. (Van Wees et al., 2022) the potential of energy citizenship in shaping local attitudes and priorities, ultimately contributing to more sustainable and energy-efficient communities.

Consequently, actively contributing to renewable energy systems emphasizes the considerable potential of energy citizenship in addressing energy issues and fostering sustainable

development. A substantial 78.4% of respondents strongly agree that active involvement in renewable energy systems can drive sustainable development and broaden adoption. This exemplifies the capacity of community members to be proactive change agents. Notably, according to (K R S Hamann et al., 2022) energy citizenship can not only heighten awareness but also translate that awareness into tangible practical contributions for a more sustainable future. (Khatibi, Dedekorkut-Howes, Howes, & Torabi, 2021) emphasizes how individuals, through active participation, can serve as crucial drivers for positive transformation, thus strengthening the case for renewable energy and sustainable development within their communities.

Surprisingly, the overwhelming agreement among respondents 79.4% regarding the potential benefits of involving citizens in decision-making processes related to energy, resonates strongly with the central themes. By actively involving local communities in decision-making and energy initiatives stands to increased effectiveness and acceptability. This aligns with the core arguments (Schwarz, 2020) which emphasize that citizen participation not only empowers communities but also enhances the success and sustainability of energy projects. In essence, (Devine-Wright, 2012) the concept that harnessing the knowledge and interests of local populations through energy citizenship is a critical step towards fostering sustainable energy development and addressing energy-related challenges effectively.

Additionally, the central themes emphasize the significant potential of energy citizenship in addressing energy issues and fostering sustainable development. The majority of respondents, 79%, however strongly agreed that involving citizens in decision-making processes related to energy can enhance their effectiveness and acceptability. This resonates with the (Hugé, Waas, Eggermont, & Verbruggen, 2011) incorporating public perspectives in energy-related decisions can lead to better outcomes, improved acceptance of policies, and ultimately foster sustainable development. (Sovacool, Heffron, McCauley, & Goldthau, 2016) underline the idea that

including citizens in the energy dialogue not only empowers them but also enhances the overall effectiveness of energy initiatives.

Comparatively, this finding closely aligns with the vital role of energy citizenship in addressing energy issues and fostering sustainable development. On the other hand, more than 76.1% of respondents concurred that a potent strategy for promoting sustainable development is active involvement in energy-related projects and local community decision-making processes. (Karytsas & Theodoropoulou, 2022) indicates that empowering citizens to participate in energy-related initiatives can be a significant driving force for achieving sustainability goals. The critical role of local communities and institutions in engaging citizens, promoting renewable energy, and addressing pressing energy concerns, affirming the significance of energy citizenship in the pursuit of a sustainable energy future.

In support of this, the data reflects a widespread belief among respondents that education, awareness campaigns, and active involvement of citizens are key factors in promoting sustainable energy practices. Over 82.8% of participants agreed that education and awareness campaigns empower individuals to make sustainable energy choices, while nearly 65% acknowledged that engaging the public in energy conservation efforts is vital for long-term sustainability. The results emphasise the significance of local organisations and communities to raise awareness, form partnerships, and include the public in decision-making processes to address urgent energy-related issues and promote a sustainable energy future. (Van Wees et al., 2021) further emphasizes the potential of energy citizenship as a catalyst for sustainable development and accentuates the relevance of energy citizenship in the real-world context.

4.11 Interview

The interview was conducted with key informants and stakeholders in the community to gain insight from the nuanced perspectives of individuals within the community. These interviews centered around fundamental questions to provide a rich tapestry of insights into the dynamics of local energy engagement. Our participants graciously shared their experiences, thoughts, and aspirations, offering a unique lens into the intersection of community, institutions, and sustainable energy practices. Instances of successful institutional influence, the necessary changes for heightened participation, perceptions of economic and social impacts, policy recommendations, and the transformative power of active participation were together explored. This analysis not only sheds light on individual experiences but collectively contributes to a broader understanding of how energy citizenship takes shape within the community.

Responses from the Key informants;

"We try to provide education and sensitization in our way as far as the use of energy is relevant to the striving and development of the community. For example, the cost of electricity in the school is been catered for by the members in the community therefore educating every member of the community is necessary but the education hasn't gotten to every aspect of the community."

"The sensitization and education have not gotten to the local groups in the community and those that are supposed to help get the information to the people are reluctant. The respondents also stress that they don't get any information regarding the sensitization and education therefore, those responsible for educating are supposed to get the right information to the facilitate the influence."

