UNIVERSITY OF CAPE COAST

ENERGY HUMANIZATION, INSTITUTIONAL ENVIRONMENT, AND SECTORAL GROWTH IN GHANA

JOSEPH KWASI ASAFO

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BY

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MARCH 2024

DECLARATION

Candidate's Declaration

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

Signature……………………………….

Date………………………………

Candidate's Name: Joseph Kwasi Asafo

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Signature……………………………….

Date………………………………

Principal Supervisor's Name: Prof. Emeritus Omowumi O. Iledare

Signature……………………………….

Date………………………………

Co-Supervisor's Name: Dr Eric Amoo Bondzie

ABSTRACT

The study constructs an energy humanization index for Ghana, estimates the impact of energy humanization dimensions on sectoral growth, and evaluates the moderating influence of institutional environment on the energy-growth relationship. The study employed the minimum-maximum normalization, exponential smoothing forecasting method, and the Dynamic Ordinary Least Square (DOLS) estimation technique for its analysis. Data was sourced from WDI, EIA, The global economy and Energy Commission of Ghana. The study reveals a positive trend in energy humanization, particularly in energy usage. However, concerning energy security, Sub dimensions such as energy acceptability, affordability, and technology application have exhibited a decreasing trend, which is anticipated to worsen in the future if significant interventions are not implemented. Conversely, energy availability has demonstrated a consistent increasing trend. Furthermore, the study highlights the positive contribution of energy humanization to growth across all sectors of the economy. Whilst energy security as a disaggregated component of energy humanization has no impact on sectoral growth, energy usage emerged as a significant factor affecting growth in Ghana. Finally, the study shows a positive moderating role of both political and economic institutions in the energy humanization and sectoral growth relationship in Ghana. The study recommends the use of carbon capture by IPPs and energy sector policies must deal with energy security and energy usage simultaneously as opposed to treating them separately. The Ministry of Finance must be circumspect in imposing more taxes on petroleum products and electricity tariffs although they are inelastic goods.

KEY WORDS

Energy Consumption

Energy Humanization

Energy Security

Energy Usage

Institutional Environment

Sectoral Growth

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DEDICATION

To my parents, Godson Worlanyo Asafo, and Stella Mawusi Asafo for their continues support, advice, and sacrifices.

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LIST OF ACRONYMS/ABBREVIATIONS

AC	Social Acceptability
AF	Energy Affordability
AP	Technology Application
APERC	Asia Pacific Energy Research Centre
AR	Autoregressive
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
AV	Energy resource Availability,
BDSs	Bulk Oil Distributing Companies
BOST	Bulk Oil Storage and Transportation Company Limited
DOLS	Dynamic Ordinary Least Square
ECG	Electricity Company of Ghana
EIA	Energy Information Administration
ES	Energy Security
ES	Energy Security
FDI	Foreign Direct Investment
GFCF	Gross Fixed Capital Formation
GNPC	Ghana National Petroleum Corporation
GRIDCo	Ghana Grid Company
ICRG	International Country Risk Guide's
IEA	International Energy Agency
IMF	International Monetary Fund
IPPs	Independent Power Producers
MA	Moving Average

MMbbl	One million barrels of oil
MMscf	Million standard cubic feet
NED	Northern Electricity Department
NGTU	Natural Gas Transmission Utility
NPA	National Petroleum Authority
OAPEC	Organization of Arab Petroleum Exporting Countries
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
OMCs	Oil Marketing Companies
PCA	Principal Composite Analysis
POP	Annual Growth Rate of Population
PURC	Public Utilities Regulatory Commission
SDG	Sustainable Development Goal
TEN	Tweneboa Enyenra Ntomme
TOT	Openness to International Trade
UN	United *Nations*
UNDP	United Nations Development Program
V-Dem	Varieties of Democracy
VRA	Volta River Authority
WB	World Bank
WDI	World Development Indicators

CHAPTER ONE

INTRODUCTION

Energy plays a crucial role in driving economic expansion, as numerous production and consumption activities heavily rely on it as a fundamental input. Looking at it from a physical perspective, the utilization of energy propels economic productivity and industrial growth, serving as a core component in the functioning of contemporary economies (Asghar, 2008). The intricacy of human civilization necessitates a steady provision of diverse forms of energy. When primary energy resources are extracted and transformed, secondary forms of energy are then created. These products are then used for a variety of purposes, including transportation, building heating, manufacturing, etc. Therefore, ensuring a steady supply of these items is essential for a nation's general welfare.

Renewable and non-renewable energy are the two primary categories into which energy sources may be divided (Kahia, Aïssa, and Charfeddine, 2016). Renewable energy resources are energy resources that are self-replenish after` being used. Examples are Solar, wind, water (hydro) and biomass. Although their supply is unlimited over the long haul, they are mostly limited in availability at a given point in time as a result of energy adaptability, technology, economics and perhaps government policy interventions.

Since the late 2000s, renewable energy has seen the world's highest rate of growth (Apergis and Payne, 2012; Güney, 2019). The primary driver of the increase in renewable energy is climate change, one of the biggest issues facing the globe today. As a result, governments increase their spending on renewable energy, particularly in the most developed and some emerging nations example

Brazil and China. The last 22 years have seen a substantial increase in interest in renewable energy (Güney, 2019). Effective renewable energy policies may, in fact, lower greenhouse gas emissions, which can slow down climate change; in other words, renewable energy can support sustainable economic growth through an energy mix approach instead of full reliance on only renewable energy and vis versa (Kim & Park, 2018; Onwuka, Iledare & Echendu, 2016). Another factor contributing to the increase in renewable energy consumption is technical advancement, which lowers the overall cost of infrastructure for installing renewable energy (Gozgor, Lau & Lu, 2018). The incredible price volatility in the oil markets over the past ten years is also an important element that has contributed to the emergence of renewable energy sources, claim Apergis and Payne (2010).

Non-renewable energy is derived from sources that have limited reserves and will not naturally replenish over thousands or even millions of years, as stated by Kahia et al., (2016). The majority of non-renewable energy sources are fossil fuels, which formed from the decomposition of ancient marine organisms over millions of years, subjected to immense pressure and heat. These fossil fuels are predominantly burned to generate energy and electricity. Examples of non-renewable energy encompass coal, oil, natural gas, and nuclear energy. While non-renewable energy has certain drawbacks, such as adverse environmental effects and the depletion of finite resources, it also offers advantages. For instance, non-renewable energy sources often exhibit greater reliability compared to renewable alternatives like wind or solar power, which can be influenced by weather conditions. Also, fossil fuels which are mostly non-renewable energy sources are extremely energy dense, containing a great quantity of energy in a small volume or mass. As a result, they are an efficient source of energy that can be readily transported and stored. Again, non-renewable energy is frequently less expensive than renewable energy. This is because the technology needed to collect and utilize non-renewable energy sources is well established, and the infrastructure is already in place.

1.1 Background of the Study

Sustainable energy has emerged as a focal point for governments and energy policymakers worldwide, owing to its crucial role in guaranteeing an uninterrupted and dependable energy supply that enhances well-being, improves the quality of life, and supports sustainable environmental and economic development. Policymakers are actively pursuing net-zero targets to curtail greenhouse gas emissions through the promotion of renewable energy sources and the enhancement of energy efficiency. The “Agenda 2030 for Sustainable Development" underscores the pressing need to humanize energy by 2030, with the goal of ensuring universal access to affordable, reliable, sustainable, and modern energy.

These efforts encompass increased investments in renewable energy projects, the implementation of energy efficiency policies, the fostering of international cooperation, and the enhancement of public awareness. Furthermore, striking a balance between sectoral growth and sustainable energy practices is of paramount importance, as it addresses the challenges faced by energy-intensive industries and ensures that economic development aligns with environmental objectives. These collective endeavours are indispensable in attaining a future that is both sustainable and secure in terms of energy.

The history of energy is a long and complex one that spans thousands of years. The earliest forms of energy use can be traced back to prehistoric times when early humans discovered the power of fire, which they used for cooking, heating, and lighting. The use of fire was so important to early humans that it is believed to have played a key role in the evolution of our species (Gipe, 2019; Smil, 2018). Over time, humans began to develop more sophisticated ways of harnessing energy. For example, the use of waterpower to grind grain dates to ancient times, with the first water mills appearing in the Middle East around 200 BC (Smil, 2018). Wind power was also used in ancient times to power sailboats and windmills, and by the 12th century, windmills had become an important source of power in Europe (Gipe, 2019).

The Industrial Revolution during the 18th and 19th centuries signified a notable transformation in the history of energy utilization. Coal became the primary source of energy for steam engines used in transportation and manufacturing, and the demand for coal increased dramatically as a result. The discovery of oil and natural gas in the 20th century further fuelled the demand for energy, and these fossil fuels became the dominant sources of energy for most of the 20th century (Gipe, 2019; Smil, 2018). Nuclear energy emerged as a new source of power in the mid-20th century, with the first nuclear power plant being built in 1954. While nuclear energy has the potential to produce large amounts of energy with relatively low greenhouse gas emissions, safety concerns and high costs have limited its adoption (Gripe, 2019). Renewable energy sources including solar, wind, hydro, and geothermal energy, which are environmentally sustainable and emit fewer greenhouse gases than fossil fuels, have attracted more attention in recent years. As nations try to cut their carbon emissions and move to a more sustainable energy future, the usage of renewable energy sources is anticipated to increase in the upcoming years (Gripe, 2019).

Due to the importance of energy in the everyday life of a nation, the security of its supply has turned into a geopolitical concern because our societies still rely significantly on these resources to operate. Initial worries about energy security emerged as a result of the oil crisis in the 1970s (Blum & Legey, 2012). The first oil crisis, which began in October 1973, demonstrated how susceptible industrialized economies are to fluctuations in oil prices (Gasser, 2020). The Organization of Arab Petroleum Exporting Countries (OAPEC) placed an oil embargo on the Netherlands, Portugal, Rhodesia (Zimbabwe), Japan, UK, Canada, USA, and South Africa. The Yom Kippur War, which had nothing to do with energy, was the catalyst for the embargo (Rabinovich, 2007). This strategy of using oil as leverage for political purposes is referred to as the "oil weapon". As a result, the price of a barrel of oil increased internationally from US$ 3 to US$ 12. In order to respond to actual interruptions in the oil supply, the International Energy Agency (IEA) was established in 1974. The IEA quickly established a reputation as a reliable source of data and information on the global energy market (Paravantis et al., 2019). It developed into a preeminent international body for energy security over time and began assisting both member and non-member countries with their policymaking (Gasser, 2020).

Following significant occurrences like the September 11 attacks in 2001, Hurricane Katrina in 2005, and the Russia-Ukraine gas dispute in 2005–2006, the idea of risks expanded beyond conventional disputes between or within states. These events introduced new dimensions of risk, encompassing manmade and natural disasters, along with threats from terrorists or non-state actors engaging in cyberattacks (Irie, 2017). Many industrialized nations today view energy security as a subject of national security (Månsson, Johansson & Nilsson, 2014). The concept of energy security and its goals may, however, differ due to the differences in natural resources, political systems, economic well-being, ideologies, and geographical locations among various countries (Gasser, 2020).

The world is so much concerned about energy due to the following reasons; energy demand, climate change, energy security, resource depletion, and cost of energy (IEA, 2019). Energy demand is making the world pay attention to energy because as the world's population and economies grow, so does the demand for energy. To fulfil the demands of a rising global population, new and sustainable energy sources must be developed. This growth in energy demand puts strain on the energy systems and resources that are currently in place. Also, energy is a vital component of modern society and is essential for powering homes, businesses, transportation, and industry. Without a reliable and affordable source of energy, growth can be hindered, and quality of life can be negatively impacted (International Energy Agency, 2019). Therefore, addressing energy demand and ensuring a sustainable energy supply is a major global challenge and requires ongoing attention and investment.

The second reason why energy is of much concern to the world is climate change. While energy is a crucial factor for advancement, the combustion of coal, natural gas, and oil to generate energy releases heat-trapping gases like carbon dioxide, contributing to climate change. The lack of effective action to tackle this issue is accelerating the ongoing climate crisis (De

Cian & Sue Wing, 2019). If emissions remain unchecked, the global temperature could rise by up to 2.7 degrees Fahrenheit compared to preindustrial levels by 2040, as indicated in the October 2018 Special Report on Global Warming by the Intergovernmental Panel on Climate Change—an assembly of international scientists authorized by the United Nations to provide guidance to world leaders (Stark, 2019).

While the significance of energy for macroeconomic stability is undisputed, numerous scientific studies, including Manoranjan (2012), emphasize that energy consumption directly affects the atmosphere and climate. The impacts of energy use are evident through heightened carbon concentrations, greenhouse effects, and global warming. Therefore, it is imperative to prioritize sustainable management and transition towards cleaner energy sources to ensure environmental sustainability. This has led to widespread concern about the impacts of climate change and the need to transition to cleaner, renewable sources of energy that produce fewer emissions and have a lower impact on the environment. As a result, many governments and organizations are investing in research and development of renewable energy technologies, such as wind and solar power, and implementing policies to encourage their adoption and reduce the use of fossil fuels. Other reasons such as energy security, resource depletion and cost of energy are expounded by IEA (2019) why energy is of much concern.

The conflict between Russia and Ukraine began in February 2014, sparked by disagreements over Crimea and Donbas. Tensions escalated dramatically after Russia's extensive invasion on February 24, 2022, leading to an unparalleled level of strain between the nations. Many governments and businesses globally have imposed significant economic sanctions on the Russian government in response (Funakoshi, Lawson, & Deka, 2022). Russia is a major exporter of oil, gas, and coal in the energy markets in particular. The battle appears to have boosted global stock prices, notably in the renewable energy industries (Umar, Riaz & Yousaf, 2022). Given that the Russian Federation is the principal supplier of natural gas and the second-largest exporter of oil, the situation in Ukraine has also had an effect on the supply of fossil fuels and the wider market.

The rising energy prices may force many developing countries out of energy markets, putting the most vulnerable people at risk. Such a situation is already having an impact on hard-won gains in energy access and poverty reduction, and progress has already been interrupted as a result of the pandemic. This situation is exacerbated by the food and financial difficulties experienced in these nations due to the conflict in Ukraine and the pandemic, placing significant social and economic pressure on governments. A potential "fuel scramble" in which only the highest-paying countries gain access would be devastating for a global system based on trust and proportionality.

Aside the fact that energy is required as a basic input for every production process, energy usage or consumption has also been speculated to have some form of relationship with quality of life which can be measured using the Human Development Index (Smil, 2004; Tasik, 2020). Figures 1.1 and 1.2 illustrate energy consumption per person and Human Development Index respectively.

From Figures 1.1 and 1.2, we can say countries or continents that use or have access to high levels of energy consumption person per person do have higher human development index. Nsenkyire, Nunoo, Sebu and Iledare (2023) alluded to the fact that the lack of access and inability to afford energy and its related services do affect the quality of life, especially, those of children in terms of their health, education and cognitive skills as in the case of Ghana.

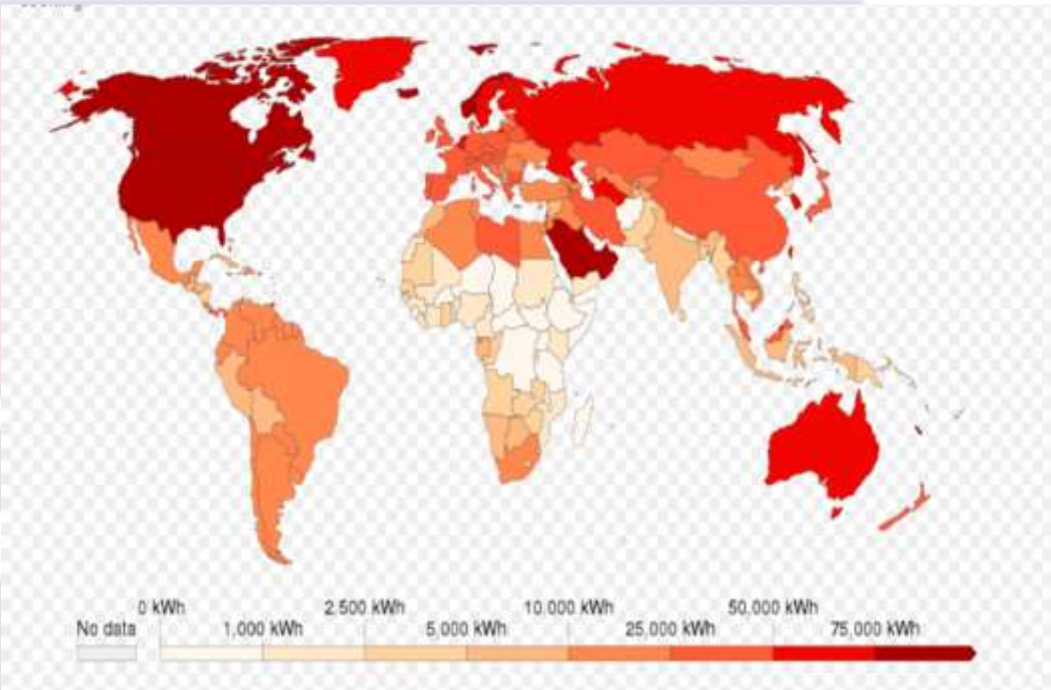

Figure 1. 1: Energy use per person, 2021
Source: Our World in Data based on BP & Shift Data Portal.

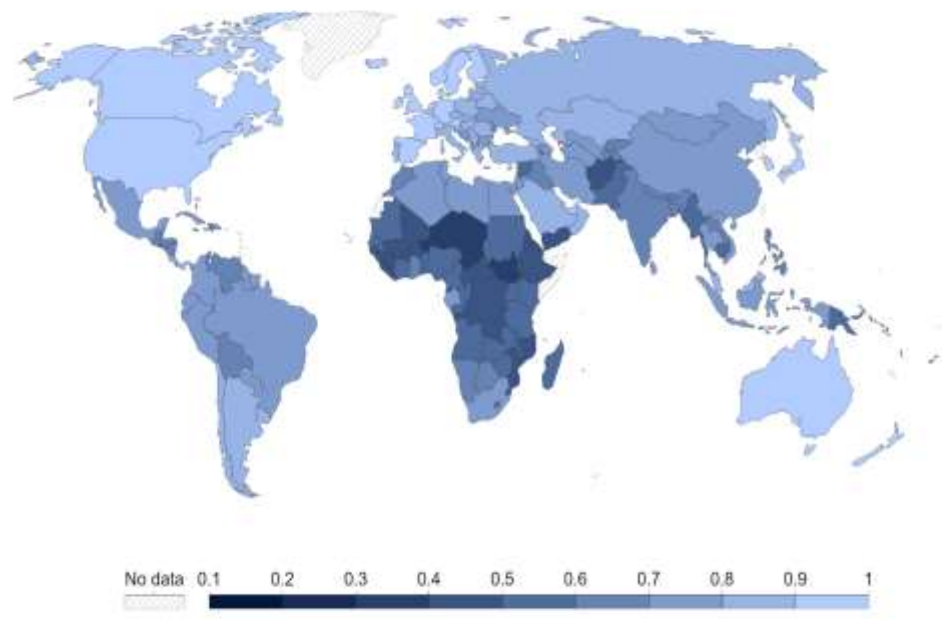

Figure 1. 2: Human Development Index, 2021
Source: Our World in Data.

The concept of "Energy humanization" is relatively new. It was prominently introduced by the World Energy Council during the November 2021 World Energy Week and further discussed at their 25th World Energy Congress in St. Petersburg in October 2022. By energy humanization we mean dealing with issues of energy security and energy usage simultaneously. According to Dr Angela Wilkinson, Secretary General of the World Energy Council, many individuals lack awareness of their energy use patterns, costs associated with energy usage, the expenses involved in transitioning to alternative sources, or their involvement in this process, in discussions about energy. Hence there need to study "energy humanization", a concept that argues that the issues of energy security and energy usage should be considered simultaneously. Whilst energy security in this context captures energy affordability, adaptability (technology application), availability, and acceptability, the concept of energy usage will capture energy use and its patterns.

Given the paramount importance of energy in every economy, ensuring the security of its supply is imperative for all economies (Ang, Choong & Ng, 2015). Numerous studies have attempted to explore the issue of energy security from numerous angles, including global relations and national security (Dyer & Trombetta 2013). A distinct and straightforward definition of energy security is hampered by several significant problems. The utilization of energy resources varies in kind and intensity at different stages of development because the nations have diverse energy resources (Chester, 2010). Each nation makes its own goals for the future and establishes diverse objectives as a result of the various historical, political, and social specificities (Leung, 2011). Therefore, it is most plausible to suggest that the approach for gauging energy security in a certain nation can only be regarded as relevant at a specific time. The measuring approach must be adjusted to reflect the Strategic priorities in time and in space.

Energy security have been defined and measured differently depending on the institution, organization or country exploring the concept (Winzer, 2012). For example, according to the Institute of Energy Economics, Japan (IEEJ), Energy security means "securing adequate energy at reasonable prices necessary for the people's lives, and economic and industrial activities of the economy" (Alekhina, 2021). Whilst IEA defines it as an "Uninterrupted physical availability of energy at a price that is affordable while respecting environmental concerns" (Smal & Wieprow, 2023). Also, Asia Pacific Energy Research Centre (APERC) defines "energy security as adequate energy supplies at reasonable and stable prices to sustain economic performance and growth" (Taghizadeh-Hesary, Sarker, Mortha, & Kim, 2021). APERC assess energy security in terms of 'availability', 'accessibility', 'acceptability', and 'affordability'. Furthermore, energy security can be defined as "Sustainable production and use of energy at reasonable costs in order to facilitate economic growth and improve the quality of people's lives" according to the World Bank. Last but not the list United Nations Development Program (UNDP) defines energy security as the "Continuous availability of energy in varied forms, in sufficient quantities and at reasonable prices"(Abdullah et al., 2020). This demonstrates that the definition of energy security, its dimensions and concerns vary from institution to institution, country to country and from one geopolitical area to another.

Africa currently ranks lowest globally in per capita modern energy usage (IEA, 2022). As the population and income levels rise, the need for modern energy is projected to increase by a third between 2020 and 2030. However, the existing price hikes have the potential to triple the energy subsidies required in African nations by 2022, posing a challenging situation for those already burdened with significant debt, as indicated in the 2022 African Energy Outlook (IEA, 2022). International assistance is essential for price control in the medium term, but it is crucial to more efficiently direct subsidies toward the most vulnerable, as stated in the Africa Energy Outlook 2022. This is important because energy poverty adversely affects health, education, and cognitive skills, underscoring the importance of better-targeting subsidies to those in dire need (Nsenkyire, et al., 2023).

Africa's trade, economy, and agriculture are all expanding, which raises the need for energy. The Africa Energy Outlook 2022 forecasts an increase in energy use in transportation, industry, and agriculture of almost 40% by 2030. Africa is actively decreasing its import dependency, constituting over 20% of its GDP, by expanding the manufacturing of steel, cement, fertilizer, automobiles, and sustainable energy technologies. Some industrial sectors use more of the most advanced, efficient technologies (IEA, 2022). Electric irrigation pumps reduce the demand for diesel generators and boost agricultural productivity and the likelihood that these products will reach urban markets.

Currently, Africa's electricity supply is in a terrible state, which is halting progress. Outside of North Africa, about 50% of people have access to electricity, despite a 4% decline since 2019. Consumption is far lower than the global average due to frequent brownouts, blackouts, and load shedding when electricity is present. The average user consumes less than 200 kWh, which is less than what is needed to run a contemporary refrigerator (Alemzero, Sun, Mohsin, Iqbal, Nadeem & Vo, 2021). Electrical networks in sub-Saharan Africa frequently fail to support the area's existing generation capacity, making it hard to meet demand, even in the industrial powerhouses of South Africa and Nigeria. Nigeria, a nation of 206 million people, is predicted to have an electrical generation capacity of 12 gigawatts (GW). Brazil has a generating capacity of 181 GW and a population of 212 million. Nigeria's grid infrastructure can only support 4 to 5 GW of the country's 12 GW total generation capacity at any given moment. 43 percent of Nigeria's population lacks access to power for a variety of reasons, including this one. Individual projects are less viable and riskier when there is a dearth of investment, especially in the view of the private sector, which has historically sponsored around 10% of infrastructure throughout the continent (Alemzero, et al., 2021; Mulugetta, et al., 2022).

Higher GDP growth in Africa is linked to increased energy usage and improvements in affordability, accessibility, acceptability, and availability of energy. Africa, which has the youngest and fastest-growing population of any continent, is projected to have 13 of the top 20 urban areas globally by the turn of the century (Alemzero, et al., 2021; IEA, 2022). In addition to driving industrialization in the modern era, Africa's young and expanding population has the potential to provide the world with a skilled workforce, leading to job creation and opportunities within African communities. This, in turn, can stimulate global economic growth, similar to China's experience over the past four decades. However, one of the limitations to achieving this milestone is the requirement for sufficient energy to support this growth (IEA, 2022; Mulugetta, et al., 2022).

Ghana, since its independence, has experienced relatively reliable energy especially electricity supply (Arthur & Locher, 2022). However, between 2014 and 2016, the country faced a severe power supply crisis, which left many unprepared businesses at risk (Arthur & Locher, 2022; Gbeve 2016). The power crisis and the ensuing load shedding, which resulted in power rationing, severely harmed a number of SMEs in key cities, including Accra, Kumasi, and Takoradi (Gbeve, 2016). Numerous businesses, particularly small ones, failed to withstand the power outage (Cobbinah & Adams, 2018). Many businesses with the needed financial muscle invested in the acquisition of pricey standby generators or plants to act as a backup for their operations as an alternate reaction to the energy crisis (Abeberese, Ackah & Asuming, 2021). Because some businesses could not afford the considerably more costly alternative, there were forced to cut back on their working hours. As a result, production decreased, profit margins shrunk, and in certain extreme circumstances, some businesses collapsed (Gbeve, 2016).

Despite facing obstacles, Ghana has made significant progress in terms of electricity coverage by 2021, with 86.63 percent of the population having access to electricity. Among them, 91 percent of urban dwellers and 50 percent of rural residents are connected to the national electricity grid. However, it is important to note that the energy industry in Ghana is burdened with debt. This is primarily due to high generation costs, government subsidies, unpaid consumer bills, infrastructure needs, financial mismanagement, and external economic influences. Unfortunately, this debt and Ghana’s high cost of electricity production are hindering the country’s Sectoral growth hence overall economic growth.

1.2 Statement of the Problem

Every economy aims to achieve sustainable economic growth and improve the quality of life of its citizens. This objective necessitates economic development through the enhancement of output levels and efficiency standards for goods and services, thus boosting overall productivity and well-being. Economists such as Adam Smith and mainstream economic theory viewed labour and capital as the main factors in production and the main forces driving growth and development (Asafo, 2020). Recent literature and theories such as endogenous growth theory proposed technological innovation, human capital development from the private sector as well as energy are important variables that must also be taken into consideration.

The progress of a nation’s economy is significantly reliant on its energy accessibility. Energy is widely utilized in agriculture and its associated sectors, encompassing the manufacturing and distribution of fertilizers, pesticides, and agricultural machinery. Additionally, households rely on energy for heating, lighting, and cooking. Without a reliable supply of energy, homes, companies, and society cannot operate to their full potential. Hence the essence of SDG 7, which seeks to “ensure access to affordable, reliable, sustainable and modern energy for all”. According to the United Nations (UN), lack of access to energy sources and transformation systems hinders human and economic development. This clearly showed that attaining several of these SDG Goals are all hinged on the attainment of Goal 7. Therefore, ensuring energy security and energy usage is essential for a nation's general welfare hence the importance of humanization energy.

Although the concept of energy security has been a topic of discussion for centuries and is often considered "ancient as fire," empirical or scientifically rigorous analyses adhering to research norms and principles were rare prior to 2001 (Ang et al., 2015). However, in the twenty-first century, it has become one of the key subjects of concern to researchers and policy makers. The concern for energy security arises from the understanding that a continuous and dependable energy supply is vital for the stability of any economy. Also, energy security has attracted renewed concern owing to the oil crises of the 1970s and 1980s, high oil prices, and recent conflicts in the global supply chain, especially the recent Russia-Ukraine.

A systematic review by Gasser (2020) argued that most of the studies on energy security largely focused on countries in North America, Europe, and Asia and even if the concept of Africa and South America comes into the conversation, it is largely how their energy resources can help the advanced world secure their energy need of which the case of Ghana is of no difference. This view of Gasser (2020) is confirmed by the works Abdullah et al., (2020), Azzuni and Breyer (2020), Augutis et al., (2020), and Radovanovic, Filipovic, and Pavlovic (2017) whose work on the measurement of energy security largely focused on developed countries.

As expounded in the background, the main reason why we are very concerned about energy humanization dimensions and energy security is the importance of energy in the growth and development of a nation. The energy-growth nexus is the subject of four hypotheses. The first, known as the "growth hypothesis," maintains that increased energy usage is a direct contributor to increased economic growth (Salari et al., 2021). The "conservation theory," which claimed that growth drives energy use, comes in second. The "feedback hypothesis," which asserts that growth and energy use are causally related in both directions, comes in third place. According to the "neutrality hypothesis," there is no statistically significant link between the expansion of the economy and energy use.

Studies such as Apergis and Payne (2012), Sebri and Ben-Salha (2014), Chang et al. (2015), Bhattacharya, Churchill, and Paramati (2017), Gozgor, Lau and Lu (2018) all conducted at the global level or in advanced countries concluded differently on the impact of energy use on growth. Specifically Apergis and Payne (2012), Chang et al. (2015), Bhattacharya, Churchill, Gozgor, Lau and Lu (2018) support the growth hypothesis whilst Sebri and Ben-Salha (2014) suggested feedback hypothesis and

In the Ghanaian context, studies conducted by Kwakwa (2012), Ameyaw, Oppong, Abruquah, and Ashalley (2017), and Gyimah, Yao, Tachega, Hayford, and Opoku-Mensah (2022) have explored the relationship between economic growth and energy use, primarily focusing on either electricity or overall energy consumption. These studies typically investigate the causality between energy use and economic growth, aiming to determine whether changes in energy consumption drive changes in economic activity. However, they often do not thoroughly examine the magnitude or specific sectors within the economy where this relationship is most pronounced.

While confirming a causal relationship is crucial for policy implications, understanding the magnitude of this effect is more important to policymakers and stakeholders. It helps identify which sectors of the economy benefit the most from increased energy consumption. By delving deeper into these dynamics, researchers can provide more nuanced insights that guide targeted policy interventions aimed at optimizing energy use for sustainable economic development in Ghana.

In addition, all the studies above also did not consider the concept of energy humanization in their analysis, a concept that seeks to balance the issue of energy security and energy use. By energy humanization, we mean awareness of energy use patterns, costs associated with energy use (affordability), Accessibility, the expenses involved in transitioning to alternative sources, adaptability, and users' involvement in this process. Therefore, there is a need for a new study that will estimate the various dimensions of the energy humanization index (EHI) by simultaneously considering issues of energy security and energy usage within the context of Ghana and also forecast the level of various dimensions of energy humanization up to 2030 to assess the plausibility of achieving the Sustainable Goal 7 in Ghana. This study also examines how the different dimensions of energy humanization affect sectoral growth in Ghana from 1980 to 2021.

Finally, according to North (1990), development is not a process that occurs in a vacuum; rather, it is influenced by the institutional context or framework that is present in the country or research area. North (1990) expound that for an economy to develop, economic actors within that economy need to have the assurance that the law will uphold contracts and defend property rights.

As a result, the market can now be trusted by energy producers, distributors, transporters, consumers, and investors, enabling them to act responsibly for the benefit of the whole economy. Up till there are strong institutions to enforce contracts and agreements, moral hazard and information asymmetry problems will be less of a concern. Producers and refineries will be forced to produce high-quality goods because of the robust institutions in place to manage and oversee production, and consumers will be provided high-quality products via Bulk Oil Distributing Companies (BDCs) and Oil Marketing Companies (OMCs). Consequently, there will be an increase in the needed investment in the energy industry, which will facilitate growth and development.

Given the importance institutions, it is possible to hypothesize that the various dimensions of energy humanization in Ghana may be influenced by the institutional cultural, political, and economic institutions that have a long-term tendency to influence growth. Although cultural aspects do not alter frequently, nations can reform their judicial systems by placing a greater emphasis on investor and consumer rights, providing more effective contract enforcement and improvement in the institutional environment that will affect energy humanization and, in turn, contribute to growth and development. The question one may ask is that, does institutional environment matter in the relationship between energy humanization and sectoral growth in Ghana?

1.3 Aim of the study

The study aims to construct an energy humanization index for Ghana, estimates the impact of energy humanization dimensions on sectoral growth, and evaluate the moderating influence of institutional environment on the energy-growth relationship.

1.3.1 Specific Objectives

Specifically, the study seeks to:

1. estimate the level of the various dimensions of energy humanization index in Ghana;
2. forecast the various dimensions of energy humanization up to 2030 to see if the Sustainable Development Goal 7 could be achieved by Ghana using the existing historic data.
3. analyse the effect of energy humanizing dimensions on the sectoral growth in Ghana.
4. quantify the moderating role of institutional environment on energy humanization dimensions and sectoral growth in Ghana.

1.4 Research Hypotheses and Questions

To achieve the study's goals, a research question was formulated for objective one and two whilst a research hypothesis was formulated for objectives three and four.

1.4.1 Research questions

1. What is the level of the various dimensions of energy humanization index in Ghana?
2. What are the projected forecasts for the various dimensions' energy humanization in Ghana up to 2030, and how do these estimates impact the potential achievement of Sustainable Development Goal 7?

1.4.2 Research hypotheses

1. H_0: energy humanizing dimensions do not affect sectoral growth in Ghana.

H_a: energy humanizing dimensions does affect sectoral growth in Ghana.

2. H_0: Institutional environment does not moderate the relationship between energy humanization and sectoral growth.

   H_a: Institutional environment does moderate the relationship between energy humanization and sectoral growth.

1.5 Significance of the Study

Energy is a driving force behind every civilization and culture, as well as an engine for economic progress, with important economic ties. Thus, because energy affects all aspects of life, it is crucial to the existence of a functioning modern civilization. As a result, increasing trend in energy humanization index is a critical social goal. The study is relevant in both practical and theoretical terms. Given the importance of energy security and energy consumption to every economy especially in a developing nation context like Ghana, policymakers must have a thorough grasp of the level of various dimensions of energy humanization and the important components of the dimensions and whether Ghana is on the path towards achieving Sustainable Development Goal 7 which seeks to "ensure access to affordable, reliable, sustainable, and modern energy for all".

It also provides policymakers with empirical evidence on how energy humanization and its dimensions affect sectoral growth. The study also provides more information on the moderating role of the institutions in the energy-growth relationship. This knowledge and information obtained will help determine which aspect of energy security requires prompt attention and how energy humanization impacts sectoral growth for the optimal formulation of policy in the sector.

Furthermore, the findings serve as a foundation for future studies. Because research is iterative, discoveries in one study may influence the path pursued by another. As a result, the research includes the review and re-examination of a specific study subject from several viewpoints. As a result, the study's findings will serve as a source of inspiration for future academic and policy research around energy humanization index, effect of energy humanization on sectoral growth, and the moderating role of institutional environment.

1.6 Scope of the Study Suggested

The study estimates the various dimensions of energy humanization index in Ghana from 1980 to 2021 and forecasts these dimensions up to 2030 to see if SDG 7 "ensure access to affordable, reliable, sustainable and modern energy for all" could be achieved by Ghana by 2030. The study further analyses the effect of energy humanizing dimensions on sectoral growth and the moderating role of the institutional environment from 1980 to 2021.

1.7 Limitations of the Study

Firstly, a notable constraint of this study is inadequate data. A research endeavour concerning Ghana's energy humanization ideally demands a comprehensive dataset with a significant volume of observations. However, some of the variables we intended to use in the estimation of the various dimensions of the energy humanization index were dropped because of data unavailability. For example, number patents application from the energy sector in Ghana, amount of money spends on energy sector research and among others.

Also, most of the institutional environment variables only have consistent data after the 2000s. Hence getting data to measure institutional environment in a time series analysis that extend before the 2000s is very difficult, which explained the use of only two institutional environment variables.

Additionally, the research did not gather qualitative insights from experts and policymakers. Qualitative data would have enhanced the understanding and interpretation of the study's results and findings. Despite these constraints, the findings and conclusions from the study remain valid and coherent.

1.8 Organization of the Study

The study is composed of five chapters to guide the reader through the research process. The first chapter, which acts as an introduction to the study, contains various essential components, including the background of the study, a statement of the problem, research objectives, hypotheses, research questions, the significance of the study, scope or delimitations, limitations, and organization of the study. In the second chapter, a comprehensive review of the literature on energy security and usage, institutions, and growth is presented, including both theoretical and empirical perspectives. The literature review aims to provide a critical analysis of the existing knowledge in the field and identify gaps that the present study can address.

Chapter Three provides an overview of the research methodology used for the analysis. Chapter Three discusses the research design and approach, data sources, their measurement and expected sign, methods and data analysis techniques involved in the study. This information allows the reader to understand the procedures used to analyse the data. The fourth chapter presents the findings and discussions of the study, where the results are contextualized with existing literature. The fourth chapter also presents the analysis of the data in relation to the research questions or hypotheses, the interpretation of the results, and a discussion of their implications. The findings from this chapter contribute to the existing literature on the topic and provide insights for practitioners and policymakers.

Finally, Chapter Five provides a summary of the key findings, draws conclusions, makes recommendations, and identifies areas for future research. The conclusion chapter synthesizes the study's main results and implications and suggests further research that could build on this study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This section starts by providing an overview of the entire energy sector of Ghana from a historic perspective. It defines the main terms and concepts employed in the study, and further presents a review of both theoretical and empirical literature as well as the conceptual framework related to the subject of energy humanization, energy security, energy usage, institutions, and sectoral growth. Regarding the theoretical review, the study assessed theories pertaining to growth, energy, and institutions and carefully chose the most relevant theories for the research. In the empirical part of the literature review, the study analysed existing literature concerning the estimation of energy security; works on growth and energy usage; energy security and growth; growth and institutions; and subsequently explored works on energy usage, institutions, and growth.

2.2 Overview of Ghana's Energy Sector

The energy industry in Ghana is primarily divided into two subsectors: power and petroleum. The power sub-sector is responsible for generating, transmitting and distributing electricity across the country. On the hand, the petroleum sub-sector consists of upstream, midstream, and downstream segment (Asumadu-Sarkodie & Owusu, 2016). The upstream segment involves the exploration, drilling, and production of crude oil and natural gas. It encompasses activities such as locating and extracting these resources from underground reservoirs. The midstream segment focuses on the transportation, storage, and wholesale marketing of crude oil and natural gas, playing a crucial role in moving raw materials from extraction sites to refineries or other distribution points.

The downstream segment involves refining crude oil into various products, including gasoline, diesel, and jet fuel, as well as the distribution and retailing of these refined products to end-users. Together, these segments form a comprehensive value chain that spans from the extraction of raw materials to the delivery of refined petroleum products to consumers, encompassing exploration, production, transportation, refining, and distribution processes. Understanding these segments helps in analysing the diverse activities and processes involved in the petroleum industry, from the initial extraction of raw materials to the final delivery of refined products to consumers. Each segment has its own set of challenges, risks, and opportunities, and companies within the petroleum industry often specialize in one or more of these segments.

2.2.1 The power sub-sector

The inception of Ghana's electrical sub-sector dates back to the early 1900s, during the British colonial era. During that time, the main focus of the electricity sub-sector was on providing power to the colonial government, the mining sector, and other commercial organizations. The first significant facility that was constructed to improve the sector was the Akosombo Dam. The British Geologist Albert Kitson first conceived the idea for the dam in 1915, but blueprints were not created until the 1940s. In 1949, there was a proposal to develop the Volta River Basin, but due to insufficient funds, the construction of the dam was made possible by the loan provided by the American company Volta Aluminium Company (Valco) to Ghana. President Kwame Nkrumah then took on the Volta River hydropower project. Ghana received its first significant supply of power after the dam's completion in 1965, it marked a significant turning point for the country's energy sector.

