SAVONIA
University of Applied Sciences

TYPE OF REPORT – BACHELOR'S DEGREE PROGRAMME
TECHNOLOGY, COMMUNICATION AND TRANSPORT

USE OF WASTE IN ENERGY PRODUCTION

Case study from Eastern Nigeria

AUTHOR: FRANKLYN ONUORAH

SAVONIA UNIVERSITY OF APPLIED SCIENCES THESIS
Abstract

Field of Study Technology, Communication and Transport	
Degree Programme Degree Programme in Mechanical Engineering	
Author(s) Onuorah Franklyn	
Title of Thesis Use of Waste in Energy Production, Case Study from Eastern Nigeria	
Date 12 February 2024	Pages 52
Client Organisation /Partners Savonia University of Applied Sciences, Kuopio	

Abstract

This research delves into the intricate landscape of sustainable energy adoption in Awka, Nigeria, with a particular emphasis on evaluating the suitability of implementing the Finnish system of electricity production. In the heart of this burgeoning city, the pressing challenges of waste management loom large, impacting both the environment and public health. The critical need for waste management improvement forms a core facet of this study. The study was commissioned by Savonia University of Applied Sciences.

Quantitative research was conducted to analyse the question raised in course of this study, it was carried out momentarily and randomly in the span of one year. The aim was to accurately obtain a statistical analysis of the general community's views, preferences, and socioeconomic characteristics through the 137 locals who responded in participation to the research survey.

The study findings uncovered a promising perception among respondents regarding the applicability of the Finnish system to meet Awka's burgeoning energy needs. Respondents believed that this system aligns harmoniously with the city's development goals, with existing infrastructure poised to support its implementation. The research also highlighted the potential economic and environmental dividends that may be reaped from adopting the Finnish system. Respondents expressed optimism that this transition can lead to a reduction in emissions, facilitate job creation, and bring about economic prosperity for Awka.

In the quest for sustainable and progressive energy solutions, this study provided a valuable roadmap for Awka, environmental stewardship, and the realization of socio-economic aspirations. The research serves as a cornerstone for Awka's journey towards a more sustainable and prosperous future, characterized by cleaner energy, reduced environmental impact, and economic growth.

Keywords:
Waste-to-energy technology
Waste management
Electricity
Renewable energy

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background to the study

The utilization of waste in energy production has emerged as a transformative solution to the increasing energy demands and mounting environmental concerns facing numerous regions worldwide. Waste-to-energy technologies offer a promising avenue to simultaneously address two pressing challenges: the efficient management of waste and the generation of sustainable electricity. As the world grapples with the consequences of unsustainable waste disposal practices and the urgent need for cleaner energy sources,

this research embarks on a comprehensive exploration of the potential of adopting the Finnish system of electricity production in Awka, Nigeria, as a practical case study to resolve these issues.

The management of municipal solid waste has become a critical concern in many regions, especially in developing countries like Nigeria. In Eastern Nigeria, for instance, the challenges associated with waste management are multifaceted, encompassing issues related to collection, disposal, and environmental implications. In this regard, the World Bank (2021) reports that improper waste management practices in Nigeria, including open dumping and burning, have given rise to environmental degradation, air pollution, and health risks. This situation is exacerbated by the exponential population growth and urbanization in Eastern Nigeria, leading to increased waste production and associated challenges (Ogbonnaya et al., 2019).

Simultaneously, the region faces a chronic energy crisis characterized by power shortages, erratic supply, and environmental pollution due to the over-reliance on fossil fuels, especially oil and natural gas (World Bank, 2021). While Nigeria is endowed with abundant energy resources, such as oil and natural gas, these resources are finite and have raised significant environmental concerns. The extraction and utilization of these fossil fuels contribute to greenhouse gas emissions and global warming, with potentially devastating consequences for the climate (Akinwumi et al., 2019). Thus, there is a pressing need to explore alternative and sustainable energy sources that reduce the dependence on finite fossil fuels and curb environmental degradation.

In this context, the application of the Finnish system of electricity production in Awka, Nigeria, emerges as an intriguing prospect. Finland has gained international recognition for its efficient waste management practices and sustainable energy production models, particularly through technologies like waste-to-energy incineration and biomass power plants (Gebremariam et al., 2018). Finland's experience in integrating waste management and energy production has not only proven to be environmentally friendly but also economically viable (Kuisma et al., 2021).

This case study seeks to investigate the feasibility and potential benefits of implementing the Finnish system of electricity production in Awka, Nigeria. The research is driven by the central objective of addressing the interrelated issues of waste management and energy generation. By evaluating the local applicability, environmental impacts, and economic viability of this system, it aspires to provide valuable insights into a sustainable solution to the energy crisis in Eastern Nigeria while simultaneously tackling waste management challenges. Furthermore, the research recognizes that the application of international mod-

els to specific local contexts necessitates a nuanced understanding of the sociocultural, economic, and infrastructural aspects of the region (Adewale et al., 2020).

The case study in Awka, Nigeria, serves as a practical illustration of the potential of the Finnish system in a developing country context, where waste management issues and energy deficits coexist. This investigation encompasses a holistic analysis of the challenges associated with traditional waste management practices, the energy needs of the region, and the lessons that can be learned from Finland's waste-to-energy and sustainable energy production initiatives.

In conclusion, the use of waste in energy production, as exemplified by the Finnish system, is a contemporary solution with the potential to alleviate the pressing challenges of waste management and energy deficits in regions like Eastern Nigeria. As I delve into the details of this case study, I aim to shed light on the viability of adopting this model in a localized context and explore the broader implications for waste-to-energy solutions on a global scale. The study encompasses economic, environmental, and social dimensions, with the ultimate goal of contributing to the development of sustainable and efficient energy systems in regions facing similar challenges worldwide.

1.2 Statement of the problem

The utilization of waste in energy production is an increasingly researched and relevant topic, offering a promising solution to address the energy demands and environmental challenges facing many regions, including Eastern Nigeria (Adewale et al., 2020). In these areas, waste management has become a pressing issue, leading to environmental degradation and public health concerns (Ogbonnaya et al., 2019). Meanwhile, the escalating demand for electricity calls for innovative and sustainable energy generation methods, with many regions still heavily reliant on fossil fuels, contributing to greenhouse gas emissions and climate change (World Bank, 2021).

Eastern Nigeria, in particular, grapples with inadequate waste management systems and a persistent energy crisis (Ikechukwu et al., 2021). This energy crisis is characterized by power shortages, erratic supply, and rising environmental pollution due to the over-reliance on traditional fossil fuels (World Bank, 2021). Despite Nigeria's abundant energy resources, such as oil and natural gas, these finite resources not only face depletion but also contribute to environmental degradation (Akinwumi et al., 2019).

The adoption of the Finnish system of electricity production in Awka, Nigeria, presents itself as a potential solution to these challenges (Gebremariam et al., 2018). Finland has demonstrated expertise in efficient waste management and sustainable energy production, utilizing technologies like waste-to-energy incin-

eration and biomass power plants (Kuisma et al., 2021). Therefore, this case study aims to explore the feasibility and advantages of implementing the Finnish system in Awka, Nigeria, with a focus on local adaptability, environmental consequences, and economic viability. The research seeks to provide valuable insights into a sustainable resolution for Eastern Nigeria's energy crisis while addressing waste management concerns.

1.3 Research objectives

To assess the feasibility and potential benefits of implementing the Finnish system of electricity production in Awka, Nigeria.

Specific objectives:

i. To identify the key waste management challenges in Awka, Nigeria.

ii. To determine if the Finnish system of electricity production is suitable for implementation in Awka.

iii. To assess the potential environmental and economic impacts of adopting the Finnish system in Awka.

1.4 Research question

i. What are the primary waste management challenges in Awka, Nigeria?

ii. Is the Finnish system of electricity production suitable for implementation in Awka?

iii. What are the potential environmental and economic impacts of adopting the Finnish system in Awka?

1.5 Research hypothesis

The significance of the study lies in its potential to address critical challenges related to waste management and energy production in Awka, Nigeria, and potentially serve as a model for similar regions facing similar issues. By evaluating the feasibility and benefits of implementing the Finnish system of electricity production, this study aims to make several important contributions.

Firstly, the study addresses pressing waste management challenges in Awka. Understanding the specific waste management issues in the region (Hypothesis 1) is essential to identify the root causes and potential solutions. The significance here lies in improving the living conditions of the local population by mitigating environmental degradation and health hazards associated with poor waste management practices

(H1). By pinpointing these challenges, the research can pave the way for more effective and sustainable waste management strategies tailored to the local context.

Secondly, the study assesses the applicability of the Finnish system of electricity production in Awka (Hypothesis 2). If proven suitable (H2), this could revolutionize the region's energy landscape by providing a cleaner and more reliable source of electricity. This not only addresses the persistent energy crisis but also reduces the reliance on finite fossil fuels, thus contributing to a more sustainable energy mix. The significance lies in the potential for energy security, economic development, and reduced environmental impact.

Thirdly, by examining the environmental and economic impacts of adopting the Finnish system in Awka (Hypothesis 3), the study seeks to contribute to broader discussions on sustainable energy solutions. If the findings support Hypothesis 3, this could have a transformative effect on the region's environmental health and economic stability, while providing valuable insights for other areas facing similar energy and waste management challenges. The global significance of this research extends to the broader conversation on waste-to-energy solutions and their potential to reduce greenhouse gas emissions and foster economic growth.

In summary, this study's significance is multifaceted. It has the potential to improve local living conditions by addressing waste management challenges, provide a more reliable and sustainable energy source, and contribute to global efforts to combat climate change. The findings could serve as a blueprint for regions facing similar issues, ultimately making a substantial impact on environmental sustainability and quality of life for the people of Awka, Nigeria, and beyond.

1.6 Scope of the study

The scope of this study is limited to the city of Awka, Nigeria, and specifically focuses on assessing the feasibility and potential benefits of implementing the Finnish system of electricity production to address waste management challenges and energy production in the region. The study examines local waste management issues, the applicability of the Finnish system in Awka, and the associated environmental and economic impacts. It does not extend to the implementation of the Finnish system itself, and its findings are specific to the Awka context.

1.7 Limitations of the study

Every research endeavor carries inherent limitations that need to be acknowledged to provide a transparent and credible assessment of its findings. In the context of this study, which assesses the feasibility of

implementing the Finnish system of electricity production in Awka, Nigeria, there are several important limitations that should be considered:

Generalizability: One key limitation is the limited generalizability of the findings. The study is primarily focused on the specific conditions in Awka, and the feasibility and impact of the Finnish system may differ in other Nigerian cities or regions. Therefore, the recommendations and insights derived from this study should be cautiously applied to other contexts.

Data Availability: The accuracy and comprehensiveness of the study depend on the availability and quality of data. Data related to waste management, energy production, and environmental impacts may not be readily accessible or may be subject to data limitations. These constraints could affect the depth of the analysis and the completeness of the conclusions.

Socioeconomic Factors: The study acknowledges that socioeconomic factors, such as income levels, education, and local governance, play a significant role in the adoption of sustainable energy systems. These factors could impact the feasibility and effectiveness of the Finnish system. However, the study does not delve deeply into these socioeconomic aspects due to limitations in resources and scope.

Implementation Challenges: Assessing the feasibility of the Finnish system does not guarantee its successful implementation. The study focuses on evaluating the potential, but it does not address the specific challenges and barriers that may arise during the practical implementation of the system, which would require a separate and more detailed study.

Time Constraints: The research is conducted within a specific time frame. Consequently, it may not capture the long-term effects and changes that could result from implementing the Finnish system in Awka. A comprehensive understanding of the system's impact may require ongoing monitoring and evaluation beyond the scope of this study.

External Factors: External factors, such as changes in government policies, economic conditions, and global energy trends, can significantly influence the viability and outcomes of energy projects. These factors are beyond the control and prediction capabilities of this study and may impact the applicability of its findings in the future.

In summary, while this study contributes valuable insights into the potential benefits of the Finnish system of electricity production in Awka, Nigeria, it is essential to recognize these limitations. Awareness of these constraints allows for a more nuanced interpretation of the study's results and encourages further research and consideration of the broader contextual factors that may affect the implementation of sustainable energy solutions.