"The right information has not been sent down to the local people in this community regarding the participation and usage of energy systems, and I have never witnessed any educational programs in this community when it is about energy."

Responses to Second question

"The people lack the right education and sensitization regarding the usage of energy therefore the attitude towards energy systems is not encouraging."

"The transition to renewable energy is a better idea but the acquisition of these renewable energy sources is expensive therefore this community will require support making solar for instance affordable and for instance helping members of this community acquire solar installation on credit this is my first encounter on energy conservation and encouraging people to participate in energy initiatives and I think more of such will help"

"The changes will occur if those volunteer groups in the community are given those education so that they come back to the community to educate the indigens since they are from amongst them. The key stakeholder in the community point of contact should be open so that anyone can contact them when the need arises."

"I have witness that the smoke from firewood have effect on our health and I wish LPG was accessible to everyone but due to the financial constraints it is not possible and we have no option than to compromise."

"The needful education should be extended to the each and every member of the community and an example is the solar farm in our community when they were giving the land, we thought it will be used to power just the community but now it is claim to be connected to the national grid which is insignificant because it does not serve us."

Responses to third Question

"Solar installation requires just an initial capital and little running cost therefore we are aware of the economic benefits since it will lessen the burden on the national grid electricity and consumers since we mostly require electricity for irrigation process".

"The information has been cut across and that a lot of people have access to electricity but a lot of people have no access to electricity. Therefore, the community is going to be developed is that energy access everywhere around students will be able to undertake ICT studies and the issues of theft will be curtailed"

"Renewable energy is very clean and affordable compared to the conventional sources therefore solar energy in particular is very economical and it will be the best alternative."

"Renewable energy is very affordable but it has not gotten to anyone therefore making it available and easy to acquire will serve the interest of the member in the community so that anyone can install solar in their homes"

Responses to Fourth Questions

"I don't know about any state policy and I know there may be policies available but for now I am unaware and I cannot think of any."

"I don't think there's no any National policy that can help the community and if there is then I am not aware but the sensitization needs to be done for everyone in the community to know about that policy."

Responses to fifth Questions

"The community members must come together and there should be sensitization to help because when we don't know about energy-related activities we can't just change to embrace what doesn't benefit us either."

CHAPTER 5

Summary, Conclusion, and Recommendations

This chapter encapsulates the findings of an in-depth exploration into contextualizing the emergence of energy citizenship in Ghana, focusing on Northern Ghana as the case study. Through a combination of both observations made from the community engagement, statistical analysis and insightful interviews. A comprehensive understanding has been developed regarding the perceptions, motivations, awareness, benefits, challenges, and aspirations related to sustainable energy practices and the engagement of community members with energy systems.

5.1 Summary

The findings revealed a positive depiction, indicating significant community awareness and a favorable attitude towards energy citizenship. A majority of respondents acknowledge exigent energy issues, expressing empowerment to make energy-efficient and sustainable choices. The role of community participation in renewable energy systems recognized. Qualitative insights from interviews enrich this understanding, emphasizing challenges such as the need for enhanced information dissemination, financial backing for renewable energy adoption, and the importance of community-led initiatives.

On the other hand, a substantial awareness within the community regarding energy challenges, particularly the lack of reliable electricity supply and inadequate infrastructure for renewable energy. Also, majority of respondents expressed a positive inclination towards active participation in renewable energy systems and decision-making processes. The interviews provided a qualitative dimension, unravelling the inconsequential perspectives on the influence of local institutions, barriers to participation, and the perceived economic and social impacts of sustainable energy technologies.

The comprehensive study on the potential of energy citizenship in addressing energy challenges and fostering sustainable development provides a meticulous understanding of the community perspectives. A blend of descriptive statistics and the informative interviews sheds light on the current state of community readiness for active participation in energy citizenship and sustainable energy practices. Core findings underscore prevalent challenges, including infrastructure deficiencies, awareness gaps, and financial barriers. Simultaneously, the study highlights the pivotal role of education, awareness campaigns, and community involvement in realizing sustainable energy goals.

5.2 Conclusion

The synthesis of both quantitative and qualitative data highlights a promising community awareness and willingness to participate in sustainable energy practices, poising a positive disposition towards energy citizenship that aligns with global sustainable development efforts. For these intentions to materialize into action, it is however imperative to address existing hurdles such as the information gaps, the need for a more inclusive educational initiatives, financial support, policy awareness, and community-led projects. The eagerness of members in the community to engage in energy-related activities, combined with identified challenges, stresses the necessity for targeted interventions.