In the 1970s and 1980s, the government embarked on a massive program of building thermal power plants to supplement the hydroelectric power from the Akosombo Dam. Prior to the late 1990s, Ghana’s power industry operated as a unified monopoly, where the Volta River Authority (VRA) was responsible for both energy generation and distribution nationwide. Additionally, the VRA’s subsidiary, the Northern Electricity Department (NED), handled distribution to the Northern Sector. In the 1990s, Ghana’s energy sector underwent significant reforms aimed at increasing private sector participation in the sector, especially in the generation component. The government also introduced the Electricity Supply Act in 1997, which established the Electricity Company of Ghana (ECG), as the main distributor of electricity in the country. VRA was made to handle only the power generation aspect of the value chain whilst transmission of power is handled by Ghana Grid Company (GRIDCo).

The government also introduced policies to encourage Independent Power Producers (IPPs) to invest in the sector. Currently, Ghana produces electricity from thermal and solar sources in addition to hydropower with the possibility of wind and nuclear in the near-term. By 2030, the country aims to produce 10% of its energy from renewable sources. The ECG oversaw power distribution in Ghana's southern region. When the VRA was split up into generation and transmission system operations in the late 1990s, more separate Power Producers (IPPs) were able to enter the market (Kumi, 2017).

Around early 2000, Ghana’s energy industry was confronted with a number of difficulties, including a lack of generation capacity, poor transmission and distribution networks, and large non-technical losses. The Public Utilities Regulatory Commission (PURC), which was established in

2000 to oversee the energy industry and guarantee that prices were cost-reflective, was one of several adjustments the government made to solve these issues.

In recent years, Ghana's energy sector has focused on increasing access to electricity, improving the dependability of the power supply, and promoting the use of renewable energy sources(Mensah, Kemausuor & Brew-Hammond, 2014). The government has implemented several policies and initiatives aimed at achieving these goals, including the "National Electrification Scheme", which aims to increase access to electricity in rural areas, and "the Renewable Energy Act", which promotes the use of renewable energy sources in the country. Ghana currently imports power from La Cote D'Ivoire when there are shortages and also exports electricity to Burkina Faso, Togo, La Cote D'Ivoire and Benin. Further grid improvements would make it possible to export more electricity to neighbouring countries in the subarea like Nigeria, Niger etc.

Overall, there have been notable obstacles and modifications to overcome these obstacles in Ghana's energy sector's electrical subsector. While there is still much work to be done to ensure a reliable and affordable energy supply for all Ghanaians, the sector has made significant progress in recent years, and there are many opportunities for growth and development in the future.

Figure 2.1 provides information on the total installed capacity for generating electricity from the grid. The Figure showed that the total installed capacity has experienced an impressive growth rate from 1,652 MW in 2,000 to 5,481 MW in 2021. This represents an annual average growth rate of 9.7%, which indicates a substantial increase in the availability of electricity for consumers over the years. We can also see from Figure 2.1 that before 2015 the largest source of power for the electricity sector was coming from the hydro source until 2015 when thermal generation took over in terms of being the major source of power. Ghana's performance with reference to renewable energy exceptions of hydro started picking up in 2016 and keeps growing year on year basis although there is more room for improvement.

Additionally, Figure 2.2, showed the dependable capacity of the power sector thus the amount of electricity that can be reliably supplied at any given time. This also saw significant growth at a yearly average rate of approximately 9.8%, rising from 1,358 MW in 2000 to 4,975 MW in 2021. It is noteworthy that the thermal generation capacity, which was installed in 2000, was 430 MW. However, this has increased about 8 times to 3,3480.6 MW in 2021 at an annual average growth rate of 14.3%. This indicates a notable increase in the production of electricity using thermal power generation over the years, contributing to the growth of the dependable electricity generation capacity.

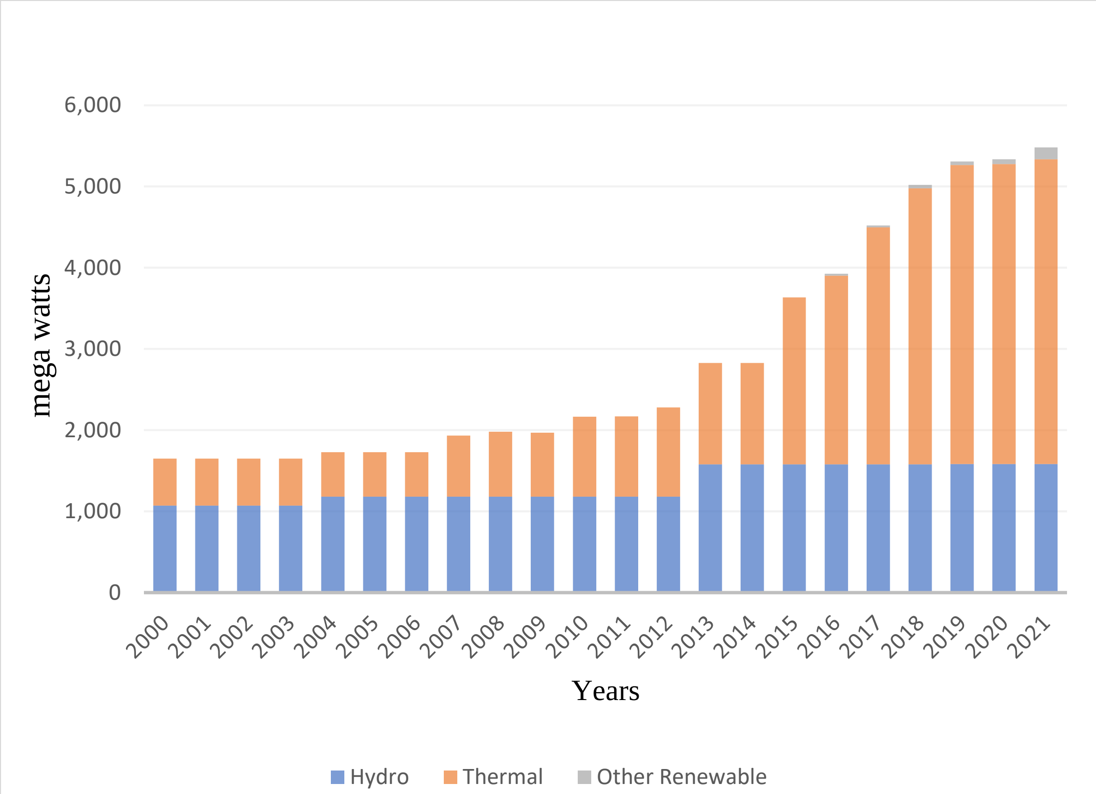

Figure 2.1: Grid Installed Capacity (MW)
Source: Asafo (2024) with data from the Energy Commission

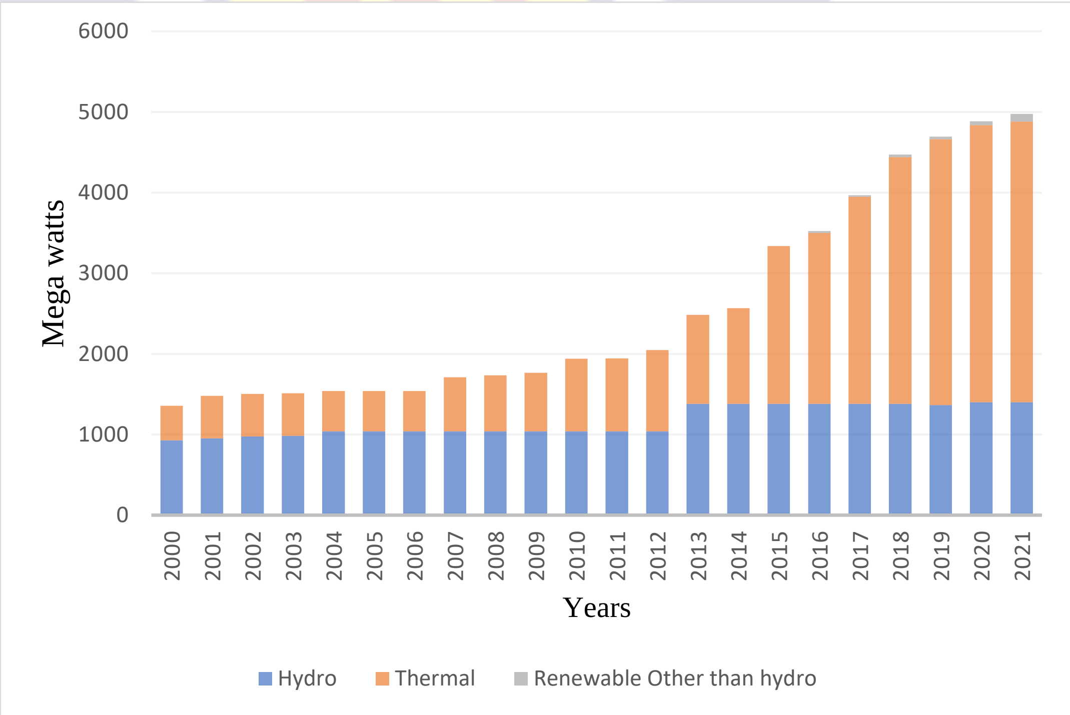

Figure 2.2: Grid Dependable Capacity (MW)
Source: Asafo (2024) with data from the Energy Commission

Table 2.1:Installed and dependable capacity (MW)

Types of Plants	Installed Capacity	Dependable Capacity
Hydro Power Plants	1,584	1,400
Thermal Power Plants	3,753	3,480.60
Other Renewables On-grid	144.05	94.65
Other Renewables Off-grid	7.44	
Other Renewables Mini-grid	0.325	
Total	**5,488.82**	**4,975.25**

Source: Asafo (2024) with data from Energy Commission

Ghana has several power-generating plants that produce electricity for the country. Some of the notable power-generating plants in Ghana include Akosombo Hydroelectric Power Plant, Kpong Hydroelectric Power Plant, Bui Hydroelectric Power Plant, Aboadze Thermal Power Plant, Takoradi Thermal Power Plant, Sunon Asogli Power Plant and TICO Thermal Power Plant. These are some of the major powers generating plants in Ghana, and there are several others that contribute to the overall electricity production in the country. Table 2.1 showed a breakdown of various types of power plants producing electricity in Ghana with their installed and dependable capacity.

2.2.2 The petroleum sub-sector

Upstream, midstream, and downstream are the three segments that make up the petroleum industry. In the upstream sector, the focus is on exploring and extracting crude oil and natural gas from reserves underground or underwater (Babusiaux et al., 2011; Inkpen, 2011). This phase involves activities like conducting seismic surveys, drilling wells, and extracting hydrocarbons from reservoirs. The midstream sector is centred around the transportation and storage of crude oil and natural gas from the upstream sector to the downstream sector (Bhandari, 2019; Inkpen, 2011). It encompasses tasks like pipeline and marine transportation, as well as the operation of storage facilities such as tanks and terminals. The downstream industry includes the refining and processing of natural gas and crude oil to create a range of finished goods, including petrochemicals, jet fuel, diesel, and gasoline (Bhandari, 2019). Within this segment, activities include refining, petrochemical production, and the marketing and distribution of these finished products to consumers.

Due to regulatory constraints, Ghana's petroleum industry is split into two main subsectors: upstream and downstream. These subsectors involve a wide range of tasks, from petroleum exploration and extraction to petroleum product refining, storage, transportation, and marketing. The upstream sector includes pre-licensing, licensing, exploration, appraisal, field development, production, disposal, and decommissioning.

Four geological basins with high potential for finding oil and gas have been discovered by Ghana. These include the Eastern Basin (Accra-Keta), Central Basin (Saltpond), and Western Basin (Tano-Cape Three Points), all of which are offshore and have undergone substantial exploration. The Voltaian Basin, which is onshore and has undergone little investigation, is another option. Ghana's first significant commercial oil discovery was the Jubilee Field in 2007. In the Upstream Subsector, Ghana has made impressive progress since then, with the discovery of 25 new oil fields within a decade of the Jubilee Field's first oil. At present, Ghana has three offshore producing fields, namely Jubilee, Tweneboa, Enyera, and Ntomme (TEN), and Sankofa and Gye Nyame Field. With Sankofa and Gye Nyame Fields as the first main gas-producing field.

The upstream petroleum industry in Ghana is relatively young compared Nigeria etc; commercial oil production only started in 2010 (Amponsah & Opei, 2017). Foreign companies, such as Tullow Oil, Kosmos Energy, and Eni, dominate the industry. Oil seeps discovered in Ghana's onshore Tano Basin in the Western Region led to the beginning of hydrocarbon exploration in that country as early as 1896. After further research activities were done between 1909 and 1913, 1923 and 1925, 1956 and 1957 (Amponsah & Opei, 2017). Hydrocarbon production began offshore for the first time in 1975 at Salt Pond Basin. In 1983, Ghana introduced its inaugural petroleum legislation, the GNPC Law, 1983 (PNDCL 64). This law established a novel statutory and regulatory framework aimed at expediting exploration and production endeavours across different regions.

Figures 2.3 and 2.4 showed crude production in Saltpond and three new fields respectively. The production of crude oil in Ghana started with Saltpond as its first official producing well starting with 62 thousand barrels of Oil reaching its peak in 2008 producing 214 thousand barrels of oil and finally declining to 47 thousand barrels in 2015.

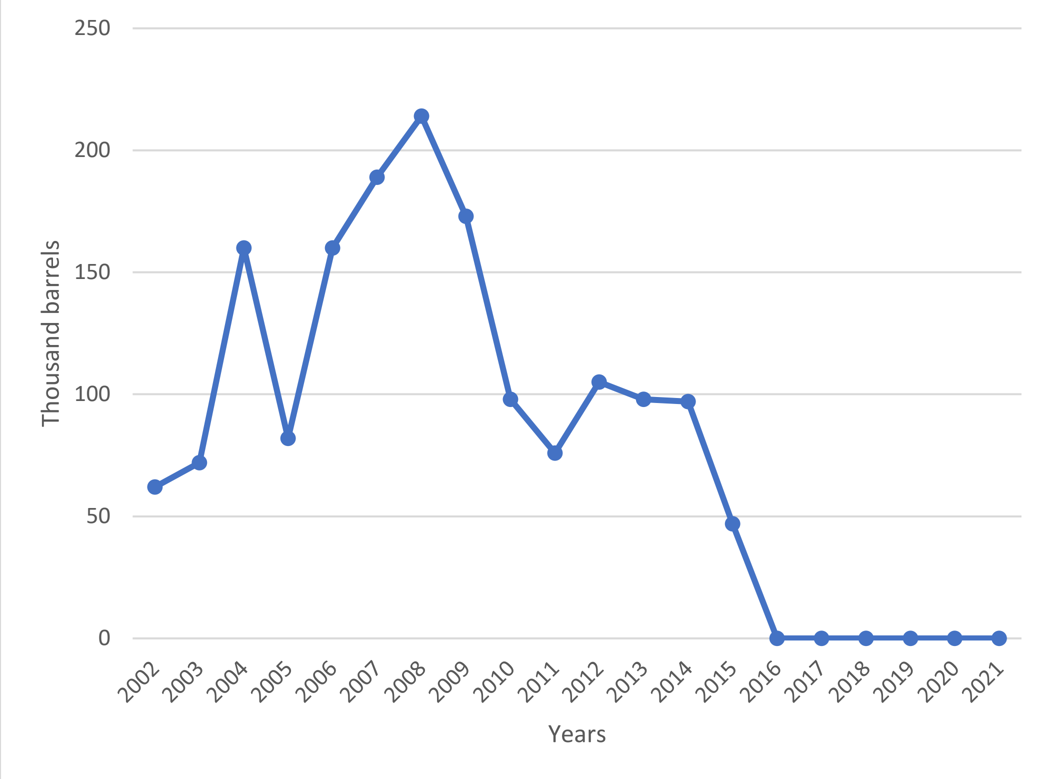

Figure 2.3: Crude Production in Saltpond
Source: Asafo (2024) with data from Energy Commission

The three new fields are currently the producing engine of Ghana's crude oil with Jubilee as the first commercial producing well with producing capacity of 1,268 thousand barrels in 2010. The highest production from the three oil fields occurred in 2019 with 71,440 thousand barrels of oil and since then production keeps declining year on year. Production from Jubilee remains the leading producing well right from the beginning but production from OCTP overtake the production from TEN in 2020. Jubilee and TEN started experiencing a decline in their production in 2020 whilst that of OCTP started in 2021.

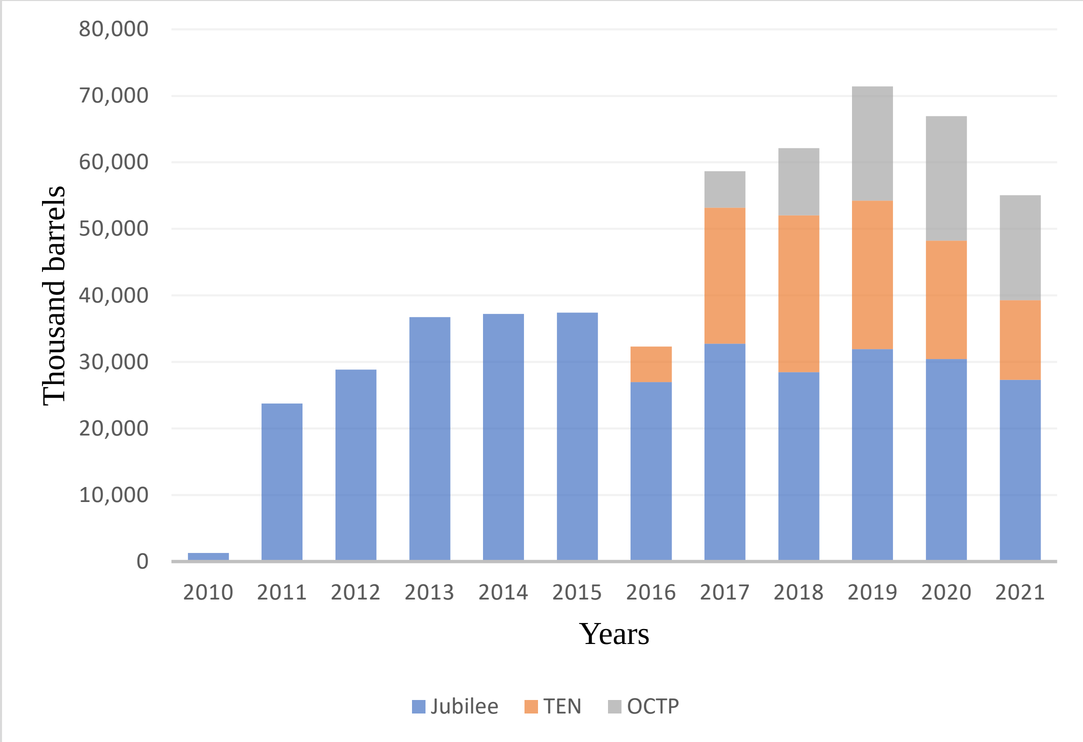

Figure 2.4: Crude production in Jubilee, TEN and OCTP.
Source: Asafo (2024) with data from Energy Commission

The selling, marketing, and distribution of refined petroleum products in Ghana, as well as the importing and refinement of crude oil, are all included in the downstream petroleum business. The National Petroleum Authority (NPA) oversees and regulates this sector, handling licensing and supervision of companies engaged in the import, storage, distribution, and sale of petroleum products. This industry plays a significant role in contributing to Ghana's GDP and involves a diverse range of commercial activities, including importing, exporting, re-exporting, shipping, transportation, processing, refining, storage, distribution, marketing, and sales of petroleum products. It stands as a vital sub-sector within the economy.

The downstream is made up of BDCs and OMCs, the BDCs are responsible for the importation of crude oil, storage, marketing, and distribution of petroleum products, primarily to bulk consumers whilst the OMCs are responsible for distributing finished petroleum products to final consumers.

Tables 6.1 and 6.2 in the Appendix provide a summary of all the BDCs and OMCs currently operating in Ghana as of the end of 2022 (NPA, 2022). Based on the data made available by the NPA, there are about 45 BDCs in Ghana and about 10 of them accounted for the 82.31percent of the entire market share for the third quarter of 2022.

Table 6.2 in the Appendix showed the market share and the performance data for the top 20 OMCs for the third quarter of 2022. The top 20 OMCs had a collective market share of 78.69%. The market share held by the remaining OMCs was 21.31%. This information showed that there is more competition between the OMCs compared to the BDCs since only 10 BDCs account for about 82.31 percent whilst almost 20 OMCs account for 78.69 percent of the market share.

Notwithstanding the advancements achieved in the energy industry, Ghana still has several issues to deal with, such as expensive power rates, lack of access to electricity in rural areas, and poor infrastructure. The nation is also very dependent on imported petroleum supplies, which makes it susceptible to changes in price on the international market. The nation also confronts environmental difficulties, notably in the petroleum industry, where oil spills and gas flaring are significant issues.

2.3 Key Participants in Ghana's Energy Industry

Ministry of Energy

The Ministry of Energy is responsible for the sector's regulation and is charged with carrying out important tasks such formulating policies, developing strategic plans, monitoring the industry, and reviewing its policies. The Ministry's goal is to provide Ghana and its neighbouring areas with a reliable and sustainable energy supply. Their goal is to guarantee that energy services are widely available and simple to acquire while maintaining an environmentally friendly strategy (Ministry of Energy and Petroleum, 2013).

Energy Commission

The Ghanaian government formed the Energy Commission as a regulatory organization to control and monitor the nation's energy industry. It was created by the Energy Commission Act of 1997 (Act 541), a law passed by Parliament. The main responsibilities of the Energy Commission of Ghana include: Regulating and promoting the development and use of renewable energy sources such as solar, wind, and biomass; Setting and enforcing energy efficiency standards and codes of practice for energy-consuming appliances and equipment; Regulating the electricity and natural gas sectors in Ghana, including licensing of operators, setting tariffs, and monitoring their performance; Developing and implementing energy policies and plans, in consultation with stakeholders and other government agencies; Promoting public awareness and education on energy issues, including conservation and efficient use of energy; Undertaking research and development on energy-related issues. The Energy Commission of Ghana plays a critical role in ensuring the development and sustainability of the energy sector in Ghana.

Ghana National Petroleum Corporation (GNPC)

GNPC holds a pivotal role in Ghana's energy sector. Established in 1983, the Corporation's purpose is to oversee the exploration, production, and commercialization of the nation's oil and gas resources, with legal backing from PNDC Laws 64 and 84. The company aspires to establish a top-tier organization that can position Ghana as the leading destination for upstream petroleum investments in West Africa (Amponsah & Opei, 2017). PNDC Law 64 mandates GNPC to engage in crude oil exploration, development, and production.

The GNPC's primary responsibilities in Ghana's energy industry include the exploration and production of oil and gas resources through the operation of its oil fields and collaborations with other foreign oil companies to carry out exploratory activities. GNPC is also in charge of making Ghana's oil and gas resources available for sale or commercialization. Ghana receives money from the company's marketing and sales of its gas and crude oil to domestic and international markets.

The twin obligations of the regulator and industry participant were stated in Section 2 of the Act that established the corporation. Up to the commercial discovery of oil and the necessity for additional private businesses to enter the market, this function appeared to be functioning successfully. Private enterprises would not have agreed to let GNPC regulate the industry and engage in joint ventures with them in the petroleum industry. To avoid conflict of interest, the Petroleum Commission (PC) was established in 2011 to take up the responsibility of a regulator.

Petroleum Commission (PC)

Reacting to substantial economic discoveries of hydrocarbons, the Petroleum Commission was formed as the sector's regulator through the enactment of Parliament Act 821 in 2011. Along with coordinating upstream petroleum sector policy, it also has oversight and control over how petroleum resources are used. Given the importance of energy for a nation's progress, it is expected that oil and gas will emerge as substantial economic catalysts in the medium to long run. Effective management of these resources is crucial, considering their significant potential.

More specifically, the PC carries out the following tasks: it is in charge of granting permits for activities connected to petroleum exploration and production. It grants licenses to qualified applicants after assessing the technical and financial viability of enterprises intending to participate in Ghana's upstream petroleum industry. The Commission oversees the activities of petroleum firms doing business upstream in Ghana in order to ensure compliance with local laws and regulations. The Commission also ensures that firms abide by environmental, health, and safety standards. The Commission supports the upstream petroleum industry in Ghana's production of local content. By setting rules, regulations, and incentives, it makes sure that local businesses and individuals are engaged in the industry. The Commission gathers and monitors information on Ghana's petroleum industry. It keeps an extensive database on the petroleum sector and provides stakeholders with access to this data.

National Petroleum Authority (NPA)

NPA is a state agency established to oversee and manage Ghana's downstream petroleum industry. In order to regulate and keep an eye on the supply, distribution, marketing, and pricing of petroleum products in Ghana, NPA was created by the National Petroleum Authority Act, of 2005 (Act 691). Below are some key responsibilities carried out by the NPA; Regulation: It oversees the activities of petroleum downstream firms in Ghana to ensure compliance with local laws and regulations. The NPA sets standards for the functionality, security, and quality of petroleum products and ensures that companies abide by them.

Granting licenses to the petroleum downstream industry in Ghana is the responsibility of the NPA. The NPA grants licenses to worthy applicants and ensures that companies with licenses follow the law. NPA is also responsible for the modulation of prices of petroleum products. While taking the situation of the market and other factors into account, the NPA determines the maximum pricing that downstream oil enterprises may impose on their products.

Again, The NPA ensures that downstream oil companies operate in a secure and environmentally responsible manner. This is done by ensuring that companies comply with safety and environmental regulations. Lastly, the NPA promotes the expansion of Ghana's competitive and efficient petroleum downstream industry. The NPA works with stakeholders to develop laws and regulations that promote market expansion and increase standards for customer service.

Bulk Oil Storage and Transportation Company Limited (*BOST*)

BOST is a private limited liability business that was founded in 1993 with the Ghanaian government as its only stakeholder. The objective is to establish an extensive network of storage tanks, pipelines, and crucial bulk transportation infrastructure spanning the entire nation. BOST is also in charge of managing Ghana's Strategic Reserve Stocks. BOST is entrusted with building the nation's natural gas infrastructure and serves as the Natural Gas Transmission Utility (NGTU). Their goal is to establish itself as West Africa's top supplier of oil and gas logistics.

Bulk Distribution Companies (BDCs) and Oil Trading Companies (OTCs)

The NPA has granted bulk distributor licenses to a number of businesses. According to Amponsah and Opei (2017), they are in charge of importing crude oil as well as purchasing, storing, and distributing processed petroleum products to wholesale clients and OMCs. The NPA lists Fuel Trade, Cirrus, Chase, ECO, Vihama, Springfield, Ebony, Oil Channel, Dominion, Alfa Petrol, Peace, Blue Ocean, TOR, PWSL, Hask, and First Deep Sea as the biggest BDCs in Ghana.

Oil Marketing Companies (OMC)

These companies buy and resell refined petroleum products to large groups of people and the public through retail outlets such as gas stations and other resale shops. Examples of well-known OMCs in Ghana with huge market share include GOIL Company Limited, Vivo Energy Ghana Limited and Total Energies Marketing Ghana Plc.

The Volta River Authority (VRA)

The Volta River Authority Act is a legislation that established VRA in Ghana. Act 46 was enacted by the Parliament of Ghana in 1961, and it provides the legal framework for the operations of the VRA. Originally, the ACT allows VRA to produce, transmit and distribute electricity in Ghana. Act 46 has been amended several times since its enactment to reflect changes in the energy sector and to improve the operations of the VRA. The Act continues to provide the legal basis for the VRA's operations and its role in Ghana's energy sector.

VRA produces power from solar, thermal, and hydroelectric sources. The VRA runs a thermal power plant (Takoradi) with a capacity of 550 MW, a solar power plant (Navrongo) with an installed capacity of 2.5 MW, and two hydroelectric power facilities (Akosombo and Kpong) with a combined total capacity of 1,020 MW. The VRA is also in charge of maintaining the effectiveness and security of its infrastructure for electricity generation. VRA carries out projects to advance its methods and technology for electricity generation. VRA works in partnership with several academic and research institutes to create cutting-edge technology and improvements in the energy industry.

The Bui Power Authority (BPA)

The Bui Power Authority is a state-owned power generation company in Ghana. Its primary responsibility is the operation and maintenance of the Bui Hydroelectric Dam, which is situated in the Banda District of the Bono Region. With an installed capacity of 404 MW, this dam plays a crucial role in providing hydroelectric power to Ghana. In addition to its involvement in hydroelectric power generation, the authority is also engaged in the development of various other renewable energy projects, including solar and wind power initiatives.

Under the Ministry of Energy’s renewable energy initiative, the Bui Power Authority has successfully completed Ghana's inaugural micro-hydropower plant, known as the Tsatsadu Generating Station (TGS). Located in the Volta Region of Ghana, the TGS has a current capacity of 45 kW, with the potential to expand by an additional 45 kW in the future. Furthermore, the authority has initiated the construction of the initial 10 MWp of its 50 MWp solar project. This project aims to promote the establishment of a 250 MWp Hydro-Solar photovoltaic (PV) Hybrid plant within the Bui enclave. For this purpose, the authority has designated 2,600 acres of land, which are located in the BPA Acquired Lands, for the development of solar power installations.

The Electricity Company of Ghana (ECG)

The largest distributor of electricity distribution in Ghana is ECG. It is a state-owned utility firm in charge of supplying power to the nation's residences, companies, and industries. The company was established in 1963 as the Electricity Division of the Public Works Department, and it was later incorporated as a separate entity under the Companies Code of Ghana.

Act 541 was passed by the Parliament of Ghana in 1997 and amended in 2004 and 2008. The main responsibilities of the ECG include The distribution of electricity to customers in Ghana; The maintenance of the electricity distribution network in Ghana; The management of the billing and collection of electricity charges from customers; The provision of customer services, including the handling of complaints and enquiries from customers; The implementation of energy efficiency programs to reduce energy consumption and promote sustainable energy use; The implementation of programs to improve the quality and reliability of electricity supply to customers. The ECG operates in eight regions of Ghana, including the Greater Accra, Eastern, Volta, Oti, Central, Ashanti, Western and Western North regions. It serves over 3 million customers and has a workforce of over 5,000 employees.

2.4 Definition of Key Concepts

This section provides definitions for some key terms or concepts employed in this study. Some of the concepts we are considering in this study include energy humanization, energy security, energy usage, institutions, and growth. The explanation and discussion of these terms or concepts will follow the order listed above.

2.4.1 Energy humanization

The concept of Energy humanization is relatively new and largely used by the World Energy Council during the November 2021 world energy week and during their 25th World Energy Congress at St Petersburg in October 2022. According to Dr Angela Wilkinson, Secretary General of the World Energy Council , many individuals lack awareness of their energy use patterns, costs associated with energy usage, the expenses involved in transitioning to alternative sources, or their own involvement in this process.

Humanizing Energy delves into the important patterns and obstacles present in the energy industry, transforming intangible technical innovations into captivating stories centred around human experiences and perspectives. If individuals are not actively engaged and do not feel that their participation is valued, they will disengage from the conversation and the process. It is crucial to move beyond one-sided declarations and actively engage a broader spectrum of society in shaping and advancing innovative energy solutions.

In the realm of energy, the focus frequently leans towards generation, production, and supply rather than on understanding how people utilize energy, its potential benefits for them, and ensuring its affordability. The best way to ensure that energy is used sustainably and environmentally friendly is to bring together the concerns of energy suppliers and energy consumers by so doing no one will be left out, hence the need to humanize energy. “Energy humanization” means dealing with the issues of energy security and energy usage simultaneously. Whilst energy security in this context captures energy affordability, technology application, availability, and acceptability, the concept of energy usage will capture energy use and its patterns.

2.4.2 Energy security

Governments frequently evaluate or define energy security from geopolitical and technological perspectives. Engineering's goal is to guarantee the protection and dependability of energy technology, which is often accomplished through regulation (Jones & Dodds, 2017). Although attention has often been focused on individual facilities, like nuclear power plants, Jones and Doods (2017) note that there is currently a trend because of the increasing use of intermittent low-carbon renewable energy in countries like the UK, Germany, and Australia to take the stability of the larger electrical system into consideration. Making sure that the state has access to stable fossil fuel pricing and supplies (Chester, 2010), as well as, to some extent, promoting energy independence and the development of indigenous fossil fuel sources, have historically been top priorities from a geopolitical perspective for many countries such as the UK, USA and others(Chester, 2010).

In recent scholarly literature, there has been an expanded interpretation of energy security that now includes the entire energy system, ranging from the procurement of fundamental energy sources to the ultimate utilization of energy (Alemzero et al., 2021). It has been stated that maintaining energy security necessitates maintaining a dependable system for providing consumers with energy in addition to guaranteeing a steady supply of fuel (Cherp & Jewell 2014; Mitchell, Watson & Britton, 2013). Increasingly, the definitions of energy security now include ensuring that energy is affordable and accessible to all consumers and has minimal negative environmental effects.

The definitions of energy security largely concentrate on the geopolitical aspects of energy security, however, occasionally some aspects are also related to the engineering components. Although a variety of indicators have been proposed to quantify various components, there are no cuts-in-stone definitions for energy security but since it keeps evolving and changing depending on the nation or the institution defining the concept. We will focus on two main definitions of energy security and explain our stand on the selected definition for our study.

a) The "Four-A" of energy security

The first definition we will look at is the "four As" definition of energy security. This approach to defining energy security was proposed by APERC in 2007. According to the Centre, in addition to the emphasis on supply security as focused on by most governments, the concept of energy security today should include a wider range of components such as availability, affordability, accessibility and acceptability.

The availability component refers to a reliable and consistent supply of energy supplies to fulfil demand (APERC, 2007; Sovacool & Mukherjee, 2011). Energy availability may be enhanced by diversifying energy sources and investing in energy infrastructure. The accessibility component of energy security refers to equitable access to energy resources for all consumers, including those in remote or disadvantaged areas. Improving accessibility can be achieved through the promotion of universal access to energy and reducing energy poverty. The affordability component refers to ensuring energy prices remain affordable for households, businesses, and industries. Improving affordability can be achieved through promoting competition in energy markets, reducing energy subsidies, and encouraging energy efficiency and conservation (APERC, 2007; Sovacool & Mukherjee, 2011). Finally, the acceptability component refers to energy production and consumption's social and environmental acceptability. Promoting the use of renewable and low-carbon energy sources, increasing energy efficiency, and addressing social and environmental concerns about energy production and usage can all help to increase acceptability (APERC, 2007).

Studies such as Cox (2014) used the idea of the APERC but modified it to suit its agenda for example he employed the concept of availability, affordability, reliability and sustainability but a careful look at the concept of reliability and sustainability is nothing different from accessibility and acceptability respectively. Sovacool and Mukherjee (2011) based on the APERC idea of energy security modified the Four-A approach into five components or dimensions which they described as: affordability, technology development, availability, sustainability, and regulation.

b) Vulnerability approach to energy security

In the view of Cherp and Jewell (2014) the question and the definition of energy security require three main questions which are; (i) "security for whom?"; (ii) "security for whose values?"; and (iii) "security from what threats?", these are vital questions in the definition of energy security. According to their definition, an energy system is said to be secure if it has a low vulnerability. Vulnerability refers to the risk of exposure and system resilience. Jewell, Cherp and Riahi (2014) employed this approach in estimating energy security by looking at weaknesses or vulnerabilities in energy systems and key energy networks.

As per Mitchell et al. (2013), energy systems exhibit a characteristic vulnerability to various evolving threats dependent on both time and location.

This underscores the need for diverse strategies to enhance the resilience of the entire energy system. Mitchell et al. (2013) contends that there are four aspects to energy security when using the vulnerability approach, including resilience, stability, durability, and robustness to handle external long-term stresses like resource depletion. Resilience refers to the capacity to withstand external shocks like supply disruptions. Stability, therefore, refers to the capacity to withstand internal shocks like infrastructure failure. Durability is the capacity of the energy system to withstand long-term internal stresses like increased demand.

There are a number of narrowed-based approaches to measuring vulnerability or energy security but the most relevant to this study is the approach expounded by Winzer (2012). Winzer argued that energy security should be limited to the risk of "continuity of the energy supply". Three kinds of risks have been identified: "technological risks" for example infrastructure failures; "human risks" for example supply constraints; and "natural risks" for example intermittent renewables, resource depletion, or natural disasters.

In conclusion, from the two main perspectives either from the Four A's approach or the vulnerability approach of measuring energy security varies among different researchers due to the diversity of energy systems and the extension of the term to other energy policy issues. Nonetheless, this does not imply the existence of distinct energy security concepts. Instead, it implies that a single concept can manifest differently depending on the circumstances. Achieving conceptual clarity is vital to aid rational policy analysis, international comparisons, and learning, even in the presence of varying energy security priorities and policies across different nations. A well-defined social science concept should improve clarity and precision by offering a shared language for effective communication between scholars and policymakers, enabling the separation of energy security from other policy issues and enhancing the clarity and predictability of its definitions.

Both the Four A's approach and the Vulnerability approach offer different perspectives and insights into understanding energy security. The Four A's approach considers energy security in terms of meeting the energy needs of a population whilst the vulnerability approach emphasizes the potential risks and threats that could disrupt energy systems. Since this study is much more interested in energy security for the purpose of making energy available, accessible, acceptable, and affordable for the development of the nation for the benefit of the population, this study will adopt the "Four A's approach" as its definition for energy security.

Again, although Ghana does not have any specific definition of energy security, the country's energy policies and strategies aim to ensure the available, affordable, and sustainable supply of energy to support economic development and social well-being. Thus, using Ghana's National Energy Policy (2010) outlines the country's energy objectives which include improving energy access and affordability, diversifying the energy mix, promoting energy efficiency and conservation, and ensuring energy security. The policy also emphasizes the need to balance economic, social, and environmental considerations in energy planning and management. Similarly, Ghana's Renewable Energy Act (2011) aims to promote the development and utilization of renewable energy sources to enhance energy security, reduce greenhouse gas emissions, and create employment opportunities in the energy sector. We will still go for the "Four A's approach" in defining energy security.

2.4.3 Energy usage (Consumption)

The term energy usage is the total amount of energy used by various economic sectors, including households, industry, service, agriculture, and transport. Common units of measurement include joules, BTUs, and kilowatt-hours. Energy Usage is mostly used interchangeably with the term energy consumption. A careful review of the term in the literature showed that there is not much difference in the definition and the measurement of the term by different institutions, countries, or researchers. For example, the International Energy Agency (IEA) defines energy usage as “the total amount of energy used by end-users, including households, industry, and transport” (Khan et al., 2021). Also, The United States Energy Information Administration (EIA) defines energy usage as “the amount of energy that is used by an entity or a country over a certain period of time” (Adua, 2020). Again, the United Nations Framework Convention on Climate Change (UNFCCC) defines energy usage as “the use of energy for various purposes, including heating, cooling, lighting, transportation, and industrial processes”(Hickmann et al., 2021). In addition, the European Environment Agency (EEA) defines energy usage as “the total energy used by a country or region, including both primary energy sources such as coal and natural gas, and secondary energy sources such as electricity and heat”. Lastly, the World Bank defines energy use as “the total energy used by a country or region to meet its energy needs, including both primary energy sources and secondary energy sources”(Brito, 2022).

These definitions emphasize the importance of understanding the total amount of energy usage across various economic sectors. They all point to the fact that when evaluating energy usage, there is the need to consider both main and secondary energy sources. From these definitions, we can say that energy usage as adopted by this study is IEA's definition of energy usage thus "the total amount of energy used by end-users, including households, industry, and transport".

2.4.4 Institutions

The word "institution" has been increasingly popular in the social sciences in recent years. This development might be traced to institutional economics, a field that has gained prominence as a way to examine economic activity within a larger social framework (Hodgson, 2006). In various other fields, including philosophy, sociology, politics, and geography, the idea of institutions has also grown in importance and use. The term "institution" is used in several domains to describe dominant social behaviour patterns that are accepted by society. As a result, the idea of "institution" has evolved into one that can be used in a variety of contexts and is crucial for comprehending the intricate social and economic processes that influence modern society.