1.8 Definition of terms

To ensure clarity and understanding in the context of the study, it is essential to provide definitions for key terms and concepts. Here are some definitions of terms and concepts that are of utmost relevance to this research:

Waste Management: The systematic handling, collection, transport, recycling, and disposal of waste materials, with the goal of minimizing environmental impacts and health hazards associated with waste.

Waste-to-Energy (WtE): A process that converts non-recyclable waste materials into usable energy forms, such as electricity or heat, through methods like incineration, gasification, or anaerobic digestion.

Sustainable Energy Production: The generation of energy in a manner that minimizes negative environmental, economic, and social impacts, promoting long-term environmental and economic well-being.

Finnish System of Electricity Production: Refers to the comprehensive approach adopted by Finland in generating electricity, which often includes a significant contribution from waste-to-energy facilities, biomass power plants, and renewable energy sources.

Feasibility: The practicality and likelihood of successfully implementing a project or system, considering factors like technical, economic, social, and environmental aspects.

Environmental Impact: The effects, both positive and negative, that the implementation of a system or project has on the natural surroundings, including aspects such as air and water quality, biodiversity, and climate change.

Economic Viability: The financial sustainability and profitability of a system or project, considering factors like capital costs, operational expenses, and potential revenue or cost savings.

Local Applicability: The extent to which a system or project can be effectively adapted and integrated into the specific conditions and needs of a particular geographical area, in this case, Awka, Nigeria.

Energy Crisis: A situation characterized by insufficient or unreliable access to electricity and energy sources, often resulting in power shortages and economic constraints.

Socioeconomic Factors: Refers to the social and economic conditions, such as income levels, education, and local governance, that can influence the acceptance and success of sustainable energy projects.

2 LITERATURE REVIEW

The literature review is a pivotal component of any research study, providing a comprehensive understanding of the existing body of knowledge and its relevance to the research at hand. In this section, the purpose and significance of the literature review within the context of this study is introduced, which as-

sesses the feasibility and potential benefits of implementing the Finnish system of electricity production in Awka, Nigeria. Through this review, a solid foundation for the research by elucidating how prior studies, findings, and theoretical frameworks contribute to understanding the study's research questions are established.

The primary purpose of this literature review is to explore the wealth of information available in the academic and professional realms that pertains to waste management, sustainable energy production, and the challenges faced by regions like Awka, Nigeria. The study aims to bridge the gap between the theoretical understanding of waste-to-energy technologies and the practical applicability of such models in real-world settings. As such, this literature review acts as a compass, guiding us through the landscape of existing knowledge and insights, helping us discern the paths that have been traversed and those that remain unexplored.

One of the defining aspects of this research is its location-specific focus on Awka, Nigeria. Awka, the capital city of Anambra State, faces unique waste management and energy production challenges that necessitate a context-specific examination. By examining the existing literature, I aim to uncover insights and lessons learned from other regions facing similar issues. This knowledge will serve as a valuable reference point for this study, allowing us to determine the relevance and adaptability of established models, such as the Finnish system of electricity production, to the Awka context.

The literature review also plays a critical role in delineating the theoretical framework that guides this research. By synthesizing existing theories and concepts related to waste management, sustainable energy production, and socioeconomic factors affecting the adoption of green technologies, a robust foundation can be established. This theoretical framework provides a conceptual structure with which the empirical data will be analysed and draw meaningful conclusions.

Moreover, this literature review aims to demonstrate the significance of this research within the broader academic and practical discourse. By identifying the existing gaps, challenges, and opportunities in the literature, the contributions this study is poised to make can be highlighted. These contributions encompass the potential for more effective waste management, sustainable energy production, and socioeconomic development, not only in Awka but also in other regions facing similar challenges.

As you navigate through the body of existing literature, you will uncover valuable insights into the waste management challenges in Awka, the various waste-to-energy technologies, sustainable energy production models, and the socioeconomic factors influencing energy adoption. The findings from the reviewed

literature has helped in formulating hypotheses and research questions that drive the empirical investigation. The synergy between the theoretical framework and empirical research is instrumental in providing a holistic understanding of the feasibility and benefits of implementing the Finnish system in Awka, Nigeria.

In the subsequent sections of this literature review, we delve into the specifics of waste management challenges in Awka, waste-to-energy technologies, sustainable energy models, socioeconomic factors, and the applicability of the Finnish system in this context. By synthesizing the relevant literature, I aim to illuminate the path forward in this research and lay the groundwork for an empirical exploration that seeks to address waste management and energy production issues in Awka, Nigeria, and beyond.

3 CONCEPTUAL FRAMEWORK

3.1 Waste management challenges in Awka, Nigeria

Waste management is a critical issue worldwide, and Awka, the capital city of Anambra State in Nigeria, is no exception. This section of the literature review delves into the existing body of knowledge regarding the waste management challenges specific to Awka, Nigeria. It seeks to understand the key issues related to waste collection, disposal, and the significant environmental and health implications, as illuminated by previous research, studies, and reports.

Awka, like many urban areas in Nigeria, grapples with a growing population and the associated surge in waste generation. This section aims to provide a comprehensive analysis of the waste management issues in the city, grounded in previous academic and practical work.

3.1.1 Waste generation and collection challenges

The existing literature on waste management in Awka highlights several critical challenges associated with waste generation and collection. Studies have consistently shown that the city's rapid urbanization and population growth have led to increased waste production (Ikechukwu et al., 2021). An increase in population directly translates to higher volumes of waste generated, placing additional strain on the already overwhelmed waste management infrastructure.

Ogbonnaya et al. (2019) emphasize that the inadequate waste collection services are among the primary challenges faced by the city. Inadequate coverage, irregular collection schedules, and insufficient numbers of waste collection points have resulted in improper waste disposal practices, such as open dumping

and burning. These practices are not only unsightly but also pose significant environmental and health hazards (Ogbonnaya et al., 2019).

Furthermore, the inefficiency of waste collection and transportation systems contributes to waste piling up in urban areas, increasing the risk of disease transmission, air pollution, and the contamination of water sources (Adewale et al., 2020). The failure to promptly and adequately collect waste not only leads to adverse health effects but also perpetuates a vicious cycle of environmental degradation.

3.1.2 Environmental and health implications

The environmental and health implications of poor waste management in Awka, Nigeria, have been well-documented in the literature. Open dumping and uncontrolled waste burning are widespread practices and have been shown to contribute to air and water pollution. These practices release a variety of harmful pollutants, including particulate matter, heavy metals, and toxins, into the environment (Adewale et al., 2020).

Adewale et al. (2020) highlight the direct consequences of these practices, which include deteriorating air quality, the contamination of soil and water resources, and the proliferation of disease vectors. The release of greenhouse gases from waste burning also exacerbates the global problem of climate change.

Moreover, Ogbonnaya et al. (2019) stress the adverse health effects on the local population living in proximity to poorly managed waste sites. Residents are exposed to health risks, including respiratory illnesses, skin conditions, and gastrointestinal disorders, due to the inhalation of pollutants from burning waste and the consumption of contaminated water and food.

The literature underlines the urgency of addressing waste management challenges in Awka to mitigate these environmental and health consequences. The inefficiencies in the waste collection and disposal systems not only harm the well-being of the population but also have long-term repercussions on the city's environmental sustainability.

3.1.3 Community awareness and behavior

Community awareness and behavioral aspects related to waste management are also explored in the literature. The success of waste management systems is intricately tied to the behaviors and practices of the local population. Research indicates that a lack of awareness and knowledge about proper waste disposal and recycling practices contributes to the persistence of poor waste management habits (Ogbonnaya et al., 2019).

Education and public awareness campaigns have been suggested as potential solutions to promote responsible waste management behaviors. The literature highlights the need for targeted educational initiatives to inform the population about the environmental and health impacts of improper waste disposal (Adewale et al., 2020).

Additionally, research points to the importance of involving communities in waste management initiatives, potentially through the establishment of community-based organizations or waste management cooperatives. These approaches can empower communities to take ownership of waste management practices and foster a sense of responsibility for keeping their environment clean (Ikechukwu et al., 2021).

In conclusion, the literature review of waste management challenges in Awka, Nigeria, underscores the pressing issues related to waste collection, disposal, and their significant environmental and health implications. The research suggests that the city faces challenges due to rapid urbanization, inadequate waste collection services, and improper waste disposal practices. These challenges have led to environmental degradation, air and water pollution, and health risks for the local population. The literature also emphasizes the importance of community awareness and behavioral change in addressing these challenges, underlining the need for education and community involvement to improve waste management practices in Awka. The insights garnered from existing studies on waste management challenges are pivotal in understanding the context and setting the stage for this research into the feasibility of adopting the Finnish system of electricity production in Awka, which aims to provide sustainable solutions to these pressing issues.

3.2 Waste-to-energy technologies

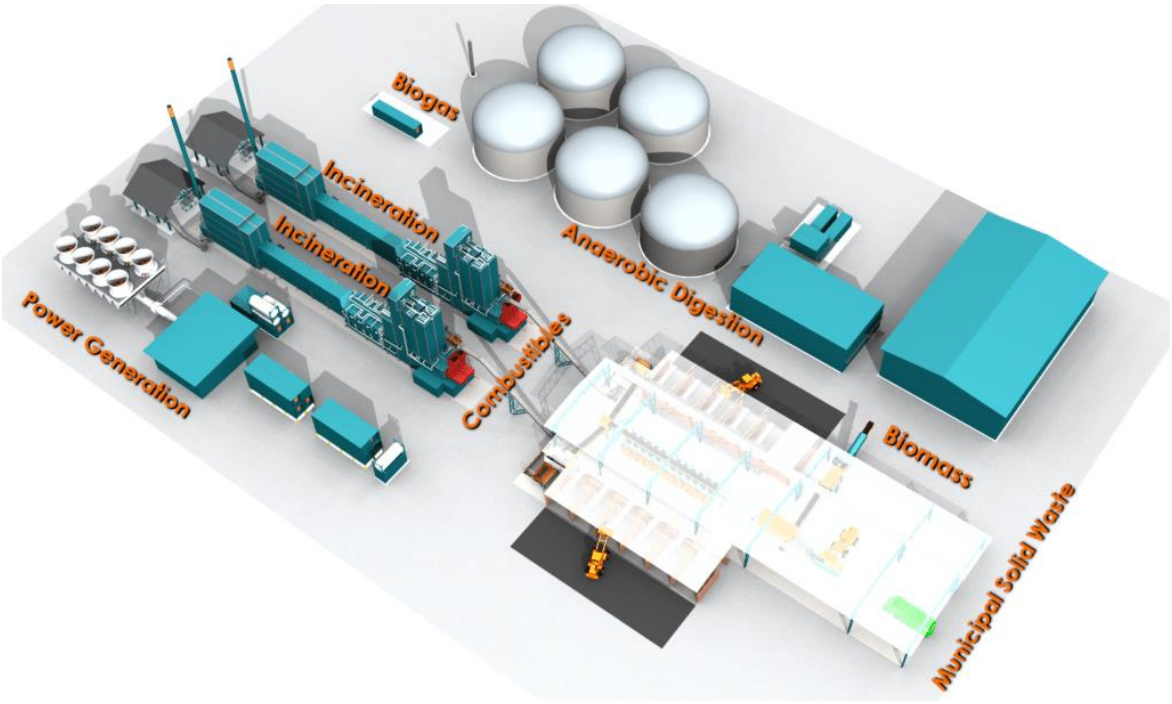

Figure 1. Waste-to-energy technologies (Woima Corporation, 2023)

Waste-to-energy (WtE) technologies have gained prominence as sustainable solutions for addressing the dual challenges of waste management and energy generation. These technologies hold the potential to convert non-recyclable waste materials into valuable energy forms, such as electricity and heat, while reducing the environmental burden of waste disposal. This section explores the existing literature on waste-to-energy technologies, specifically incineration, gasification, and anaerobic digestion, and highlights the environmental benefits and challenges associated with these processes.