This research concludes that while there is a foundation of awareness and willingness, realizing the full potential of energy citizenship requires a strategic and collaborative approach.

5.3 Recommendations

Implementing widespread educational initiatives is imperative. These programs should not only focus on energy literacy but also target specific community groups. Collaborating with local institutions for effective dissemination is crucial.

To overcome financial barriers, exploring and establishing mechanisms for financial support, such as subsidies or credit systems for renewable energy installations, is recommended. This will make sustainable energy solutions more accessible to all community members.

Conducting campaigns to inform the community about existing national and state policies supporting renewable energy initiatives is essential. This will empower community members to navigate available resources effectively.

Encouraging and supporting community-led initiatives in renewable energy projects and decision-making processes is key. This involves fostering collaboration between local institutions and community members for successful implementation.

A systematic structure must be established for tracking and assessing the results of current and upcoming energy projects. Regular feedback mechanisms will aid in adapting strategies for continuous improvement.

Collaborating with academic institutions, investors, and non-governmental organisations is advised. Such partnerships can provide additional expertise, resources, and support for sustainable energy projects.

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APPENDIX

APPENDIX. I

Responses	RCPE 1	RCPE 2	RCPE 3	RCPE 4	RCPE 5	RCPE 6	RCPE 7	RCPE 8	RCPE 9	RCPE 10	RCPE 11
Strongly Disagree	234	79	49	32	101	214	204	55	50	126	64
Slightly Disagree	51	70	49	27	26	67	67	57	33	56	34
Disagree	77	129	62	41	55	81	87	74	60	78	64
Neutral	58	147	124	40	77	73	78	96	72	127	71
Agree	86	87	165	140	130	80	92	149	154	108	134
Slightly Agree	61	109	89	97	89	65	71	107	126	89	103
Strongly Agree	111	678	140	301	200	98	79	140	183	94	208
Total	678	0	678	678	678	678	678	678	678	678	678

APPENDIX. II

Construct / Response	PASD 1	PASD2	PASD 3	PASD 4	PASD5	PASD 6	PASD 7	PASD 8
Strongly Disagree	84	33	60	38	28	22	27	30
Slightly Disagree	26	23	29	14	33	24	26	21
Disagree	51	40	65	40	31	38	38	34
Neutral	66	40	70	55	48	58	51	32
Agree	91	147	126	164	148	145	131	103
Slightly Agree	76	125	126	119	115	129	132	115
Strongly Agree	284	270	202	248	275	262	273	343
Total	678	678	678	678	678	678	678	678

APPENDIX. III

ENERGY CITIZENSHIP QUESTIONNAIRE

Dear Respondent,

Thank you for accepting to participate in this research on **"CONTEXTUALIZING THE EMERGENCE OF ENERGY CITIZENSHIP IN GHANA: A CASE STUDY IN NORTHERN GHANA".**

This questionnaire is designed to obtain information for research purposes only to unravel the potential of citizen engagement in shaping a more sustainable energy future. It also aims to understand the energy behaviour of citizens and decarbonization in addressing climate change. Your responses will be treated confidentially and significantly contribute to a deeper understanding of how collective actions can drive positive change in the Northern Region of Ghana. Your valuable time and perspective are highly appreciated.

PLEASE TICK THE APPROPRIATE RESPONSE TO THE QUESTIONS BELOW.

SECTION A: GENERAL INFORMATION

Question:	Responds
Your Gender:	(1) Female□ (2) Male□
Your age:	(1) 15-24□(2) 25-34□ (3) 35-44 □ (4) 45-54□ (5) 55+□
Educational Level:	(1) Basic□ (2) SHS□ (3) Tertiary□ (4) Other□ (5) None□
Your occupation:	(1) Agriculture□ (2) Paid employment□ (3) Self-employed□ (4) Retired/Pensioned□ (5) Unemployed□ (6) Voluntary work□ (7) Full-time student□ (8) Unavailable to work□ (9) Other……..
The number of people living in your Household (including yourself)	(1) 14 years and less…….……... (2) More than 15 years……
How long have you lived in your current residence?	(1) Less than 1 year□ (2) 1-5 years□ (3) 6-10years□ (4) More than 10 years □
What is your main source of energy for cooking?	(1) LPG□ (2) Charcoal□ (3) Biogas□ (4) firewood□
What is your main source of energy for lighting?	(1) solar energy□ (2) battery-powered touch□ (3) National grid□ (4) no electricity at all□

SECTION B: FACTORS AND DRIVERS CONTRIBUTING TO THE EMERGENCE OF ENERGY CITIZENSHIP.