According to North (1990), an institution is defined as "a set of formal and informal rules that constrain human behaviour" (p. 3). Institutions are shaped by historical, cultural, and economic factors, and they can take various forms, including laws, regulations, norms, customs, and traditions. Institutions provide a framework of rules and norms that guide human behaviour and interactions, and they play a crucial role in shaping social, political, and economic structures.

Institutions are classified into two types: informal institutions and formal institutions. Informal institutions are conventions, beliefs, culture, and practices that impact the behaviour of economic market participants. Formal institutions are rules that are constructed and communicated in order to guide, govern, and control economic agents' behaviour (Acemoglu, Johnson & Robinson, 2005). The two most fundamental sorts of formal institutions are political and economic institutions. Political institutions impact policymakers' actions by limiting their alternatives, which are sometimes referred to as limits (Acemoglu et al., 2005). Economic institutions are organizations that defend property rights, give permits to organizations, and supervise economic activities (Acemoglu et al., 2005).

Because most empirical studies make distinguishing between economic institutions and governance unfeasible, economic institutions and governance are regarded as synonyms in this study. This study therefore defines an institution as a set of formal and informal rules that governs a society or a people which serve as a constraint on their behaviour.

2.4.5 Sectoral growth

Economic growth is a broad concept that "refers to the sustained increase in the level of the economic output of a country or region over time" (Lewis, 2013). A nation's growth can be measured using three main approaches namely: the income approach, the expenditure approach and the output or value-added approach.

The income approach sums income earned by all individuals and businesses in a country during a certain period. It is calculated by summing all of the many forms of revenue generated, such as earnings, wages, profits, and rental income. This outcome produces a term called "Gross Domestic Income or GDI" The Expenditure approach calculates the total amount of money spent in a country on products and services during a specific time period. It is computed by adding together consumption, investment, government expenditures, and net exports. This computation is normally called "Gross Domestic Expenditure or GDE". The output approach computes the value of all goods and services produced in a country during a certain time period. GDP is calculated by summing the value of all final items and services produced in the economy. This produces a computation normally called "Gross Domestic Product (GDP)". All three approaches are expected to generate approximately the same value or outcome (Mankiw, 2020).

Sectoral growth refers to the expansion or decline in economic sectors of an economy (Todaro & Smith, 2014). It is an important component of economic growth since it reflects changes in an economy's output and employment mix. In this discussion, the major sectors for consideration are the agriculture sector, service sector and industrial sectors. Changes in output, value-added, or employment in distinct sectors can be used to analyse sectoral growth through time.

Sectoral growth may be facilitated by improvements in energy resources, modifications in technology, consumer preferences, governmental regulations, and international economic conditions. Sectoral growth may have a considerable influence on welfare, growth, and development. The expansion of high-wage and labour-intensive sectors like manufacturing, high technology and other industrial sub-sectors can reduce income disparity and poverty.

In conclusion, sectoral growth refers to an increase in output or value added for individual sectors of the economy.

2.5 Theoretical Review

This sub-section focused on the discussion of theories related to energy security and usage, institutions, and growth. Theories on energy, energy security and energy use are followed by theories on institutions and theories on growth.

2.5.1 Theories of energy, energy humanization, energy security and energy usage

The rebound effect theory

The rebound effect theory, often referred to as the Jevons paradox, posits that enhancements in energy efficiency can result in a rise in energy usage rather than energy preservation. This is attributed to a heightened demand for energy-intensive goods and services (Gillingham, Rapson & Wagner, 2015). The theory is based on the idea that when the cost of energy decreases due to improved efficiency, consumers and firms may increase their use of energy-intensive products and services, offsetting any energy savings achieved through efficiency improvements. For example, if a household installs energy-efficient light bulbs, they may be inclined to leave their lights on for longer periods, as the cost of running the lights has decreased. Similarly, if a factory invests in more efficient equipment, it may be able to produce more goods at a lower cost, leading to increased production and energy usage.

This phenomenon can be partially or completely true, depending on various factors such as the price elasticity of energy demand and the behaviour of consumers and firms (Gillingham et al., 2015). Sorrell (2007) was of the view that the rebound effect can be as high as 60%, meaning that energy efficiency improvements result in only a 40% reduction in energy use. While energy efficiency improvements remain an important strategy for reducing energy use and greenhouse gas emissions, the rebound effect highlights the need for policies and incentives that encourage sustainable behaviour and discourage excessive energy use (Gillingham et al., 2015; Sorrell, 2007).

Energy justice theory

Energy justice theory proposed by McCauley et al., (2013) emphasizes the distributional and procedural dimensions of energy use, arguing that access to affordable, reliable, and clean energy is a matter of social justice. The theory suggests that energy policies and programs should prioritize the needs and interests of marginalized groups, such as low-income households and their involvement in the decision-making processes (Heffron & McCauley, 2017; Sovacool & Dworkin, 2015).

The theory views energy as a fundamental human necessity and contends that the availability of energy services is a fundamental requirement for human welfare and progress (Sovacool & Dworkin, 2015). It highlights the unequal distribution of energy resources both within and between countries may negatively impact vulnerable populations, such as those living in energy poverty, exposed to environmental hazards, or affected by climate change (Heffron & McCauley, 2017).

The theory also emphasizes the importance of procedural justice in energy decision-making, which involves fairness, transparency, and participation in the processes by which energy policies and programs are designed, implemented, and evaluated (Sovacool & Dworkin, 2015). This includes involving affected communities in the planning and implementation of energy projects, providing access to information and resources, and ensuring that decision-making processes are accountable and responsive to community needs and interests.

The Four-A theory of energy security

The Four-A theory of energy security is a framework proposed by the Institute of Energy Economics, Japan (IEEJ) that emphasizes four key dimensions of energy security (IEEJ, 2016). These dimensions are:

1. Availability: This refers to the stable and reliable supply of energy resources to meet demand. The availability of energy can be improved through diversification of energy sources and investments in energy infrastructure.
2. Applicability: This is the capacity to apply modern technology to guarantee the preservation and efficient use of the existing oil and gas reserves. This component, which involves creating new infrastructures to support renewable energy technologies, might be seen as an example of innovation in the use of both renewable and non-renewable energy technologies. The advancement of cutting-edge technology is a crucial sign of how far we have gone in the search for a sustainable energy system.
3. Affordability: This refers to ensuring energy prices remain affordable for households, businesses, and industries. Improving affordability can be achieved through promoting competition in energy markets, reducing energy subsidies, and encouraging energy efficiency and conservation.
4. Acceptability: This speaks to how well-accepted energy production and use are on a social and environmental basis. Enhancing acceptability may be achieved by encouraging the use of clean, low-carbon energy sources, increasing energy efficiency, and resolving social and environmental issues connected to energy production and use.

The Four-A theory offers a comprehensive framework for addressing the complex and interconnected challenges of energy security. It emphasizes the importance of a balanced and integrated approach that considers economic, social, environmental, and political factors in ensuring a sustainable and secure energy system.

The selected for energy security and energy usage.

The theory selected to explain energy security is the Four-A theory of energy security since it carefully explains the various dimensions of energy security that are important to our study. The theory selected for energy usage is both the rebound effect theory and energy justice theory which explains the importance of energy for production and other activities whiles trying to implement efficiency measures to improve energy efficiency, usage, security, and energy humanization.

2.5.2 Institutional theory

Institutional theory has been developed by multiple scholars and researchers over the years. However, some of the most prominent proponents of institutional theory are Douglass North, an American economist, whose work explains the role of institutions in economic development (North, 1990). John Meyer, an American sociologist, another leading figure in the development of institutional theory. His work on institutions focused on the role of institutions in shaping organizational behaviour. Lastly, Walter Powell, also an American sociologist, published extensively on the role of institutions in shaping social and economic behaviour.

The institutional theory postulates that institutional variations among countries largely explains long-run growth gaps (Acemoglu et al., 2005). The study's definition of an institution is based on the economic theory that says institutions are limitations that allow the market to operate as intended (Acemoglu, Johnson & Robinson, 2005). According to Acemoglu and Robinson (2010), political institutions frequently dictate the breadth and depth of economic institutions. Political institutions frequently have a considerable influence on the expansion and development of certain economies. This is due to the fact that those in power pick which economic institutions to establish and how powerful and wide they should be (Acemoglu et al., 2005).

According to Acemoglu et al., (2005), the primary reason for the variations in economic growth among Africa, Eastern Europe, and Western Europe lies in changes in the institutional environment. They contend that when economic institutions undergo reform and when economic actors entrust their property rights to these reformed institutions, it becomes more probable that trade barriers are eliminated, property rights are established and safeguarded, and long-term economic growth is promoted. This transformation is often associated with shifts in political power, moving from autocracy to monarchy and ultimately to democracy. Economic actors are more willing to invest in capital and innovate when they believe their property rights will be safeguarded by economic institutions, leading to long-term economic growth. Although nations with extractive institutions struggle to develop, those with progressive institutions are always developing (Chung, 2014).

The hypothesis proposes that there is a connection between energy humanization, energy usage, institutions, and sectoral growth. Specifically, it suggests that designing energy systems to meet human needs (energy humanization) can enhance accessibility and affordability, ultimately leading to more efficient and sustainable energy usage. Effective institutions play a crucial role in providing governance, regulation, and incentives, which create an environment conducive to optimal energy utilization. As a result, this supports the growth of various economic sectors, including industrial, agricultural, and service sectors, by ensuring a reliable and efficient energy supply. Therefore, the integration of human-centred energy policies, efficient usage, and strong institutional frameworks is instrumental in driving sectoral growth and overall economic development.

In summary, institutions can help to ensure that energy humanization leads to growth by implementing policies and practices that promote energy efficiency, renewable energy, and sustainable development (Sovacool et al., 2016). By prioritizing these goals, institutions can create new economic opportunities while also addressing the urgent challenges of climate change and energy security.

2.5.3 Growth theories

Classical growth theory

John Smith, David Ricardo, and Thomas Malthus are the prominent proponents of the classical growth hypothesis. This idea aimed to explain the elements that influence development throughout time. Notwithstanding some conflicts, they believe that growth is not just influenced by production inputs such as land, money, labour, and technology, but also by social, political, and economic institutions (Ucak, 2015). They went on to say that surplus output value must be invested for any economy to thrive. They emphasized that not all economic activities generate surplus value (Liu, 2011). Smith (1876) contends that in order to fully use the optimal advantage of production for long-term economic success, a society must prioritize labour division and foreign commerce.

Harrod-Domar growth model

Harrod (1939) and Domar (1946) conceptualized this version of the growth model, proposing that a nation's progress is fundamentally driven by its savings and investment. According to Harrod and Domar, as an economy increases its savings, money become available for investment, and this surge in investment not only raises aggregate demand and national income but also amplifies aggregate supply, spurring further investment. The initial increase in investment is designed to improve output, which will result in an increase in income.

With the injection of this additional money into the economy, aggregate demand experiences further expansion. If the multiplier effect is substantial, aggregate demand continues to grow progressively. According to Harrod (1939) and Domar (1946), economic growth is significantly impacted by both the marginal savings rate and the capital-output ratio, highlighting that capital accumulation is a crucial prerequisite for growth. They advocated for government interventions to bridge the capital deficit and emphasized the necessity for macroeconomic environment regulation to facilitate growth and achieve this objective.

Neoclassical growth theory

Robert Solow, a prominent advocate of the neoclassical growth model, articulated that growth initially stems from augmenting labour and capital. However, this surge in growth is temporary, as the marginal output of capital diminishes as the economy progresses towards a long-term growth trajectory

(Solow, 1956). Labor, capital, and output will all rise at a constant rate in a steady-state economy. Technical inequalities, according to Solow (1956), explain the disparity in growth rates among nations. According to the paradigm, growth is exogenous and unrelated to capital investment.

Endogenous growth theory

David Romer (1994) originated the concept of the endogenous growth hypothesis. In contrast to the neoclassical viewpoint, he suggested that economic development is the result of forces within the system or economy, making it an internal phenomenon. Rather than unknown external reasons, productivity and growth are directly the outcomes of innovation, human capital improvement, and investment capital. Endogenous growth economists argue for public and private institutions to encourage ideas, create incentives, and safeguard property in order to boost innovation through the establishment of R&D funds.

The growth model chosen for this study

The endogenous growth theory is generally considered to be better suited to explain the relationship between energy and growth than other growth models such as neoclassical growth theory and the Harrod-Domar growth model. According to Grossman and Helpman (1993), endogenous growth theory emphasizes the role of endogenous factors such as innovation, knowledge, and human capital, which are closely linked to energy use. In this framework, energy can play a crucial role in driving economic growth by enabling technological innovation and improving productivity.

Research has shown that energy is a key factor in driving innovation and productivity growth in many sectors of the economy, including transportation, manufacturing, and information technology (Bridges, Gago & Cullen, 2020). Additionally, the use of renewable energy sources and energy-efficient technology may lower costs and boost competitiveness, both of which can promote economic growth. On the other hand, the neoclassical growth theory ignores the importance of energy in driving economic growth and instead claims that external variables like technology, population expansion, and capital accumulation are the main drivers of economic growth (Solow, 1956).

In conclusion, it is generally agreed that the endogenous growth hypothesis is more appropriate for illuminating the connection between energy and growth. This theory emphasizes the significance of energy in promoting economic growth and development by highlighting the influence of endogenous variables like innovation and productivity. The development of human capital via access to education, training, and fundamental services like healthcare and sanitation depends on the availability and dependability of energy. As a result, the endogenous growth model has been chosen as the growth model for this study.

2.6 Empirical Review

Empirical works on estimating and measuring energy security were first considered, followed by studies on growth and energy usage, in addition, studies on institutions and growth were also considered and finally works on energy usage institutions and growth.

2.6.1 Studies on the measurement of energy security

A systematic review was conducted by Gasser (2020) to look at studies that focused on indicators for energy security to compare national performances. The study discovered around 102 studies, after removing all duplicates 63 of them were utilized in the systematic review. The study concluded that since energy security has so many different aspects, indicator-based approaches are especially well suited for nation comparisons since the resulting indices are easy to understand and are useful instruments for policymakers' communication. The majority of research, according to the findings, were conducted mostly in North America, Europe, and Asia resulting in limited literature in case of Africa and South America. The rapid population growth across numerous continents is intricately linked to the world's rising energy needs. Gasser (2020) suggested that in order to provide a secure and ecologically friendly energy supply that will sustain growth and development, it is essential to carry out in-depth analyses of the energy security of South American and African nations.

Winzer (2012) attempted to conceptualize the concept of energy security since the fundamental goal of energy policy is energy security. The study examined the many perspectives on energy security. Based on risk factors, effect categories, and severity filters, the impacts' velocities, sizes, sustenance, dispersion, certainty, and singularity may be divided into groups. To illustrate the impact of defining conceptual boundaries based on these aspects on the outcome, the research offers a simplified case study involving three European countries. Winzer (2012) also highlighted that achieving a more precise distinction between supply security and other policy objectives may face challenges. Hence, any study that tries to estimate energy security should endeavour to consider the conceptual boundaries.

Azzuni and Breyer (2020) using 15 energy sector indicators estimate the level of energy security of the selected countries. Among the counties that were used for the study, energy security was at its highest levels in the United States and Germany, and its lowest in Turkmenistan and the Central African Republic. They concluded that there are several avenues and choices, not just one, for advancing energy security. Nations must exchange knowledge about what works best in their local settings to put these strategies into practice and increase energy security. Despite the effort made by this study it failed to account for the various dimensions of energy security and some of the indicators used in the analysis do not relate to the concept of energy security.

Shepard and Pratson (2020) have devised and utilized a distinct hybrid input-output database that traces energy flows within and between 136 major world economies. This database was employed to evaluate and compare energy security indicators concerning both direct and indirect energy. Their findings revealed that approximately 23% of the world's embodied energy network is attributed to indirect energy trade connections, especially between primary energy-producing nations and others they do not engage with directly. Additionally, the analysis exposed a substantial reliance of the global economy on indirect energy imports, which are about 90% higher than direct energy imports. Consequently, nations tend to have a significantly greater number of indirect energy trade partners compared to direct energy trade partners. The research investigated these variations in energy security indices on a global scale, within different sectors, and across individual countries from 2000 to 2015. The results underscored the role of major intermediary nations like the United States, China, and Russia in shaping these disparities in energy security. This highlights the importance of analysing energy security matters on a country-by-country basis, emphasizing the necessity for a fresh study focusing on the case of Ghana.

Augutis et al., (2020) analyse the Baltic States' performance in terms of their level of energy security using indicators. The study takes into consideration the significant changes the energy industry of the Baltic States underwent between 2008 and 2016. The level of energy security is evaluated using the index-based methodology. Employing an indicator framework that considers the technical, economic, geopolitical, and socio-political aspects of energy security. The results show that Lithuania has less energy security than Latvia and Estonia. The major causes of these variations are that Lithuania imports a lot of electricity whereas Estonia and Latvia have substantial domestic energy resources like oil shale and hydropower, respectively. Hence, they perceive that each country needs to look at their energy security from their perspective.

The primary objective of Radovanovic et al., (2017) is to create a fresh energy security indicator that prioritizes long-term sustainability. They applied this indicator to a set of 28 European Union nations from 1990 to 2012 to evaluate the impact of six different indicators on energy security. When employing the Energy Security Index and analysing data from 1990 to 2000, the ratings showed a decline in energy security for most countries. However, between 2000 and 2008, the values exhibited a positive trend, but post-2008, some nations experienced a gradual decline once again. The Netherlands, Slovenia, and Spain had the biggest rises in the Index value. The United Kingdom, France, Germany, and Italy, the four EU countries with the strongest economy, had substantially less volatility in energy security for 23 years than other countries. Radovanovic et al., (2017) using Principal Component Analysis, it was determined that GDP per capita, Energy Intensity, and Carbon Intensity had the most effects on the Energy Security Index. Due to fast economic expansion and heavy reliance on imported energy-generating equipment, the nations of the former Eastern Bloc are currently experiencing unique problems regarding energy security. Poland and Hungary had the most constant change in terms of energy security.

Abdullah et al., (2020) evaluate Pakistan's performance in terms of energy security based on an analysis of its energy security index from 1991 to 2018. The study emphasizes the ideas of "availability," "affordability," "technology," "government," and "environment". From a pool of twenty-two indicators, the Energy Security Indicators for Pakistan (ESIP) were selected. These indicators were assigned weights through principal component analysis and then normalized using the z-score approach. The research utilizing this index showcased a decline in Pakistan's energy security performance from 1991 to 1999, followed by an improvement until 2018. The maximum achievable score was recorded as 8.36 in 1991, while the lowest score was 7.59 in 1999. The performance increased between 2000 and 2018, earning a score of 8.29 in that year. Indicators of supply, consumption, and imports were crucial to the performance of energy security over the research period. As depicted by the result of the study different dimensions of energy security performance varied across time in Pakistan, hence the need to understand the case on how Ghana is performing on the various dimensions of energy security over time.

Alemzero, Sun, Mohsin, Iqbal, Nadeem, and Vo (2021) using data from a sample of 28 African nations from the years 2000 to 2018, this study creates a composite index of the continent's energy security and then assesses its effects and trends using PCA using a set of 13 variables. The main findings point to a propensity toward energy insecurity among the studied nations, which is confirmed by their high per capita emissions and preponderance of reliance on energy imports. These findings confirm the depressing situation that exists across Africa. The article proposes enhancing energy trade within regions by promoting collaboration among different power pools across the continent. Additionally, it emphasizes local investments in renewable energy, energy infrastructure, strategies to reduce electricity system losses, environmental sustainability, and the implementation of energy-efficient technologies.

Meierding (2011) noted that most global energy geopolitics and energy security focus on the objectives and actions of major energy importers like the US and China to the neglect of Africa. However, the study did not attempt to measure energy security but tried to examine how the activities of energy importers to increase their energy security through Africa are affecting that security inside Africa. It then describes several other tactics that have been used to improve African energy security after observing the limitations of these attempts. It concludes that while neighbourhood-based development initiatives have enhanced the quality of life for many households, they are insufficient as a safety net for energy. Poor access to petroleum continues to be a problem for development. The security of energy for people living in Sub-Saharan Africa is being threatened by foreign countries' efforts to strengthen their oil security.

Trollip et al., (2014) also noted that the idea of energy security is complex hence there need for a comprehensive definition of energy security based on the principles of accessibility, availability, and acceptability established by the World Energy Council. However, given how crucial the energy system is to the growth and survival of the modern state, it is crucial to take prompt, informed action. Furthermore, a multidisciplinary approach is essential for insightful policy research, particularly if confronting an energy security crisis. This is because energy system policies and investments are path dependent. As a result, it can be challenging to identify and address an energy security crisis. However, given how crucial the energy system is to the growth and survival of the modern state, it is crucial to take prompt, informed action. This further highlights the need for a study in Ghana that will estimate her energy security performance.

Ofosu-Peasah et al., (2021) integrated a study of the literature and carried out content analyses on 52 relevant research. They used a literature search technique, taking into account writing from both West Africa and the Global North. The study's findings showed that governance, sustainability, dependability, affordability, and regional energy integration are among the main elements affecting energy security in both the Global North and West Africa. Moreover, they identified sector-specific elements like energy demand-side management, availability, and security that exhibited similarities across these regions. The variation is mostly caused by characteristics that are specific to each region and only somewhat by how similar components develop in each region, which can be altered by subregional needs, threats, and objectives. It also notes that variables like sustainability, security, and investments in the energy industry have not received enough attention; as a result, future research should concentrate on these issues.

In the context of Ghana, Arthur and Locher (2022) examined the relationship between energy security and the productivity of SMEs in Ghana's Greater Accra Region. In the study, 246 responses from 500 SMEs were analysed. To gauge respondents' opinions on the idea of energy security, the research uses a Likert scale. Utilizing means, the Relative Importance Index (RII), and P-values for the variable's availability, affordability, efficiency, and environmental stewardship, the link between ES and the productivity of SMEs was evaluated. Environmental responsibility, efficiency, and availability are of equal importance to SMEs, with affordability being the foremost consideration. Sales volume, industrial output at a given cost, labour productivity, and capital efficiency are all substantially positively correlated with SMEs' access to energy.

Acquah et al., (2015) was the only study that attempted to measure Ghana's energy security using the composite energy security index (CESI) developed by. Sovacool (2011). In this study, an assessment was conducted to gauge Ghana's energy security status relative to 34 other nations using principal composite analysis (PCA). The availability, cost, technology development and efficiency, environmental sustainability, and regulatory and governance elements were among the indicators that were taken into account and categorized. Among the countries evaluated, Tunisia, Libya, Algeria, Egypt, and Morocco exhibited the weakest performance, while Brunei, Japan, New Zealand, the United States, and the EU demonstrated the most robust results. Notably, some of the top-performing African nations were Congo DR, Cameroun, Angola, Tanzania, and Zambia. Ghana ranked 17th in this comparative analysis. However, it is important to note that the study fell short in comprehensively explaining the variables constituting the diverse dimensions of energy security as intended, encompassing availability, affordability, technology development and efficiency, environmental sustainability, as well as regulatory and governance categories, along with the specifics of how these variables were assessed. The study also failed to explain and indicate the procedure employed in the data normalization before employing PCA in aggregating the data. Therefore, there is a need for a new study that will estimate the various dimensions of energy security in the context of Ghana and also forecast the level of various dimensions of energy security up to 2030 to assess if Sustainable Development Goal 7 could be achieved by Ghana.

2.6.2 Energy usage and growth

Tang et al. (2016) (investigated the relationship between energy usage and growth in Vietnam spanning from 1971 to 2011, employing the neoclassical Solow growth framework. Granger causality and cointegration were applied to analyse the outcomes. The findings indicated that energy consumption, FDI, and capital positively influenced Vietnam's economic progress. Moreover, the causality test uncovered a unidirectional relationship, suggesting that overall economic growth significantly affects energy usage. Since energy is essential to Vietnam's economy, any environmental or energy policy created to save energy may harm the nation's efforts to grow economically. The question one will ask is, what is the effect of energy usage on sectoral growth?

Gozgor et al., (2018) utilized panel data encompassing 29 countries from the OECD during the period of 1990 to 2013, to investigate, empirically, the connection between the development of economic growth and the use of renewable and non-renewable energy. Using panel quantile regression and panel ARDL estimation methods, the study revealed a positive association between energy consumption, economic complexity, and growth.

Eggoh, Bangake and Rault (2011) used the Granger causality test to investigate the connection between energy use and economic development in

21 African countries between 1970 and 2006. Based on their energy trade balance, the nations were divided into two categories: net energy exporters and net energy importers. Within each set of countries as well as across all of them, the analysis found a long-term equilibrium link between energy consumption, real GDP, prices, labour, and capital. This finding holds up when many endogenous structural breaks are taken into consideration. It is unaffected by possible cross-country dependency. This finding suggests that the impact of energy use on growth may differ among nations, industries, and historical periods; hence, fresh research utilizing up-to-date data to analyse Ghana's situation is required.

Similarly, Eggoh et al. (2011) and Ouedraogo (2013) explored the connection between energy accessibility and growth within 15 ECOWAS countries from 1980 to 2008, employing panel cointegration methodologies. The study established a causal relationship between growth and energy usage. Consequently, this research presents substantial empirical proof of enduring and causal links between energy usage and growth across the fifteen countries in the sample. It emphasizes how a lack of modern energy services or restricted access to them might hinder growth and threaten these countries' development potential.

Kwakwa (2012) examined the associations between growth, agricultural and manufacturing expansion, and energy use in Ghana from 1971 to 2007 using the Granger causality test. The findings indicated a one-way causal association between growth and fossil fuel and electricity consumption, as well as a one-way relationship between power consumption and agricultural output over the short and long terms. Since energy does not seem to play a vital role in the production of the agriculture sector but holds importance in the manufacturing sector, it is recommended to focus efforts on ensuring a consistent and ample supply of energy to the manufacturing sector. This will help in sustaining its contribution to the economy. This demonstrates that energy usage may affect the different sectors of the economy differently hence the need for a fresh study that will estimate econometrically the actual effect of energy use and its disaggregated components on sectoral growth.

Gyimah, et al. (2022) investigated the impacts of renewable energy on growth from 1990 to 2015. The study employed both Granger causality and the mediation model for its analysis. The findings reveal a mutually reinforcing connection between growth and the utilization of renewable energy; however, this relationship is relatively moderate in strength.

Using the Granger causality test, Ameyaw et al. (2017) investigated the relationship between energy use and economic development in Ghana. The Cobb-Douglas growth model was used to evaluate time series data from 1970 to 2014, and the results showed a one-way causal link between GDP and electricity consumption. This data-driven causality chain supports the theory that economic growth drives energy usage.

2.6.3 Economic growth and institutions

Asghar, Qureshi and Nadeem (2015) examined the effect of institutions on growth within 13 developing Asian countries from 1990 to 2013. The outcomes obtained from the panel ARDL analysis indicated a favourable impact of institutional quality on growth. This suggests that the countries in the study region should persist in enhancing their institutional framework. Nevertheless, there is room for debate regarding whether this finding is applicable to Ghana.

Akinlo (2016) investigated the correlation between growth and institutions across 32 SSA nations from 1996 to 2013. The findings revealed that institutions, physical capital, and interest rates exhibited a negative influence on regional growth. Conversely, factors that can be controlled, such as human capital and the money supply, demonstrated a positive effect on growth. Even if the estimating method is valid, the study results may differ if additional institutional components are considered.

Ferreira and Ferreira (2016) employed a non-linear Tobit model to analyse how institutional quality impacted the ability of 48 SSA countries to attract FDI inflows in the year 2011. The results showed that FDI inflows into the region were significantly positively influenced by the institutional environment's quality.

Gori, Kun and Dolfsma (2018) examined the options that managers could make in the face of a bad institutional environment using a sample of 17,757 observations from 35 SSA countries between 2006 and 2015. Managers who live in high-quality environments, according to the research, spend a significant amount of time dealing with rules and regulations. Recognizing its effect on output, individuals opt for informal payments, often referred to as bribery and corruption, as a means to bypass the system. Sub-regional institutions must put in significant effort to make them less time-consuming.

2.6.4 Energy security and economic growth

Alekhina (2021) argued that recent growth in Asia has significantly influenced the global demand and prices for energy. However, efforts to enhance energy security in the region have been somewhat limited. In order to assess the advancements in energy security across Asia and its impact on the growth of real income per capita, the research incorporated the Four-A energy security framework—encompassing energy availability, accessibility, affordability, and acceptability dimensions—into a cross-country GMM model. This model utilized data from 20 Asian nations during the period from 1995 to 2015. The findings indicate a positive correlation between energy security, as measured by the expansion of renewable energy utilization, increased access to electricity, and growth in electric power consumption per capita, with real income per capita growth. On the other hand, increased energy intensity and a greater reliance on imported energy stifle economic expansion. Additionally, we included climate security within the framework of energy security, highlighting the negative effects of growing CO2 emissions on growth. One of the weaknesses of this study was that it could not pinpoint the overall impact of energy security on growth since the research employed individual indictors of energy security rather than an overall indictor hence the inconclusive finding. The present study will fill this gap by generating an overall index for energy security as well as test this impact on sectoral growth.

Xu and Wang (2022) opined that energy security has emerged as a significant priority for both the global community and national security strategies. They study utilizes data from 59 countries during the period from 2000 to 2018 to quantify the influence of energy security on growth. The empirical findings show a strong and favourable correlation between growth and energy security. Furthermore, improvements in domestic political stability and the expansion of international trade are recognized as favourable factors aiding energy security and, consequently, fostering economic growth.

Particularly for nations heavily reliant on energy imports, the influence of energy security on growth is observed to be more substantial.

Lee, Xing and Wang (2023) delve into understanding the influence of energy security on the growth of China by conducting an analysis using panel data spanning 30 provinces over the period from 2006 to 2018. The research employs a combination of the entropy method and a panel quantile regression model to explore this relationship. The results showed that there is a discernible upward trajectory in energy security levels over the years. Secondly, the study uncovers notable variations in energy security levels across different regions within China. Lastly, a crucial discovery is the strong and positive association between energy security and China's economic development. However, it's worth noting that this positive impact diminishes gradually as the levels of economic development improve.

Arani and Rostami (2022) analysed the impact of energy security on the growth of ten Middle Eastern nations, all of which are energy-exporting countries. The analysis is grounded in a standard model that is an adapted version of Cobb Douglass's production function. The study employs a comprehensive set of ten metrics to assess energy security, covering five fundamental dimensions: availability, accessibility, acceptability, cost-effectiveness, and development capability. The model estimation technique applied include the generalized least squares (GLS) and panel-corrected standard error (PCSE) methods. The findings of the study highlight a positive correlation between energy security and the economic growth of the selected Middle Eastern energy-exporting nations, particularly when energy production is not differentiated from energy consumption. Moreover, a range of elements, including 'the nation's energy production capacity', 'the structure of the national energy system', 'utilization of renewable energy', 'carbon dioxide emissions stemming from fossil fuel usage', 'stability in the political arena', and 'oil prices' are recognized for their role in bolstering economic growth within these nations. Conversely, 'energy intensity' and 'the proportion of carbon dioxide emissions relative to GDP' are noted to negatively impact their economic growth.

2.6.5 Energy usage, institutions, and economic growth

Bhattacharya, Churchill and Paramati (2017) examined the effects of institutions and the use of renewable energy on economic growth and the decrease of CO2 emissions in 85 industrialized and developing nations between 1991 and 2012. These results showed that there is a lot of variation within subsamples. In conclusion, the findings of the system-General Methods of Moment and fully modified OLS studies show that increasing the use of renewable energy has a noticeable positive influence on economic growth and a notable negative impact on CO_2 emissions. Institutions largely promote economic progress and aid in the reduction of CO_2 emissions. Since the result varies among the sample it is prudent to conduct a country-level analysis to examine the role of the institution in moderating the relationship between sectoral growth and energy use.

Christoforidis et al. (2021) explored the link between nuclear energy usage and economic development using panel data from 18 of the world's leading nuclear power-consuming countries from 1995 to 2017, and how institutional structures influence this relationship. By employing a combined institutional quality index derived from the rule of law and regulatory quality, the study conducted a cointegration test, demonstrating a long-term relationship among the variables of interest. The pooled mean group analysis revealed substantial long-term economic growth benefits associated with the use of nuclear energy and institutional quality. Conversely, higher institutional quality exhibited a negative long-term influence on the utilization of nuclear power. Consequently, a unidirectional causal relationship between economic advancement and nuclear energy usage in the short term was observed. Our findings imply that governments seeking nuclear energy as a long-term clean energy option should reassess their institutional frameworks, given the current worldwide conversation over the role of nuclear power in generating sustained growth.

According to Uzar (2020), renewable energy has arisen as a viable strategic option due to the greenhouse gas emissions produced by fossil-fuelled energy sources. While renewable energy is essential for addressing environmental issues, research on its drivers is limited. This study focused on renewable energy's macroeconomic and environmental drivers, political and institutional issues are frequently disregarded. The research investigates the correlation between institutional environment and renewable energy usage among 38 countries from 1990 to 2015. The findings suggest that institutional quality has a long-term favourable effect on renewable energy uptake. Additionally, usage of renewable energy is significantly positively influenced by CO_2 emissions. On the other hand, economic expansion hinders the development of renewable energy. In this context, improving institutional quality stands out as a crucial tactical decision to encourage increased usage of renewable energy sources and solve environmental issues.

Acheampong, Dzator and Savage (2021) argued that the majority of economic policy goals have been to promote energy efficiency and growth while minimizing carbon emissions. Less attention has been devoted to the amount to which economic institutions are responsible for the global shift toward sustainable energy consumption and carbon emission reduction, despite the emphasis placed on the importance of economic institutions in economic growth by scholars. This study looked at the connections between 45 Sub-Saharan African countries' economic systems, energy use, carbon emissions, and economic development between 1960 and 2017. The findings showed that economic expansion had a beneficial impact on financial institutions and carbon emissions, with no negative feedback effects on the GMM-PVAR system. It also demonstrated that there is no direct relationship between economic growth and electricity power usage. Given the divergent findings across different regions in SSA, there is a necessity for a country-level analysis that explores how institutions moderate energy usage, including its disaggregated components, concerning sectoral growth.

Table 2.2 presents a summary of the empirical literature that was reviewed in connection to the objectives of the study. The table includes information about the authors, methods employed, topic objectives, and identified gaps in the various works examined.

Table 2.2: Author(s) Topic Estimation techniques Gap

Author(s)	Topic	Estimation techniques	Gap
Studies on the measurement of energy security			
Augutis et al., (2020).	Analysis of energy security level in the Baltic States based on indicator approach	Index Approach	The study was limited to Baltic states and it also come to the conclusion that each country needs to look at their energy security from their perspective hence the need to consider the case of Ghana.
Alemzero et al (2021)	Assessing energy security in Africa based on a multi-dimensional approach of principal composite analysis	Principal component analysis (PCA)	The study only considered some aspects of energy security neglecting the rest
Trollip et al., (2014)	Energy Security in South Africa	PCA	The study uses only accessibility, availability, and acceptability neglecting the dimension of energy affordability
Ofosu-Peasah et al., (2021)	Factors characterizing energy security in West Africa: An integrative review of the literature	Content analyses	The conclusions drawn on energy security are based on studies that predominate the Global North.

Table 2.2 Continue

Author(s)	**Topic**	**Estimation techniques**	**Gap**
Azzuni & Breyer (2020).	Global Energy Security Index and Its Application on National Level	Standardization and normalization approach.	The study failed to account for the various dimensions of energy security and some of the indicators used in the analysis do not relate to the concept of energy security.
Winzer (2012)	Conceptualizing energy security	Case study	
Shepard and Pratson (2020)	Hybrid input-output analysis of embodied energy security.	Input-Output analysis	The study highlights the need to research or analysing energy security matters on a country-by-country basis, emphasizing the necessity for a fresh study focusing on the case of Ghana.
Abdullah et al., (2020).	Energy security indicators for Pakistan: An integrated approach	Z-score method and PCA	The study only considered Pakistan's energy security performance and came to the conclusion the result may be country specific hence the need for us to consider the case of Ghana.
Radovanović et al., (2017).	Energy security measurement – A sustainable approach	PCA	The study was limited to 28 European countries and African countries were neglected.

Table 2.2 Continue

Author(s)	Topic	Estimation techniques	Gap
Eggoh, Bangake and Rault (2011)	The connection between energy use and economic development in 21 African countries	Causality test	The study only focused on the testing of the causality and does not only test the actual effect.
Kwakwa (2012)	Examined the associations between growth, agricultural and manufacturing expansion, and energy use	Granger causality test	There was a methodological gap in that the study since it only uses causality test for its analysis
Ouedraogo (2013)	The connection between energy accessibility and growth within 15 ECOWAS countries	panel cointegration	The study only focused on the testing of the causality and does not stimulate the actual effect.
Gyimah et al., (2022)	The effect of renewable energy on growth	Granger causality and the mediation model	The study limited European countries and African countries were neglected
Ameyaw et al. (2017)	The relationship between energy use and economic development in Ghana.	Granger causality	The study has a methodological limitation in terms method of analysis.

Table 2.2 Continue

Author(s)	Topic	Estimation techniques	Gap
Lee, Xing and Wang (2023)	Delve into understanding the influence of energy security on the growth of China	Entropy method and a panel quantile regression	The study was geographical limited to only China and the case of Ghana was not considered.
Arani and Rostami (2022)	The impact of energy security on the growth of ten Middle Eastern nations	The GLS and panel-corrected standard error (PCSE)	The study was geographical limited to only Middle Eastern and the case of Ghana need to be considered

Energy usage, institutions, and economic growth

Author(s)	Topic	Estimation techniques	Gap
Christoforidis et al., (2021)	the link between nuclear energy usage and economic	pooled mean group analysis	The study was limited in terms its methodology and coverage limited to world's leading nuclear power-consuming countries
Uzar (2020)	The research investigates the correlation between institutional environment and renewable energy usage	panel ARDL-PMG method	The study ignores African countries in its analysis
Acheampong, Dzator and Savage (2021)	The role of economic institutions in electricity consumption, economic growth, and CO2 emissions linkages: evidence from sub-Saharan Africa	system GMM-PVAR	The study only considered the power sector impact of growth whilst neglecting other energy sectors.

2.7 Conceptual Framework

The conceptual framework for energy humanization and its dimensions, institutional environment and sectoral growth includes the following key components (See Figure 2.5):

1. Energy Humanization: Is basically the combination of the concept of energy security and energy usage. Whilst energy security in this context captures energy affordability, technology application, availability and acceptability, the concept of energy usage will capture energy use and its patterns. Therefore, energy humanization involves incorporating energy use and energy security into perspective.
2. Energy security: This refers to the availability, technology application, affordability, and acceptability of energy resources. It includes access to energy services for all, protection against energy supply disruptions, and the ability to manage energy demand.
3. Energy usage: This refers to the consumption of energy by different sectors, such as transportation, industry, and residential buildings. It includes two main final energy usage (petroleum fuel products and electricity) and the efficiency with which energy is consumed.
4. Institutions: This refers to the policies, regulations, and institutions that govern energy production, distribution, and consumption. It includes the roles and responsibilities of different actors, such as government agencies, energy companies, and civil society organizations.
5. Sectoral growth: This refers to the growth and development of different economic sectors, such as the industrial, service, and agricultural sectors.

In this framework, the relationships between these components can be explored in several ways. For example: Energy security and energy usage together form's energy humanization through policies that promote energy efficiency and reduce energy demand and enhance energy security. Energy humanization, energy usage and energy security may impact sectoral growth. For example, policies that ensure availability, technology application, affordability, and acceptability energy will promote sustainable development, while investment in energy-intensive sectors such as heavy industry can increase energy demand and create challenges for energy security.

Institutions can shape both energy humanization and its dimensions, and sectoral growth. For example, policies that support research and development of new energy technologies can promote innovation and enhance energy efficiency, while regulations that limit carbon emissions can incentivize businesses to adopt cleaner production methods and promote sustainable sectoral growth.

Overall, a conceptual framework for energy humanization, energy security and usage, institutions, and sectoral growth can help to identify the complex relationships between these different components and guide research and policy efforts to address the challenges and opportunities associated with energy production, distribution, and consumption.