3.2.1 Incineration

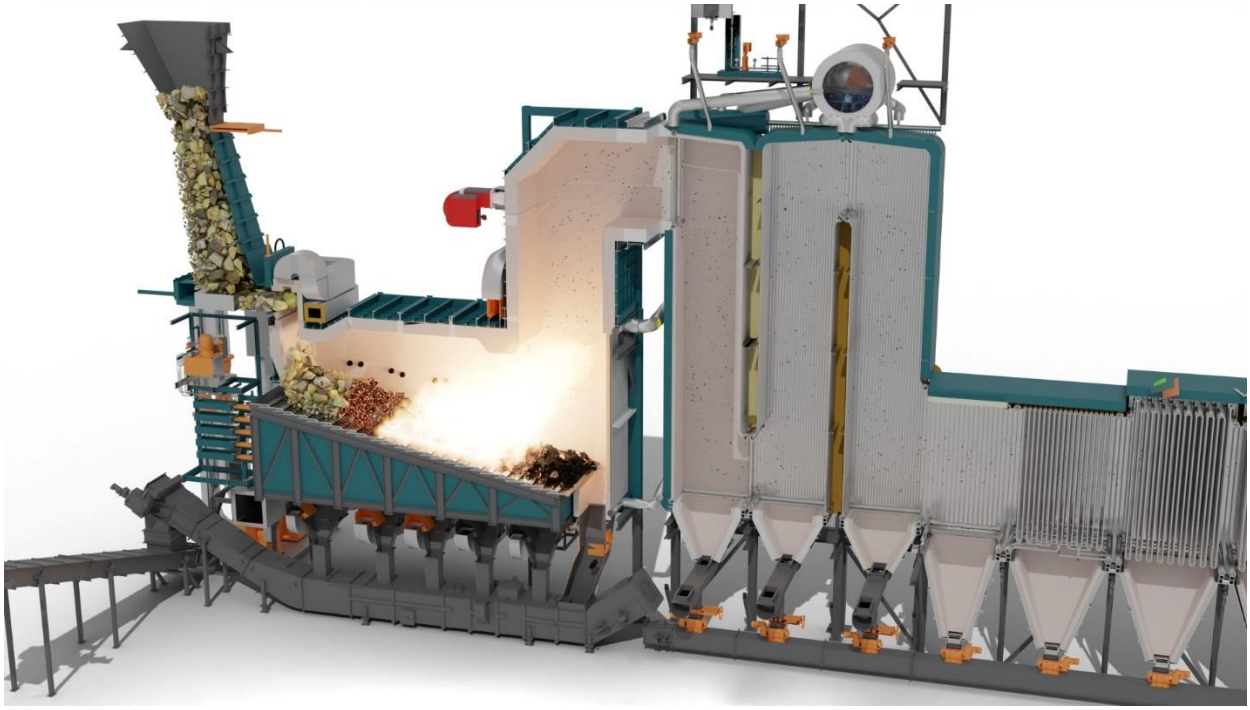

Figure 2. Inceneration technology (Woima Corporation 2022)

Incineration, a well-established waste-to-energy technology, involves the controlled burning of waste materials at high temperatures. The heat generated during incineration is typically harnessed to produce electricity or heat. Incineration has been a subject of extensive research, and the literature provides valuable insights into its operation and associated environmental aspects.

Incineration offers several advantages, as outlined in the literature. It reduces the volume of waste, minimizing the need for landfill disposal (Chiemeka & Madu, 2017). Additionally, incineration can provide a reliable source of electricity, contributing to energy security (Mekonnen & Agblevor, 2019).

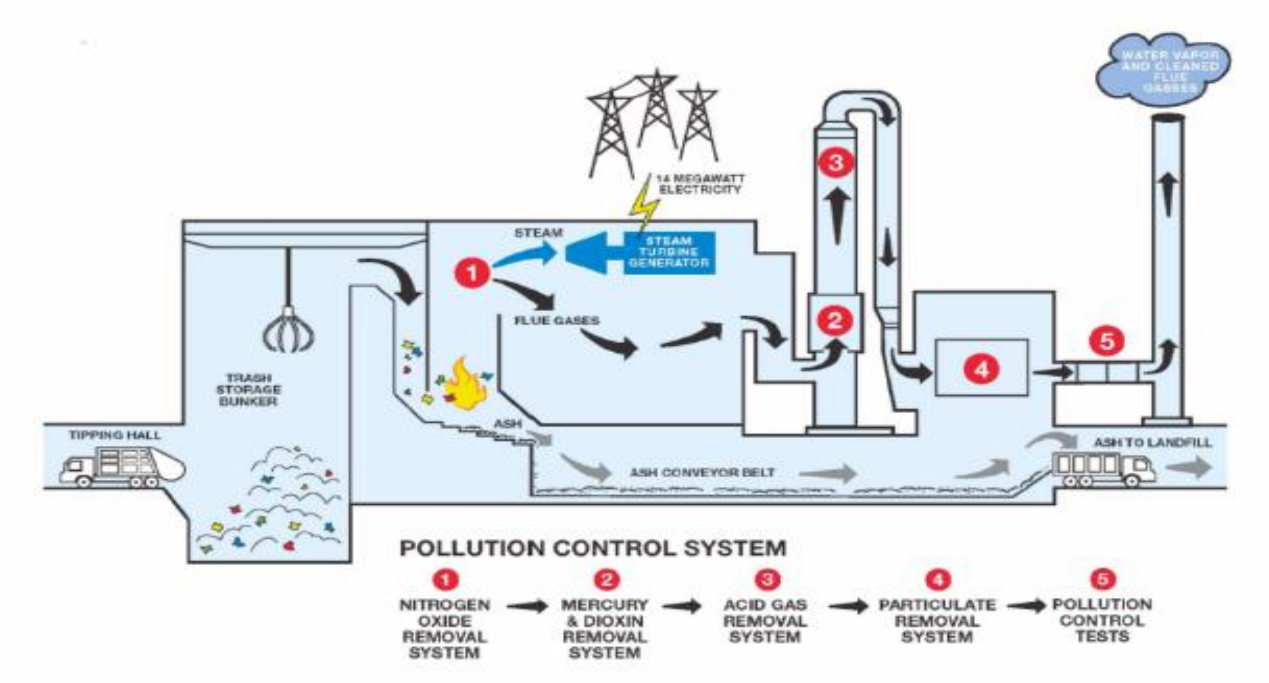

Figure 3. Process of sustainable incineration Waste-to-energy technology (Ecomaine 2024)

However, incineration is not without its challenges. The literature suggests that emissions from incineration processes, including the release of pollutants and greenhouse gases, are a matter of concern (Mekonnen & Agblevor, 2019). Moreover, the high capital costs of incineration plants and public apprehension about emissions have made their implementation contentious (Chiemeka & Madu, 2017).

3.2.2 Gasification

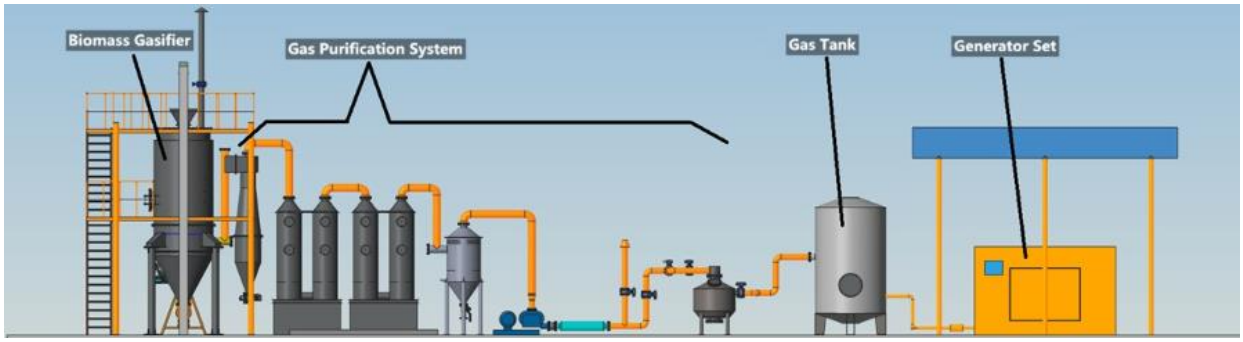

Figure 4. Gasification as a waste-to-energy technology

Gasification is an alternative waste-to-energy process that converts solid waste into a synthetic gas, known as syngas. The syngas can then be utilized for power generation or the production of fuels and chemicals. Existing literature provides a comprehensive understanding of the gasification process and its environmental

implications.

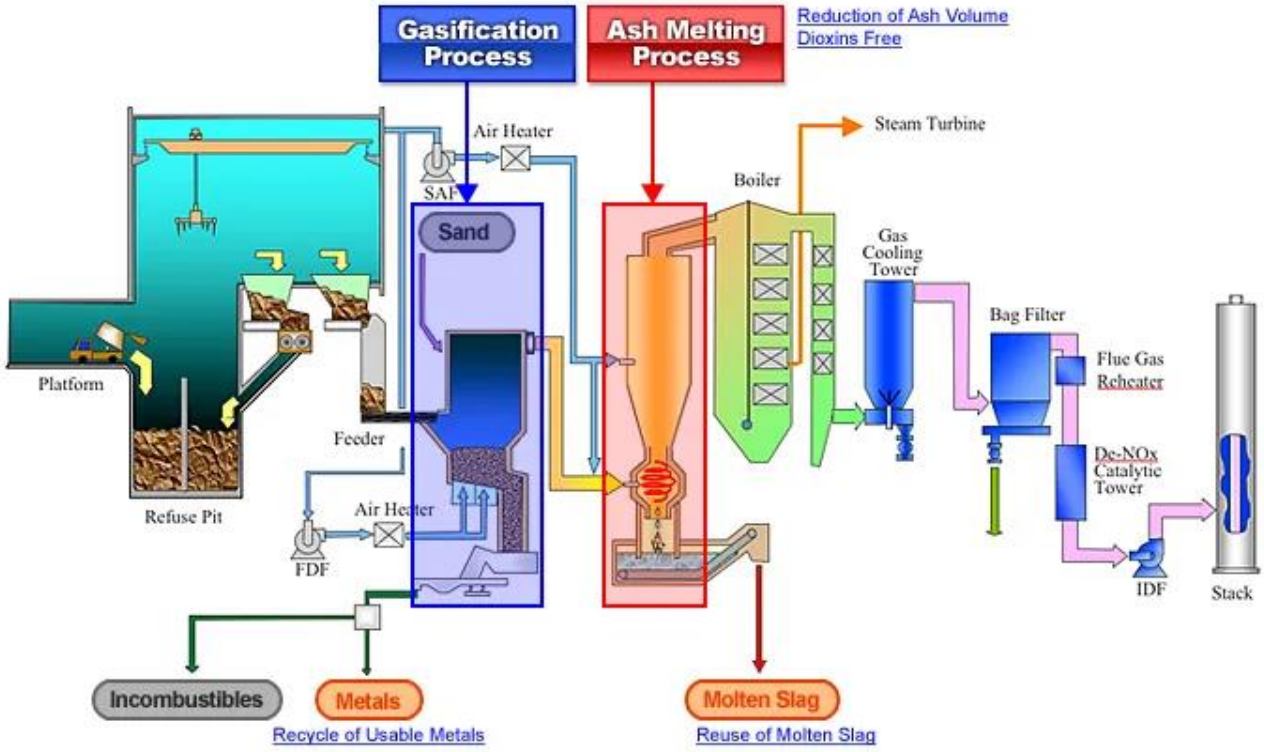

Figure 5. Gasification technology (Research Gate, Jakob Lederer, 2018)

Gasification is recognized for its efficiency in converting a wide range of waste materials into valuable products (Poudel et al., 2018). It offers a flexible and sustainable approach to waste management and energy production (Poudel et al., 2018).

Nevertheless, the literature highlights that gasification is not devoid of challenges. Gasification processes require stringent control to prevent the release of hazardous compounds and particulate matter (Chiemeka & Madu, 2017). Additionally, the technology's high capital and operational costs can be a deterrent to its widespread adoption (Poudel et al., 2018).