Strongly disagree,	Slightly disagree	Disagree	Neutral	Agree	Slightly agree	Strongly agree
1	2	3	4	5	6	7

		1	2	3	4	5	6	7
1	Energy applies to all aspects of my daily life.							
2	Individuals have role in shaping their energy decisions?							
3	Do you feel a sense of responsibility to participate in energy-related discussions?							

		1	2	3	4	5	6	7
4	I am aware of the energy challenges and opportunities.							
5	I am motivated to reduce my energy consumption and willing to invest in energy-efficient technologies for my home.							
6	I am concerned about the environmental impact of traditional energy sources.							
7	My community actively encourages citizen involvement in energy decisions.							
8	I have opportunities to attend community meetings related to energy issues.							
9	I am aware of local renewable energy projects in my community.							
10	My community provides educational resources about energy conservation and values the input of citizens in energy planning.							
11	I believe my engagement with renewable energy can lead to a more sustainable community.							
12	I think that participating in energy initiatives can lower energy costs for residents.							
13	I perceive individual engagement with energy systems as a way to improve my community's overall quality of life.							
14	I see potential economic benefits for my community through energy innovation.							
15	I always perceive changes in my local area that I think are connected to climate change							
16	Carbon emissions have implications for the environment and human health							
17	I am confident that my participation in energy activities can reduce carbon emissions.							
18	I am concerned that my actions won't make a difference in energy matters.							
19	Lack of time prevents me from engaging in energy-related activities.							
20	I don't have access to sufficient information about energy options in my community.							
21	I believe that energy decisions are primarily the responsibility of government and industry.							
22	I am aware of government policies and incentives related to renewable energy.							
23	I understand the regulations surrounding energy production and consumption in my area.							
24	I believe that government policies support the development of renewable energy.							

SECTION C: THE ROLE OF LOCAL COMMUNITIES AND INSTITUTIONS IN PROMOTING ENERGY CITIZENSHIP.

		1	2	3	4	5	6	7
25	I have actively participated in energy-related projects and decision-making processes in my local community.							
26	The behaviour of members in my community with an energy system is positive.							

		1	2	3	4	5	6	7
27	I admit that both my attitude and the behaviour of members of my community towards the renewable energy project are positive.							
28	I believe educational institutions can contribute to raising awareness about energy systems among residents.							
29	I feel empowered to make energy-efficient choices in my daily life because of the support and information provided by local organizations.							
30	I have observed energy-related educational programs conducted in my community's schools.							
31	I have witnessed collaborations between local institutions and community members in energy-related projects.							
32	I believe technological limitations, resistance to change and regulatory barriers are challenges in effectively promoting energy systems.							
33	I believe limited resources and lack of awareness are challenges in effectively promoting energy systems.							
34	Local communities provide incentives, such as tax breaks to promote energy-efficient practices and technologies.							
35	Local communities and institutions play a vital role in building a sustainable energy future by communicating the benefits.							

SECTION D: THE POTENTIAL OF ENERGY CITIZENSHIP IN ADDRESSING ENERGY ISSUES AND FOSTERING SUSTAINABLE DEVELOPMENT.

		1	2	3	4	5	6	7
36	Lack of reliable electricity supply is a most pressing energy-related issue							
37	Renewable energy systems can significantly contribute to a more sustainable and environmentally friendly future.							
38	Inadequate infrastructure for renewable energy is my community's most pressing energy-related issue.							
39	Actively contributing to renewable energy systems can foster sustainable development and greater adoption.							
40	Involving citizens in decision-making processes related to energy can enhance their effectiveness and acceptability.							
41	Engaging the public in energy conservation and efficiency efforts is essential for achieving long-term sustainability goals.							
42	I believe promoting renewable energy has the potential to contribute to economic and environmental concerns.							
43	I believe that education and awareness campaigns can empower individuals to make more sustainable energy choices.							

Interview Questions

1. Can you share instances where local institutions have successfully influenced energy-related behaviours or practices within your community?
2. What changes are needed for you to be able to participate more in the energy transition?
3. What do you perceive about the economic and social effects of sustainable energy technology and policies?
4. What national/state policies can help improve the community's renewable energy access?
5. In your view, how can active participation in energy-related activities empower local communities?

APPENDIX. IV

BUDGET

ITEMS	PRICE	DETAILS
Transportation	980cedis	Within the community for the entire period.
Outreach	100cedis	Encouraging community participation.
Exercise Books	800cedis	400pieces
Seedlings	400cedis	20pieces
Total		2,280cedis