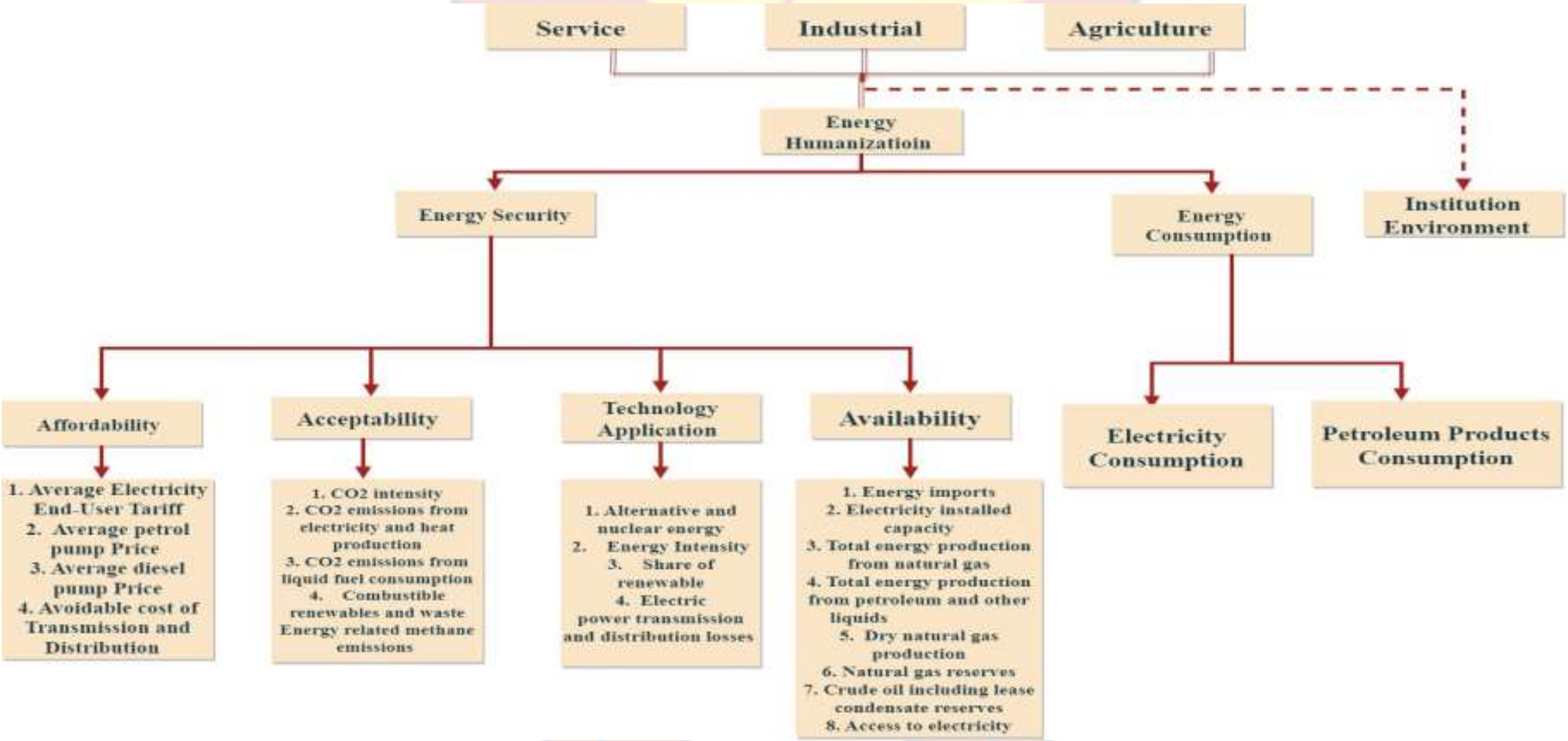

Figure 2.5: Conceptual Framework
Source: Asafo (2024)

2.8 Chapter Summary

This chapter provides an overview of the energy sector in Ghana and defines key concepts central to the study. It delves into a review of theoretical and empirical literature, along with the conceptual framework pertaining to energy security, energy usage, institutions, and sectoral growth, positioning the present study within the existing knowledge frontier. The endogenous growth model was chosen from various theoretical growth models due to its ability to account for both the level and growth effects of energy usage. Additionally, the Four-A theory of energy security was adopted to elucidate the concept and estimation of energy security, drawing from theoretical models of growth. The literature review on institutional theory underscored the significance of institutions in influencing growth, emphasizing their role in mediating the impact of energy utilization on growth.

CHAPTER THREE

RESEARCH METHODS

3.1 Introduction

In this chapter, the researcher presents the research design, approach, description of data sources and analysis procedures and any other relevant information that is necessary for the reader to understand how the study was conducted. The aim of this section is to provide a clear and concise explanation of the research methods used to achieve the objectives of the study and to demonstrate the rigour and validity of the research. The methodology helps evaluate the reliability and generalizability of the research findings. In short, the methodology chapter is a critical component of any thesis, as it provides the foundation for the research and ensures that the study is conducted systematically and rigorously.

3.2 The Research Design and Approach

To accomplish the study's goals, a positivist research philosophy and a quantitative research design were used. The positivist research approach is a scientific method that emphasizes the use of empirical evidence, rigorous methods, and quantitative data analysis in research. Positivist researchers seek to uncover objective truths about the world by using scientific methods and collecting empirical evidence (Park, Konge & Artino, 2020). They believe that knowledge can be gained through systematic observation and experimentation and that this knowledge can be used to develop theories and make predictions about the world. One reason why researchers use the positivist research approach is that it allows for the use of standardized methods and procedures, which help to ensure that the research is conducted in a systematic and unbiased manner (Leong, 2014).

Quantitative research design is often used for its objectivity, precision, accuracy, generalizability, replication, and hypothesis-testing capabilities. By emphasizing objectivity, quantitative research design aims to minimize personal bias or interpretation in data analysis. Precise and accurate measurements of variables are important for drawing reliable conclusions and making valid predictions. The ability to generalize findings to a larger population is useful for drawing conclusions about a particular phenomenon or group. Replication of research methods allows for comparison of results across studies. Finally, the use of quantitative research design enables researchers to test hypotheses and theories with statistical analysis, making it a useful tool in scientific research. Consequently, the conclusion and result are more consistent, reproducible, valid, and generalizable.

3.3 Model Specification

For objective one, where we estimate the various dimensions of energy humanization, which is basically a composite index for energy security and energy usage. To estimate energy security a dimension of energy humanization, we employed different sub-dimensions of energy security where the study adapts the "Four-A" of energy security (availability, accessibility, affordability, and acceptability) established by the APERC (2007) since it was able to address contemporary issues in the definition of energy security. The study further modifies the Four A's to include technology application (applicability) as suggested by Tongsopit et al. (2016) and Yao and Chang (2014). Hence considering the crucial 4-A factors of resource availability (AV), technological application (AP), social acceptability (AC), and affordability of energy resources (AF), with sub-indicators in each to assess Ghana's energy security.

In attempt to estimate total energy usage as a dimension of energy humanization the study employed total electricity consumption and total petroleum products consumption as a measure for total energy usage. The framework for energy humanization estimation is represented graphically as shown in Figure 3.1.

To estimate the various sub-dimensions of energy security dimensions-- resource availability (AV), technological application (AP), social acceptability (AC), and affordability of energy resources (AF), several parameters or indicators are assigned to each dimension as shown in Figure 3.1. These parameters are measured in different units, hence the need for the normalization of data units on a uniform scale for easy and meaningful computation of the various dimensions of energy security. Subsequently, all the parameters are assigned equal weight and applied in the estimation of the different dimensions of energy security. The parameters within a dimension are given equal weights of data insufficiency on the weight to assign the parameters individually.

Similarly, in the aggregation of the Energy Security (ES) index, the dimensions are given equal weights. If there is a valid reason to assign specific weights to either the dimensions or the parameters in the future, then there is potential for improvement in the methodology. This method has also been adopted by Azzuni and Breyer (2020), Kamsamrong and Sorapipatana (2014) and Wu et al. (2012).

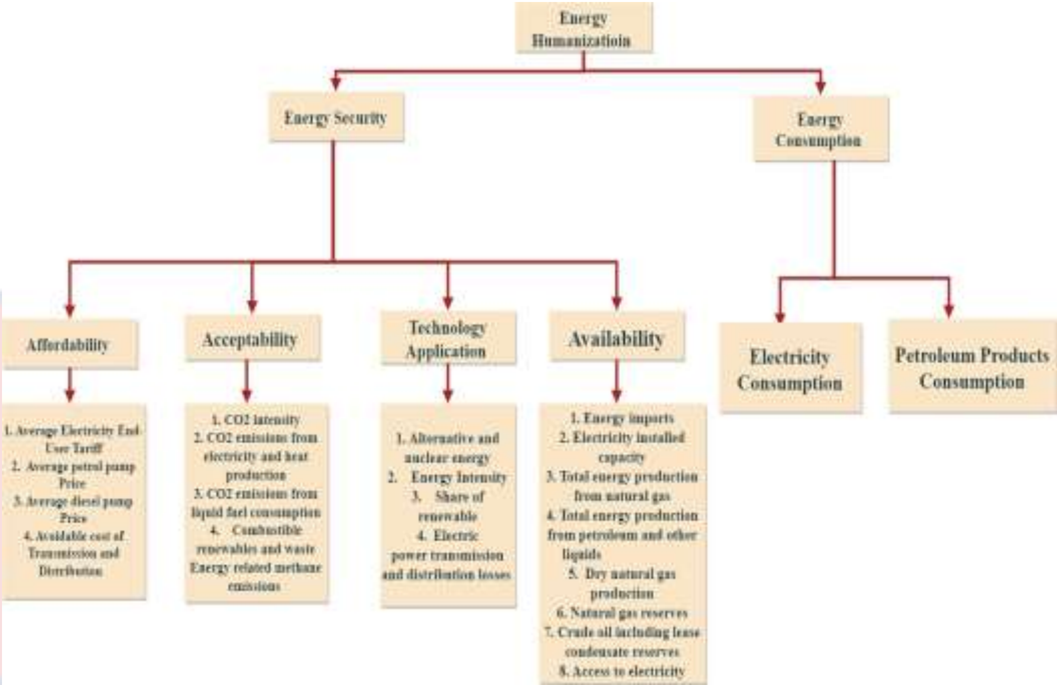

Figure 3.1: Indicators for Energy Humanization
Source: Asafo (2024)

The various parameters were transformed and normalized using the Max-Min approach ranging between 0 and 1. With 1 indicating the maximum and 0 as the minimum expected value of each dimension. The adjustment was made using the formula stated in Equation (1).

$$X^1 = \frac{X - Min_A}{Max_A - Min_A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

X^1 denotes transformed parameter, X represent untransformed parameter, A represent data range of X, Min_A denotes the minimum value in A and Max_A denotes maximum value in A.

Yet, certain parameters are inversely related to the scale. The greater value in this inverse relationship is correlated with poorer energy security. A higher proportion of imported energy, for instance, denotes weaker energy security. The lowest raw score corresponds to the greatest raw score, which on the scale translates to 1, and the highest raw score translates to the lowest raw score, which is equivalent to 0. In this situation, the Equation is:

$$X^1 = \frac{X - Max_A}{Min_A - Max_A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

After the normalization and assignment of equal weight to each parameter, the normalized values are then summed up using Equation (3) to derive the different dimensions of energy security.

$$D_i = \frac{\sum_1^n X^1}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where D_i denotes the dimensions of energy security, X^1 the transformed parameter, and n the number of parameters.

Furthermore, using Equation (4) the value of energy security over the period.

$$ES = \sum_1^{n=4} V_i D_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where ES denotes estimated energy security, D_i dimensions of energy security, V_i equal weight assigned to all the dimensions of energy security and n number of dimensions.

For us to calculate energy usage index, we employed Equation (5) to estimate the value of energy usage index over time.

$$EU = \sum_1^{n=2} V_i W_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$EU\ represent$ calculated Energy Usage Index, W_i the normalized indicators for energy usage, V_i the equal weight assigned to the normalized indicators for energy usage and n the number of indicators.

Finally, to derive our main variable of interest, Energy Humanization Index, using Equation (6) as stated below.

$$EHI = \sum_1^{n=2} V_i W_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

EHI denoted the calculate Energy Humanization Index, H_i the dimensions of energy humanization, V_i is the equal weight assigned to all the dimensions of energy humanization index and n the number of dimensions.

By converting the data in this way, we can identify the improvement indicator. However, only relative performance regarding the data ranges from which the indicators were produced is evaluated by the scale. As a result, the interpretation or assessment of the transformed values will be in line with the untransformed values. The different dimensions of the energy humanization are represented graphically using a heptagonal radar chart over the period of study.

For objective two, the study forecasts energy humanization up to 2030 to ascertain if SDG 7 could be achieved. The study initially uses the Autoregressive integrated moving average (ARIMA) method, which combines autoregressive (AR), moving average (MA) and differencing (I) components to forecast the different dimensions of energy humanization and overall energy humanization up to 2030. If the data showed signs of seasonality a more complex seasonal ARIMA (SARIMA) model would have been employed to capture the seasonal patterns in the data.

The study adopts the exponential smoothing techniques since none of the partial autocorrelation function (PACF) lags nor the autocorrelation function (ACF) lags are significant making the use of ARIMA practically impossible. Exponential Smoothing techniques is a good forecasting substitute in such a circumstance. Simple exponential smoothing, Holt's linear exponential smoothing, and Holt-Winters seasonal exponential smoothing are examples of exponential smoothing techniques that aim to capture time series patterns without primarily depending on autocorrelation. These techniques are able to deal with data that contains patterns, seasonality, and even a small amount of noise.

For objectives three and four, the endogenous growth model is used as the theoretical framework in this study to analyse the effect of energy humanization and the moderating role of institutions on energy humanization and sectoral growth in Ghana. The research used the Cobb-Douglas production function for sectoral economy, which was later expanded to include energy humanization. This is because labour-augmentation technology (A) is not the only element that leads to technological advancement; energy is also a factor (Martchamadol & Kumar, 2014; Nguyen et al., 2019; Odularu & Okonkwo, 2009; Sharaf, 2016).

Research has shown that energy is a key factor in driving innovation and productivity growth in many sectors of the economy, including transportation, manufacturing, and information technology (Bridges, Gago & Cullen, 2020). Moreover, the adoption of energy-efficient technologies can lead to cost savings and improved competitiveness, which can drive economic growth. Energy availability and reliability are also essential for the development of human capital through access to education, training, and basic services such as healthcare and sanitation.

To assess the relationship between energy humanization and sectoral growth, the study employed a Cobb Douglas production function with the constant return to scale and productivity growth that is to labour-augmenting (Harrod Neutral) and t = 1, 2, …, n Given as:

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha} \quad (7)$$

$$L_t = L_0 e^{n_t} \quad (8)$$

$$A_t = A_0 e^{g_t + EH_t} e^{u_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

where Y_t is sectoral growth, K_t is capital, L_t is the labour force available and A_t is a labour-augmenting factor for assessing the level of technology and efficiency at a point in time. n_t and g_t are the labour force growth rate and the rate of technological progress at a point in time respectively. A_0 is time-invariant technology. EH_t is energy humanization, which can affect the level of technological progress and its efficiency.

Re-writing Equation (7) in an intensive form gives: $y_t = k_t^{\alpha}(A_t)^{1-\alpha} \ldots\ldots (10)$

Applying natural log to Equation (10) gives:

$$lny_t = \alpha lnk_t + (1-\alpha)lnA_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Applying natural log to Equation (9) yields:

$$lnA_t = lnA_0 + g_t + EH_t + u_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Putting Equation (12) into Equation (11) gives:

$$lny_t = \alpha lnk + (1-\alpha)lnA_0 + (1-\alpha)g_t + (1-\alpha)EU_t + u_t \ldots\ldots\ldots\ldots (13)$$

Let x_t represent other control variable that influences growth and substituting x_t into Equation (13) yields:

$$lny_t = \alpha lnk + lnA_0 + (1-\alpha)g_t + (1-\alpha)EU_t + x_t + u_t \ldots\ldots\ldots\ldots (14)$$

According to Equation (14), growth (sectoral growth) is a function of growing capital stock (k) and other drivers such as technical advancement, energy humanization, energy usage, and labour efficiency improvement. Energy humanization promotes technical advancement and economic efficiency.

Equation (14) in the functional form gives $Y_t = f(\mathrm{K}, \mathrm{EH}, \mathrm{X})$, where K represents capital (human and physical capital) and EH represents energy humanization and its dimensions. The study adopts the endogenous model, which postulates that energy humanization has both level and growth impacts.

The extended version of the functional form which includes all control variable can be expressed as; Y= f (K, EH, TOT, GFCF, Gov_Exp, FDI) Where is Y represent sectoral growth [thus Service sector growth (SG), Agric sector growth (AG), Industrial sector growth (IG)], EH is energy humanization and its dimensions (Total energy use and energy security), K is gross fixed capital formation, gross capital both human and physical capital, TOT is trade openness, Gov_Exp is general government Expenditure and FDI is foreign direct investment.

Adopting the framework espoused by Ameyaw et al., (2017), Eggoh et al., (2011), Gyimah, Yao, Tachega, Hayford, and Opoku-Mensah (2022), Kwakwa (2012), Tang et al. (2016), Twerefou, Iddrisu and Twum (2018), the empirical model to investigate the study objective three can be specified as;

$$Y_t = \beta_0 + \beta_1 EH_t + \beta_2 \mathrm{GFCF}_t + \beta_3 TOT_t + \beta_4 Gov\_Exp_t + \beta_5 FDI_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

The subscripts *t* time or period.

To achieve objective four, analysing how institutions present are playing their moderating role of ensuring that energy humanization efficiently propel the needed growth for development, the researcher specifies the empirical model as;

$$Y_t = \beta_0 + \beta_1 EH_t + \beta_2 INS_t + \beta_3 (INST * EH)_t + \beta_4 \mathrm{GFCF}_t + \beta_5 TOT_t + \beta_6 Gov\_Exp_t + \beta_7 FDI_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Where INST represent all institutional variables (Liberal Political Institution and Economic Freedom index) which are measures for institutions in this study.

3.4 Sources of Data and A Priori Expectations

Data on the needed variables were sourced from World Development Indicators (WDI), the Energy Commission, the International Energy Agency (IEA), V-Dem's index and Fraser Institute. The research utilized yearly data spanning from 1980 to 2021. The variables used in the study are presented in Table 3.1 and 3.2 where Table 3.1 captures the variables used in the estimation of energy humanization whilst Table 3.2 captures the variables used in the estimation of the effect of energy humanization and its dimensions on sectoral growth as well as the moderating role institutional environment plays in the relationship.

Table 3.1: Description of Variables used in calculation of Energy Humanization

Variables	Description	Source
CO2 intensity	CO2 intensity kg per kg of oil equivalent energy use	WDI
CO2 emissions from electricity and heat production	CO2 emissions from electricity and heat production, % of total fuel combustion)	WDI
CO2 emissions from liquid fuel consumption	CO2 emissions from liquid fuel consumption % of total	WDI
Combustible renewables and waste	Combustible renewables and waste % of total energy	WDI
Energy related methane emissions	Energy related methane emissions % of total	WDI
Share of renewable in total energy consumption	Share of renewable in total energy consumption % of total	WDI
Alternative and nuclear energy	Alternative and nuclear energy % of total energy use	WDI
Energy intensity	MMBtu per person	EIA
Electric power transmission and distribution losses	Electric power transmission and distribution losses % of output)	EIA
Average Electricity End-User Tariff	Average Electricity End-User Tariff (US$/kWh)	The global economy, Energy Commission and WDI

Table 3.1 Continue

Average Petrol Pump Price	Average petrol pump Price (US$/lt)	The global economy and WDI
Average Diesel Pump Price	Average diesel pump Price (US$/lt)	The global economy and WDI
Avoidable cost of Transmission	Avoidable cost of Transmission (GHc)	EIA
Energy imports	Energy imports, net % of energy use	EIA
Electricity installed capacity	Electricity installed capacity in million kilowatts	EIA
Total energy production from natural gas	Total energy production from natural gas in quadrillion Btu	EIA
Total energy production from petroleum and other liquids	Total energy production from petroleum and other liquids in quadrillion Btu	EIA
Natural gas reserves	Natural gas reserves, Ghana in TCF	EIA
Dry natural gas production	Dry natural gas production in BCF	EIA
Crude oil including lease condensate reserves	Crude oil including lease condensate reserves, Ghana in Barrels	EIA
Access to electricity	Access to electricity % of population)	WDI
Electricity consumption	Electricity consumption in billion kilowatt-hours	EIA
Petroleum and other liquids consumption	Petroleum and other liquids consumption in quadrillion Btu	EIA

Source: Asafo (2024)

Table 3.2: Variables, data source and expected signs of variable used in Model Estimation

Variable	Symbols	Description	Source	Expected Sign
Service growth	SG	Service, value-added (millions GH₵)	WDI	
Agriculture growth	AG	Agriculture, forestry, and fishing, value added (millions GH₵)	WDI	
Industry growth	IG	Industry, value added (millions GH₵)	WDI	
Energy Humanization	EHI	Energy Humanization	Authors Construct	Positive
Institutions	INST	All institutional variables	V-Dem's index and Fraser Institute	Positive
Gross fixed capital formation	GFCF	Gross fixed capital formation % of GDP	WDI	Positive
Trade Openness	TOT	Trade openness as a % GDP	WDI	Positive
Foreign direct investment	FDI	FDI are the net inflows of investment as % of GDP	WDI	Positive
General government Expenditure	Gov_Exp	Government final consumption as % of GDP	WDI	Positive/Negative

Source: Author's compilation, 2024

3.5 Discussion of Estimated Model Variables

This section provides detailed information on the variables used in the analysis and measurement or construction of these variables study. First, we look at the variables used in the assessment of objective one and two in this section.

3.5.1 Energy humanization

Energy humanization is basically a composite index of energy security and energy usage. Where energy security has four main sub-dimensions such as resource availability (AV), technological application (AP), social acceptability (AC), and affordability of energy (AF) with their individual indicators. For total energy usage or consumption in this study, we have two main sub-dimensions, total electricity consumption and total petroleum products consumption. The indicator is constructed using the interval 0 to 1, where approaching 0 means less energy humanization and approaching 1 means more energy humanization.

3.5.2 Energy security

Energy security is simply defined as the assurance that there is a reliable and sufficient supply of energy sources that are available, affordable, adaptable applicable and acceptable to meet the needs of individuals, businesses, and societies, while also minimizing environmental impact. The definition is a modified version of the "four A's" of energy security proposed by APERC in 2007. In the APERC definition, energy security was defined to cover availability, affordability, accessibility, and acceptability but this study proposed the replacement of accessibility with technology application, which may cover issues related to technology application in the energy sector, whilst we combine the measurements of accessibility and availability as availability.

Availability component of energy security

The availability component refers to the stable and reliable supply of energy resources to meet demand. The availability component demonstrates the existence and sufficient of energy especially fossil fuels and other indigenous energy sources to meet demand. The higher the score on this aspect, the greater its reserves, potential, and sufficiency of indigenous energy sources to meet demand. The availability of energy can be improved through diversification of energy sources and investments in energy infrastructure. The accessibility component of energy security refers to equitable access to energy resources for all consumers, including those in remote or disadvantaged areas. Improving accessibility can be achieved through the promotion of universal access to energy and reducing energy poverty. The concept of equitable access to energy, which maintains that everyone should have access to energy regardless of financial level, is also covered by this dimension (Malik et al., 2020). The parameters or indicators used in the estimation of energy availability include energy imports, electricity installed capacity, total energy production from natural gas, total energy production from petroleum and other liquids, dry natural gas production, natural gas reserves, crude oil including lease condensate reserves and access to electricity. An increase in the composite index is an indication of improvement in energy availability and hence, energy security.

Affordability measurement

The affordability component refers to ensuring energy prices remain affordable for households, businesses, and industries. According to Tongsopit et al. (2016), the affordability component refers to the ability or capability of a societies or an economy to acquire energy at a reasonable cost. When a country's level of affordability drops, it means that its citizens have less access to energy, which makes it more difficult for them to satisfy their energy needs. Improving affordability can be achieved through promoting competition in energy markets and encouraging energy efficiency and conservation. Variables employed in calculating affordability include average electricity end-user tariff, average petrol pump Price (US$/lt), average diesel Ex-pump Price (US$/ltr), and avoidable cost of distribution (GHC). An increase in the composite index is an indication of improvement in energy affordability and security.

Technology applications

The component of technology applicability (Energy Adopttion or adaptability) displays the ability of a region to exploit and expand its indigenous energy supplies. The capacity to apply new technology, for example, to minimize energy waste and increase energy conservation, so prolonging the use of the same energy reserves, enhances application performance (Malik et al., 2020). Similarly, applying new technologies that broaden the scope of the country's indigenous energy reserves (extracting previously inaccessible resources) boosts the country's applicability rating. Parameters employed in these measurements include alternative and nuclear energy, energy Intensity, share of renewable, and electric power transmission and distribution losses. An increase in the index is an indication of improvement in energy technology application and security.

Acceptability component

The acceptability component refers to the social and environmental acceptability of energy production and consumption (Tongsopit et al., 2016). Promoting the use of renewable and low-carbon energy sources, improving energy efficiency, and addressing social and environmental concerns related to energy production and consumption can enhance acceptability(Malik et al., 2020). The indicators employed in measuring energy acceptability include CO2 intensity, CO2 emissions from electricity and heat production, CO2 emissions from liquid fuel consumption, combustible renewables and waste and energy related methane emissions.

3.5.3 Sectoral growth

Sectoral growth refers to the expansion or decline in economic sectors of an economy (Todaro & Smith, 2014). It is an important component of economic growth since it reflects changes in an economy's output and employment mix. In this discussion, the major sectors for consideration are the agriculture, service, and industrial sectors. Each sector's growth is measured using the value-added approach. It is just the sector's net production after removing intermediates from the total of all outputs. Ghanaian cedis is used as the unit of measurement.

3.5.4 Energy use

Energy use which is synonymous to total energy consumption in this study is the total amount of energy used by various economic sectors, including households, industry, service, agriculture, and transport. It is measured using the United States EIA measurement of total energy consumption. According to the EIA definition "total energy consumption includes the consumption of petroleum, dry natural gas, coal, net nuclear, hydroelectric, and non-hydroelectric renewable electricity". Two main components of the energy consumption are electricity consumption and petroleum products consumption. Total electricity consumption is calculated as the sum of net electricity generation, electricity imports, and the subtraction of electricity exports and losses during transmission and distribution. Petroleum and other liquids consumption encompass both domestic usage and international bunkering of refined products, refinery fuel, and, where applicable, the direct combustion of crude oil and refinery by-products.

3.5.5 Institutional variables

Political Institution: Liberal Political Institutions Index of is derived from expert evaluations and V-Dem's index. Political institution refers to a framework or system of governance characterized by principles and practices that emphasize individual rights, freedoms, equality, and limitations on the concentration of power. These institutions often include democratic processes, the rule of law, protection of civil liberties, separation of powers, an independent judiciary, free and fair elections, freedom of speech and press, and respect for human rights. The aim of such institutions is to promote democratic governance and safeguard the rights and liberties of citizens within a society. It encompasses evaluations of individual and minority rights, legal equality, and limitations on executive power by legislative and judicial bodies. The scale ranges from 0 to 1, with higher values indicating a more political institutional quality performance.

Economic freedom index: Economic freedom from the Fraser Institute typically refers to a concept that encompasses the degree to which individuals and businesses have the freedom to engage in voluntary economic activities without undue restrictions or interference from the government or other external entities. The Fraser Institute, a Canadian think tank, is known for its annual publication of the "Economic Freedom of the World" report. Economic freedom, as defined by the Fraser Institute, involves elements like free markets, protection of property rights, rule of law, limited government intervention in the economy, open trade and investment policies, and a competitive marketplace.

The higher the level of economic freedom in a country, the more conducive it is believed to be for economic growth, innovation, and overall prosperity. It is measured on a scale ranging from 0 to 10, with higher scores indicating a higher level of economic freedom hence higher economic institutional quality performance.

3.5.6 Control variables

Gross Fixed Capital Formation (GFCF) is the indicator of domestic investment used in this study since it accounts for investments made in physical capital within an economy by both the public and private sectors, the GFCF is a trustworthy indicator of investment. Growth is eventually aided by investments in tangible capital, such as machinery and technology, which increase worker productivity and lower production costs. Based on the literature assessment and theoretical perspective, it is anticipated that GFCF as a proportion of GDP will have a positive association with growth. The adoption of GFCF as a measure of investment is consistent with the works of Bhattacharya et al. (2017), Effiong (2015), Ofori-abebrese, Pickson, and Diabah (2017), Effiong (2015), and Ofori-abebrese et al., (2017).

Trade openness (TOT) is the sum of imports and exports represented as a proportion of GDP. In terms of trade volume and the legal systems that facilitate the exchange of goods and services, it serves as an illustration of how a country's economy engages in international trade. Trade openness can have a good or negative influence on growth, according to theoretical and empirical research by Effiong (2016), Prowd (2018) and Ibrahim & Alagidede (2018).

General government final consumption expenditure (Gov_Exp) encompasses all current expenditures made by the government for acquiring goods and services, including employee compensation as a percentage of GDP. This category also covers a majority of spending on national defence and security, excluding military expenses that contribute to government capital development. It is expected to have positive or negative impact on growth depending on the approach to the expenditure.

Foreign direct investment (FDI) is the amount of money invested in a country's economy by individuals or enterprises from other countries, expressed as a percentage of GDP. FDI may be calculated by dividing the entire amount of foreign investment by the country's GDP. Depending on the characteristics of the investment and the conditions of the countries involved, there may be a positive or negative relationship between FDI and growth.

3.6 Model Estimation Procedures

For objective three and four, which requires an econometric modelling, model estimation, and empirical analytic of results, the following procedures have been adopted. The study uses time series variables; thus, data stability is crucial. The assessment of the degree of variable integration using stationary tests, one of the numerous types of stationary verification tests available is essential. The ADF unit root test was used to determine the stationarity of the variables. If all of the variables were integrated at the same level, the study would have employed a linear regression estimate (Ordinary Least Square), if the series is made up of only I(1) fully modified OLS would have been employed but since it was made up of I(0) and I(1) dynamic OLS was employed.

3.6.1 Dynamic Ordinary Least Square

The study employed the Dynamic Ordinary Least Square (DOLS) proposed by Stock and Watson (1993) in the estimations of the models because the approach can deal with endogeneity problems by introducing lags and leads to deal with the problem, this estimation approach is preferred over a two-stage OLS because it does not require an IV for its estimation. The DOLS is efficient even in small samples or deals with small sample bias and it is also able to deal with autocorrection problems compared to other time series estimation approaches. This estimation approach produces efficient results when the variables are either I(0), I(1) or both.

Dynamic Ordinary Least Square (DOLS) is a parametric solution that incorporates lags and leads to addressing the issue regardless of the integration order and presence or absence of cointegration. There is no theoretical basis for choosing the number of leads and lags but the literature largely proposes the idea of moving from general to specific in which we include a lot of leads and lags and then trim them down by removing insignificant lags until the model comes to the point of parsimonious state with relevant leads and lags. DOSL is equally applicable in small or large sample sizes, and it is able to deal with autocorrelation using the feasible GLS procedures.

We specified the Dynamic Ordinary Least Square (DOLS) estimator following Stock and Watson (1993) as follows:

$$Y_t = \alpha + \beta X_t + \sum_{j=q}^{j=r} \delta \Delta X_{t-j} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Under the assumption that adding q lags and e leads of the first differenced regressors soaks up all the long run correlation between the error terms. For example, if we formulate Equation (15) using only one lag and one lead, we will have:

$$Y_t = \alpha + \beta_1 X_t + \beta_2 \Delta X_t + \beta_3 \Delta X_{t+1} + \beta_4 \Delta X_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

The long-run coefficient β_1 is what the researcher will focused on when interpreting the result since the differenced leads and lags $(\beta_2, \beta_3, \beta_4)$ are not interpreted in an DOLS estimated result. As Stock and Watson (1993) viewed the differenced leads and lags as incidental parameters aimed at mitigating feedback effects and autocorrelation.

For objective three we specified the DOLS model as

$$Y_t = \beta_0 + \beta_1 EHI_t + \beta_2 \mathrm{GFCF}_t + \beta_3 TOT_t + \beta_4 Gov\_Exp_t + \beta_5 FDI_t + \sum_{j=q}^{j=r} \beta_6 \Delta EHI_{t-j} + \sum_{j=q}^{j=r} \beta_7 \Delta \mathrm{GFCF}_{t-j} + \sum_{j=q}^{j=r} \beta_8 \Delta TOT_{t-j} + \sum_{j=q}^{j=r} \beta_9 \Delta Gov\_Exp_{t-j} + \sum_{j=q}^{j=r} \beta_{10} \Delta FDI_{t-j} + \varepsilon_t \quad (17)$$

For objective four we specified the DOLS model as

$$Y_t = \beta_0 + \beta_1 EHI_t + \beta_2 INS_t + \beta_3 (INST * EHI)_t + \beta_4 \mathrm{GFCF}_t + \beta_5 TOT_t + \beta_6 Gov\_Exp_t + \beta_7 FDI_t + \sum_{j=q}^{j=r} \beta_8 \Delta EHI_{t-j} + \sum_{j=q}^{j=r} \beta_9 INS_{t-j} + \sum_{j=q}^{j=r} \beta_{10} \Delta (INST * EHI)_{t-j} + \sum_{j=q}^{j=r} \beta_{11} \Delta \mathrm{GFCF}_{t-j} + \sum_{j=q}^{j=r} \beta_{12} \Delta TOT_{t-j} + \sum_{j=q}^{j=r} \beta_{13} \Delta Gov\_Exp_{t-j} + \sum_{j=q}^{j=r} \beta_{14} \Delta FDI_{t-j} + \varepsilon_t \quad (18)$$

3.7 Post Estimation Test

***Jarque-Bera Test*:** It is a statistical test that examines the skewness and kurtosis from a regression model. The Jarque-Bera test helps in assessing whether the residuals follow a normal distribution. Since deviations from normality can affect the accuracy and efficiency of statistical inferences made from the model.

***Breusch-Godfrey Serial Correlation LM Test*:** This test is employed to identify serial correlation or autocorrelation in the residuals of a time series model. Serial correlation occurs when there is a pattern or correlation among the residuals at different time points. This can violate the assumption of independence of errors and affect the reliability of the model's estimates. The Breusch-Godfrey test assesses whether there is a significant relationship between the residuals at different lags, indicating the presence of serial correlation.

***Breusch-Pagan-Godfrey Heteroskedasticity Test*:** It refers to the unequal variance of the residuals across different observations in a time series. It violates the assumption of homoscedasticity (constant variance of errors) in the model, potentially affecting the precision and reliability of estimators. The Breusch-Pagan-Godfrey test examines whether the variance of the residuals is constant over time. If heteroskedasticity is present, necessary adjustments or transformations may be needed to account for this issue.

***CUSUM (Cumulative Sum)*:** CUSUM involves calculating the cumulative sum of deviations of individual observations from a specified reference value or target. The CUSUM value at any given time is the sum of the differences between the observed values and the target value, considering all observations up to that point. CUSUM helps in detecting shifts or changes in the process by identifying when the cumulative sum exceeds a predefined threshold. It is a powerful tool for identifying trends or deviations from the expected behaviour in a sequential manner.

CUSUM Square: CUSUM Square is an extension of the CUSUM method. Instead of using the absolute differences between observed and target values, the squared differences are used in CUSUM Square. This provides a more sensitive measure, giving higher weight to larger deviations from the target. The CUSUM Square is particularly effective in detecting smaller, persistent shifts in the process.

3.8 Chapter Summary

The chapter primarily outlined the approaches employed in attaining the research goals and provided rationale for the selection of each research method and technique. It encompassed the research approach, types and sources of data, explanations of variables and measurements, model specification, estimation approach, and subsequent the post estimation.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The study constructs an energy humanizing index for Ghana, estimates the impact of energy humanization on sectoral economic growth, and the moderating role of institutional quality in the energy humanization and sectoral growth analysis. Specifically, the study estimates the various dimensions of energy humanizing index in Ghana. Second, forecasts of various dimensions of energy humanization up to 2030 provide understanding to whether Sustainable Development Goal 7 could be achieved by Ghana using existing historical data. The study also analyses the effect of energy humanizing dimensions on sectoral growth. Finally, the moderating role of institutional quality in the energy humanization and sectoral growth is evaluated.

The chapter is divided into four sections. The first section presents descriptive statistics of the variables used in the estimation of energy humanization index and the estimation of the various dimensions of energy humanization. The second section presents the descriptive statistics of the variables used in the analyses and examines the effect of energy humanization and sectoral growth. The last section focuses on the estimation of the moderating role of institutional quality in energy humanization and sectoral growth analytics.

4.2 Estimated Energy Humanization Index (EHI) Model

To estimate energy humanization, we employed the conceptual framework shown in Figure 3.1. Energy humanization has two main dimensions: energy security and energy usage (energy consumption). The energy security dimension of energy humanization also has four sub-dimensions: energy availability, technology application, energy acceptability, and affordability. Energy usage (energy consumption) can also be divided into two sub-dimensions: net electricity consumption and petroleum and other liquid consumption.

4.2.1 Descriptive Statistics of EHI Model Variables

Table 4.1 shows the descriptive statistics for the EHI model variables and its different dimensions. As shown in Table 4.1, CO_2 intensity, CO_2 emissions from liquid fuel consumption, combustible renewables and waste, energy-related methane emissions, and share of renewable energy in total energy consumption served as measures of the energy acceptability dimension of energy security (environmental sustainability). The average values of these indicators are variables are 1.005 kg per kg of oil equivalent energy use, 13.398% of total fuel combustion, 101.778 percent of total, 49.328 % of total energy, 36.421% of total methane, and 41.367% of total energy consumption.

An increase in the values of CO_2 intensity, CO_2 emissions from liquid fuel consumption, and energy-related methane emissions may indicate a decrease in energy acceptability, hence lower energy security and energy humanization (Arroyo & Miguel, 2020; Winzer, 2012). While an increase in combustible renewables and waste and the share of renewable energy in total energy consumption indicates an increase in energy acceptability, hence an improvement in energy security and energy humanization (Arroyo & Miguel, 2020). A critical look at the standard deviation and mean values of all the indicators showed that the data were normally distributed as the mean values exceeded the standard deviations.

Table 4.1: Descriptive Statistics of the Variables Used in the Estimation of Energy Humanization Index

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
CO2 intensity	42	1.005	0.375	0.468	1.677
CO2 emissions from electricity and heat production	42	13.398	10.085	0.833	31.466
CO2 emissions from liquid fuel consumption	42	101.778	21.563	68.365	160.518
Combustible renewables and waste	42	49.328	17.801	26.171	83.653
Energy related methane emissions	42	36.421	8.323	19.476	48.234
Share of renewable in total energy consumption	42	41.367	14.869	15.128	65.06
Alternative and nuclear energy	42	6.798	1.647	3.943	11.277
Population (MMBtu/person)	42	7.251	1.909	3.827	11.888
Electric power transmission and distribution losses	42	10.427	8.275	2.111	27.786
Average Electricity End-User Tariff	42	0.068	0.063	0.008	0.21
Average Petrol Pump Price	42	0.627	0.249	0.2	1.06
Average Diesel Pump Price	42	0.55	0.295	0.19	1.03
Avoidable cost of Transmission	42	88657.9	94739.65	640	275500
Energy imports	42	16.874	17.842	-13.083	45.908

Table 4.1 Continue

Electricity installed capacity	42	2.082	1.366	1.06	5.4
Total energy production from natural gas	42	0.009	0.024	0	0.108
Total energy production from petroleum and other liquids	42	0.081	0.135	0	0.433
Natural gas reserves	42	0.569	0.376	0	0.848
Dry natural gas production	42	8.686	23.183	0	103
Crude oil including lease condensate reserves	42	180.000	290.000	0.500	660.000
Access to electricity	42	45.325	23.437	14	86.3
Electricity consumption	42	6.924	3.653	1.6	18
Petroleum and other liquids consumption	42	0.091	0.059	0.029	0.208

Source: Asafo (2023)

In this study, data on technology application in the energy sector, is proxied using alternative and nuclear energy, energy intensity, the share of renewable energy, and electric power transmission and distribution losses. The average values of the indicators listed in Table 4.1 are 6.798 percent for alternative and nuclear energy, 7.251 MMBtu per person for energy intensity, 41.367% for the share of renewable in total energy consumption, and 10.427 % of total electricity output. An increase in alternative and nuclear energy as a percentage of total energy use and the share of renewable energy in total energy consumption serves as an improvement in technology application in the energy sector, while an increase in energy intensity act otherwise.