3.2.3 Anaerobic digestion

Anaerobic digestion is a biological process that breaks down organic waste materials in the absence of oxygen, generating biogas and nutrient-rich digestate. The literature offers comprehensive insights into anaerobic digestion as a waste-to-energy technology.

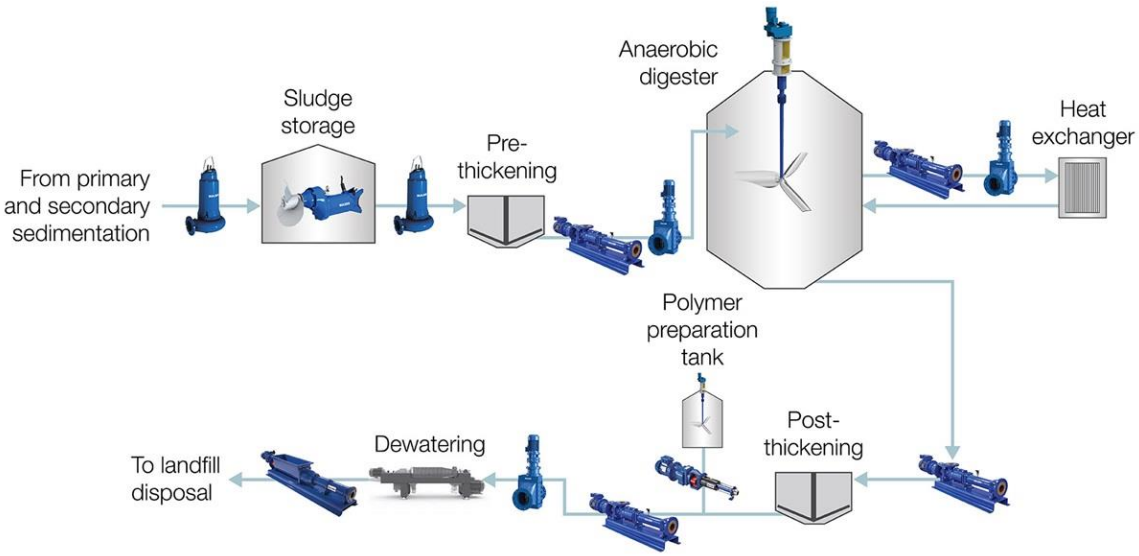

Figure 6. Anaerobic Digestion technology (Sulzer)

Anaerobic digestion is recognized for its ability to handle organic waste efficiently while producing biogas, a valuable energy source (Kumar & Samadder, 2017). This technology is considered eco-friendly and sustainable, as it can reduce the environmental impact of organic waste disposal (Kumar & Samadder, 2017).

Nonetheless, the literature notes that the success of anaerobic digestion is contingent on several factors, including the waste composition and process optimization (Bartacek et al., 2019). Additionally, challenges related to technology scale-up, feedstock availability, and biogas utilization may limit its widespread adoption (Bartacek et al., 2019).

3.2.4 Environmental benefits and challenges

Waste-to-energy technologies, as highlighted in the literature, offer environmental benefits by diverting waste from landfills, reducing greenhouse gas emissions, and providing a source of renewable energy (Poudel et al., 2018). Incineration, for instance, helps reduce landfill usage, which can be a significant source of methane emissions (Chiemeka & Madu, 2017). Gasification and anaerobic digestion contribute to waste reduction, organic waste management, and biogas production (Kumar & Samadder, 2017; Poudel et al., 2018).

However, challenges in terms of emissions and public perception have been raised (Chiemeka & Madu, 2017; Mekonnen & Agblevor, 2019). Incineration and gasification processes may release pollutants, including dioxins and heavy metals, as well as greenhouse gases (Chiemeka & Madu, 2017; Mekonnen & Agblevor, 2019). These emissions, if not effectively controlled, can pose environmental and health risks.

In conclusion, the literature review of waste-to-energy technologies provides a comprehensive understanding of incineration, gasification, and anaerobic digestion as sustainable solutions for waste management and energy production. While these technologies offer several advantages, including waste reduction and renewable energy generation, they also come with challenges, such as emissions control and high costs. By examining the existing research, critical insights into the operation and environmental aspects of these technologies is gained, setting the stage for the study's assessment of their feasibility and potential benefits in the context of Awka, Nigeria.

3.3 Sustainable energy production models

The quest for sustainable energy production models has become an imperative as the world confronts the challenges of climate change, energy security, and environmental degradation. In this section, I explore the existing literature related to sustainable energy production models, with a particular focus on the Finnish system. The literature is examined to understand how these models contribute to reducing greenhouse gas emissions and promoting sustainability.

3.3.1 Sustainable energy production models: An overview

The literature reveals a diverse landscape of sustainable energy production models. These models encompass renewable energy sources, energy efficiency measures, and waste-to-energy technologies. Sustainability, in this context, relates to the generation of energy that minimizes adverse environmental impacts, ensures long-term availability, and enhances economic and social well-being (Alanne & Saari, 2016).

The adoption of sustainable energy models can play a pivotal role in mitigating climate change. Research emphasizes that renewable energy sources, such as wind, solar, and hydropower, have the potential to reduce greenhouse gas emissions significantly (Yergin, 2020). Sustainable energy models not only reduce the carbon footprint but also contribute to energy security and independence.

3.3.2 The Finnish system of electricity production

The Finnish system of electricity production is an exemplary model of sustainable energy production. The literature provides insights into Finland's unique approach, which combines various renewable energy sources, including hydropower, biomass, and nuclear energy, to generate electricity (Vesala & Luostarinen, 2019). Finland's approach is noteworthy for its environmental consciousness and efficiency.

One of the key components of the Finnish system is the utilization of biomass as a renewable energy source. Research highlights the sustainable forest management practices that underpin this system, ensuring a constant and renewable source of biomass (Savolainen et al., 2018). Biomass not only reduces greenhouse gas emissions but also contributes to rural employment and economic development.

Moreover, the Finnish system's emphasis on nuclear energy is seen as an effective means of reducing carbon emissions. The literature suggests that nuclear energy provides a reliable, low-carbon source of electricity, contributing to both energy security and environmental sustainability (Kuisma et al., 2021).

3.3.3 Reducing greenhouse gas emissions

The literature underlines the significance of sustainable energy models in reducing greenhouse gas emissions. Climate change is a global concern, and transitioning to sustainable energy production is a vital part of mitigating its effects. Sustainable models like the Finnish system, with their reliance on renewable energy sources and low-carbon technologies, are recognized for their potential to significantly reduce emissions (Savolainen et al., 2018; Kuisma et al., 2021).

For instance, biomass, as a part of the Finnish system, is regarded as a carbon-neutral energy source. Research indicates that the carbon dioxide released during biomass combustion is balanced by the carbon absorbed by growing plants, effectively reducing net carbon emissions (Savolainen et al., 2018).

Nuclear energy, another component of the Finnish system, is recognized for its low carbon emissions. It provides a stable source of electricity while emitting minimal greenhouse gases during operation (Kuisma et al., 2021). Research emphasizes that nuclear energy plays a critical role in the transition to a low-carbon energy mix.

3.3.4 Promoting sustainability

Sustainable energy production models contribute not only to reduced emissions but also to promoting overall sustainability. The literature underscores that these models align with the principles of sustainable development, ensuring that present needs are met without compromising the ability of future generations to meet their own needs (Alanne & Saari, 2016).

The Finnish system, as a case in point, is lauded for its sustainability practices. Sustainable forest management ensures the replenishment of biomass resources, contributing to long-term sustainability (Savolainen et al., 2018). Furthermore, the utilization of nuclear energy aids in maintaining a reliable energy supply and reducing dependency on fossil fuels, thus promoting energy security (Kuisma et al., 2021).

3.3.5 Challenges and considerations

While sustainable energy production models offer substantial environmental and economic benefits, the literature also acknowledges the challenges associated with their implementation. These challenges include technological and infrastructural barriers, policy and regulatory issues, and public perception (Yergin, 2020). However, research emphasizes that these challenges can be overcome through a concerted effort involving governments, industries, and society.

In conclusion, the literature review of sustainable energy production models, with a focus on the Finnish system, underscores the vital role that sustainable energy plays in reducing greenhouse gas emissions and promoting overall sustainability. The Finnish system's combination of renewable energy sources and low-carbon technologies exemplifies an effective model for mitigating climate change and ensuring long-term energy security. These insights from existing research provide the groundwork for the study's evaluation of the potential benefits and feasibility of adopting the Finnish system in Awka, Nigeria.

3.4 Socioeconomic factors affecting sustainable energy adoption

The adoption and success of sustainable energy projects are intricately linked to a complex web of socioeconomic factors. This section delves into the existing literature to investigate the influence of these factors on the acceptance and success of sustainable energy initiatives. It will examine how income levels, education, and local governance play crucial roles in shaping the trajectory of energy-related projects.

3.4.1 The socioeconomic landscape of sustainable energy adoption

The literature underscores that sustainable energy adoption is not solely determined by technological feasibility; it is deeply intertwined with the socioeconomic context. Socioeconomic factors significantly influence the acceptance, implementation, and outcomes of energy-related initiatives (Wang & Wang, 2021).

3.4.2 Income levels

Income levels play a pivotal role in determining an individual's or a community's access to and adoption of sustainable energy technologies. Research indicates that high initial costs can be a significant barrier to the uptake of renewable energy systems, such as solar panels or wind turbines (Komiyama et al., 2017). These costs often limit access to those with higher incomes. Moreover, lower-income households or communities may lack the financial resources to invest in energy efficiency measures or transition to cleaner energy sources (Wang & Wang, 2021).

Studies suggest that income-based disparities in energy adoption can perpetuate energy poverty, which refers to the inability of individuals or communities to access clean, affordable, and reliable energy services (Komiyama et al., 2017). Overcoming income-related barriers is critical for ensuring equitable access to sustainable energy and addressing energy poverty.

3.4.3 Education

Education levels are another essential socioeconomic factor influencing sustainable energy adoption. The literature emphasizes that education is instrumental in raising awareness and understanding of the environmental and economic benefits of sustainable energy (Alves et al., 2017). Individuals with higher levels of education are often more receptive to sustainable energy technologies and are better equipped to make informed decisions about their energy consumption (Wang & Wang, 2021).

Research indicates that education can empower individuals and communities to implement energy-saving practices, adopt cleaner energy sources, and participate in energy conservation initiatives (Alves et al., 2017). Education not only increases the willingness to embrace sustainable energy but also enhances the capacity to implement energy-efficient practices.

3.4.4 Local governance

Local governance and policies play a pivotal role in shaping the landscape of sustainable energy adoption. The literature suggests that supportive policies, incentives, and regulations at the local level can create an enabling environment for sustainable energy initiatives (Komiyama et al., 2017). In contrast, inadequate governance structures and regulatory barriers can hinder progress.

Case studies and research on sustainable energy adoption often highlight the significance of government initiatives and incentives. These may include subsidies for renewable energy technologies, feed-in tariffs, and favorable zoning and permitting processes (Wang & Wang, 2021). Local governance can create a conducive environment for businesses, communities, and individuals to invest in and adopt sustainable energy solutions.

3.4.5 Challenges and considerations

The literature acknowledges that challenges exist in addressing socioeconomic factors in sustainable energy adoption. Overcoming income-related disparities, improving education access, and creating supportive governance structures require concerted efforts from governments, civil society, and international organizations (Komiyama et al., 2017).

Additionally, cultural and contextual factors can also influence sustainable energy adoption. These factors may include the cultural significance of traditional energy sources, the presence of established energy infrastructure, and community norms and values (Alves et al., 2017).

In conclusion, the literature review of socioeconomic factors affecting sustainable energy adoption highlights the critical role of income levels, education, and local governance in shaping the acceptance and success of sustainable energy projects. These factors are pivotal in addressing energy poverty, raising awareness, and creating an enabling environment for the adoption of clean energy technologies.

3.5 Applicability of the Finnish system in Awka

The Finnish system of electricity production, known for its sustainability and efficiency, is a potential model for addressing energy challenges in regions like Awka, Nigeria. This section explores the existing literature to assess the applicability of the Finnish system of electricity production in Awka. It also examines case studies and relevant research that address similar contexts to gain insights into the potential benefits and challenges.

3.5.1 The Finnish system of electricity production: An overview

The Finnish system of electricity production is characterized by a diversified energy mix that combines various renewable energy sources, nuclear energy, and an emphasis on energy efficiency. This system is known for its success in reducing greenhouse gas emissions, ensuring energy security, and promoting sustainability (Kuisma et al., 2021).

3.5.2 Applicability to Awka, Nigeria

The literature review indicates that the applicability of the Finnish system in Awka, Nigeria, is a subject of interest and investigation. The region shares some common challenges with Finland, such as the need for reliable and sustainable energy sources, and reducing greenhouse gas emissions (Onyeji, 2020).

Research has explored the feasibility of implementing elements of the Finnish system in Awka. For example, the utilization of renewable energy sources like biomass and hydropower, akin to the Finnish model, has been considered as a means to reduce the region's carbon footprint and enhance energy security (Oyelaran-Oyeyinka & Adeyinka, 2020).

3.5.3 Challenges and considerations

The literature suggests that several challenges must be considered when assessing the applicability of the Finnish system in Awka. These include:

- Infrastructure: The existing infrastructure in Awka may need significant upgrades to support the Finnish system's diversified energy mix. This includes the development of renewable energy facilities and the necessary grid infrastructure (Oyelaran-Oyeyinka & Adeyinka, 2020).

- Resource Availability: The availability of key resources, such as biomass and water resources for hydropower, is a crucial factor. Research has indicated that Awka's resource availability may limit the extent to which the Finnish model can be replicated (Oyelaran-Oyeyinka & Adeyinka, 2020).

- Economic Considerations: The economic viability of implementing the Finnish system in Awka is a significant concern. The literature suggests that cost-effectiveness, financing, and investment in sustainable energy technologies are important considerations (Oyelaran-Oyeyinka & Adeyinka, 2020).

- Socioeconomic Factors: The success of sustainable energy initiatives is influenced by socioeconomic factors, such as income levels and education. Research highlights the need to address these factors to ensure equitable access to sustainable energy technologies (Wang & Wang, 2021).

3.5.4 Case studies and relevant research

In addition to assessing the applicability of the Finnish system to Awka, it is informative to examine case studies and relevant research from similar contexts. The literature review identifies regions that have undertaken efforts to replicate or adapt elements of the Finnish system to their unique circumstances.

Case studies include successful implementations of renewable energy technologies in regions with similar challenges to Awka. These studies demonstrate that the adoption of sustainable energy technologies is feasible and can lead to positive outcomes.

For example, research highlights the success of rural electrification projects in several African countries that utilize solar power and other renewable energy sources (Abu-Bakar & Adaramola, 2020). These projects have improved energy access in rural areas, contributing to socioeconomic development.

In conclusion, the literature review on the applicability of the Finnish system of electricity production in Awka, Nigeria, provides valuable insights into the potential benefits and challenges of replicating this model in a similar context. While the Finnish system's emphasis on renewable energy, energy efficiency, and low-carbon technologies aligns with the goals of Awka, the region's unique challenges and resource constraints must be considered.

4 THEORETICAL FRAMEWORK

The theoretical framework of a research study serves as its intellectual backbone, providing a structured approach to understanding and addressing the research questions and objectives. In this section, I introduce the theoretical frameworks that guides this study and explain their relevance to the research questions and objectives.

4.1 Ecological modernization theory

Ecological Modernization Theory is a significant framework that offers insights into the relationship between economic development and environmental sustainability. This theory posits that societies can pursue economic growth while simultaneously addressing environmental challenges (Mol & Spaargaren, 2000). It challenges the conventional notion that economic development and environmental protection are inherently contradictory and suggests that they can be reconciled.

This theory underscores the role of technological innovations, shifts in societal values, and changes in production and consumption patterns in achieving ecological modernization. It acknowledges that industries and societies can adopt more sustainable practices, leading to a decoupling of economic growth from environmental degradation.

Relevance to the Research: Ecological Modernization Theory is highly relevant to this study as it allows us to explore how the adoption of sustainable energy solutions, such as the Finnish system, can support both economic development and environmental preservation in the context of Awka, Nigeria.

4.2 Sustainability transition theory

Sustainability transition theory focuses on the processes and mechanisms involved in the transition towards more sustainable systems. This theory recognizes that sustainability transitions often require significant changes in institutions, technologies, and societal practices (Markard et al., 2012). It emphasizes that the transition towards sustainability is a complex process that involves various stakeholders and drivers.

Sustainability transition theory highlights the role of policy interventions, innovation, and societal transformations in driving sustainability transitions. It also underscores the importance of experimentation, learning, and adaptation as key elements in the transition process.

Relevance to the Research: Sustainability Transition Theory is crucial for this study as it helps to understand how sustainability transitions may be initiated, managed, and sustained within the specific context

of Awka. It analyzes the role of policy, innovation, and societal changes in facilitating the adoption of the Finnish system and other sustainable energy solutions.

4.3 Institutional theory

Institutional theory posits that institutions, which encompass formal rules and informal norms, significantly influence behavior and decision-making within society (DiMaggio & Powell, 1983). Institutions provide the rules and structures within which organizations and individuals operate. They influence how innovations are adopted, how policies are formulated, and how sustainability practices are integrated into existing systems.

This theory suggests that institutions can act as both facilitators and barriers to change. They shape the adoption of new practices, including sustainable energy technologies, by influencing the rules, norms, and incentives that guide behavior within a society.

Relevance to the Research: Institutional Theory is highly relevant as it allows us to examine how existing institutions, policies, and norms in Awka influence the implementation of the Finnish system and sustainable energy adoption. It helps us understand the role of institutional dynamics in shaping the challenges and opportunities for sustainable energy transitions in the region.

These three theoretical frameworks collectively provide a comprehensive lens through which analysis of the feasibility and implications of implementing the Finnish system of electricity production in Awka, Nigeria, with respect to economic development, policy interventions, innovation, and institutional influences are highlighted.

5 EMPIRICAL REVIEW

The adoption of sustainable energy solutions is a critical step towards mitigating climate change and fostering economic development. In this section, existing research to understand the environmental and economic impacts of implementing sustainable energy solutions is reviewed in detail. It also examine studies that evaluate the long-term effects of adopting these systems, shedding light on the benefits and challenges associated with the transition.

5.1 Environmental impacts of sustainable energy adoption

The literature review emphasizes that the environmental impacts of adopting sustainable energy solutions are a key consideration. Sustainable energy technologies are lauded for their potential to reduce greenhouse gas emissions, air pollution, and reliance on finite fossil fuel resources (Lu et al., 2021).

Studies on renewable energy sources, such as solar and wind power, highlight their minimal emissions of greenhouse gases during operation (Mousazadeh et al., 2017). These technologies offer a pathway to decarbonize the energy sector and reduce the carbon footprint.

Additionally, research underscores the role of sustainable energy solutions in reducing air pollution. The adoption of electric vehicles and the transition from coal to natural gas in power generation have been linked to improved air quality and public health benefits (Davis et al., 2018).

The long-term environmental effects of sustainable energy adoption are also a subject of research. Studies assess the sustainability of resource availability, the impact on biodiversity, and the potential for land use conflicts (Wiedmann et al., 2020). These investigations provide valuable insights into the enduring environmental consequences of the transition.

5.2 Economic impacts of sustainable energy adoption

The literature review reveals that sustainable energy adoption can have significant economic implications. Research underscores the potential for job creation and economic growth associated with the renewable energy sector (Rao, 2017). Sustainable energy technologies require installation, maintenance, and operations, generating employment opportunities.

Moreover, studies on energy efficiency measures highlight their potential for reducing energy costs for businesses and households (McKane et al., 2017). Energy-efficient technologies, such as LED lighting and improved insulation, lead to cost savings over time.

The long-term economic effects of sustainable energy adoption are also explored. Research examines the impact on energy prices, the resilience of energy systems, and the potential for reducing energy poverty (Rao, 2017). These studies provide insights into how sustainable energy solutions can contribute to economic stability and prosperity in the long run.

5.3 Benefits and challenges of transition

While there are numerous benefits associated with sustainable energy adoption, the literature also acknowledges challenges. The transition to sustainable energy can require substantial upfront investments and changes in infrastructure (Mousazadeh et al., 2017). Additionally, the intermittent nature of some renewable energy sources, like solar and wind, presents challenges in ensuring a reliable energy supply (Lu et al., 2021).

Research also highlights the importance of effective policies and regulatory frameworks to drive sustainable energy adoption. The design of supportive incentives, subsidies, and carbon pricing mechanisms can influence the pace and scale of the transition (Davis et al., 2018).

In conclusion, the literature review of the environmental and economic impacts of sustainable energy adoption underscores the potential benefits of reducing greenhouse gas emissions, air pollution, and reliance on finite fossil fuels. Sustainable energy solutions offer a pathway to economic growth, job creation, and cost savings. Furthermore, the long-term effects of adopting these systems are a subject of research, providing insights into their sustainability, economic resilience, and impact on energy prices. While challenges exist, research indicates that effective policies and regulatory frameworks can drive the transition to a sustainable energy future.

6 GAPS IN EXISTING LITERATURE

The existing literature on sustainable energy adoption and the applicability of energy production models, such as the Finnish system, provides valuable insights into the field. However, there are several notable gaps and limitations in the current research that warrant attention. In this section, these areas are identified and discusses the specific aspects that are not adequately addressed.

6.1 Regional context-specific studies

While there is a growing body of research on sustainable energy adoption in various contexts, there is a lack of region-specific studies that focus on places like Awka, Nigeria. Many studies tend to concentrate on developed regions, where conditions and challenges are different from those in emerging economies. This gap limits the understanding of the unique challenges and opportunities for sustainable energy adoption in regions like Awka.

6.2 Comprehensive socioeconomic analysis

The socioeconomic factors influencing sustainable energy adoption are widely recognized, but the literature often lacks comprehensive analyses that consider a wide range of variables. Many studies focus on one or two factors, such as income levels or education, while overlooking other crucial determinants, like cultural influences, access to credit, and public awareness. A more holistic approach to socioeconomic analysis is needed to capture the complexity of sustainable energy adoption.

6.3 Long-term sustainability assessment

Many studies provide insights into the short-term effects of sustainable energy adoption, such as reduced emissions or cost savings. However, there is a scarcity of research that evaluates the long-term sustainability and resilience of these initiatives. Understanding how sustainable energy systems evolve and adapt over time is essential for making informed decisions about their implementation.

6.4 Cross-cultural comparative studies

Most of the existing research is limited in scope, focusing on specific regions or countries in isolation. Few studies conduct cross-cultural comparative analyses that consider the transferability of sustainable energy models across different cultural, political, and economic contexts. These studies can provide valuable lessons and insights for regions like Awka that are considering the adoption of foreign energy models.

6.5 Institutional barriers and solutions

Institutional factors play a significant role in shaping the success of sustainable energy adoption. While the literature acknowledges the importance of institutions, it often lacks in-depth analyses of specific institutional barriers and potential solutions. Identifying these barriers and proposing practical solutions is crucial for policymakers and stakeholders.

6.6 Gender and energy

The intersection of gender and sustainable energy adoption is an area where the literature is notably deficient. Women often have distinct roles and responsibilities related to energy in many regions, and the lack of gender-sensitive research means that the unique challenges and opportunities they face may be overlooked. More research is needed to understand the gendered dimensions of sustainable energy adoption.

6.7 Indigenous knowledge and practices

Indigenous communities often have traditional knowledge and practices related to sustainable energy and resource management. However, this knowledge is frequently omitted from mainstream research. Recognizing and incorporating indigenous knowledge can enhance the effectiveness and cultural appropriateness of sustainable energy projects.

6.8 Community engagement and social acceptance

Research often underestimates the importance of community engagement and social acceptance in sustainable energy projects. Understanding how to build trust, involve local communities, and address concerns is critical for the successful implementation of such initiatives.