The affordability component of energy security is calculated using average electricity end-user tariff measured in US$/kWh, average Petrol pump Price (US$/lt), average diesel pump Price (US$/lt) and the avoidable cost of Transmission and Distribution (GH₵). The pump prices of diesel and petrol represent the average cost at which the most purchased types of diesel and gasoline fuels are sold at fuel stations. This price is expressed in U.S. dollars. The average price of diesel was US$ 0.550 per litter with the highest price been US$ 1.030 per litre and the lowest price being US$ 0.190 per litre between 1980 and 2021. The price of petrol averages around US$ 0.627 per litre with the lowest and highest price and of US$ 0.200 and US$ 1.060, respectively. The average electricity end-user tariff and avoidable cost of electricity transmission and distribution are 16.874 US$/kWh and GH₵ 88657.9 per year. These variables were used as indicators to measure the energy affordability components of energy security. An increase indicates low affordability, and hence, low energy security and energy humanization.

In assessing availability dimension of energy security, the study used the following indicators: energy imports with an average value of 16.874 % of energy use and standard deviation of 17.84%; electricity installed capacity have a mean value of 2.082 million kilowatts with a deviation of 1.366 million kilowatts; total energy production from natural gas has a minimum value of 0 and maximum value of 0.108 quadrillion Btu with an average value of 0.009 quadrillion Btu. Total energy production from petroleum and other liquids has an average value of 0.0813 quadrillion Btu and a standard deviation of 0.135 quadrillion Btu within the period of study thus 1980 to 2021.

Natural gas reserves, another indicator used to measure energy availability, have an average value of 0.569 trillion cubic feet, with maximum and minimum values of 0.848 trillion cubic feet and 0 trillion cubic feet, respectively. Dry natural gas production had a mean value of 8.685 billion cubic feet, with a deviation of 23.183 billion cubic feet. The minimum value of dry natural gas production is 0 and the maximum value is 103 billion cubic feet. Crude oil including lease condensate reserves has a minimum value of 0.5 million barrels and maximum value of 660.000 million barrels with an average value of 180.000 million barrels. Access to electricity a percentage of the population has a maximum value of 86.3% and a minimum value of 14%, with an average value of 45.325%.

4.2.2 Assessing Security Dimension

The "Four-A's" approach evaluate energy security established by the Asia Pacific Energy Research Centre (APERC, 2007) was adopted and modified. The Four-A's in the adopted energy security conceptual framework are energy acceptability, technological application, energy availability, and affordability.

Energy acceptability assessment

To assess the energy acceptability dimension of energy security, this study used indicators such as CO_2 intensity, CO_2 emissions from liquid fuel consumption, combustible renewables and waste, energy-related methane emissions, and share of renewable energy in total energy consumption to proxy the energy acceptability dimension of energy security (environmental sustainability). Employing Equations (1) and (2), and thus the minimum-maximum normalization approach, we normalized the values of the various indicators, as shown in Figure 4.1 with orange background. To derive the values of the energy acceptability dimension, we employed Equation (3), which applied equal weight to the normalized values of individual indicators to generate the energy acceptability index, as shown in Figure 4.1, using the green background.

For us to fully understand the performance of Ghana in terms of the energy acceptability index of energy security and hence energy humanization, this study employed a line graph and heptagonal radar chart, as shown in Figure 4.2 and 4.3. A careful look at Figure 4.2 showed that energy acceptability continues to decrease over the years of study. The heptagonal radar chart in Figure 4.3, provides accurate information on the performance of Ghana over the study period. The highest performance in terms of energy acceptability was recorded in 1980, with a value of 0.762, with the lowest being 2021, which is approximately 0.376. Figure 4.2 shows that energy acceptability continues to decrease over the years, and a possible explanation may be an increase in the share of electric power generation from hydro to thermal power over the years. Another possible explanation may be the increase in the use of automobile transport, other equipment, and gadgets, which may be significant contributing factors.

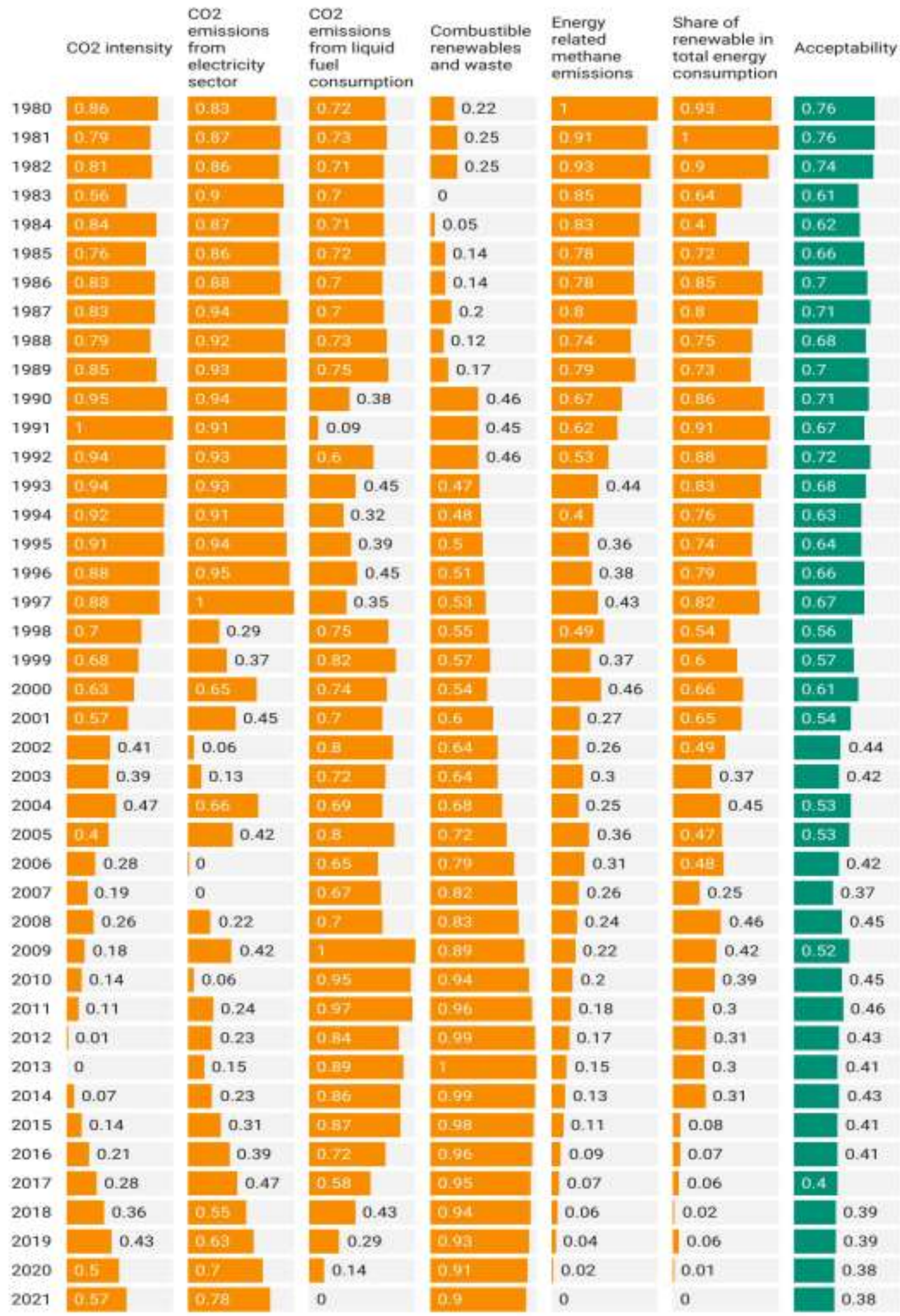

Figure 4.1: Annual Energy Acceptability Index.
Source: Asafo (2024)

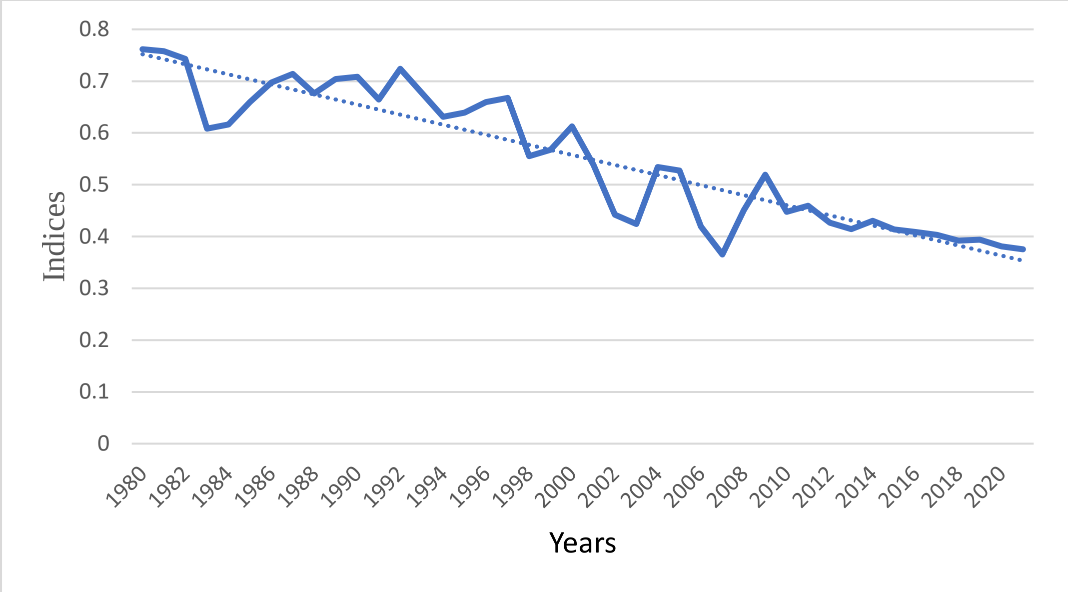

Figure 4.2: Trends in Energy Acceptability Index.
Source: Asafo (2023)

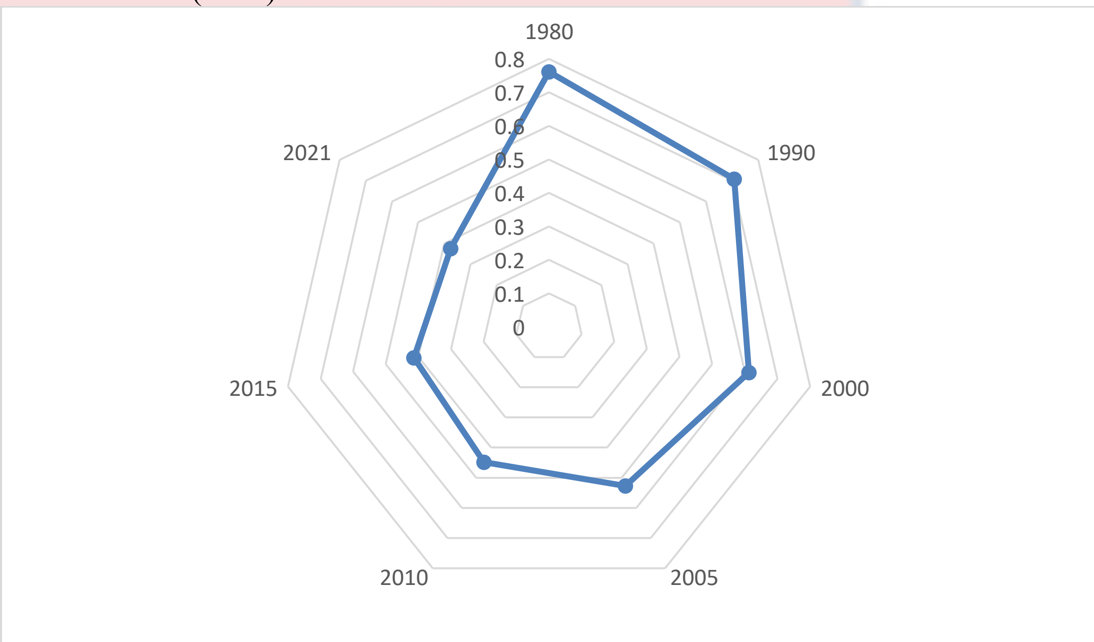

Figure 4.3: Energy Acceptability Index Radar.
Source: Asafo (2024)

Forecasting energy acceptability index

Further, to forecast energy acceptability up to 2030 to determine if energy acceptability will improve, remain the same, or deteriorate. The study initially set out to use the ARIMA model to forecast the series; however, upon checking the correlogram for both the autocorrelation function and Partial Correlation function, none of the lags were significant, which indicated that the series did not follow the ARIMA, ARMA, AR, or MA processes. The next forecasting approach suggested in the literature is exponential smoothing, which is an effective forecasting technique.

This study adopted Holt-Winters Additive Seasonal Exponential Smoothing to forecast the future values of the energy acceptability dimensions of energy security. Figure 4.4 shows that the energy acceptability forecast continues to decrease when using existing data for future forecasts. The forecast indicates that unless significant changes occur, energy acceptability will continue to decrease, which will prevent the achievement of environmental sustainability by 2030.

Environmental sustainability is a paramount global objective, ensuring that energy practices and policies align with environmental preservation, climate change mitigation, and responsible use of energy resources. Failure to achieve these goals can result in adverse environmental impacts and hinder long-term energy security. Therefore, the study recommends that various stakeholders, including policymakers, energy industry leaders, environmental advocates, and the public, take action to reverse the declining trend in energy acceptability. Potential measures include policy adjustments, renewable energy investments, public awareness campaigns, and energy efficiency initiatives.

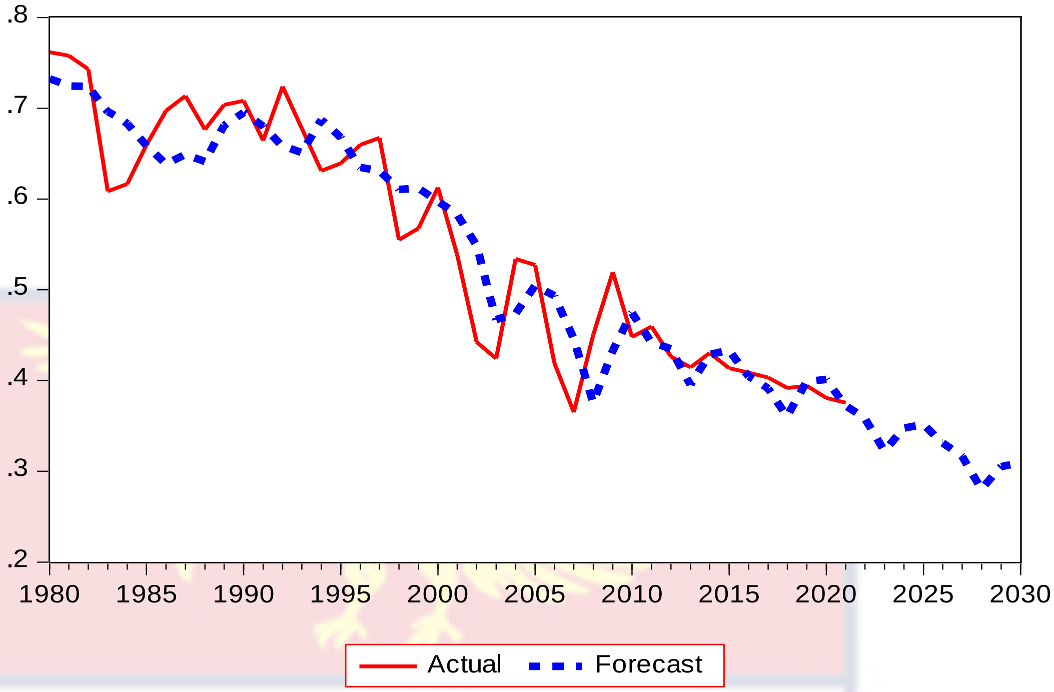

Figure 4.4: Energy Acceptability Forecast
Source: Asafo (2024)

Technology application assessment

In assessing technology application dimension for energy security, this study employed alternative and nuclear energy as a percentage of total energy use, energy intensity measured using MMBtu per person, share of renewable energy in total energy consumption as a percentage of total energy consumption, and electric power transmission and distribution losses as a percentage of total output. An increase in alternative and nuclear energy as a percentage of total energy use and the share of renewable energy in total energy consumption serves as an improvement in technology application in the energy sector, while an increase in energy intensity, transmission, and distribution is depicted otherwise.

Employing the minimum-maximum normalization approach, Equations (1) and (2), we normalized the values of the various indicators, as shown in Figure 1 in the Appendix, with an orange background. To calculate the values of the technology application dimension of energy security, we used Equation (3) and subsequently applied equal weight to the normalized values of individual indicators to generate the technology application index, displayed in Figure 1 in the Appendix, using the green background.

To gain a thorough understanding of Ghana's performance in the technology application index, the study examined the dimension of energy security using both a line graph and a heptagonal radar chart. Figure 4.5 reveals a consistent decline in technology applications from 1980 to 2002, after which it appeared to be stable.

Figure 4.6, the heptagonal radar chart, illustrates that the highest score was observed in 1980, with a recorded value of 0.845, whereas the lowest was noted in 2021, at approximately 0.289. Although the performance declined throughout the period of the study, variation after 2005 was relatively smaller. Perhaps, this pattern is possibly due to the drastic measures adopted by the Governments of Ghana, the Energy Commission, and other institutions to improve energy efficiency. Examples of such policies are the National Energy Efficiency and Conservation Policy (NEECP), which provides a comprehensive framework for promoting energy efficiency and conservation across all sectors of the economy, energy efficiency standards and labels for appliances and equipment that inform consumers on energy efficiency ratings of appliances, and energy efficiency in public buildings, which includes retrofitting and adopting energy-efficient technologies, promotion of renewable energy, and other policies.

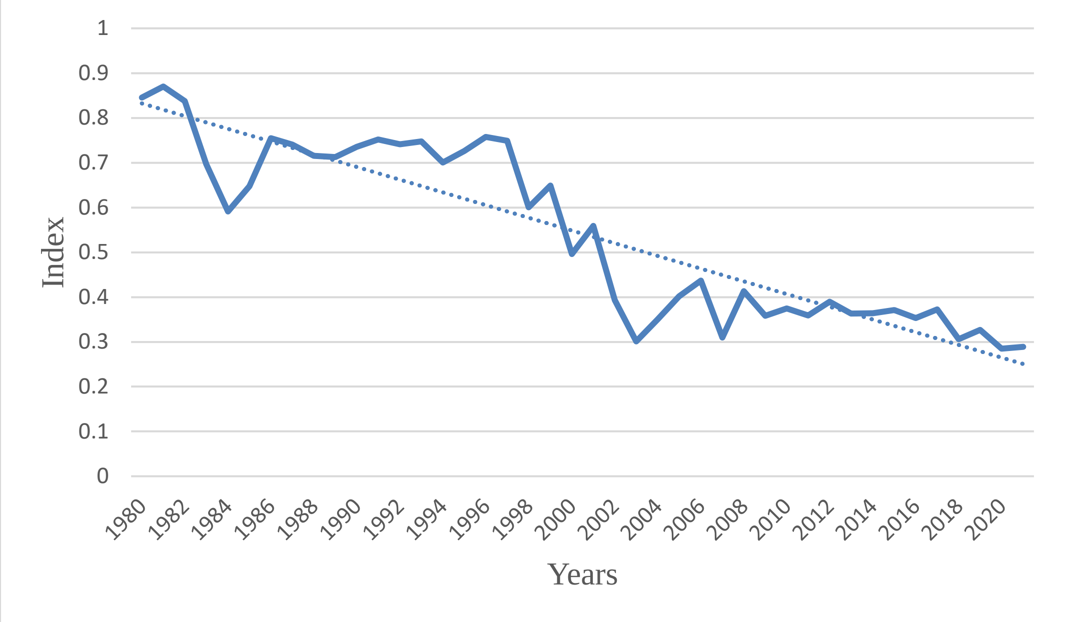

Figure 4.5: Trends in Technology Application Index.
Source: Asafo (2024)

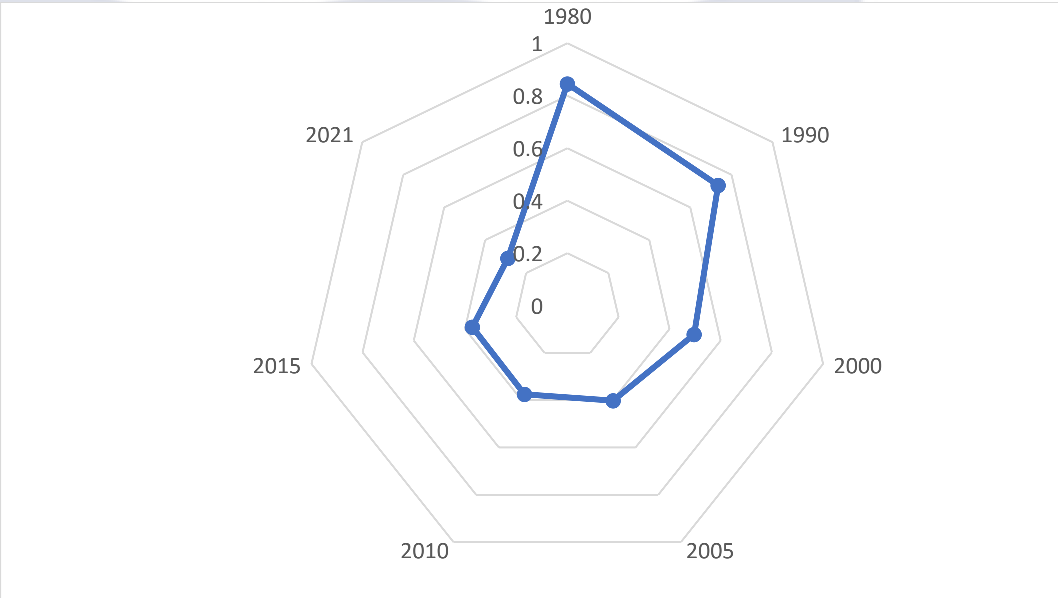

Figure 4.6: Technology Application Index Radar.
Source: Asafo (2024)

Despite all these efforts, the decrease in technology application can be attributed to low performance in energy intensity and the continuous decrease in the share of renewable energy in our energy mix. This suggests that we need to increase the use of solar, wind energy, and other renewables in our energy sure, but the performance in the reduction of transmission and distribution loss is encouraging.

Forecasting of technology application index

This research extended its analysis by forecasting the technology application index up to 2030, aiming to determine whether there would be an enhancement, stability, or decline in technology application. Examining the correlogram for both Autocorrelation and Partial Correlation functions, none of the lags appeared statistically significant, indicating that the series did not adhere to ARIMA, AR, or MA processes. Therefore, this study employed exponential smoothing, as suggested in the literature for forecasting under such circumstances.

This study used Holt-Winters Multiplicative Seasonal Exponential Smoothing method as selected by the root mean squared error for the forecasting of the future values of technology application index. From Figure 4.7, we can see that the technology application index continues to decrease when using existing data for future forecasts. From the forecast we can see that if nothing changes drastically technology application index will keep decreasing and energy security will not be achieved by 2030.

For technology applications to increase the energy sector, conscious effects must be put in place to decrease energy intensity, more technology must be employed to reduce distribution and distribution loss, and research must also be conducted on technologies that could improve the technology application of the Ghanaian energy sector.

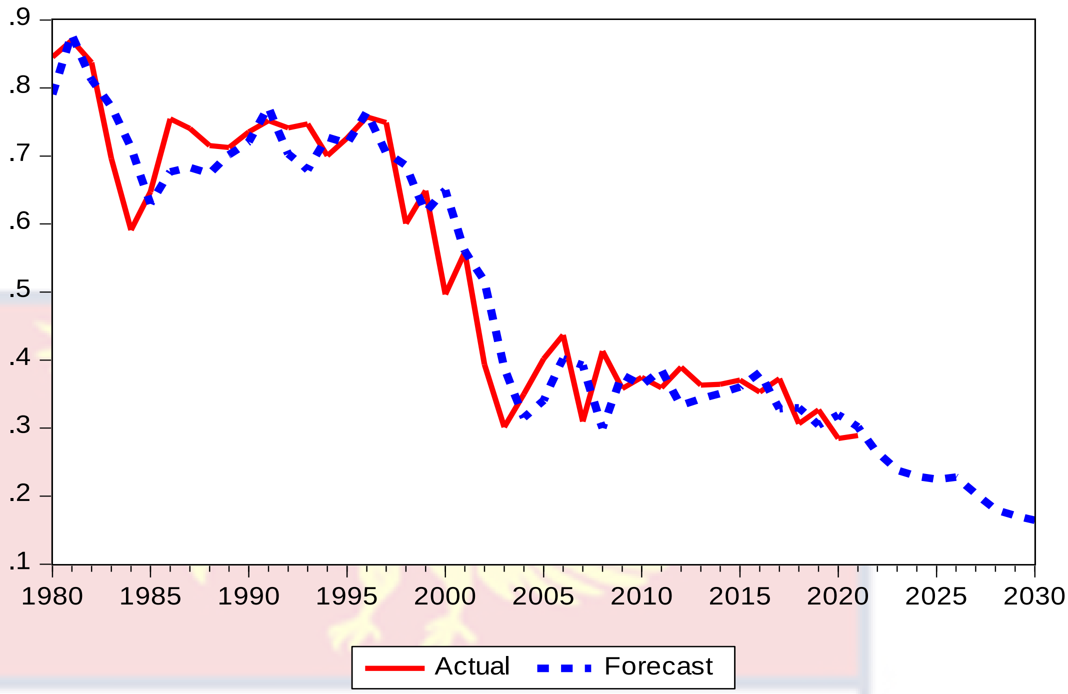

Figure 4.7: Technology Application Forecast
Source: Asafo (2024)

Energy affordability assessment

To calculate the affordability component of energy security, the study employed the average electricity end-user tariff, average petrol pump price, average diesel pump price, and avoidable costs of transmission and distribution. To normalize the values of these diverse indicators, Equations (1) and (2) were employed; thus, the minimum-maximum normalization approach was employed. The normalized values of these indicators are visually represented in Figure 2 in the Appendix and highlighted with an orange background. In an effort to estimate the energy affordability index Equation (3) was employed. This equation assigned equal weight to the normalized values of each individual indicator. The outcome of this calculation is depicted in Figure 2, in the Appendix indicated by a green background, and it represents the generated energy affordability index.

To obtain an extensive insight into how Ghana has fared in terms of the energy affordability index, a critical aspect of both energy security and energy humanization, our study utilized two distinct visualization tools: a line graph and a heptagonal radar chart, showcased in Figures 4.8 and 4.9, respectively. A meticulous examination of Figure 4.8 reveals a relatively little decline in energy affordability starting from 1980 until 1990 possibly because Ghana experienced economic difficulties in the 1980 to 1990, including high inflation and external debt. These economic issues made a bit difficult to buying energy, but this was much managed with subsidies and low taxation of the sector. But energy affordability improved from 1991 until the 2000 possibly due to some level of economic stability and also government deliberate decision of not increasing the electricity tariffs and price of fuel to be cost reflective.

After the establishment of Public Utilities Regulatory Commission (PURC) in the 1998, resulting in regular increase in the electricity tariff and coupled with rise in the global oil prices, Ghana been petroleum importing country experienced a decrease in affordability index. Also, after the 2000s the was a deliberate attempt by successive government to reduce subsidy in the energy and a lot of taxes were introduced in the sector which may be another reason for the decrease, we experience in energy affordability.

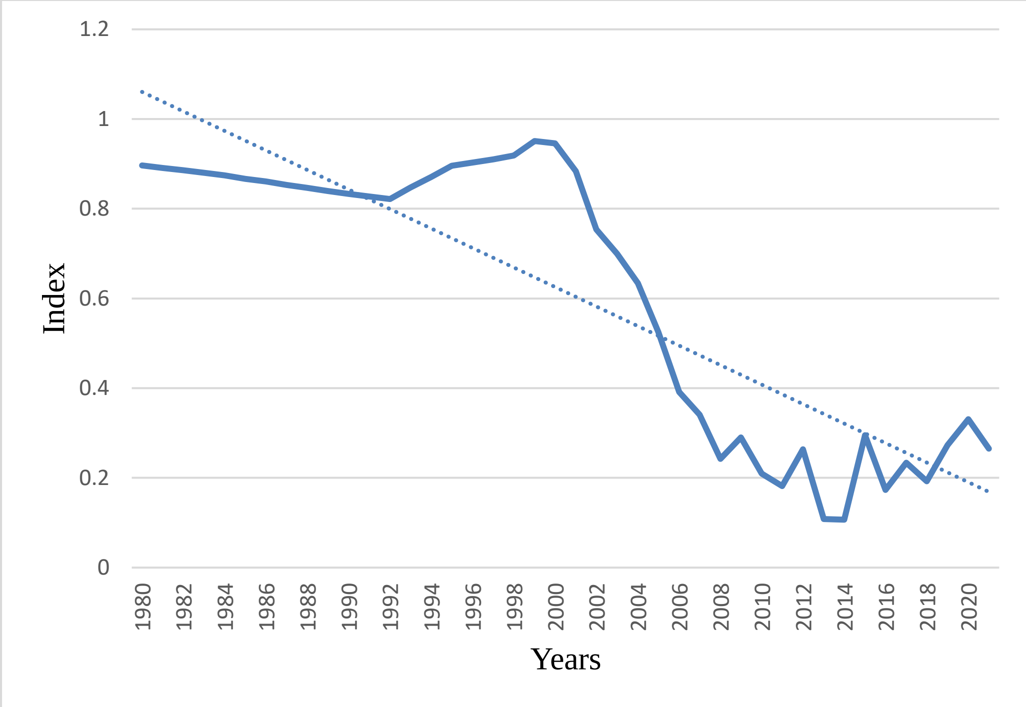

Figure 4.8: Trends in Energy Affordability Index.
Source: Asafo (2024)

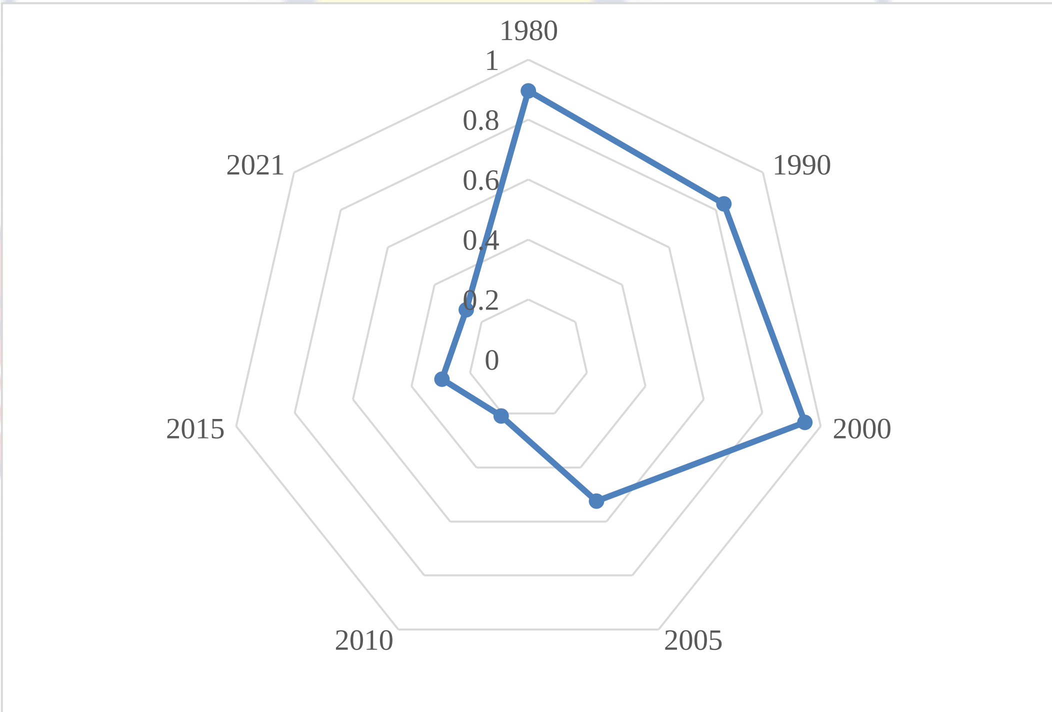

Figure 4.9: Energy Affordability Index Radar
Source: Asafo (2024)

To gain more precise and granular insights into Ghana's performance within this timeframe, spanning from 1980 to 2021, we directed our attention to the heptagonal radar chart. We could see that there was not much change in energy affordability from 1980 to 2000 but after 2000s energy affordability decreases largely because of reduction in subsidies and the introduction of a lot of taxes into the sector. 2013 and 2014 recorded the worst performance because Ghana faced electricity supply challenges during this period, including frequent power outages and load shedding. The cost of backup power sources, such as generators, increased for both households and businesses, contributing to higher energy expenses.

Forecasting of energy affordability Index

The study went one step further and forecasted energy affordability using Holt-Winters multiplicative seasonal exponential smoothing method as the lags of the autocorrelation function and the partial correlation function were not significant. Employing Holt-Winters multiplicative seasonal exponential smoothing for the forecasting of the future values of energy affordability dimensions of energy security, there result from Figure 4.10 showed that although we expect energy affordability to fluctuate much in the near future, on the average, energy affordability will improve or increase overtime leading to the attainments of SDG 7, which is directly related to energy affordability. It calls for universal access to affordable and clean energy sources. Improving energy affordability is a crucial component of achieving this goal, as high energy costs can limit access for households and businesses.

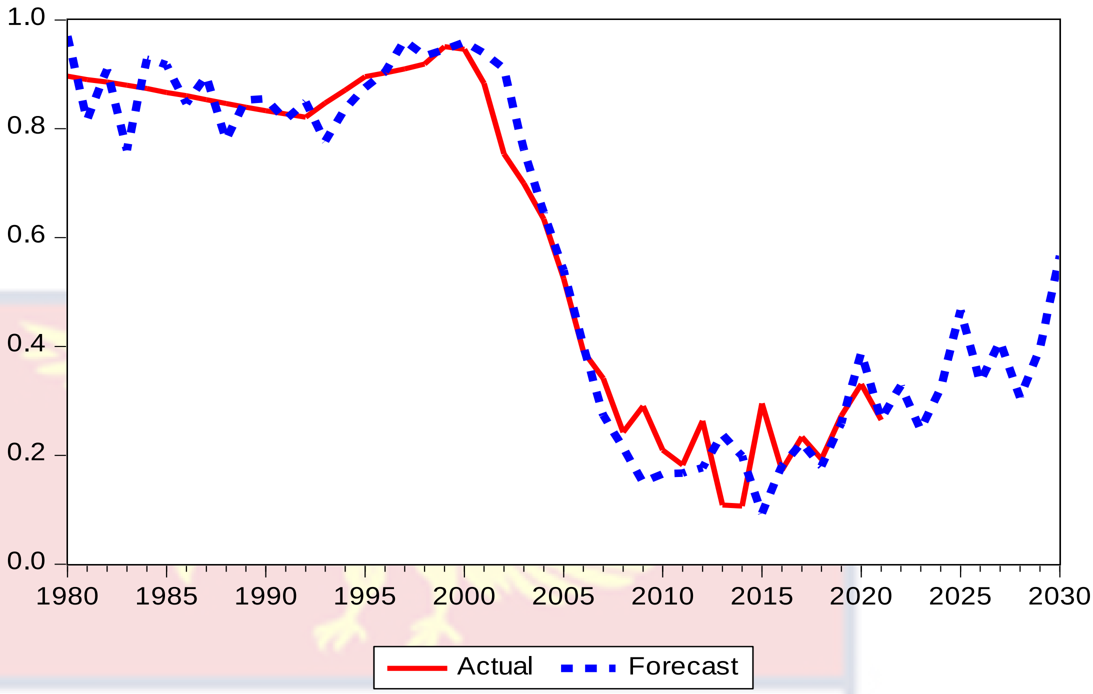

Figure 4. 10: Forecast of Energy Affordability Index
Source: Asafo (2024)

Energy availability assessment

In estimating availability dimension of energy security, the study used the following indicators: energy imports, electricity installed capacity, total energy production from petroleum and other liquids, Natural gas reserves, Dry natural gas production, crude oil including lease condensate reserves and access to electricity. An increase in all the indicators in indicators in exception energy import is an indication of improvement in energy security.

Utilizing the minimum-maximum normalization method, as outlined in Equations (1) and (2) in the methodology section, we normalized the values of the diverse indicators, as illustrated in Figure 3 in the Appendix with an orange background. To estimate energy availability index dimension of energy security, we applied Equation (3), which assigned equal weight to the normalized values of each individual indicator, resulting in the generation of energy index, as displayed in Figure 3 in the Appendix, denoted by a green background.

To acquire a thorough grasp of how Ghana has performed in terms of energy availability index, a critical component of both energy security and energy humanization, our research utilized two visual tools: a line graph and a heptagonal radar chart, showcased in Figures 4.11 and 4.12, respectively. Figure 4.12, the heptagonal radar chart, illustrates that the highest score was observed in 2021, with a recorded value of 0.974, while the lowest was noted in 1980, approximately at 0.019. Ghana experienced issues with its energy supply during the 1980s and 1990s, including poor infrastructure maintenance and insufficient energy sector investment. These difficulties led to frequent power outages and load shedding, which had an impact on the consistency of the energy supply.

Ghana started energy sector reforms and attracted private sector investments in power generation from 2000 to 2010. The market saw the entry of several independent power producers (IPPs), which enhanced the capacity for producing energy. The development of thermal power plants and financial support for renewable energy initiatives like wind and solar helped to diversify the energy mix even further. The discovery of natural gas and crude oil deposits in Ghana’s Western Region in the 2010 prompted the formation of the Western Corridor Gas Infrastructure Development Project. This project increased natural gas supply for electricity generation, lowering dependency on expensive liquid fuels.