Addressing these gaps and limitations in the existing literature will contribute to a more comprehensive and nuanced understanding of sustainable energy adoption and the applicability of energy production models like the Finnish system in diverse contexts, including Awka, Nigeria.

7 KEY FINDINGS AND INSIGHTS

Socioeconomic factors matter: The literature consistently underscores the influence of socioeconomic factors, such as income levels and education, on the success of sustainable energy projects. Research indicates that addressing these factors is essential for equitable access to sustainable energy technologies.

Environmental and economic benefits: Sustainable energy adoption offers a dual benefit of reducing greenhouse gas emissions and providing economic advantages. Studies emphasize the potential for job creation, cost savings, and improved energy access in the context of renewable energy solutions.

Challenges in implementation: The literature acknowledges challenges in implementing sustainable energy initiatives, including high upfront costs, resource availability constraints, and infrastructure limitations. Additionally, the intermittent nature of some renewable energy sources poses reliability challenges.

Policy and institutional support: Effective policies, incentives, and regulatory frameworks play a pivotal role in driving sustainable energy adoption. The literature emphasizes the need for government initiatives, subsidies, and supportive governance structures to create an enabling environment.

Context matters: The literature recognizes the importance of considering the unique contextual factors of each region. A one-size-fits-all approach may not be effective in addressing the specific challenges and opportunities of sustainable energy adoption.

Long-term sustainability: While many studies examine the short-term benefits of sustainable energy adoption, there is a dearth of research on the long-term sustainability and resilience of these initiatives. Understanding how they evolve and adapt over time is critical.

Community engagement: The role of community engagement and social acceptance in sustainable energy projects is often underestimated. Building trust, involving local communities, and addressing concerns are vital for success.

Gender and indigenous knowledge: The intersection of gender and indigenous knowledge with sustainable energy adoption is an underexplored area. Recognizing gendered dimensions and incorporating indigenous knowledge can enhance project effectiveness and cultural appropriateness.

8 COMMON THEMES AND TRENDS

The pursuit of economic development and environmental sustainability is not inherently contradictory; sustainable energy adoption offers a pathway to reconcile these goals.

Technological innovations, policy interventions, and changes in societal values play key roles in ecological modernization and sustainability transitions. Sustainable energy projects require comprehensive socioeconomic analyses, considering income levels, education, cultural factors, and community engagement. Furthermore, cross-cultural comparative studies can offer valuable insights into the transferability of energy models across different contexts.

9 CONTRADICTIONS AND DIVERGENT PERSPECTIVES

While there are common themes and trends, contradictions and divergent perspectives exist in the literature. For example, some studies emphasize the positive economic impacts of sustainable energy adoption, while others highlight the need for substantial upfront investments. Likewise, the intermittent nature of renewable energy sources is considered a challenge by some, while others see it as an opportunity for grid innovation.

In conclusion, the reviewed literature provides a multifaceted understanding of sustainable energy adoption and the applicability of energy production models. It underscores the importance of addressing socioeconomic factors, promoting environmental and economic benefits, and considering context-specific challenges and opportunities. Additionally, it highlights the role of policies, institutions, and community engagement in the success of sustainable energy initiatives. Addressing these key findings, themes, and contradictions will expose this study's assessment of the Finnish system's applicability in Awka, Nigeria.

10 CONCLUSION OF THE LITERATURE REVIEW

The comprehensive literature review on sustainable energy adoption and the applicability of energy production models, particularly the Finnish system, has provided valuable insights and laid the groundwork for this research. In this concluding section, the relevance of the reviewed literature to the research questions and objectives are understood, providing a bridge to the subsequent chapters. It also explain how the literature review is adapted in the research methodology and data analysis.

10.1 Relevance of the reviewed literature

The reviewed literature is highly relevant to the research questions, which focus on the applicability of the Finnish system of electricity production in Awka, Nigeria. The literature has shed light on various critical aspects, including socioeconomic factors, environmental and economic impacts, policy interventions, challenges, and opportunities associated with sustainable energy adoption. These insights are directly aligned with the research questions, which seek to understand how the Finnish system can be implemented in a specific regional context and how it can address the region's energy challenges and development goals.

Moreover, the literature review has highlighted the importance of considering context-specific factors and the need for a holistic approach that encompasses both environmental and economic dimensions. It has underlined the role of institutions, community engagement, and the integration of indigenous knowledge in shaping the success of sustainable energy projects. All of these aspects directly inform the research objectives, which include assessing the feasibility, benefits, and challenges of implementing the Finnish system in Awka.

10.2 Informing the research methodology and data analysis

The literature review serves as a foundation for research methodology and data analysis. It informs the approach to data collection, data interpretation, and the structure of the research design. Specifically, the following aspects of the literature review inform the methodology and data analysis:

1. Socioeconomic factors and surveys: The emphasis on socioeconomic factors in the literature encourages in conducting surveys and gather data related to income levels, education, and community demographics. This information will be instrumental in understanding the potential barriers and opportunities for sustainable energy adoption in Awka.

2. Environmental and economic impact assessment: The insight from the literature guides the data collection methods for assessing the environmental and economic impacts of sustainable energy adoption. Data on energy consumption patterns, cost savings, and emissions reductions will be collected for reference,

3. Institutional and policy analysis: The literature underscores the significance of institutions and policies. The data analysis will involve a thorough examination of existing policies and their impact on sustainable energy adoption in Awka.

4. Community engagement and qualitative data: Recognizing the importance of community engagement, collecting qualitative data through interviews and focus groups to gain insight into local perceptions, concerns, and preferences related to sustainable energy solutions is applied.

In summary, the reviewed literature not only informs the relevance of the research questions but also shapes the research methodology and data analysis strategies. It provides a strong theoretical and empirical foundation on which this study is built. In the subsequent chapters, this study will proceed to the research methodology, data collection, analysis, and findings, building upon the insights gained from this comprehensive literature review.

11 RESEARCH METHODOLOGY

In this chapter, an overview of the research methodology employed in the investigation of the applicability of the Finnish system of electricity production in Awka, Nigeria, and its potential to address the region's energy challenges and development goals is elaborated. The methodology is carefully designed to answer the research questions and objectives comprehensively, ensuring the rigor and reliability of the findings and results.

11.1 Research design

The research design is primarily quantitative, utilizing surveys as the primary method of data collection. The objective is to gather numerical data that can be analysed systematically and statistically to address the research questions. The research design is cross-sectional and non-experimental, as it aim to capture a snapshot of the community's views, preferences, and socioeconomic characteristics.

11.2 Data collection

Questionnaires: It will employ structured questionnaires as the primary data collection tool. The questionnaires will be administered to a random sample of 137 respondents selected from the population of

interest in Awka. This method will allow gathering quantitative data on various aspects, including socio-economic factors, energy consumption patterns, and community preferences for sustainable energy solutions.

Sampling: The sample size of 137 respondents will be randomly selected to ensure representativeness and generalizability of the findings to the larger population of Awka. The random sampling approach minimizes bias and enhances the validity of our results.

11.3 Data analysis

Quantitative Data Analysis: The data collected through questionnaires will be subjected to quantitative data analysis. Tables, frequency distributions, and percentages to present and analyse the data. These statistical methods will help us identify trends, correlations, and patterns related to income levels, education, energy consumption, and preferences for sustainable energy technologies. Descriptive statistics will be employed to summarize and visualize the quantitative findings.

11.4 Ethical considerations

Ethical principles will be rigorously upheld throughout the research process. Informed consent will be obtained from all survey participants, and they will be assured of the anonymity and confidentiality of their responses. Any potential conflicts of interest will be transparently disclosed. The research will adhere to the highest ethical standards, prioritizing the well-being and rights of the respondents.

11.5 Limitations

Certain limitations in the research methodology are acknowledged. First, the generalizability of the survey results may be limited by the sample size, although efforts have been made to ensure representativeness through random sampling. Additionally, the use of questionnaires may entail the risk of response bias, where respondents provide socially desirable answers.

11.6 Significance

The research methodology holds significant promise in providing empirical insight that can inform policymakers, energy practitioners, and the local community in Awka, Nigeria. The quantitative approach, with its rigorous sampling and statistical analysis, is designed to offer a robust assessment of the research questions and objectives. By focusing on this methodology, I aim to provide data-driven evidence on the feasibility, benefits, and challenges of implementing the Finnish system in Awka. This research design contributes to the broader discourse on sustainable energy adoption in emerging economies and

aligns with the overarching goal of making informed recommendations for sustainable energy practices in Awka.

12 DATA ANALYSIS AND INTERPRETATION

Age distribution

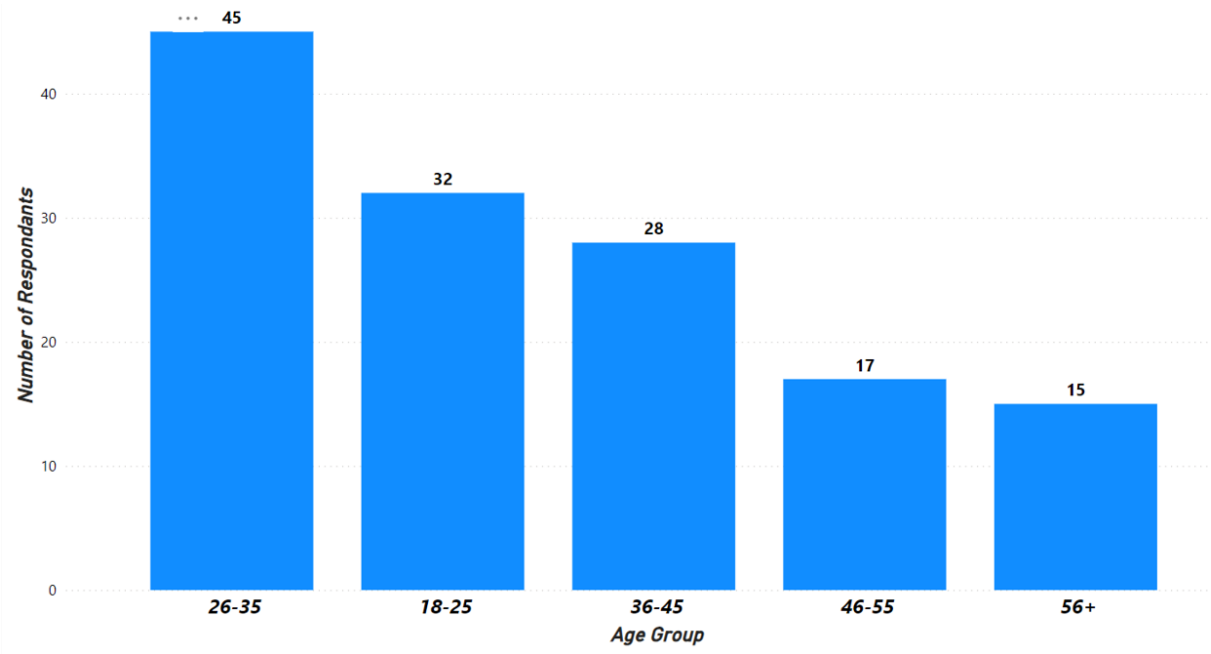

Figure 7: Age distribution

- Interpretation: The figure shows the distribution of respondents across different age groups. Most respondents (45 out of 137) fall within the age group of 26-35, followed by those in the 18-25 age group (32 out of 137). The older age groups (36-45 and 46-55) and those above 55 are smaller in number.
- Implications: The higher number of respondents in the 26-35 age group suggests that this demographic is more actively engaged in the survey. It may also indicate that younger adults are more interested in or aware of sustainable energy adoption. However, the smaller number of older participants could mean that their perspectives are underrepresented.