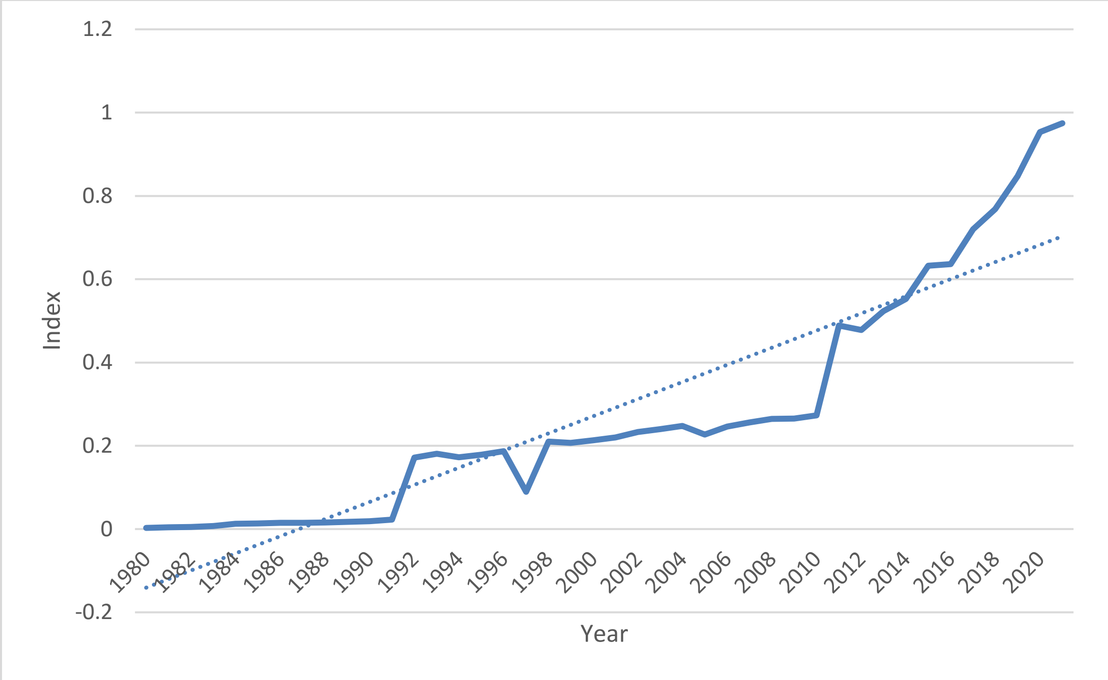

Figure 4.11: Trends in Energy Availability Index.
Source: Asafo (2024)

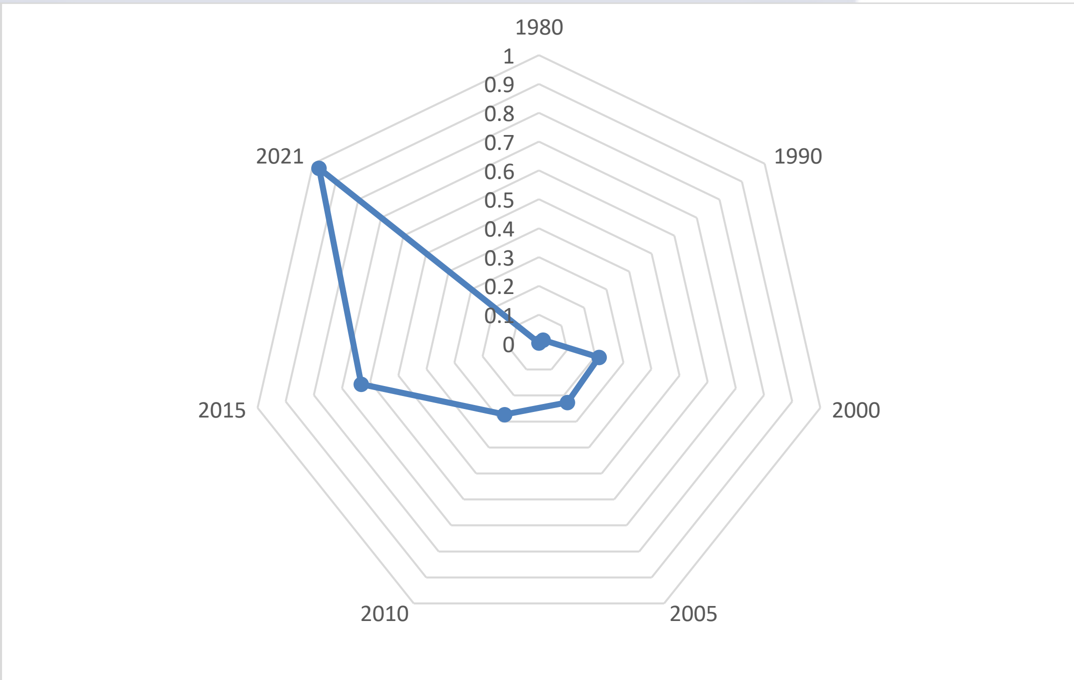

Figure 4.12: Energy Availability Index Radar
Source: Asafo (2024)

Despite advances, Ghana's energy industry continues to face obstacles, including financial difficulties among power providers, fuel supply concerns, and swings in electricity pricing. Due to a variety of circumstances, including budgetary limits and maintenance concerns, the country had periodic power outages, known as “damsor”, in some years. Ghana has since been investing aggressively in renewable energy sources such as solar and wind power to diversify its energy mix and increase energy availability. Various programs, such as the Rural Electrification Project, are still working to bring energy to rural and off-grid regions. All these activities led an increase in energy availability index over the period under study.

Forecasting of energy availability index

Using a single exponential smoothing method to forecast the energy availability dimension within the context of energy security, the findings presented in Figure 4.13 indicate that based on the past values of energy availability we anticipate that energy availability to remain very high throughout the near future, the overall trend suggests an improvement or sustainable increase in energy availability up to 2030. This implies that Ghana will be at the point of attaining some aspect of SDG 7.

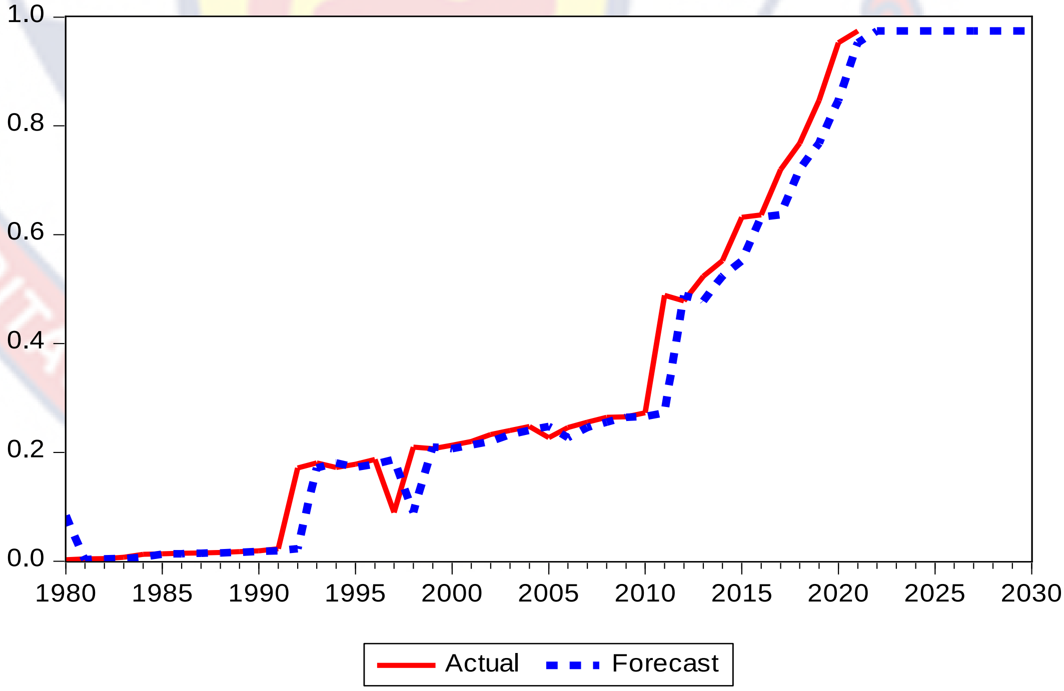

Figure 4.13:Forecast of Energy Availability Index
Source: Asafo (2024)

Energy security assessment

For us to calculate energy security index, we aggregate the different dimensions of energy security thus energy acceptability index, technology application index, energy affordability index and energy availability index to estimate the Energy Security (ES) index. To aggregate these indices, the study employed Equation (4) where equal weight is applied to the different energy security dimensions. The output from this discussion is presented in Figure 4.14.

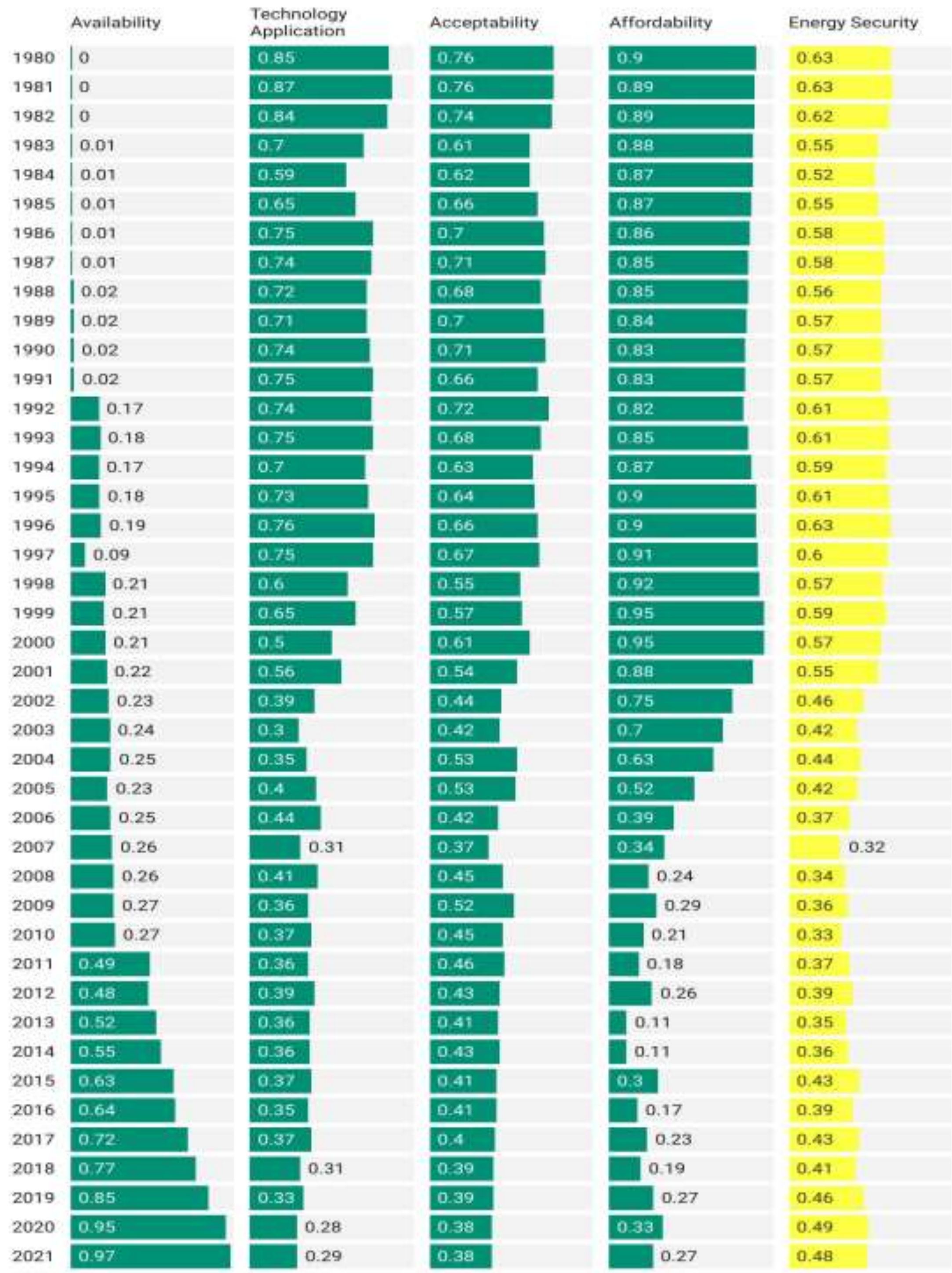

Figure 4.14: Annual Energy Security Index.
Source: Asafo (2024)

Figures 4.15 and 4.16 provide an insight into the performance of Ghana in-terms of energy security indices from 1980 to 2021. Upon conducting a meticulous examination of Figure 4.15 and 4.16, we could see that Ghana performance in-terms of energy security did not change much from 1980 to

2000 but turn to decrease from 2001 to 2010, only started showing positive trend upon the discovery and drilling of crude oil and gas in Ghana.

The decrease in energy security may be attributed to the following reason: Ghana's primary source of electricity generating between the period 2000 to 2010 was hydropower. Inconsistent rainfall patterns drastically decreased reservoir water levels and, as a result, hydropower producing capacity. The over dependence on hydropower makes the energy source susceptible to changes in the weather. Coupled with the earlier point raised rapid population expansion boosted energy consumption, further taxing other energy product especially petroleum products by government to raise revenue worsen the situation.

Some arguments that could be advanced for the relative improvement in the positive trend of energy security index from 2010 to 2021 could be as a result of the discovery of crude oil and natural gas in Ghana which increases energy availability; government deliberate policy to diversify generation of electricity thus the introduction of thermal and the private sector into generation helped to increase the generation capacity; gride expansion and other rural electrification programmes and projects. This therefore presupposed that much of the improvement we are seeing in the energy security is driven by energy availability component of energy security. There for much attention must be given to the other dimensions of energy security.

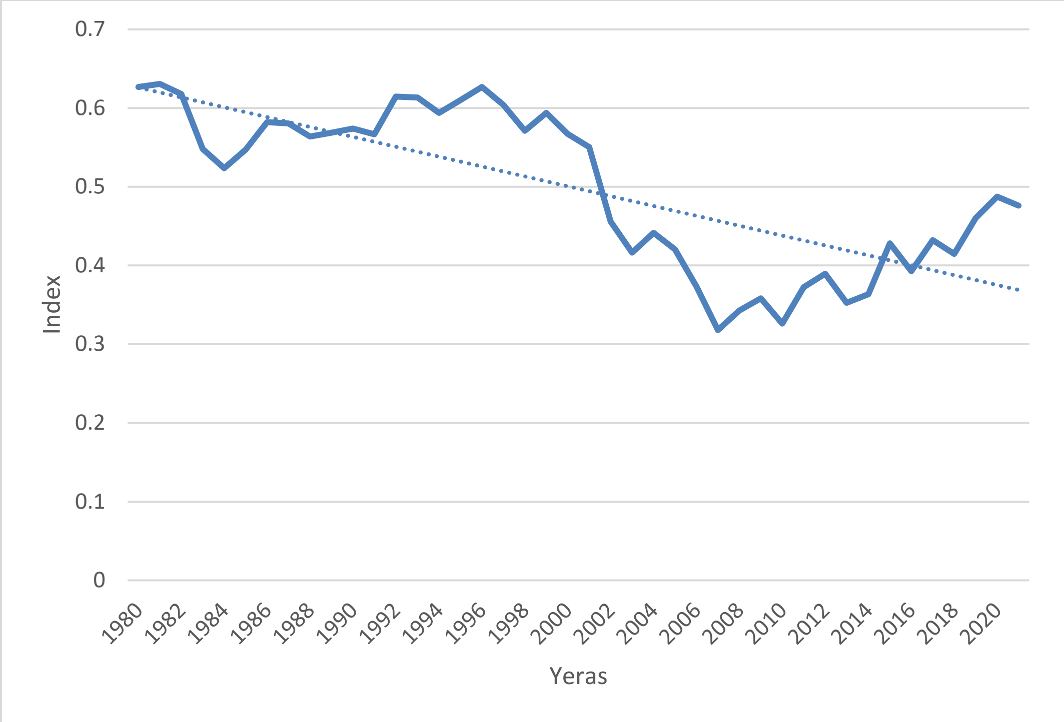

Figure 4.15: Trends in Energy Security Index.
Source: Asafo (2024)

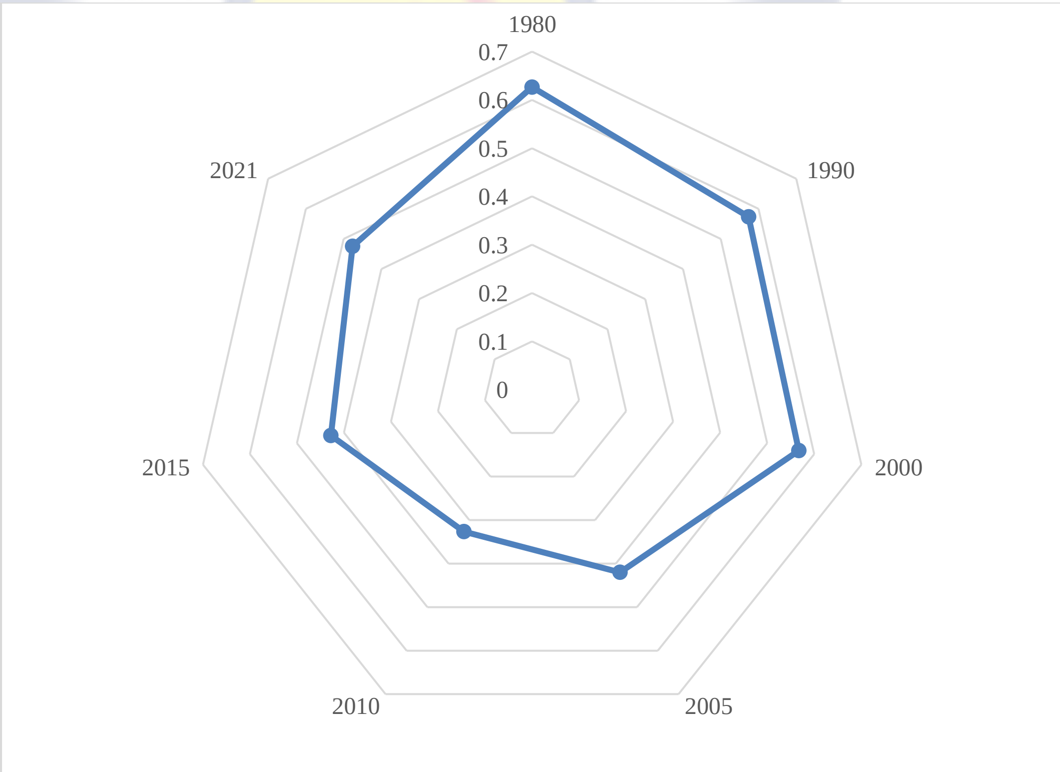

Figure 4.16: Radar chart for Energy Security Index.
Source: Asafo (2024)

Forecasting of energy security index

The study forecasted the future values of energy security using the Holt-Winters Additive Seasonal exponential smoothing method. The result from Figure 4.17 indicates that if things continue as they are in the sector, energy availability will remain high in the future according to the forecast graph. However, there may be a decline in other indicators, particularly energy acceptability and technology application, which could lead to a decrease in energy security. This decrease in energy security may affect the effort of the country in the attainment of SDG 7.

Some of the policies and programmes that could help address the decrease in energy security include government continuous investment and the creation of a conducive investment climate for private sector investors into the sector; continuous improvement in the energy efficiency programs and standards across the industries; continuous modernization of the electricity grid to improve its efficiency, reliability, and capacity to integrate renewable energy sources; massive investment in research and development for innovative and sustainable energy technologies tailored to Ghana's specific needs and conditions; and Enforce and strengthen environmental regulations to minimize the environmental impact of energy production and consumption.

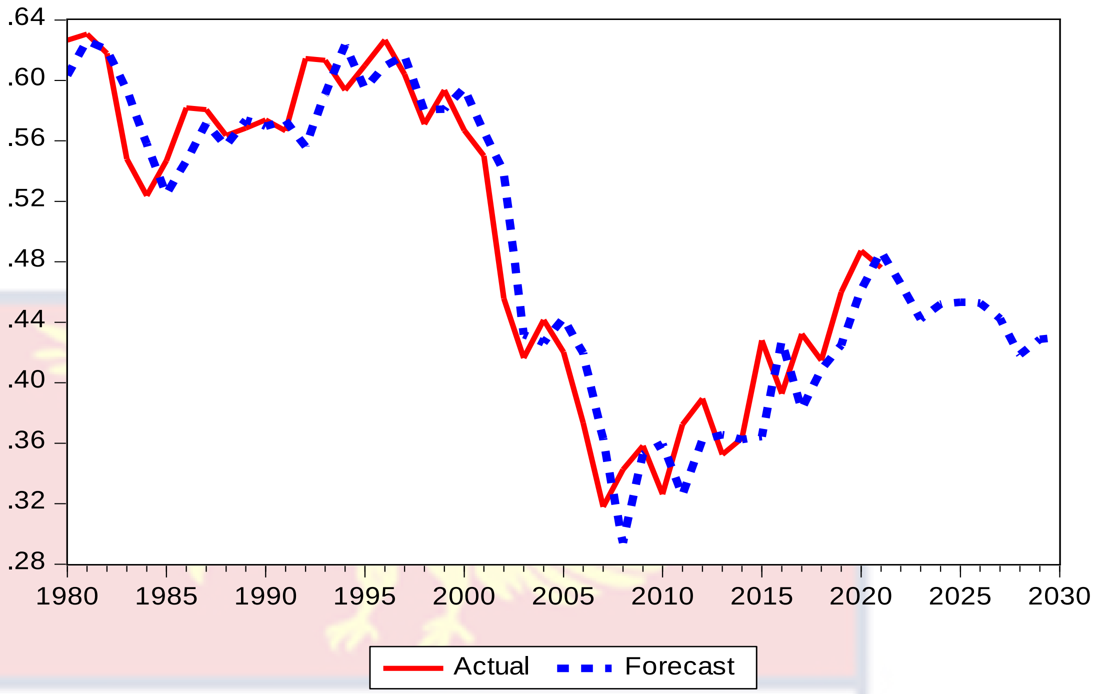

Figure 4. 17: Forecast of Energy Security Index
Source: Asafo (2024)

4.2.3 Energy Usage (Consumption) Dimension

To estimate an index for energy usage to aid estimation of energy humanization index, this study made use of two main indicators thus total electricity consumption measure in in billions of kilowatt-hours and total petroleum and other liquids consumption measured in quadrillion Btu. Using Equations (1) and (2) in Chapter Three thus minimum-maximum normalization method, we transformed the values of the two indicators, as illustrated in Figure 4.18, highlighted in green. To estimate energy usage index, we utilized Equation (5), which assigned equal weight to the normalized values of each indicator, resulting in the creation of the energy usage index displayed in Figure 4.18, highlighted in yellow.

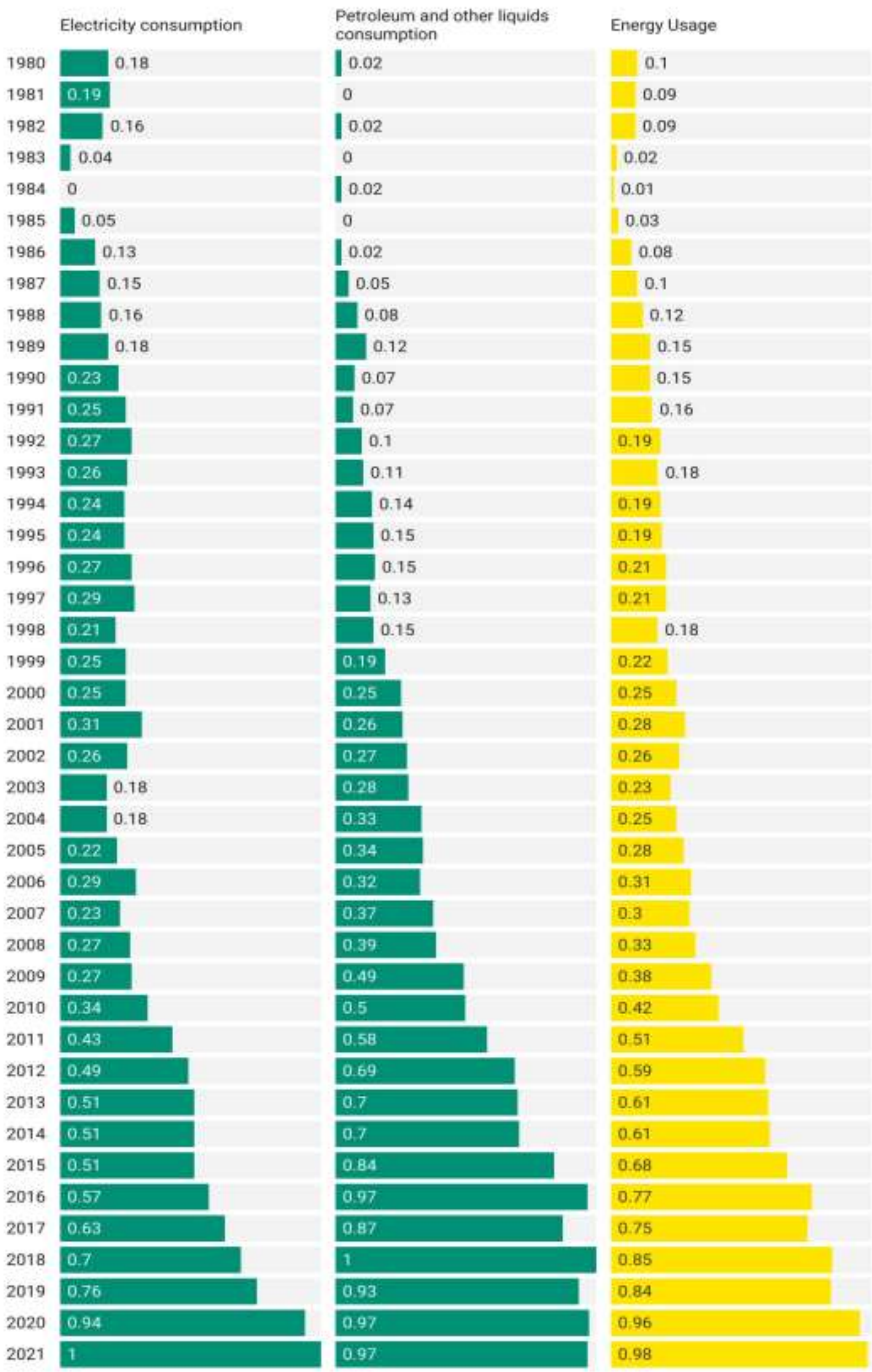

Figure 4.18: Annual Energy Usage Index.
Source: Asafo (2024)

Figures 4.19 and 4.20 clearly showed that energy consumption has been on the increase over the period of study with the lowest consumption been 1983 to 1984 which is much understandable due to the severe famine and drought the nation experience during that period.

Some of the reasons that may account for the consistent increase in energy usage in Ghana could be an increase in electricity accessibility in rural and underserved areas, increase competition among the Oil Marketing Companies, urbanization leading to the development of cities and towns, where energy consumption is typically higher due to increased commercial activities, transportation needs, and greater energy use in homes and increase in the nation's population.

Forecasting of energy usage index

The study forecasted the future values of energy security using the single exponential smoothing method. The findings presented in Figure 4.21 indicate that energy consumption in Ghana will continue to be significantly high in the foreseeable future, as depicted by the projected graph. This can be attributed to the fact that Ghana is a developing nation, where we anticipate a steady rise in energy demand due to various factors. Firstly, there is an ongoing effort to improve electricity accessibility in rural and underserved areas. Secondly, there is growing competition among Oil Marketing Companies, which is likely to contribute to increased energy consumption. Additionally, the process of urbanization is leading to the development of cities and towns, resulting in higher energy requirements. Furthermore, as the population increases, there is a corresponding rise in energy usage in residential areas.

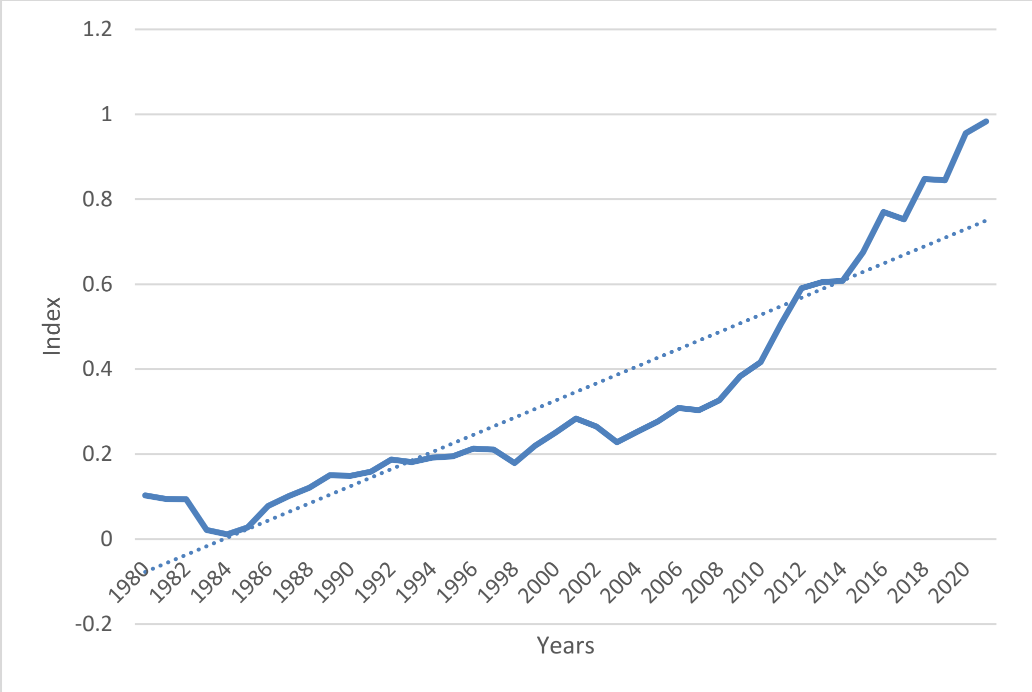

Figure 4.19:Trends in Energy Usage Index.
Source: Asafo (2024)

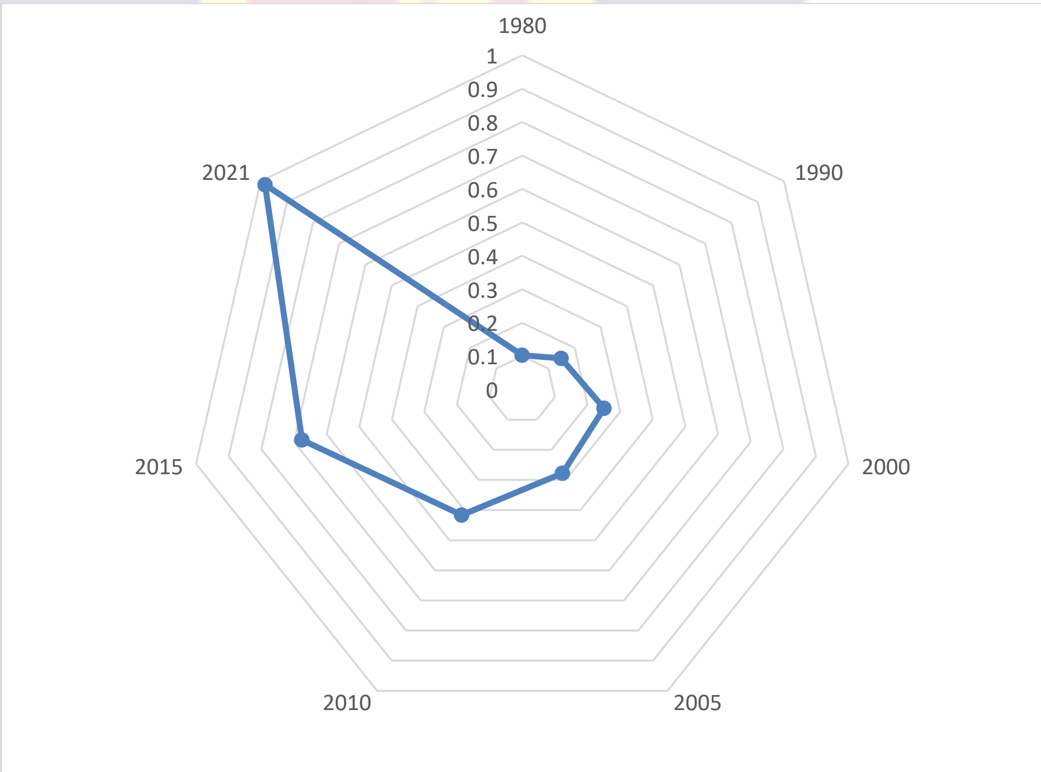

Figure 4.20: Radar chart for Energy Usage Index.
Source: Asafo (2024)

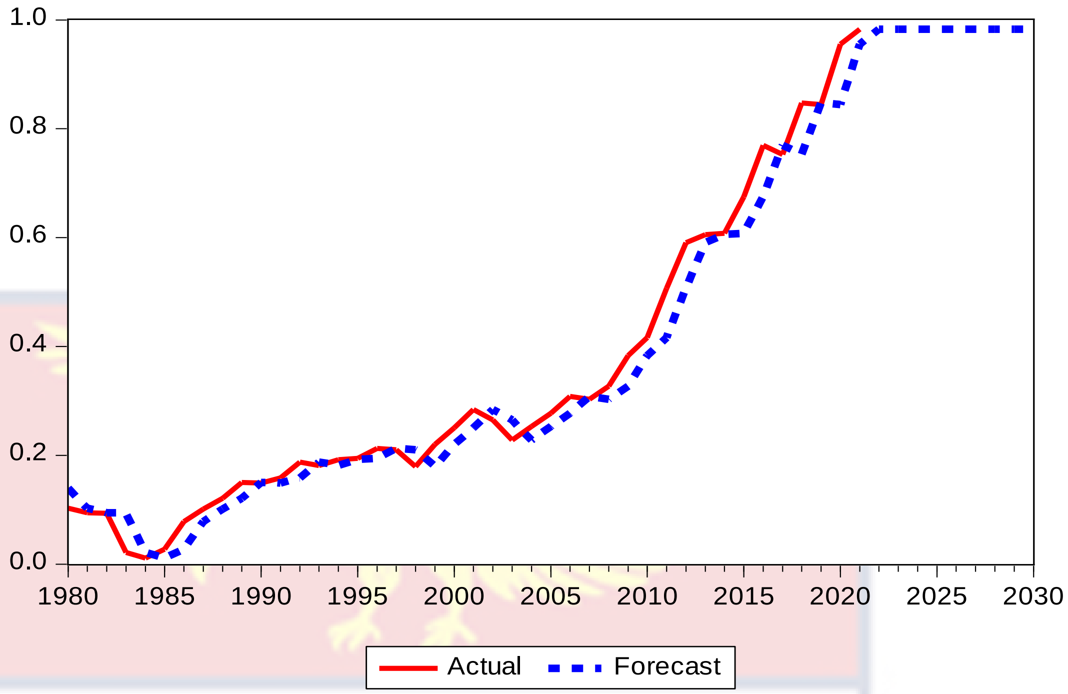

Figure 4.21: Forecast of Energy Usage Index
Source: Asafo (2024)

4.2.4 Appraisal of Energy Humanization Index

To attain the objective of estimating energy humanization index, the study generates a composite index by combining energy security index and energy usage index. To create this composite index, we utilize Equation (5) in Chapter Three, which assigns equal importance to both energy security index and energy usage index. The results of this analysis can be visualized in Figure 4.22. From the Figure 22, we can see that energy usage index has always been on the rise whilst energy security from was on the decrease until 2011 where we stated seeing some positive trends in the index.

Figure 4.22: Annual Energy Humanization Index.
Source: Asafo (2024)

The data presented in Figures 4.23 showed the energy humanization index applying different weight to energy security index and energy usage index. From the three-line graphs we could see that increasing changing the weight does not really affect the trend in the Energy Humanization Index. For example, when we applied more weight specifically to the energy security index (2/3 weight) compared to the energy usage index (1/3 weight) as shown by the red line graph, the energy humanization index appeared to be higher than the blue line graph where equal weight was applied in earlier years thus 1980 to 2010 but after 2010 the opposite appeared to be true.

In the same vein when we applied more weight specifically to the energy usage index (2/3 weight) compared the to energy security index (1/3 weight) as shown by the green line graph, the energy humanization index appeared to be lower than the blue line graph where equal weight was applied in earlier years thus 1980 to 2010 but after 2010 the opposite appeared to be true.

However, a comprehensive analysis of Figures 4.23 indicates that alterations in weight have minimal impact on the overall performance and the trajectory of the energy humanization index. Therefore, this study utilized data with equal weighting, as it has demonstrated fairness and greater accuracy.

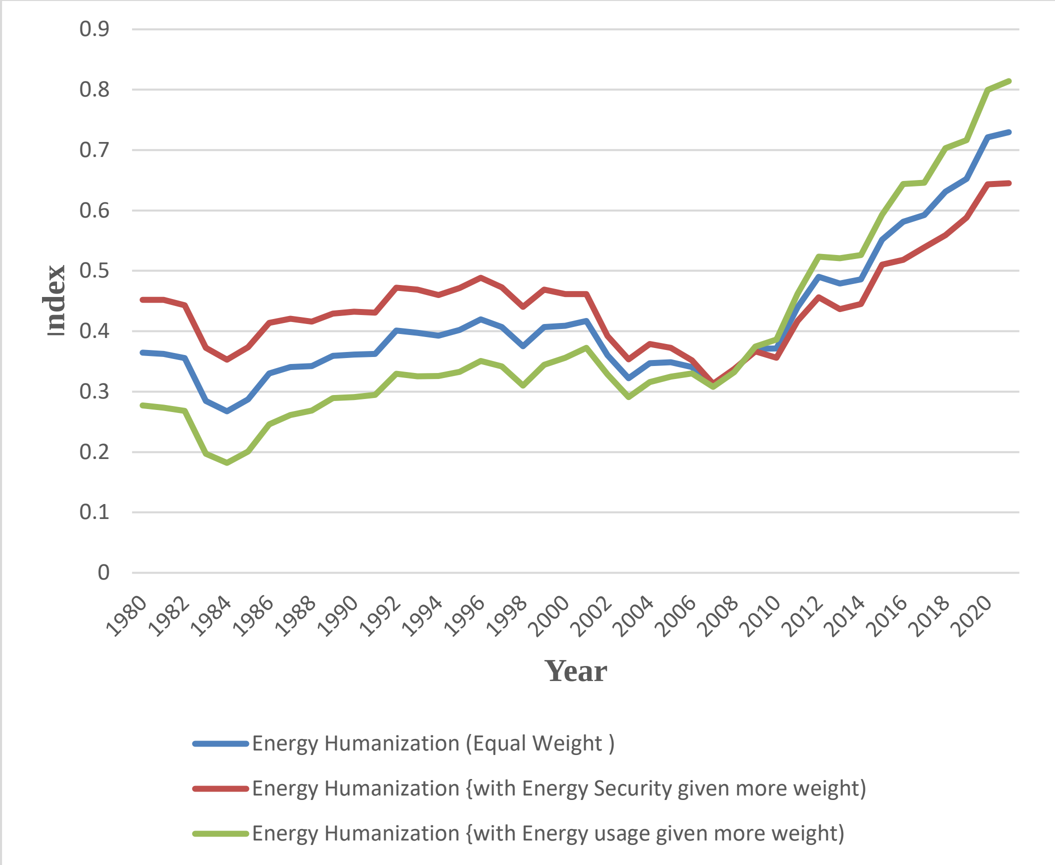

Figure 4.23: Trends in Energy Humanization Index.
Source: Asafo (2024)

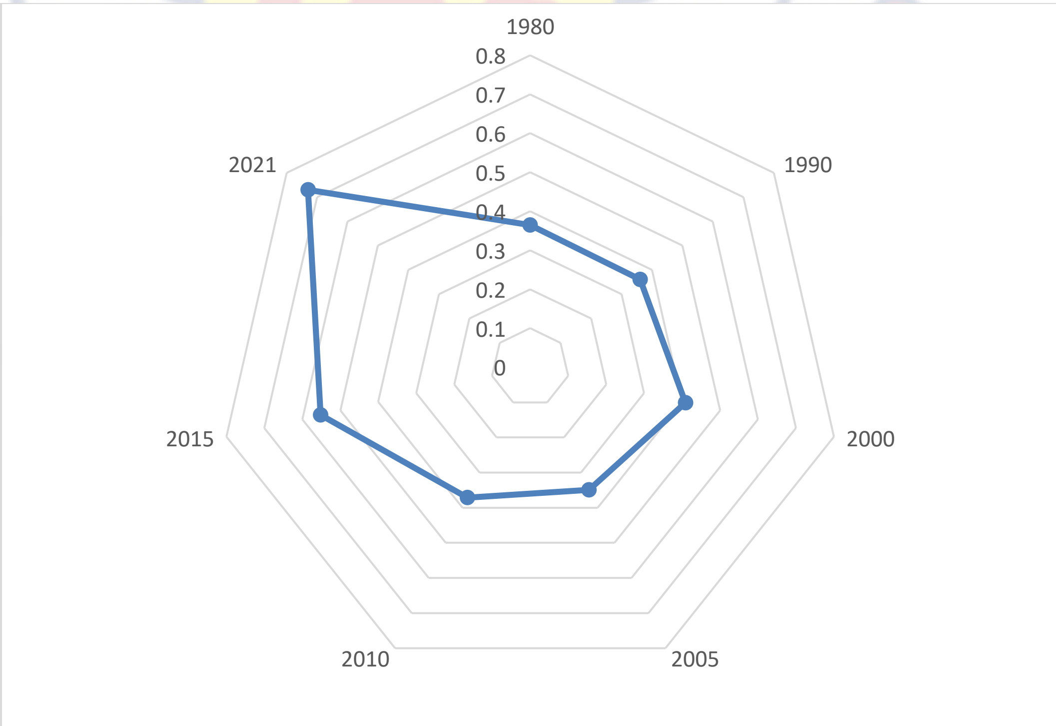

Figure 4.24: Energy Humanization Index Radar
Source: Asafo (2024)

Using the heptagonal radar chart as presented above, energy humanization index revolves around 0.4 from 1980 from 2010 but since increase to 0.6 in 2015 and 0.7 in 2021. This demonstrates that there has been much improvement in energy humanization index from 2010 which is likely to be driven by increase in energy usage index and energy availability component of energy security index.