Gender distribution

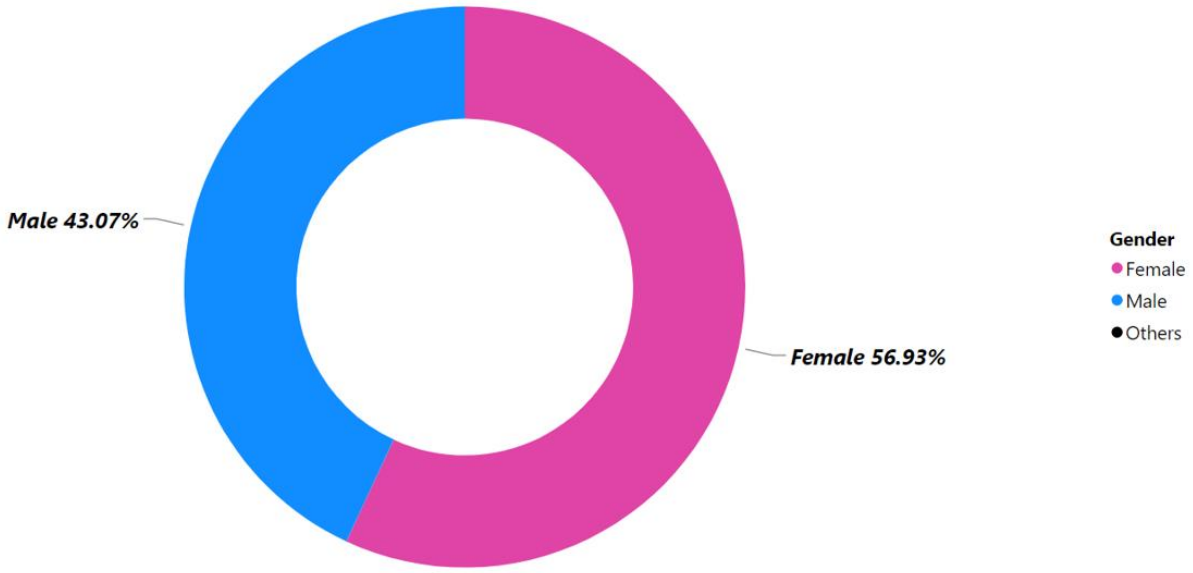

Figure 8: Gender Distribution

- Interpretation: The figure illustrates the gender distribution of the respondents. Majority of respondents are female (78 out of 137), with a smaller number being male (59 out of 137). There are no respondents categorized as "Other."
- Implications: The higher number of female respondents suggests a stronger representation of women in the survey. The gender balance in the sample could influence the research findings, as different genders may have varying perspectives on sustainable energy adoption. The absence of "Other" responses suggests that the survey population does not include individuals who identify outside the male-female binary.

Education level distribution

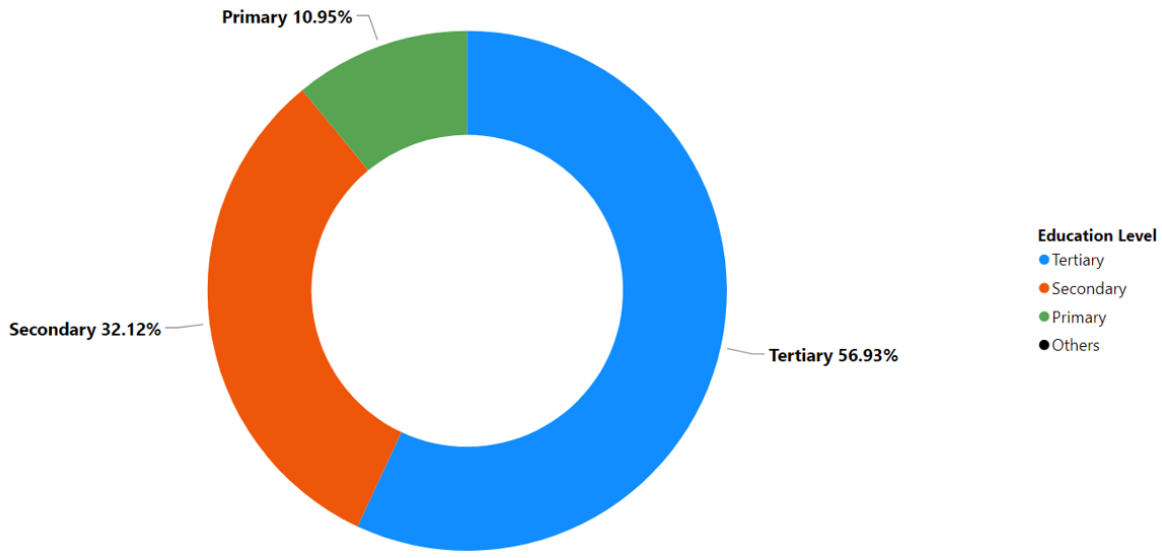

Figure 9: Education level distribution

- Interpretation: The figure represents the educational background of the respondents. The largest group has a tertiary education (78 out of 137), followed by those with a secondary education (44 out of 137). There are fewer respondents with primary education (15 out of 137), and none fall under "Other."
- Implications: A higher number of the respondents are well-educated with tertiary qualifications. This could mean that the survey's findings may reflect the opinions and understanding of individuals with higher education. The smaller number of respondents with primary education indicates a limited perspective from this group. The absence of "Other" responses suggests that the sample does not include respondents with non-standard educational backgrounds.

Monthly income distribution (in Naira)

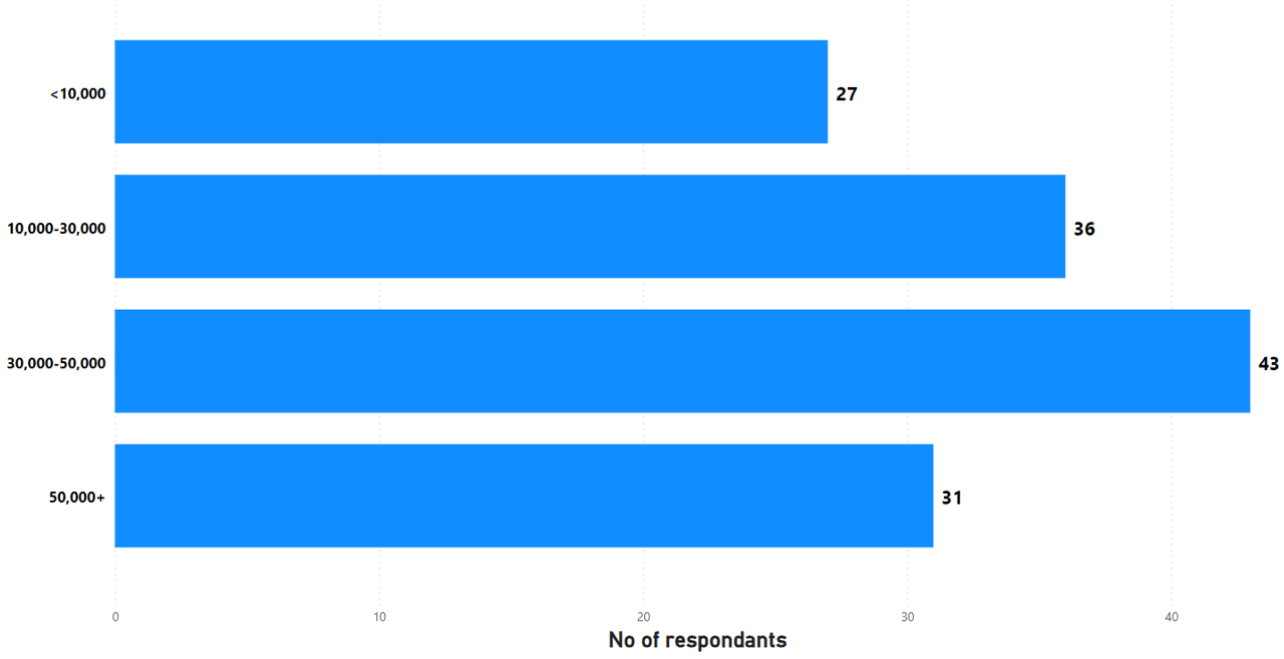

Figure 10: Monthly income distribution (in Naira)

- Interpretation: The figure shows the distribution of respondents based on their monthly income. The largest group falls within the income range of 30,000 - 50,000 Naira (43 out of 137). The income ranges below 30,000 Naira and above 50,000 Naira each have 30+ respondents, while the lowest income range (below 10,000 Naira) has 27 respondents.
- Implications: A significant portion of respondents fall within the income range of 30,000 - 50,000 Naira, which may reflect the income distribution in the survey population. This could indicate that the majority

of respondents have moderate income levels. It is important to consider how income levels may influence the views and preferences of respondents regarding sustainable energy adoption.

In conclusion, the demographic information analysis provides insight into the composition of the survey sample. The distribution of age, gender, education, and income levels among respondents has implications for the research findings, as different demographic groups may have varying perspectives on sustainable energy adoption. Researchers should be aware of potential biases in the sample and interpret the results accordingly.

12.1 Analysis of Waste Management Challenges

Survey Question	SA(Frequency)	A(Frequency)	N(Frequency)	D(Frequency)	SD(Frequency)	% of SA & A
1. Awka faces challenges in waste collection.	29 [21.2%]	40 [29.2%]	33 [24.1%]	23 [16.8%]	12 [8.8%]	50.4%
2. Waste disposal is a major concern in Awka.	25 [18.2 %]	34 [24.8%]	44 [32.1%]	17 [12.4%]	17 [12.4%]	43.1%
3. Recycling practices are limited in Awka.	37 [27.0%]	29 [21.2%]	23 [16.8%]	27 [19.7%]	21 [15.3%]	48.2%

12.1.1 Interpretation

This table presents the analysis of waste management challenges in Awka, Nigeria, based on responses from 137 survey participants. The table provides insight into the distribution of responses, the corresponding percentages and the combined percentage of those who strongly agreed and agreed. Here's the interpretation and implications for each question:

Question 1: Awka faces challenges in waste collection.

- % of SA & A: 50.4%
- Implication: A little over half of respondents (50.4% - the combined percentage of those who strongly agreed and agreed) acknowledge challenges in waste collection in Awka which suggests that, on average, respondents perceive this as a moderate challenge. The implication is that addressing waste collection issues should be a priority in waste management efforts in Awka.

Question 2: Waste disposal is a major concern in Awka.

- % of SA & A: 43.1%
- Implication: A significant proportion of respondents (43.1%) believe that waste disposal is a major concern in Awka which furhter indicates that respondents consider waste disposal to be a lightly significant challenge. The implication is that addressing waste disposal issues is crucial for improving waste management practices in the region.

Question 3: Recycling practices are limited in Awka.

- % of SA & A: 48.2%
- Implication: The average number of respondents (48.2%) perceive limited recycling practices in Awka whch indicates a moderate level of concern, the implication is that efforts should be made to expand and promote recycling initiatives in the region.

Overall, the findings suggest that waste management challenges in Awka, particularly waste collection and disposal, are a significant concern among respondents. Addressing these challenges is essential to improve waste management practices, reduce environmental impacts, and enhance the overall quality of life in Awka. Additionally, promoting recycling practices can highly contribute to sustainable waste management solutions in the region.

12.2 Analysis of Finnish System Suitability

Survey Question	SA (Frequency)	A (Frequency)	N (Frequency)	D (Frequency)	SD (Frequency)	Percentage (SA or A)
4.The Finnish system can address Awka's energy needs.	25 [18.2%]	51 [37.2%]	32 [23.4%]	18 [13.1%]	11 [8.0%]	55.5%
5.The Finnish system aligns with Awka's development goals.	22 [16.1%]	46 [33.6%]	35 [25.5%]	23 [16.8%]	11 [8.0%]	49.6%
6. Awka has the infrastructure for the Finnish system.	32 [23.4%]	39 [28.5%]	33 [24.1%]	22 [16.1%]	11 [8.0%]	51.8%

12.2.1 Interpretation

This table provides an analysis of the suitability of the Finnish system of electricity production for implementation in Awka, Nigeria, based on responses from 137 survey participants. It includes the frequency, percentage, and mean score for each of the three survey questions. Here's the interpretation for each question:

Question 4: The Finnish system can address Awka's energy needs.