4.2.5 Forecasting of Energy Humanization Index

The study forecasted energy humanization index using Holt-Winters multiplicative seasonal exponential smoothing method as the lags of the autocorrelation function and the partial correlation function were not significant. The result from Figure 4.25 showed that energy humanization index will remain relatively high into the near future as shown by the forecast graph.

Although we have observed a noticeable increase in the trend of the energy humanization index, there has also been a significant amount of fluctuation due to changes in energy security. The positive trend can be attributed to the expected future rise in energy usage values. In order to fully reap the benefits of the energy humanization index, it is crucial to make a conscious effort to enhance energy security. Failure to address this issue could have a detrimental impact on energy humanization.

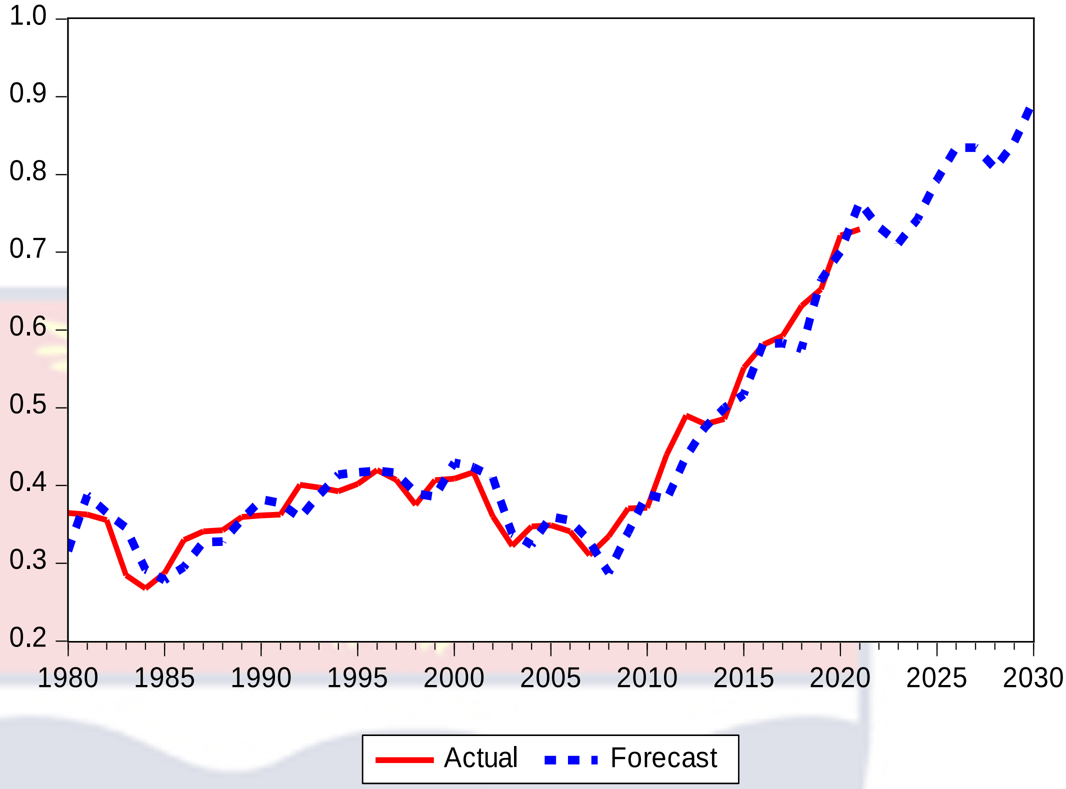

Figure 4. 25: Forecasting of Energy Humanization Index
Source: Asafo (2024)

4.3 Effect of Energy Humanization and its Dimensions on Sectoral Growth.

This second section presents the descriptive statistics of the variables used in the analyses and examines the effect of energy humanization and its dimensions on sectoral growth. We will first start with the descriptive statistics, followed by the estimation of the relationship between energy humanization and its dimension and sectoral growth analytics using Equation 17 and 18.

4.3.1 Descriptive Statistics of the Variables Used in the Regression Analysis

The descriptive statistics for the variables used in the variables used in the estimation of objectives three and four (thus Equations 17 and 18) are presented in Table 4.2 below.

Table 4.2: Descriptive Statistics of the Variables used in the Regression Analysis

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
Services value added	42	29.244	54.371	0.471	210.882
Agriculture value added	42	13.445	22.980	0.248	90.489
Industry value added	42	19.569	36.526	0.509	129.771
Energy Humanization	42	0.417	0.114	0.267	0.730
Energy Security	42	0.497	0.101	0.318	0.631
Total energy consumption	42	4.073	2.289	1.287	9.834
Electricity consumption	42	6.961	3.704	1.590	18.274
Petroleum Consumption	42	2.300	1.485	0.728	5.246
Gross fixed capital formation	42	17.457	6.891	3.761	29.002
Trade Openness	42	62.118	27.627	6.320	116.048
General government Expenditure	42	9.846	2.276	5.861	15.308
Foreign direct investment	42	3.016	2.865	0.045	9.467
Liberal Political Institution	42	0.698	0.243	0.272	0.881
Economic Freedom index	42	5.464	1.351	3.060	7.050

From the Table 4.2 the average value for services value added, agriculture value added, and industry value added are approximately GH₵ 29.244 billion, GH₵ 13.445 billion and GH₵ 19.569 billion respectively with standard deviation of GH₵ 54.371 billion, GH₵ 22.980 billion and GH₵ 36.536 billion respectively. From the descriptive analysis the sector that is contributing more to the overall GDP over the period of this study is the service sector followed by industry before the agricultural sector. But a critical analysis of the average and standard deviation showed that the standard deviation of the data is higher than the mean values hence the need to take natural log of the data to make it normally distributed and also aid interpretation of the result from the analysis.

Energy humanization index, an index that ranges between 0 and 1. Energy Humanization has an average value of 0.417 with a standard deviation of 0.114. The least and highest value are 0.267 and 0.730, respectively. The average value is an indication that we are performing below the average of 0.50 when it comes to energy humanization. Table 4.2 again showed that energy security index another variable that range between 0 and 1 has its average value been 0.497 and standard deviation of 0.101 with minimum and maximum values been 0.318 and 0.631 respectively.

To measure energy usage, the study employed total energy consumption measured in million metric tons of oil equivalent, Electricity consumption measured in billion kilowatt-hours and Petroleum Consumption measured in million metric tons of oil equivalent. From the Table 4.2 total energy consumption, electricity consumption and Petroleum Consumption have average values 4.073 mmtoe, 6.961 billion kilowatt-hours and 2.300 mmtoe with a deviation of 2.289 mmtoe, 3.704 billion kilowatt-hours and 1.485 respectively.

Variables such as gross fixed capital formation, Trade Openness, general government expenditure and foreign direct investment all expressed as percentage of gross domestic product (GDP). The mean values of gross fixed capital formation, Trade Openness, general government expenditure and foreign direct investment are 17.457 percent, 62.118 percent, 9.846 percent, and 3.016 percent respectively. Since the mean values are all higher than their respective standard deviations, we can conclude that the data is normally distributed.

In achieving the last objective, the study used the economic freedom index and liberal political institutions index as measurements of the institutional environment in this study. The economic freedom index measures economic institutions which range between 1 and 10 whilst the liberal political institutions index serves as a measure for political institutions, ranging between 0 and 1. The mean value for the economic freedom index is 5.464 with a standard deviation of 1.351 and minimum and maximum values are 3.060 and 7.050 respectively. This means that Ghana is performing averagely when it comes to economic institutions therefore more room for improvement in our economic institutional activities. When it comes to political institutional performance Ghana has an average of 0.698 which is far better compared to economic institutional performance.

4.3.2 Testing for Stationarity (Augmented Dickey-Fuller (ADF))

Table 4.3: Testing for Stationarity at Levels

Variables	T-Statistics	Critical value 5%	Critical value 10%	Decision
Services value added	-2.089	-3.54	-3.204	Non-stationary
Industry value added	-2.243	-1.687	-1.305	Stationary
Agriculture value added	-1.723	-3.54	-3.204	Non-stationary
Energy Humanization	-0.716	-3.54	-3.204	Non-stationary
Energy Security	-1.278	-3.54	-3.204	Non-stationary
Total energy consumption	-3.481	-3.54	-3.204	Non-stationary
Electricity consumption	-3.816	-3.54	-3.204	Stationary
Petroleum Consumption	-2.94	-3.54	-3.204	Non-stationary
Gross fixed capital formation	-2.201	-3.54	-3.204	Non-stationary
Trade Openness	-1.338	-3.54	-3.204	Non-stationary
General government Expenditure	-3.222	-1.687	-1.305	Stationary
Foreign direct investment	-1.686	-1.687	-1.305	Non-stationary
Liberal Political Institution	-2.449	-3.54	-3.204	Non-stationary
Economic Freedom index	-2.144	-1.687	-1.305	Stationary

Source: Asafo (2024)

Table 4.4: Testing for Stationarity at First difference

Variables	T-Statistic	Critical value 5%	10%	Decision
Services value added	-4.431	-3.544	-3.206	Stationary
Industry value added	-3.996	-1.688	-1.306	Stationary
Agric value added	-5.374	-3.544	-3.206	Stationary
Energy Humanization	-4.972	-3.544	-3.206	Stationary
Energy Security	-4.955	-3.544	-3.206	Stationary
Total energy consumption	-5.095	-3.544	-3.206	Stationary
Electricity consumption	-5.857	-3.544	-3.206	Stationary
Petroleum Consumption	-4.448	-3.544	-3.206	Stationary
Gross fixed capital formation	-5.275	-3.544	-3.206	Stationary
Trade Openness	-6.360	-3.544	-3.206	Stationary
General government Expenditure	-5.594	-1.688	-1.306	Stationary
Foreign direct investment	-4.495	-1.688	-1.306	Stationary
Liberal Political Institution	-6.326	-3.544	-3.206	Stationary
Economic Freedom index	-2.237	-1.688	-1.306	Stationary

Source: Asafo (2024)

The results from the stationarity tests are shown in Tables 4.3 and 4.4, specifically in Table 4.3 presents the ADF test results at levels whilst the first difference result is shown in Table 4.4. We observed that variables such as industry value added, electricity consumption, general government expenditure, and economic freedom index are all at stationary levels, while the remaining variables are non-stationary. The result from the first difference ADF test in Table 4.4 demonstrates that all variables are stationary at first difference.

Choosing between Fully Modified Ordinary Least Square, Dynamic Ordinary Least Square, ARDL, VECM, and VAR models, the study will use Dynamic Ordinary Least Square since it is more efficient estimator compared to ARDL, VECM, and VAR. Secondly, Dynamic Ordinary Least Square is also preferred to Fully Modify Ordinary Least Square if the variables are made up of levels and first difference variables.

Effect of Energy Humanization and its Dimensions on Sectoral Growth

In examining the relationship between energy humanization and its dimension on sectoral growth, the study first estimates the effect of total energy usage on sectoral growth, followed by the effect of energy security on sectoral growth and finally, how moderate institutional environment the relationship energy humanization affects sectoral growth.

4.3.3 The Effect of Energy Usage on Sectoral Growth

From the Dynamic OLS estimated result provided in Table 4.5, a 1 percentage point increase in the energy usage (consumption) is associated with a significant 4.0123 percent rise in value added for the service sector, a 3.06 percent increase for the industrial sector, and a 1.562 percent increase for the agricultural sector. With service sector and industrial sector significant at a 1 percent alpha level whilst the Agricultural sector is significant at 5% alpha level. This outcome suggests that an increase in energy consumption leads to heightened output across all three sectors of the economy, with the service sector having the most substantial impact and the Agricultural sector having the least. The works of Twerefou, Iddrisu, and Twum (2018) and Ouedraogo (2013) lend credence to this result in that energy consumption has a positive on growth but this study also confirms the impact of energy consumption on sectoral growth.

Trade openness was positive in all three models but was only significant in the service sector model. The result from the sectoral growth analysis showed that every one percent increase in trade openness as a percentage of GDP increases service sector value added by 0.024 percent. The results of this study align with the research conducted by Keho (2017) and Ozturk and Radouai (2020) and are in contrast to the conclusions drawn by Tahir, Mazhar, and Afridi (2019) who argued although trade openness affects the Agric and industrial sectors positively it has a negative impact on the service sector.

The result from Table 4.5 also showed that gross fixed capital formation a proxy for physical investment has a positive and significant impact on the industrial and agricultural sectors of the economy. More specifically, a 1 percent increase in gross fixed capital formation as a percent of GDP will increase industrial sector value added, and agricultural sector value added by 0.172 percent and 0.407 percent respectively. This means that physical investment is critical for growth in the industrial sector and agricultural sectors of the economy.

Table 4.5: The Effect of Energy Usage on Sectoral Growth

Variables	Service	Industry	Agric
Log of Energy Usage	4.012***	3.06***	1.562**
	(0.483)	(0.663)	(0.554)
Trade Openness	0.024***	0.007	0.003
	(0.006)	(0.008)	(0.007)
Gross fixed capital formation	-0.005	0.172***	0.164***
	(0.040)	(0.053)	(0.041)
General government expenditure	-0.133**	-0.098	-0.135**
	(0.059)	(0.069)	(0.057)
Foreign direct investment	0.291***	0.364***	0.407***
	(0.054)	(0.073)	(0.063)
Constant	15.120***	12.598***	15.720***
	(0.583)	(0.674)	(0.587)
Observation	42	42	42
F-statistic	206.529	211.489	155.908
Prob(F-statistic)	0.000	0.000	0.000
Log likelihood	11.262	15.528	10.737
Jarque-Bera	2.113	0.659	1.245
Prob (Jarque-Bera)	0.348	0.719	0.537
Breusch-Godfrey Serial Correlation LM Test	0.459	0.243	0.259
Prob-Value	0.642	0.789	0.775
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.593	1.286	1.176
Prob-Value	0.871	0.333	0.379

Standard errors are presented within parentheses. Significance levels are denoted as follows: *p< 0.1, **p< 0.05, ***p< 0.01, representing significance at 10%, 5%, and 1%, respectively.
Source: Asafo (2024)

General government expenditure has a negative impact on all three sectors of the economy but was only significant in the service sector and agricultural sector models. This implies that a 1 percent increase in General government expenditure will decrease growth in the service sector, and the agricultural sector by 0.133 percent and 0.135 percent respectively. The negative impact of general government expenditure on sectoral growth in Ghana can be attributed to crowding out private sector investment, inefficient allocation of resources, and high public debt levels may also result in a significant portion of government expenditure going towards servicing the country's debt and government expenditure may sometimes be allocated based on political considerations rather than economic merit. These can lead to suboptimal allocation of resources and hinder sectoral growth.

Foreign direct investment as a percentage of GDP has a positive impact on all three sectors of the economy. This implies that a one percent increase in FDI will result in the growth of the service sector, industrial sector, and Agric sector service sector growth by 0.291 percent, 0.364 percent, and 0.407 percent respectively. FDI has a positive influence on sectoral growth due to increased capital inflows, technology transfer and innovation, knowledge, and skills transfer.

The study also performed the necessary post-estimation test which indicates that the result is consistent, efficient, and stable over time. specifically, the outcome from the post-estimation presented in Table 4.5. reveal that the p-values associated with the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey Heteroskedasticity Test do not hold statistical significance. This provides confidence that our model passes the normality test, exhibits no serial correlation, and upholds efficiency and consistency. Supplementary Cusum and Cusum of Squares graphs can be referenced in Appendix F, confirming the stability of our models.

4.3.4 The Effect of Energy Security on Sectoral Growth

Table 4.6: The Effect of Energy Security on Sectoral Growth

Variable	Service	Industry	Agric
Energy Security	2.237	3.859	2.949
	(3.826)	(2.223)	(3.249)
Trade Openness	0.018*	0.015*	0.028**
	(0.009)	(0.007)	(0.008)
Gross fixed capital formation	0.207***	0.225***	0.154***
	(0.036)	(0.029)	(0.030)
General government expenditure	-0.497***	-0.412***	-0.359***
	(0.087)	(0.057)	(0.074)
Foreign direct investment	0.639***	0.740***	0.571***
	(0.119)	(0.069)	(0.101)
Constant	18.071***	15.967***	16.681***
	(1.602)	(1.001)	(1.360)
Observation	42	42	42
F-statistic	266.998	323.481	287.76
Prob(F-statistic)	0.000	0.000	0.000
Log likelihood	38.997	35.439	45.042
Jarque-Bera	1.621	0.289	0.739
Prob (Jarque-Bera)	0.445	0.865	0.691
Breusch-Godfrey Serial Correlation LM Test	2.004	1.902	3.776
Prob-Value	0.249	0.229	0.119
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.346	0.604	0.462
Prob-Value	0.976	0.846	0.925

Standard errors are presented within parentheses. Significance levels are denoted as follows: *p< 0.1, **p< 0.05, ***p< 0.01, representing significance at 10%, 5%, and 1%, respectively.
Source: Asafo (2024)

From Table 4.6 we have realise that energy security does not have any significant effect on any sector of the economy. While the study initially anticipates that energy security to influence sectoral growth positively and statistically, the opposite appeared to the case in the case of Ghana. Some scenarios that might account for insignificant impact of energy security on sectoral growth are energy affordability and price fluctuations, energy import dependency and inefficient use of energy.

The findings indicated that for each one percent rise in trade openness, there is a corresponding growth of 0.0177 percent, 0.0151 percent, and 0.028 percent in the service, industrial, and agricultural sectors, respectively. These outcomes are consistent with the research carried out by Keho (2017) and Ozturk and Radouai (2020). In contrast, they differ from the conclusions of Tahir, Mazhar, and Afridi (2019), who contended that while trade openness has a positive influence on the agricultural and industrial sectors, it negatively impacts the service sector.

Government expenditure has a detrimental impact on all three sectors of the economy. This means that a one percent rise in general government spending will lead to a reduction in growth within the service, industrial, and agricultural sectors by approximately 0.497 percent, 0.412 percent, and 0.359 percent, respectively. The adverse consequences of government expenditure on specific sectors in Ghana can be attributed to several factors. These factors encompass the displacement of private sector investments, ineffective allocation of resources, a substantial burden of public debt that directs a notable portion of spending towards debt repayment, and the potential for government funds to be allocated based on political considerations rather than sound economic principles. These combined factors contribute to suboptimal resource allocation and hinder growth across sectors.

Foreign Direct investment significantly increases growth in all the three sectors of the economy. Specifically, a one percent augmentation in FDI correlates to an expansion in the service sector by 0.6389 percent, the industrial sector by 0.7396 percent, and the agricultural sector by 0.5712 percent. This positive impact on sectoral growth stems from heightened capital influx, the transference of technology, fostering innovation, and the exchange of knowledge and skills.

The study also conducts essential post-estimation assessments to ensure the results are reliable, efficient, and consistent over time. Specifically, the outcomes of the post-estimation process, as displayed in Table 4.6, demonstrate that the p-values linked with the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey Heteroskedasticity Test do not possess statistical significance. This assures us that our model successfully passes tests for normality, demonstrates no serial correlation, efficiency, and consistency. Additional verification of model stability can be found in the Supplementary Cusum and Cusum of Squares graphs located in the Appendix.

4.3.5 The Effect of Energy Humanization on Sectoral Growth

Employing Dynamic OLS estimation technique, the examined the effect of humanization on sectoral growth in Ghana. From the estimation result presented in Table 4.7, the result showed that an increase in energy humanization has a positive impact on all the three sectors of the economy. This implies that an increase in energy humanization will increase growth in the service sector by 6.779 percent, a 7.675 percent increase for the industrial sector, and a 5.242 percent increase for the agricultural sector, all significant at a 1% alpha level. We can see that if people are aware of energy use patterns, costs associated with energy usage, the expenses involved in transitioning to alternative sources and users' involvement in this process of reducing the environmental impact of energy consumption, it increases sectoral growth more compare looking at just energy consumption on sectoral growth. The gives support to the viewpoint of Dr Angela Wilkinson, Secretary General and CEO, World Energy Council, who argued that energy transition cannot be achieved through technology innovation only or without shifting away from the still dominant supply-centric mindset, but customer-centric solutions, broader innovation and more inclusive cooperation are essential.

From Table 4.7, we also notice that the control variables we included in the analysis are significant in affecting sectoral growth. Specifically, trade openness, gross fixed capital formation and foreign direct investment have positive effect on all sectors of the economy whilst general government expenditure has negative effect on sectoral growth. This implies that an increase trade openness, gross fixed capital formation and foreign direct investment will increase growth in all sectors of the economy whilst an increase in general government expenditure will decrease sectoral growth. The possible explanation might be that trade openness, gross fixed capital formation, and FDI can synergistically contribute to economic growth by promoting efficiency, technology transfer, market expansion, investment, and job creation across all sectors of the economy. It's important for policymakers to create a conducive environment that encourages these factors to maximize their positive impacts on growth.

Table 4.7: The Effect of Energy Humanization on Sectoral Growth

Variable	Service	Industry	Agric
Energy Humanization	6.779***	7.675***	5.242***
	(1.750)	(1.777)	(1.177)
Trade Openness	0.022**	0.024***	0.027***
	(0.007)	(0.007)	(0.005)
Gross fixed capital formation	0.139**	0.145***	0.105***
	(0.038)	(0.041)	(0.028)
General government expenditure	-0.318***	-0.238***	-0.203***
	(0.049)	(0.050)	(0.045)
Foreign direct investment	0.518***	0.541***	0.400***
	(0.039)	(0.035)	(0.029)
Constant	15.516***	14.083***	15.999***
	(0.717)	(0.759)	(0.578)
Observation	42	42	42
F-statistic	523.743	485.768	267.019
Prob(F-statistic)	0.000	0.000	0.000
Log likelihood	51.455	46.073	26.155
Jarque-Bera	0.423	2.191	2.244
Prob (Jarque-Bera)	0.809	0.335	0.326
Breusch-Godfrey Serial Correlation LM Test	2.765	1.945	1.537
Prob-Value	0.176	0.237	0.258
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.413	0.393	0.556
Prob-Value	0.950	0.964	0.897

Standard errors are presented within parentheses. Significance levels are denoted as follows: *p< 0.1, **p< 0.05, ***p< 0.01, representing significance at 10%, 5%, and 1%, respectively.
Source: Asafo (2024)

The negative impacts of government expenditure on particular sectors in Ghana can be attributed to several factors. These encompass crowding-out of private sector investments, ineffective allocation of resources, a considerable burden of public debt diverting a notable portion of expenditure towards debt repayment, and the likelihood of government funds being distributed for political reasons rather than sound economic principles.

The research also conducts crucial post-estimations to ensure the results' reliability, efficiency, and consistency over time. Specifically, the outcomes of this post-estimation analysis, are presented in Table 4.7, reveal that the p-values associated with the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey Heteroskedasticity Test are not statistically significant implying that our model successfully passes tests for normality, shows no serial correlation, and maintains efficiency and consistency. Further confirmation of model stability can be found in the Cusum and Cusum of Squares charts provided in the Appendix F.

4.4 The Moderating Effect of Institutions in The Energy Humanization – Sectoral Growth Analytics

The section basically examines the moderating role institutional environment play in the energy humanization -sectoral growth relationship. In this analysis we employed two main institutional variables; thus, economic freedom index from the Fraser Institute which serve as a measure for economic institutions and Liberal Political Institution index from the Varieties of Democracy (V-Dem) project produced by V-Dem Institute, located at the University of Gothenburg in Sweden served as a measure for political institutional environment. We will first begin with the examination of the moderating role of economic institutional environment in the energy humanization- sectoral growth analysis and followed by the moderating role Liberal Political Institution index in the energy-sectoral growth analysis.

4.4.1 The Moderating Role of Economic Freedom Index in the Energy Humanization – Sectoral Growth Analysis

Table 4.8: The Moderating Role of Economic Freedom Index in the Energy Humanization – Sectoral Growth Analysis

Variables	Service	Industry	Agric
Energy Humanization	49.881***	41.898***	46.488***
	(10.630)	(9.201)	(9.853)
Economic Freedom Index	3.204***	2.513***	3.209***
	(0.634)	(0.549)	(0.588)
Economic Freedom Index * Energy Humanization	-6.520***	-4.709**	-6.121***
	(2.043)	(1.768)	(1.893)
Trade Openness	0.002	0.006	0.0004
	(0.021)	(0.018)	(0.019)
Gross fixed capital formation	0.043	0.071	0.035
	(0.097)	(0.084)	(0.090)
General government Expenditure	-0.428**	-0.307*	-0.345*
	(0.189)	(0.164)	(0.175)
Foreign direct investment	0.472	0.573**	0.375
	(0.298)	(0.258)	(0.276)
Observations	42	42	42
F-statistic	1199.703	1562.738	1370.426
Prob(F-statistic)	0.0000	0.000	0.000
Log-likelihood	-13.653	-8.024	-10.693
Jarque-Bera	1.272	2.537	1.826
Prob (Jarque-Bera)	0.529	0.281	0.402
Breusch-Godfrey Serial Correlation LM Test	1.057	1.089	1.602
Prob-Value	0.387	0.377	0.254
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.958	1.148	1.146
Prob-Value	0.565	0.431	0.432

Standard errors are presented within parentheses. Significance levels are denoted as follows: *p< 0.1, **p< 0.05, ***p< 0.01, representing significance at 10%, 5%, and 1%, respectively.
Source: Asafo, 2024

Investigating the moderating function of economic freedom index which is a proxy for economic institutions in the context of energy humanization and sectoral growth in Ghana. We assess the moderating role of economic freedom index using the net effect approach by employing Equation (18) which provides insight into the moderating effect of institutions.

From Equation (18), $\frac{\Delta Sectoral\ growth_t}{\Delta EH_t} = \beta_1 + \beta_2 INS_t$

For the service sector, we estimate the net effect as follows

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 49.881 + (-6.520)(EFI)_t$$

Utilizing the average value of Economic freedom 5.464, as indicated in the descriptive statistics, yields the following result:

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 49.881 + [(-6.520)(5.464)]$$

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 49.881 - 35.625$$

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 14.256$$

This indicates that, using the average value of economic freedom, a 1% increase in energy humanization will lead to a 14.256% increase in service sector growth. This suggests that enhancing economic freedom amplifies the influence of energy humanization on service sector.

Again, for the industrial sector, we estimate the moderating role of economic freedom index on energy humanization – sectoral growth relationship as follows:

$$\frac{\Delta\ Industrial\ Sector\ growth_t}{\Delta EH_t} = 41.898 + (-4.709)(EFI)_t$$

Utilizing the average value of Economic freedom 5.464, as indicated in the descriptive statistics, yields the following result:

$$\frac{\Delta\ Industrial\ Sector\ growth_t}{\Delta EH_t} = 41.898 + (-4.709)(5.464)$$

$$\frac{\Delta\ Industrial\ Sector\ growth_t}{\Delta EH_t} = 41.898 - 25.730$$

$$\frac{\Delta\, Industrial\ Sector\ growth_{\,t}}{\Delta EH_t} = 16.168$$

This implies that, on average, given the present level of economic freedom, a 1% increase in energy humanization results in a 16.168% growth in the industrial sector. This indicates that improving economic freedom increases the impact of energy humanization on the industrial sector.

In addition, for the Agricultural sector, we estimate the moderating role of economic freedom index on energy humanization – sectoral growth relationship as follows:

$$\frac{\Delta\, Agric\ Sector\ growth_{\,t}}{\Delta EH_t} = 46.488 + (-6.121)(EFI)_t$$

Utilizing the average value of Economic freedom 5.464, as indicated in the descriptive statistics, yields the following result:

$$\frac{\Delta\ \ Agric\ Sector\ growth_{\,t}}{\Delta EH_t} = 46.488 + (-6.121)(5.464)$$

$$\frac{\Delta\ \ Agric\ Sector\ growth_{\,t}}{\Delta EH_t} = 46.488 - 33.445$$

$$\frac{\Delta\, Agric\ Sector\ growth_{\,t}}{\Delta EH_t} = 13.043$$

This suggests that, typically, with the existing degree of economic freedom, a 1% rise in energy humanization corresponds to a 13.043 expansion in the Agricultural sector. It highlights that enhancing economic freedom enhances the influence of energy humanization on the agricultural sector growth. In a nutshell, we can see that considering institutional environment from economic institutions perspective result in an improvement in the effect of energy humanization on sectoral growth across all the sectors of the economy.

General government expenditure exerts an adverse influence on all three economic sectors. This means that a 1 percent increase in general government expenditure will lead to a reduction in growth for the service sector, industrial sector, and agricultural sector by 0.428 percent, 0.307 percent, and 0.345 percent, respectively. The negative impact of general government expenditure on sectoral growth in Ghana can be attributed to various factors, including crowding out private sector investment, inefficient resource allocation, a high level of public debt that requires a significant portion of government expenditure for debt servicing, and the possibility that government spending decisions are sometimes made for political reasons rather than economic merit. These factors can result in the suboptimal allocation of resources and hinder the growth of these sectors.

Foreign direct investment (FDI) positively affects all three sectors of the economy but was only significant the industrial sectors growth. This means that a one percent increase in FDI as percentage of GDP would lead to growth in the industrial sector by approximately 0.573 percent. FDI exerts a favourable influence on the industrial sectors growth by facilitating increased capital inflows, technology transfer and innovation, as well as the transfer of knowledge and skills to the sector.

To ensure the robustness, consistency, and reliability of our results, we performed post-estimation evaluations, including the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, the Breusch-Pagan-Godfrey Heteroskedasticity Test, Cusum, and Cusum squares. The outcomes presented in Table 4.8 reveal that the p-values for the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey Heteroskedasticity Test do not demonstrate statistical significance. This assures that our model successfully meets the normality test, shows no evidence of serial correlation, and maintains efficiency and consistency. The Cusum and Cusum of Squares graphs, available in Appendix F, further confirm the stability of our models.

4.4.2 The Moderating Role of Liberal Political Institution Index in the Energy Humanization – Sectoral Growth Analysis

In this section, we begin by investigating how the Liberal Political Institution index, which signifies political institutions, influences the relationship between energy humanization and sectoral growth in Ghana. We assess the moderating influence of political institutions using the net effect approach, employing Equation (18) to gain a deeper understanding of the moderating role of institutions.

From Equation (18), $\frac{\Delta Sectoral\ growth_t}{\Delta EH_t} = \beta_1 + \beta_2 INS_t$

For the service sector, we estimate the net effect as follows

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 46.706 + (-41.408)(LPI)_t$$

Utilizing the average value of Liberal Political Institution 0.698, as indicated in the descriptive statistics, yields the following result:

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 46.706 + (-41.408)(0.698)$$

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 46.706\ - 28.903$$

$$\frac{\Delta\ Service\ Sector\ growth_t}{\Delta EH_t} = 17.803$$

This suggests that, on average, given the existing level of Liberal Political Institution index, a 1% increase in energy humanization leads to a substantial 17.803% surge in service sector growth. It implies that augmenting Liberal Political Institution intensifies the impact of energy humanization on the service sector, showcasing a reinforcing relationship between economic freedom and its facilitation of energy-driven growth in this sector.

Similarly, in the industrial sector, we compute the moderating influence of the Political Institutions on the relationship between energy humanization and industrial sector growth as follows:

$$\frac{\Delta\, Industrial\ Sector\ growth_t}{\Delta EH_t} = 47.331 + (-46.737)(EFI)_t$$

Using the mean value of the Liberal Political Institution, which stands at 0.698 as shown in the descriptive statistics, produces the subsequent outcome:

$$\frac{\Delta\, Industrial\ Sector\ growth_t}{\Delta EH_t} = 47.331 + (-46.737)(0.698\,)$$

$$\frac{\Delta\, Industrial\ Sector\ growth_t}{\Delta EH_t} = 47.331 - 32.622$$

$$\frac{\Delta\, Industrial\ Sector\ growth_t}{\Delta EH_t} = 14.709$$

This signifies that, on average, with the current level of Liberal Political Institution, a 1% boost in energy humanization leads to a notable 14.709% expansion in the industrial sector. It demonstrates that enhancing Political Institution augments the influence of energy humanization on the industrial sector, highlighting the positive role of liberal political institutions in fostering growth in industrial sector.

Furthermore, concerning the agricultural sector, we calculate the moderating effect of the political institutions on the relationship between energy humanization and agricultural sector growth as depicted below:

$$\frac{\Delta\, Agric\ Sector\ growth_t}{\Delta EH_t} = 47.675 + (-46.018)(\mathrm{LPI})_t$$

Using the mean value of the Liberal Political Institution, which is 0.698 as provided in the descriptive statistics, produces the subsequent outcome:

$$\frac{\Delta\ Agric\ Sector\ growth_t}{\Delta EH_t} = 47.675 + (-46.018)(0.698)$$

$$\frac{\Delta\ Agric\ Sector\ growth_t}{\Delta EH_t} = 47.675 - 32.121$$

$$\frac{\Delta\ Agric\ Sector\ growth_t}{\Delta EH_t} = 15.555$$

This indicates that, on average and given the existing level of political institution, a 1% increase in energy humanization is associated with a notable 15.555% growth in the agricultural sector. This underscores the idea that improving political institutional environment amplifies the impact of energy humanization on the growth of the agricultural sector, emphasizing the constructive role of political institution in stimulating growth within this sector. The synergy between political institution and energy humanization significantly contributes to the progress and development of agriculture, a pivotal aspect of the overall economic landscape.

In summary, it is evident that considering the institutional environment from the perspective of political institutions leads to an enhancement in the impact of energy humanization on sectoral growth within all sectors of the economy. By evaluating and incorporating the political institutional framework, we observe a favourable advancement in how energy humanization positively influences the growth of each sector. This underscores the critical role of institutions in shaping the dynamics of energy humanization's effect, ultimately contributing to growth and progress across various sectors, which is a significant factor in overall economic development.

Foreign Direct Investment (FDI) notably has positive impact on growth in all three sectors of the economy, but it was significant in service and industrial sector models. More precisely, a one percent increase in FDI corresponds to a growth of approximately 0.578 percent in the service sector and 0.364 percent in the industrial sector. This favourable influence on sectoral growth and industrial sector arises from increased capital inflow, technology transfer, stimulation of innovation, and the transfer of knowledge and skills.

Table 4.9: The Moderating Role of Liberal Political Institution Index in the Energy Humanization – Sectoral Growth Analysis

Variables	Service	Industry	Agric
Energy Humanization	46.706***	47.331***	47.675***
	(8.033)	(7.340)	(7.482)
Liberal Political Institution	16.539	22.808**	19.040*
	(10.242)	(8.552)	(9.540)
Liberal Political Institution* Energy Humanization	-41.408*	-46.737***	-46.018**
	(17.534)	(15.360)	(16.332)
Trade Openness	-0.003	-0.022	-0.007
	(0.021)	(0.025)	(0.020)
Gross fixed capital formation	0.061	0.109	0.059
	(0.052)	(0.068)	(0.048)
General government Expenditure	0.039	-0.238	0.014
	(0.373)	(0.326)	(0.348)
Foreign direct investment	0.578*	0.364*	0.450
	(0.274)	(0.187)	(0.255)
Observations	42	42	42
F-statistic	5725.498	5878.479	6590.152
Prob(F-statistic)	0.000	0.000	0.000
Log-likelihood	8.763	8.468	11.461
Jarque-Bera	2.338	2.544	2.237
Prob (Jarque-Bera)	0.311	0.280	0.327
Breusch-Godfrey Serial Correlation LM Test	0.073	0.442	0.326
Prob-Value	0.931	0.662	0.736
Heteroskedasticity Test: Breusch-Pagan-Godfrey	1.349	2.359	1.449
Prob-Value	0.379	0.120	0.341

Standard errors are presented within parentheses. Significance levels are denoted as follows: *p< 0.1, **p< 0.05, ***p< 0.01, representing significance at 10%, 5%, and 1%, respectively.
Source: Asafo, 2024

The research also conducts essential post-estimations to ensure the reliability, efficiency, and consistency of the results over time. Specifically, the outcomes of this post-estimation analysis, as presented in Table 4.9, indicate that the p-values associated with the Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey Heteroskedasticity Test do not show statistical significance. This suggests that our model successfully meets the tests for normality, demonstrates no serial correlation, and maintains efficiency and consistency. Additionally, to further affirm the stability of the model, the Cusum and Cusum of Squares charts provided in the Appendix offer additional confirmation.

Chapter Summary

This chapter presents an analysis of the descriptive statistics of model variables, the estimated results and discussion of the results. The study constructs an energy humanizing index in Ghana, forecasts various dimensions of energy humanization from 1980 to 2030, estimates the impact of energy humanization on sectoral growth, and evaluates the moderating role of institutional quality in the energy humanization and sectoral growth analysis. The empirical results revealed that energy humanization itself has been improving over years especially with the energy usage dimension. However, whilst the energy security aspects are improving, others are getting worse. For example, the performance of energy acceptability, energy affordability and technology application keep on decreasing will even decrease into the future if nothing significant happened, energy availability keeps increasing.

Again, we discovered that energy humanization positively contributes to growth in all sectors of the economy but energy security a disaggregated component of energy humanization on its own does not affect sectoral growth whilst energy usage was significant in affecting growth. Lastly, we also discovered that both political and economic institutions positively moderate the relationship between the energy humanization and sectoral growth in Ghana.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a comprehensive summary, conclusions, and recommendations based on the study's investigation. The summary section encapsulates an overview of the problem statement, research objectives, research questions, hypotheses, and the methodology employed in the study. This ensures a clear understanding of the study's foundations and the approach taken to address the identified research questions. Moving on to the conclusions, the study's findings are synthesized and analysed to derive key insights. These insights are then used to draw conclusions regarding the research objectives and questions. The conclusions provide a succinct summary of what has been established through the study, highlighting the key findings and their implications.

Further the chapter offers policy recommendations directed towards relevant authorities. These recommendations are based on the research findings and are designed to provide actionable insights to address the identified issues and challenges. By offering policy recommendations, the study aims to contribute to informed decision-making and actions that can positively impact the subject of investigation. In essence, this chapter serves as a crucial culmination of the study, summarizing the journey from problem identification to methodology, findings, and ultimately providing actionable recommendations for consideration by stakeholders and policymakers.

5.2 Summary

The study aims to construct energy humanizing index in Ghana, estimate the impact of energy humanization on sectoral growth and the moderating role of institutional environment in the energy-growth relationship. Specifically, the study estimates the level of the various dimensions of energy humanizing index in Ghana, forecast the various dimensions of energy humanization up to 2030 to see if the Sustainable Development Goal 7 could be achieved by Ghana using the existing historic data, analysed the effect of energy humanizing dimensions on the sectoral growth in Ghana and finally, we examine the moderating role of institutional environment on energy humanization and sectoral growth in Ghana.

To estimate the various dimensions of the Energy Humanization Index, the study adopted the minimum-maximum normalization approach. Equal weight was assigned to each of the different indicators and dimensions, resulting in the calculation of the overall Energy Humanization Index. This normalization process ensured that each dimension had a proportional influence on the overall index. Initially, for forecasting future values of the different dimensions of the Energy Humanization Index and the EHI, itself, realizing that the lags in the Partial Autocorrelation Function and the Autocorrelation Function were not significant, the exponential smoothing forecasting approach was adopted. Exponential smoothing is particularly effective when the time series data does not exhibit significant autocorrelations.