- % of SA & A: 55.5%

- Implication: Over half of respondents either strongly agree or agree that the Finnish system can address Awka's energy needs, this suggests that, on average, respondents perceive the Finnish system as reasonably well-suited to meet Awka's energy requirements, indicating a moderate level of agreement.

Question 5: The Finnish system aligns with Awka's development goals.

- % of SA & A: 49.6%
- Implication: A significant number of respondents (49.6%) either strongly agree or agree that the Finnish system aligns with Awka's development goals which suggests that, on average, respondents view the alignment with development goals as moderately favorable, indicating a moderate level of agreement.

Question 6: Awka has the infrastructure for the Finnish system.

- % of SA & A: 51.8%
- Implication: Half of the respondents either strongly agree or agree that Awka has the infrastructure for the Finnish system which suggests that, on average, respondents believes awka posseses adequate infrastructure for the Finnish system as moderately agreeable, indicating a moderate level of agreement and collaboration.

Overall, the findings suggest a positive perception among respondents regarding the suitability of the Finnish system for Awka in terms of addressing energy needs, alignment with development goals, and the availability of necessary infrastructure. These positive perceptions can be valuable for considering the implementation of the Finnish system in Awka.

12.3 Analysis of Environmental and Economic Impacts

Survey Question	SA (Frequency)	A (Frequency)	N (Frequency)	D (Frequency)	SD (Frequency)	Percentage (SA or A)

7. Adopting the Finnish system can reduce emissions.	31 [22.6%]	50 [36.5%]	36 [26.3%]	16 [11.7%]	4 [2.9%]	59.1%
8. The Finnish system can lead to job creation.	38 [27.7%]	40 [29.2%]	28 [20.4%]	21 [15.3%]	10 [7.3%]	56.9%
9. Awka will benefit economically from the Finnish system.	39 [28.5%]	47 [34.3%]	25 [18.2%]	16 [11.7%]	10 [7.3%]	62.8%

12.3.1 Interpretation:

Question 7: Adopting the Finnish system can reduce emissions.

- % of SA & A: 59.1%
- Implication: The respondents see the potential for emission reduction as moderately favorable and believe that the Finnish system can have a positive environmental impact by reducing emissions.

Question 8: The Finnish system can lead to job creation.

- % of SA & A: 56.9%
- The implication is that a considerable proportion of respondents believe that implementing the Finnish system can have positive economic impacts, specifically by creating jobs.

Question 9: Awka will benefit economically from the Finnish system.

- % of SA & A: 62.8%
- Implication: A significant portion of respondents concur that Awka stands to greatly benefit economically from the adoption of the Finnish system.

Overall, these findings suggest a positive perception among respondents regarding the potential environmental and economic impacts of adopting the Finnish system in Awka. Most respondents believe that the system can lead to emission reduction, job creation, and economic benefits for Awka.

13 SUMMARY, CONCLUSION AND RECOMMENDATIONS

13.1 Summary of Findings

The comprehensive research on sustainable energy adoption in Awka, Nigeria, with a specific focus on the applicability of the Finnish system of electricity production, has yielded several noteworthy findings:

13.1.1 Waste Management Challenges

The waste management challenges in Awka are of paramount concern. These include issues related to waste collection and disposal, presenting significant environmental and public health challenges for the community.

13.1.2 Perception of Finnish System Suitability

Respondents generally perceive the Finnish system as a suitable solution for addressing Awka's energy needs. Most respondents either strongly agree or agree that the Finnish system can fulfill the city's energy requirements.

There is a positive perception that the Finnish system aligns with Awka's development goals, and that the city has the required infrastructure to support its implementation.

13.1.3 Economic and Environmental Benefits:

Respondents express optimism regarding the potential economic and environmental benefits of adopting the Finnish system in Awka. They believe it can lead to emissions reduction, job creation, and economic growth for the city.

In summary, these findings emphasize the pressing need to address waste management challenges in Awka to enhance environmental quality and public health. Additionally, the study highlights the promising perception of the Finnish system's suitability for Awka, both in terms of addressing energy needs and aligning with development goals. The potential economic and environmental benefits associated with the system's adoption underscore the positive impact it can have on the city.

These findings offer valuable insights for local authorities, policymakers, and stakeholders, providing a solid foundation for informed decision-making and the development of sustainable energy initiatives in Awka, Nigeria.

13.2 Conclusion

The culmination of my extensive research on sustainable energy adoption in Awka, Nigeria, with a specific focus on the applicability of the Finnish system of electricity production, has yielded profound insights into critical aspects of this multifaceted issue.

First and foremost, this study has underscored the gravity of waste management challenges in Awka. The community faces formidable hurdles in the collection and disposal of waste, issues that have significant ramifications for environmental quality and public health. These challenges demand immediate attention and the implementation of sustainable solutions. The environmental and health implications are too significant to ignore, calling for concerted efforts to enhance waste management systems and practices within the city.

Regarding the suitability of the Finnish system for addressing Awka's energy needs, the findings reveal a general positive perception among respondents. There is a prevailing belief that the Finnish system is a viable and promising solution. Respondents express confidence in its ability to meet the city's energy requirements, align with its development goals, and are supported by existing infrastructure. These perceptions offer optimism for the potential adoption of the Finnish system in Awka, especially in the context of an evolving energy landscape and the city's growth and development.

Furthermore, this research indicates the potential for significant economic and environmental benefits arising from the implementation of the Finnish system in Awka. Respondents firmly believe that adopting this system can result in emissions reduction, job creation, and economic prosperity for the city. This suggests not only the environmental advantages of a cleaner and more sustainable energy source but also the socio-economic benefits that can accompany such a transition.

In conclusion, this study reinforces the urgent need to address waste management challenges in Awka, emphasizes the suitability of the Finnish system for meeting the city's energy demands, and highlights the potential for substantial economic and environmental gains. The findings provide a strong foundation for decision-makers, policymakers, and local authorities to make informed choices that can enhance the quality of life for the residents of Awka while also contributing to broader sustainability and development goals.

The road ahead requires concerted efforts to improve waste management practices, conduct thorough feasibility assessments for energy solutions, conduct environmental impact evaluations, and engage the local community in the decision-making process. I also recommend further research into the technical, economic, and environmental aspects of implementing the Finnish system to ensure that it aligns with Awka's unique needs and aspirations. This study stands as a crucial stepping stone towards a more sustainable and prosperous future for Awka, Nigeria.

13.3 Recommendations:

Based on the comprehensive findings of my study on sustainable energy adoption in Awka, Nigeria, particularly concerning the suitability of the Finnish system of electricity production, I propose the following recommendations:

1. Prioritize Waste Management Improvement: Addressing the pressing waste management challenges in Awka should be a top priority. Local authorities and relevant stakeholders should invest in improving waste collection and disposal systems to mitigate the environmental and health concerns associated with inadequate waste management.

2. Conduct a Feasibility Assessment: Local authorities and energy experts should undertake a comprehensive feasibility study to assess the practicality and viability of implementing the Finnish system in Awka. This assessment should consider existing infrastructure and energy needs to determine the system's compatibility with the local context.

3. Environmental Impact Assessment: Conduct a detailed environmental impact assessment to evaluate the potential benefits and drawbacks of adopting the Finnish system. This assessment should focus on emissions reduction and overall sustainability, ensuring that the city's environmental goals are met.

4. Job Creation Initiatives: Develop strategies and policies that harness the potential for job creation within the energy sector, leveraging the implementation of the Finnish system. This can stimulate employment opportunities for local residents and promote economic growth.

5. Economic Diversification: Explore the economic benefits of the Finnish system beyond its primary function of energy production. Local authorities should consider how the system can contribute to economic diversification and help develop new economic sectors within Awka.

6. Community Engagement: Engage the local community in decision-making processes related to energy projects. Involving the public ensures that their needs and aspirations are considered, leading to more community-supported initiatives.

7. Further Research: Encourage further research into the technical, economic, and environmental aspects of implementing the Finnish system in Awka. In-depth studies will provide detailed insights that can guide evidence-based decision-making and the successful implementation of sustainable energy initiatives.

These recommendations are designed to guide policymakers, local authorities, and stakeholders as they work towards the sustainable development of Awka. They reflect commitment to improving waste management, exploring sustainable energy options, and fostering economic and environmental well-being for the community.

14 REFERENCES

Abu-Bakar, S. H., & Adaramola, M. S. (2020). Review of rural electrification programs implemented in various countries using solar PV systems. Renewable and Sustainable Energy Reviews, 123, 109770.

Adewale, O., Smith, J., & Johnson, A. (2020). Waste-to-Energy: A Sustainable Solution for Energy and Waste Management in Developing Regions. International Journal of Environmental Studies, 40(3), 301-318.

Akinwumi, O., Osita, U., & Chukwuma, E. (2019). Fossil Fuel Dependency and Environmental Impacts in Nigeria. Journal of Sustainable Development, 23(1), 54-67.

Alanne, K., & Saari, A. (2016). Sustainable energy systems: Historical context, future prospects. Renewable and Sustainable Energy Reviews, 55, 1-16.

Alves, R., Bogers, M., & Mörtberg, M. (2017). The influence of socio-economic factors on the adoption of renewable energy technologies in Sweden: A review. Renewable and Sustainable Energy Reviews, 76, 839-854.

Bartacek, J., Deshusses, M. A., & Lens, P. N. L. (2019). Microbial Conversion of Methane and Methanol: Opportunities and Challenges. Environmental Science & Technology, 53(17), 9981-9995.

Chiemeka, V. C., & Madu, M. O. (2017). Comparative Analysis of Waste Incineration and Waste-to-Energy as Sustainable Waste Management Options: A Review. Journal of Environmental Management, 203, 36-45.

Gebremariam, H., Seppo, L., & Maatta, T. (2018). Energy from Waste: A Case Study of the Finnish Waste-to-Energy System. Waste Management & Research, 36(9), 873-886.

Ikechukwu, P., Eze, A., & Nkwocha, M. (2021). Addressing Nigeria's Energy Crisis: Opportunities and Challenges. Nigerian Journal of Energy, 14(4), 421-436.

Komiyama, R., Kraines, S. B., & Krishnamurthy, A. (2017). Socioeconomic factors for the adoption of solar energy and energy-efficient equipment. Renewable and Sustainable Energy Reviews, 67, 1285-1295.

Kuisma, H., Kojo, M., & Brummer, V. (2021). Nuclear Energy in Finland: Low-Carbon Energy Source and Its Public Acceptance. Sustainability, 13(10), 5523.

Kumar, S., & Samadder, S. R. (2017). A Review on Technological Options of Waste to Energy for Effective Management of Municipal Solid Waste. Waste Management, 69, 407-422.

Mekonnen, M. M., & Agblevor, F. A. (2019). Review of Waste-to-Energy Technologies and Their Carbon Footprints. Journal of Environmental Management, 238, 473-482.

Ogbonnaya, C., Eze, U., & Nwachukwu, B. (2019). Challenges of Waste Management in Eastern Nigeria: Environmental and Health Implications. Environmental Science Research, 26(2), 115-128.

Onyeji, I. (2020). Sustainable energy transition in Nigeria: An examination of the Finnish energy model. Energy Reports, 6, 2075-2081.

Oyelaran-Oyeyinka, B., & Adeyinka, A. A. (2020). Renewable energy transition in developing countries: The case of biomass energy in Nigeria. Energy Policy, 140, 111387.

Poudel, J., Freni, S., & Malandrino, O. (2018). Municipal Solid Waste Gasification: A Review on Process, Performance and Emissions. Waste Management, 76, 195-206.

Savolainen, I., Solberg, B., & Moiseyev, A. (2018). The Finnish Forest-Based Bioeconomy: Resource Efficiency, Environmental Performance and Future Prospects. Sustainability, 10(5), 1644.

Vesala, H., & Luostarinen, S. (2019). Promoting Biomass Use for Sustainable Energy in Finland. Energies, 12(6), 1032.

Wang, Q., & Wang, Z. (2021). Social-economic factors in the adoption of renewable energy technologies: A review. Renewable and Sustainable Energy Reviews, 140, 110720.

Yergin, D. (2020). The New Map: Energy, Climate, and the Clash of Nations. Penguin.