For assessing the effect of energy humanization and its disaggregated dimensions on sectoral growth, as well as, testing for the moderating role of institutional environments on this relationship, the study employed the Dynamic

Ordinary Least Square (DOLS) estimation technique. DOLS is a method often used in econometrics to estimate models with integrated variables and is suitable for addressing issues related to endogeneity and autocorrelation. The study's dataset spans from 1980 to 2021 and was sourced from reputable databases, including the World Development Indicators (WDI), the Energy information Administration (EIA), Varieties of Democracy (V-Dem) project produced by V-Dem Institute and Fraser Institute. These databases provided a rich and extensive dataset, allowing for a thorough analysis of the relationship between energy humanization, its dimensions, institutional factors, and sectoral growth over the specified period.

The research also conducts essential post-estimation assessments to ensure the results are reliable, efficient, and consistent over time. Specifically, some of the post-estimation test considered includes Jarque-Bera test, the Breusch-Godfrey Serial Correlation LM Test, and the Breusch-Pagan-Godfrey heteroskedasticity test, Cusum and Cusum of Squares test.

The analysis revealed a positive trend in energy humanization, particularly within the dimension of energy usage. However, with energy security, whilst some aspects have shown improvement, others have demonstrated a decline over time. Notably, energy acceptability, affordability, and technology application have exhibited a decreasing performance, which is anticipated to worsen in the future if significant interventions are not implemented. Conversely, energy availability has demonstrated a consistent increase.

Furthermore, the findings highlight a positive contribution of energy humanization to growth across all sectors of the economy. However, an examination of energy security as a disaggregated component of energy humanization, it is evident that energy security does not directly impact sectoral growth. On the other hand, energy usage emerged as a significant factor affecting growth. These insights emphasize the importance of focusing on energy usage to drive growth within individual sectors of the economy.

Finally, we uncovered a positive moderating role played by both political and economic institutions in the relationship between energy humanization and sectoral growth in Ghana. The effectiveness and stability of these institutions were found to enhance the impact of energy humanization on sectoral growth, underscoring the need for a supportive institutional environment to optimize the benefits of energy humanization.

5.3 Key Findings

The following are key findings the of the study:

The heptagonal radar chart in Figure 4.3, shows that the highest performance in terms of energy acceptability was recorded in 1980, with a value of 0.762, with the lowest being 2021, which is approximately 0.376. This clearly shows that energy acceptability continues to decrease over the years, and a possible explanation may be an increase in the share of electric power generation from hydro to thermal power over the years and increase in the use of automobile transport. From the forecast graph we can see that the energy acceptability will continues to decrease when using existing data for future forecasts. The study also reveals a consistent decline in technology applications from 1980 to 2002, after which it appeared to be fairly stable. Figure 4.6, the heptagonal radar chart, illustrates that the highest score was observed in 1980, with a recorded value of 0.845, whereas the lowest was noted in 2021, at approximately 0.289. Although the performance declined throughout the period of the study, variation after 2005 was relatively smaller, possibly due to the drastic measures adopted by the governments of Ghana, the Energy Commission, and other institutions to improve energy efficiency. From the forecast we can see that if nothing changes drastically technology application index will keep decreasing and energy security will not be achieved by 2030.

For energy affordability index, we also could see that there was not much change in energy affordability from 1980 to 2000 but after 2000s energy affordability decreases largely because of reduction in subsidies and the introduction of a lot of taxes into the sector. 2013 and 2014 recorded the worst performance because Ghana faced electricity supply challenges during this period, including frequent power outages and load shedding. The cost of backup power sources, such as generators, increased for both households and businesses, contributing to higher energy expenses. The forecast showed that although we expect energy affordability to fluctuate much in the near future, on average, energy affordability will improve over time. Energy availability has been on the rise over the period of the study. Specifically, the highest score was observed in 2021, with a recorded value of 0.974, while the lowest was noted in 1980, approximately at 0.019. From the forecast graph, we anticipate that energy availability to remain very high throughout the near future.

Ghana performance in-terms of energy security did not change much from 1980 to 2000 but turn to decrease from 2001 to 2010, only started showing positive trend upon the discovery and drilling of crude oil and gas in Ghana. Although energy availability will remain high going into the future as shown by the forecast graph energy availability but the fall in other indicators especially energy acceptability and technology application may result in a decrease in energy security. This decrease in energy security may affect the effort of the country in the attainment of SDG 7.

For energy humanization we can see that the index revolves around 0.4 from 1980 from 2010 but since increase to 0.6 in 2015 and 0.7 in 2021. This demonstrates that there has been much improvement in the energy humanization index from 2010 which is likely to be driven by increase in energy usage index and energy availability component of energy security index. The forecast result showed that the energy humanization index will remain relatively high into the near future.

An increase in energy usage by one percentage point increases service sector growth by 4.0123 percent, a 3.06 percent increase for the industrial sector, and a 1.562 percent increase for the agricultural sector. We also discovered that energy security on its own does not have any significant effect on any sector of the economy. From the estimation result an increase in energy humanization has a positive impact on all the three sectors of the economy. This implies that an increase in energy humanization will increase growth in the service sector by 6.779 percent, a 7.6745 percent increase for the industrial sector, and a 5.242 percent increase for the agricultural sector.

The result indicates that, on average, with the current state of economic freedom, a rise in energy humanization will by 1% will lead to a 14.256% percent increase in service sector growth. Also, on average, given the present level of economic freedom, a 1% increase in energy humanization results in a 16.166% growth in the industrial sector. In addition, with the existing degree of economic freedom as an indicator for economic institutions, a 1% rise in energy humanization corresponds to a 13.0425% expansion in the Agricultural sector.

Given the existing level of Liberal Political Institution index, a 1% increase in energy humanization leads to a 17.803% surge in service sector growth. On average, with the current level of Liberal Political Institution, a 1% boost in energy humanization leads to a notable 14.708% expansion in the industrial sector. With the existing level of Political Institution, a 1% increase in energy humanization is associated with a notable 15.969% growth in the Agricultural sector.

General government expenditure has a negative impact on all the three sectors of the economy in almost all the models we estimated. For example, in the effect of energy security on sectoral growth model, a 1 percent increase in general government expenditure decreases growth in service sector, industrial sector and Agric sector by 0.497 percent, 0.412 percent, and 0.359 percent, respectively. Foreign Direct investment increases growth in among the three sectors of the economy in most of the models. For example, in the effect of energy security on sectoral growth model, a one percent increase in FDI correlates to an expansion in the service sector by 0.6389 percent, the industrial sector by 0.7396 percent, and the agricultural sector by 0.5712 percent. Trade Openness positively affects sectoral growth in Ghana. For instant, in the effect of energy security on sectoral growth model, the result also showed that every one percent increase in trade openness will increases service sector, industrial sector, and agricultural sector by 0.0177 percent, 0.0151 percent, and 0.028 percent, respectively.

5.4 Conclusion

The primary objectives of this research include the creation of an Energy Humanization Index within the context of Ghana, the assessment of how energy humanization influences growth across various sectors, and the examination of how the institutional environment moderates the relationship between energy humanization and sectoral growth. To achieve these goals, the study utilized exponential smoothing forecasting and the Dynamic Ordinary Least Square (DOLS) estimation method to estimate the impact of energy humanization, including its individual dimensions, on sectoral growth, while also analysing the influence of institutional factors in this dynamic.

The analysis revealed a positive trend in energy humanization, particularly within the dimension of energy usage. However, with energy security, whilst some aspects have shown improvement, others have demonstrated a decline over time. Notably, energy acceptability, affordability, and technology application have exhibited a decreasing performance, which is anticipated to worsen in the future if significant interventions are not implemented. Conversely, energy availability has demonstrated a consistent increase.

Again, the findings showed that energy humanization positively contribute to growth across all sectors of the economy. However, when examining energy security as a disaggregated component of energy humanization, it became evident that it does not directly impact sectoral growth. On the other hand, energy usage emerged as a significant factor affecting growth. Finally, the study uncovered a positive moderating role played by both political and economic institutions in the relationship between energy humanization and sectoral growth in Ghana.

5.5 Recommendations

Considering the study's findings and resulting conclusions, the subsequent policy suggestions are formulated with respect to the objectives.

1. Energy Commission together with the Ministry of Energy should propose and implement the policy of carbon capture which will then force the independent power producers (IPPs) to adopt this technology in power generation process and also encourage the adoption of electric vehicles once we can guarantee stable electricity and charging points. Since energy acceptability component of energy security is expected to decrease into the future possibly due to CO_2 emissions and CO_2 intensity largely from the energy sector in-terms of power generation and the transport sector,
2. The Ministry of Finance must be circumspect in imposing more levies on petroleum products and electricity tariff although it is an inelastic good an increase in the price will result in a decrease in affordability, energy security, energy humanization and growth. This must be considered because energy affordability a dimension of energy security is expected to fluctuate much in the future and a decrease in energy affordability will result in energy humanization and growth.
3. The Energy Commission, Ministry of Energy together Ministry of Finance must commit resources to finance research and adaptation of smart technologies, especially in the transmission and distribution of electricity, energy efficiency technologies, and public education on the need to use standard and energy efficient equipment's and gadgets which will help promote technology application in the energy sector.

4. The Energy Commission, Ministry of Energy, National Petroleum Authority, Public Utility, and Regulatory Commission should deal with energy security and energy usage simultaneously (Energy Humanization) as opposed to treating them separately. Since energy humanization has more impact on sectoral growth compared to just energy usage.
5. Ghana as a nation should focus on improving and strengthening economic institutions, ensuring they are transparent, accountable, and efficient. This can be done by ensuring that the Judicial and legal systems as a whole is efficient and effective in promoting property rights, Bank of Ghana must also implement sound monetary policies, the Ministry of Trade must also ensure sound trade policies and regulations.
6. Since political institutions also positively moderate the relationship between energy humanization and sectoral growth, the legislature and the judiciary branch of government must play their role efficiently as a check and constraint on the executive arm of government so as to promote sound political institutions. Since we also know from literature that sound political institutions promote sound economic institutions whilst weak or extractive political institutions also promote weak or destructive economic institutions.

5.6 Suggestions for Future Research

Future studies can delve into refining the methodology for constructing the Energy Humanization Index (EHI). Exploring alternative weighting schemes based on stakeholder preferences or expert opinions could enhance the accuracy and relevance of the index. Future studies can also conduct a comparative analysis of the Energy Humanization Index across multiple countries to identify best practices, policy strategies, and potential lessons that can be applied in

Ghana. Understanding how different nations address energy humanization can provide valuable insights.

Explore the impact of energy humanization at a micro-level, considering the effects on households, local communities, and specific industries. Analyse how energy humanization influences the well-being of individuals and the growth of micro and small enterprises. Future studies supplement the quantitative analysis with qualitative research methods, such as interviews, surveys, or case studies, to gain a deeper understanding of the socio-cultural, political, and economic factors influencing energy humanization in Ghana.

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APPENDICES

Appendix A: BDCs in Ghana and their Market share

Table 6.1: BDCs in Ghana and their Market share

No	Company	Total Products Distributed (MT)	Market Shares
1	GoEnergy Company Limited	213,565	21.02%
2	Juwel Energy Limited	157,720	15.52%
3	Dominion Int. Petroleum Limited	83,032	8.17%
4	Fueltrade Limited	71,369	7.02%
5	Maranatha Oil Services Limited	70,386	6.93%
6	Astra Oil Services Limited	65,796	6.48%
7	Blue Ocean Investments Limited	57,308	5.64%
8	Cirrus Oil Services Limited	52,591	5.18%
9	Sage Distribution Limited	38,153	3.75%
10	Vihama Energy Limited	26,478	2.61%
11	Eagle Petroleum Company Limited	23,219	2.29%
12	Alfapetro Ghana Limited	17,150	1.69%
13	Chase Pet. Ghana Limited	16,753	1.65%
14	Oil Channel Limited	14,610	1.44%
15	Petroleum Warehousing & Supply Limited	13,769	1.36%
16	International Petroleum Resources Ghana Limited	11,092	1.09%
17	Oil Trade Company Limited	9,693	0.95%
18	Akwaaba Oil Refinery Limited	8,147	0.80%
19	Everstone Energy Limited	7,769	0.76%
20	Matrix Gas Ghana Limited	7,676	0.76%
21	Rhema Energy Company Limited	6,274	0.62%
22	Nenser Petroleum Ghana Limited	5,607	0.55%

23	SA Energy Limited	5,103	0.50%
24	Glorymay Petroleum Company Limited	4,263	0.42%
25	Nation Services Limited	4,137	0.41%
26	Misyl Energy Company Limited	3,889	0.38%
27	Cubica Energy Limited	3,619	0.36%
28	Hask Oil Company Limited	3,471	0.34%
29	Mariaje Linx Investment Limited	2,289	0.23%
30	Rama Energy Limited	2,100	0.21%
31	Genysis Global Limited	2,009	0.20%
32	Globex Energy Limited	1,944	0.19%
33	Reston Energy Trading Limited	1,728	0.17%
34	Med Petroleum Company Limited	1,203	0.12%
35	Tema Oil Refinery	977	0.10%
36	Firm Energy Limited	269	0.03%
37	Ebony Oil & Gas Limited	262	0.03%
38	Platon Gas Oil Limited	194	0.02%
39	Woodfields Energy Resources Limited	178	0.02%
40	Comanda Energy Limited	144	0.01%
41	Dome Energy Resources Limited	82	0.01%
42	Hilson Petroleum Ghana Limited	82	0.01%
43	Battop Energy Limited		0.00%
44	Kpabulga Energy Limited		0.00%
45	Lemla Petroleum Limited		0.00%
	GRAND TOTAL	**1,016,103**	**100%**

Source: Asafo (2024) with data from the National Petroleum Authority.

Appendix B: OMCs in Ghana and their market share

Table 6. 2: OMCs in Ghana and their market share

No	Company	Total Products Distributed (MT)	Market Shares
1	GOIL Company Limited	212,613	20.92%
2	Vivo Energy Ghana Limited	95,168	9.37%
3	TotalEnergies Marketing Ghana Plc	86,106	8.47%
4	Zen Petroleum Limited	76,540	7.53%
5	Star Oil Company Limited	62,913	6.19%
6	Puma Energy Distribution Ghana Limited	45,749	4.50%
7	Benab Oil Company Limited	26,149	2.57%
8	Gaso Petroleum Limited	24,348	2.40%
9	Pacific Oil Ghana Limited	22,509	2.22%
10	Petrosol Ghana Limited	20,479	2.02%
11	IBM Petroleum Limited	19,653	1.93%
12	Frimps Oil Company Limited	18,577	1.83%
13	Dukes Petroleum Company Limited	18,555	1.83%
14	Goodness Energy Limited	15,171	1.49%
15	Allied Oil Company Limited	12,111	1.19%
16	Engen Ghana Limited	10,586	1.04%
17	Mobik Energy Limited	8,875	0.87%
18	Reliance Oil Limited	8,381	0.82%
19	Maxx Energy Limited	7,692	0.76%
20	Radiance Petroleum Limited	7,440	0.73%
	SUBTOTAL	799,614	78.69%
	OTHERS	216,489	21.31%
	GRAND TOTAL	**1,016,103**	**100.00%**

Source: Asafo (2024) with data from the National Petroleum Authority

Appendix C: Estimation of Technology Application Index

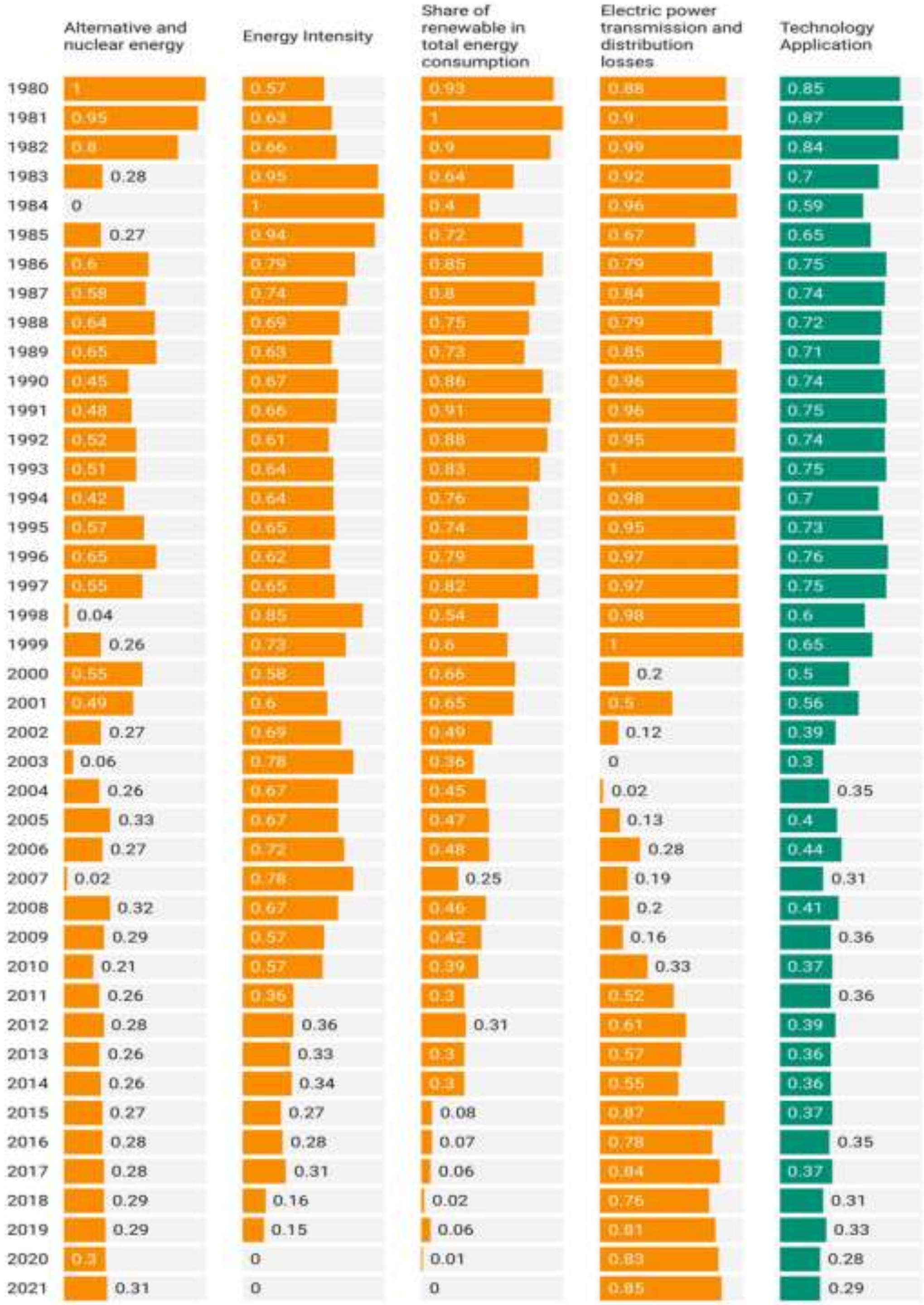

Figure 6.1: Estimation of Technology Application Index
Source: Asafo (2024)

Appendix D: Estimation of Energy Affordability Index

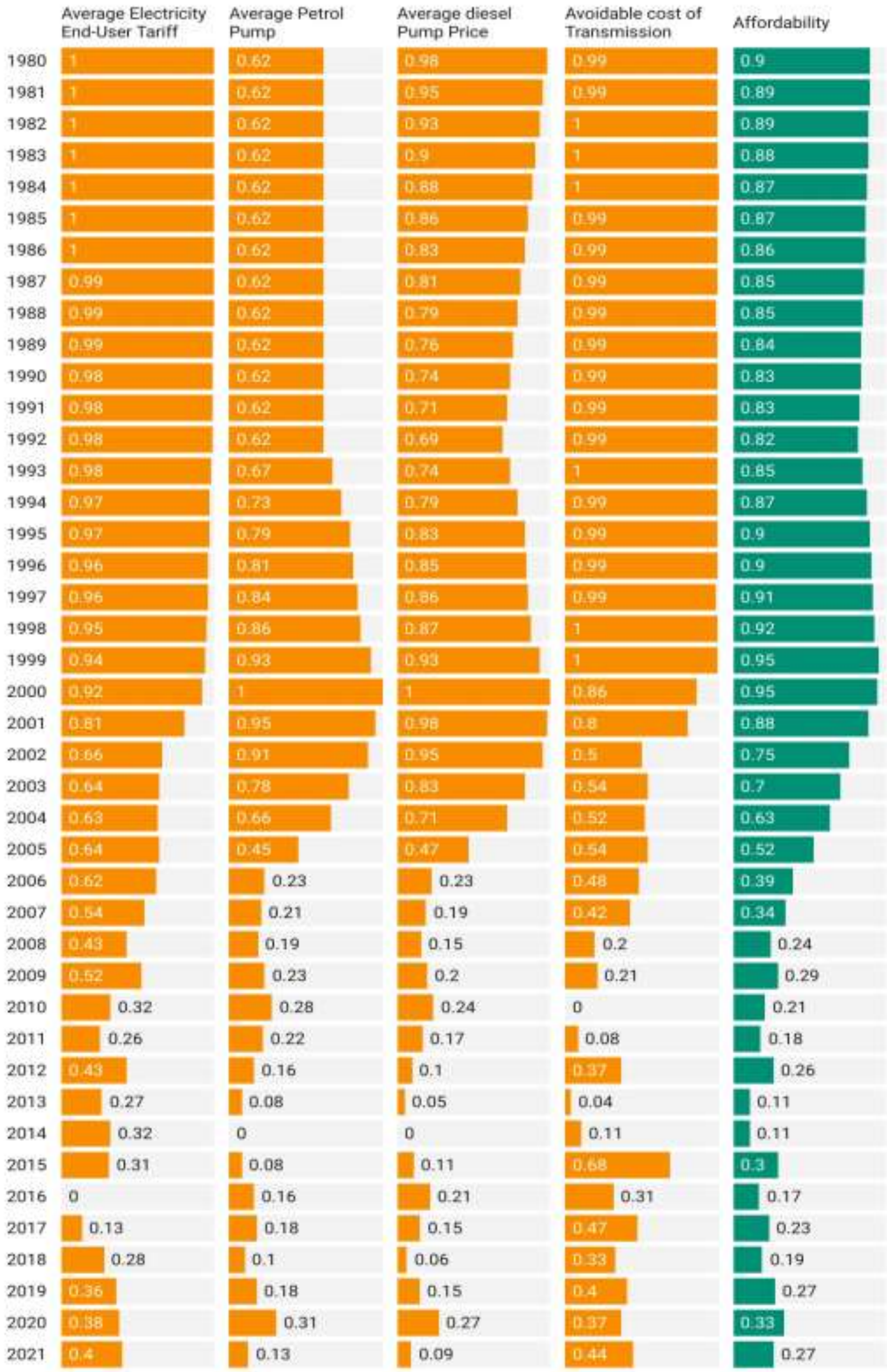

Figure 6.2: Estimation of Energy Affordability Index
Source: Asafo (2024)

Appendix E: Estimation of Energy Availability Index

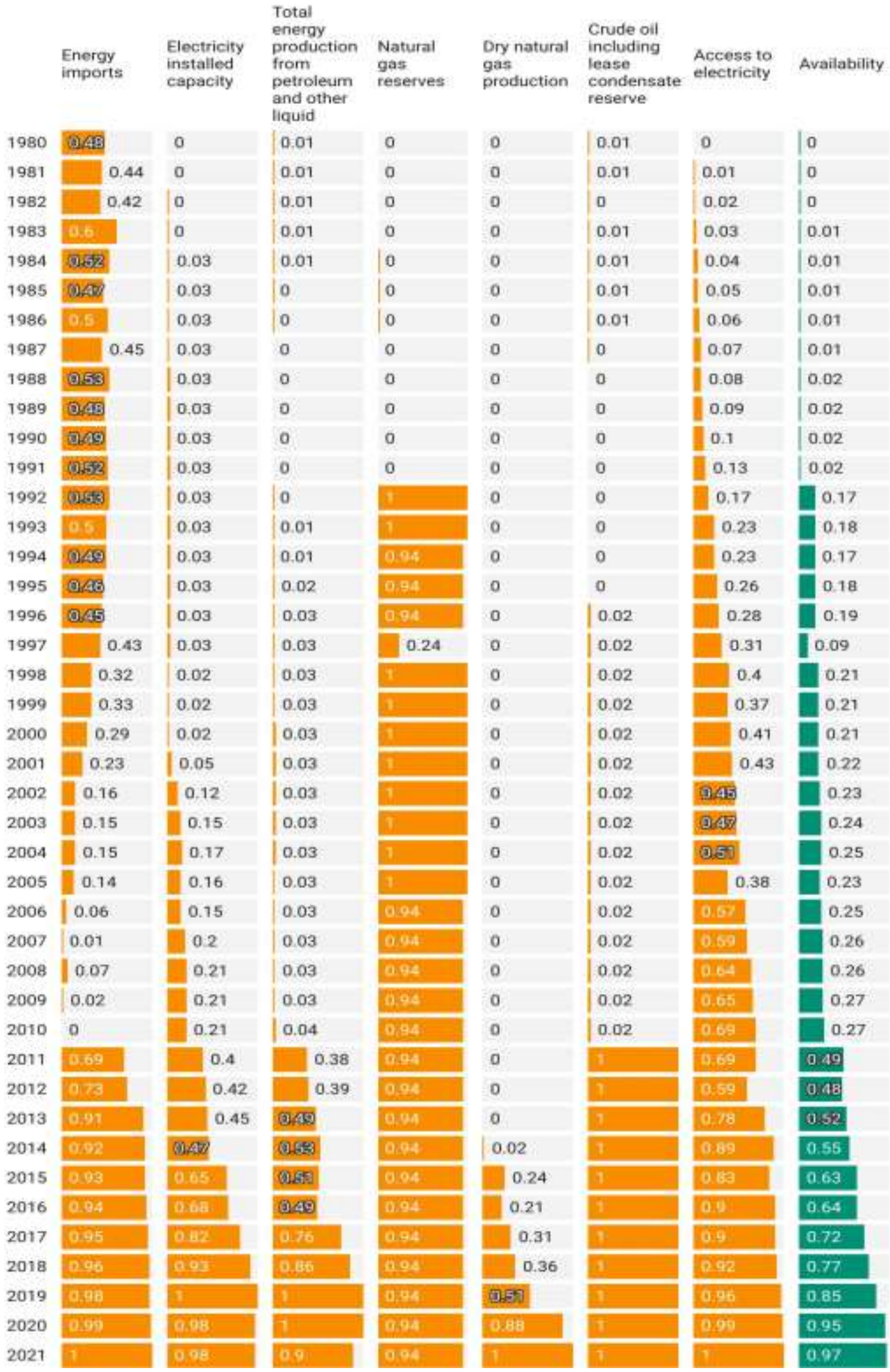

Figure 6.3: Estimation of Energy Availability Index

Source: Asafo (2024)

Appendix F: Cusum and Cusum of Squares for the Regression Analysis

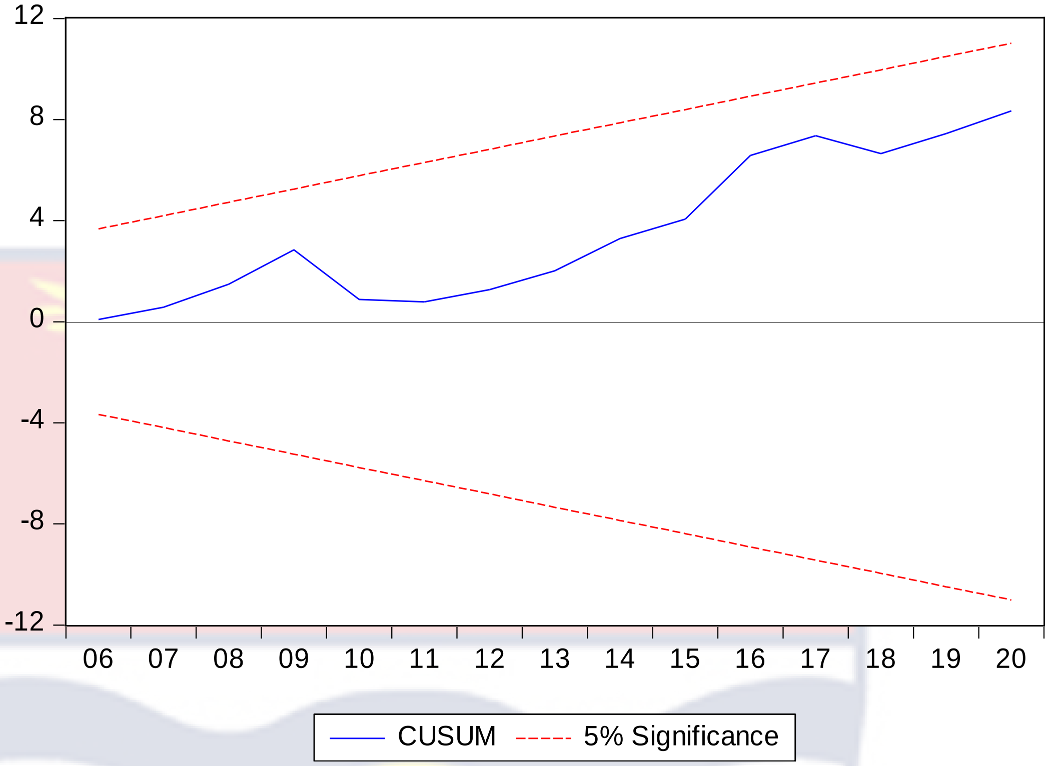

Figure 6.4: Cusum for Effect of Energy Usage on Service Sector
Source: Asafo (2024)

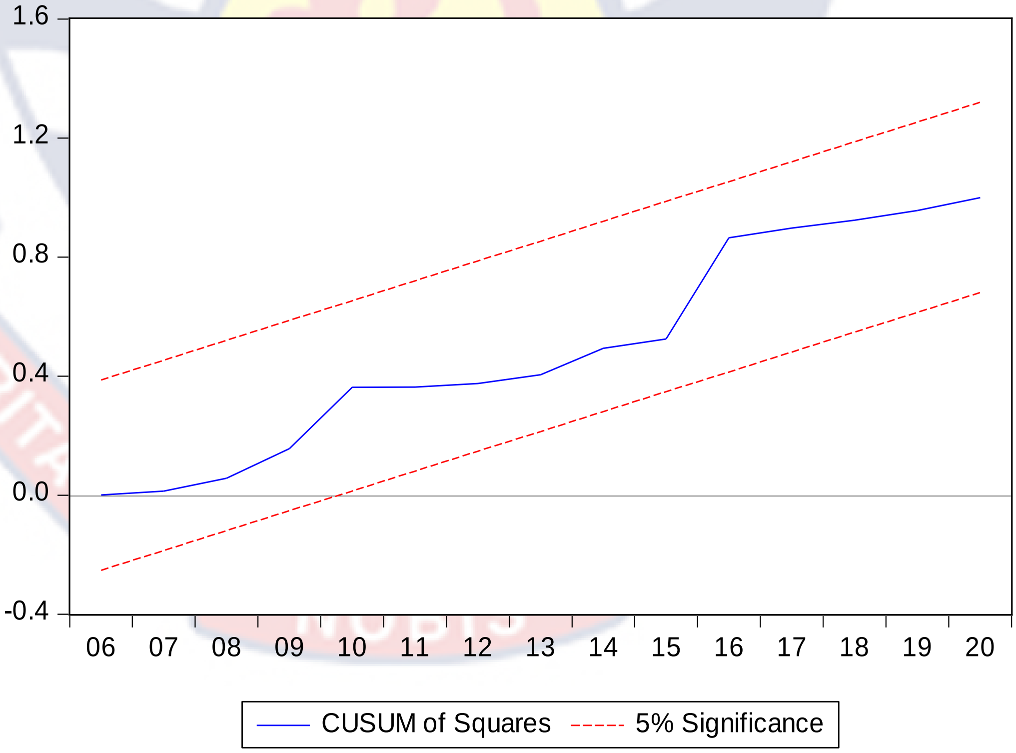

Figure 6. 5: Cusum of Squares for Effect of Energy Usage on Service Sector
Source: Asafo (2024)

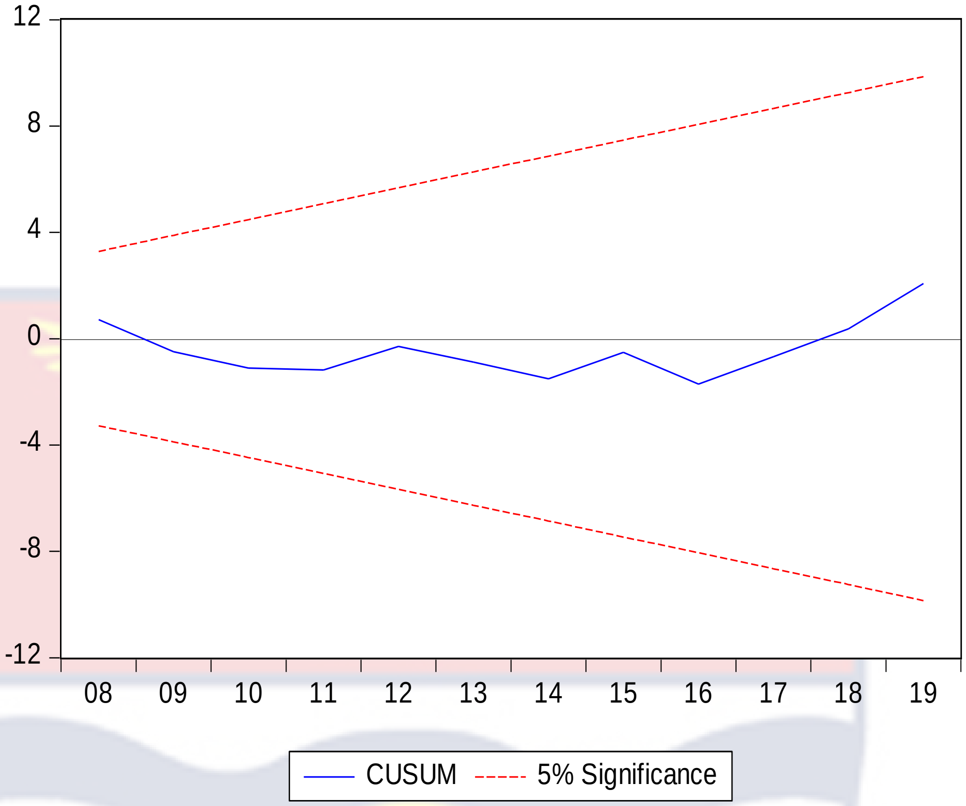

Figure 6.6: Cusum for Effect of Energy Usage on Industrial Sector
Source: Asafo (2024)

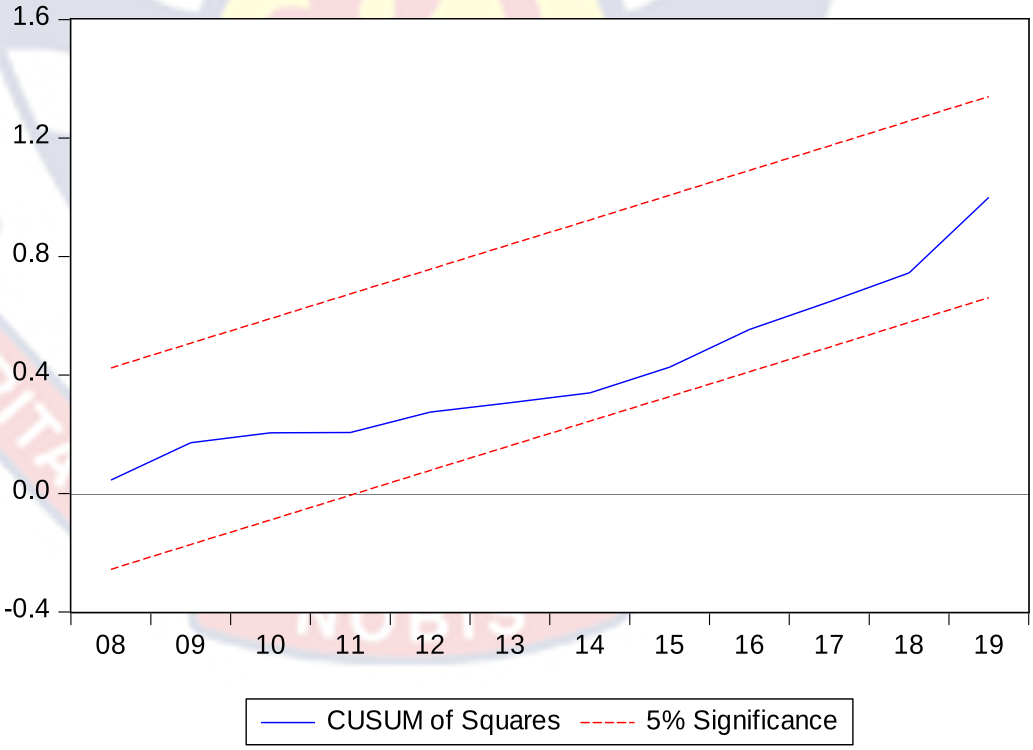

Figure 6.7: Cusum of Squares for Effect of Energy Usage on Industrial Sector
Source: Asafo (2024)

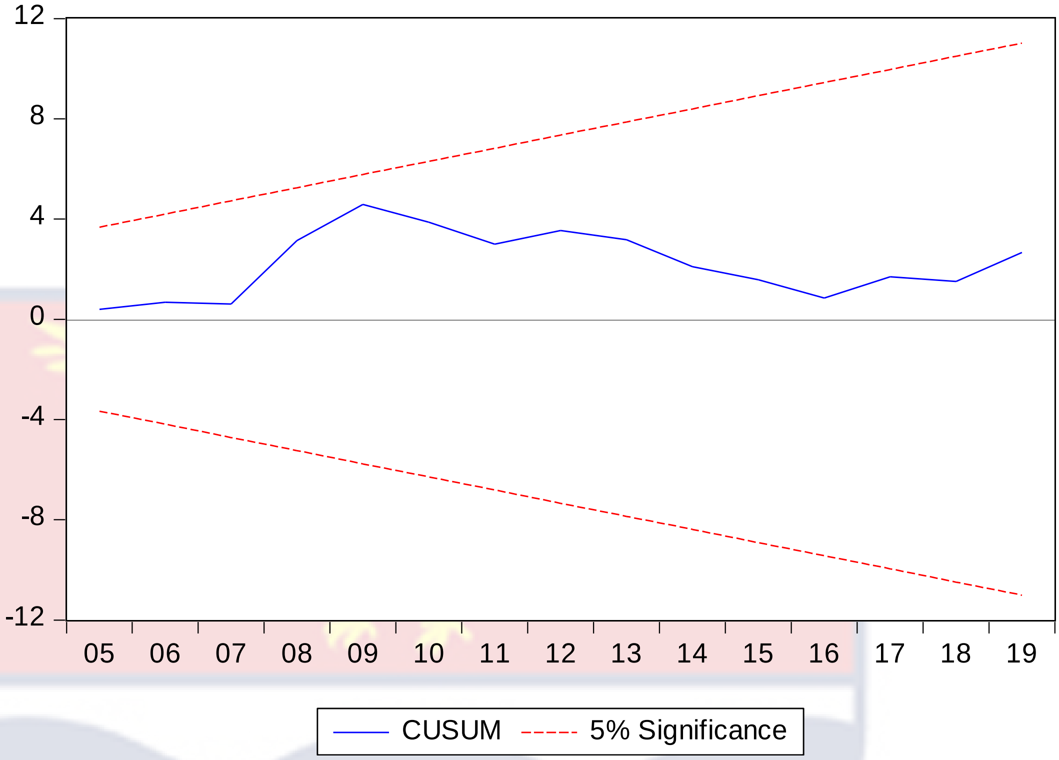

Figure 6.8: Cusum for Effect of Energy Usage on Agric Sector
Source: Asafo (2024)

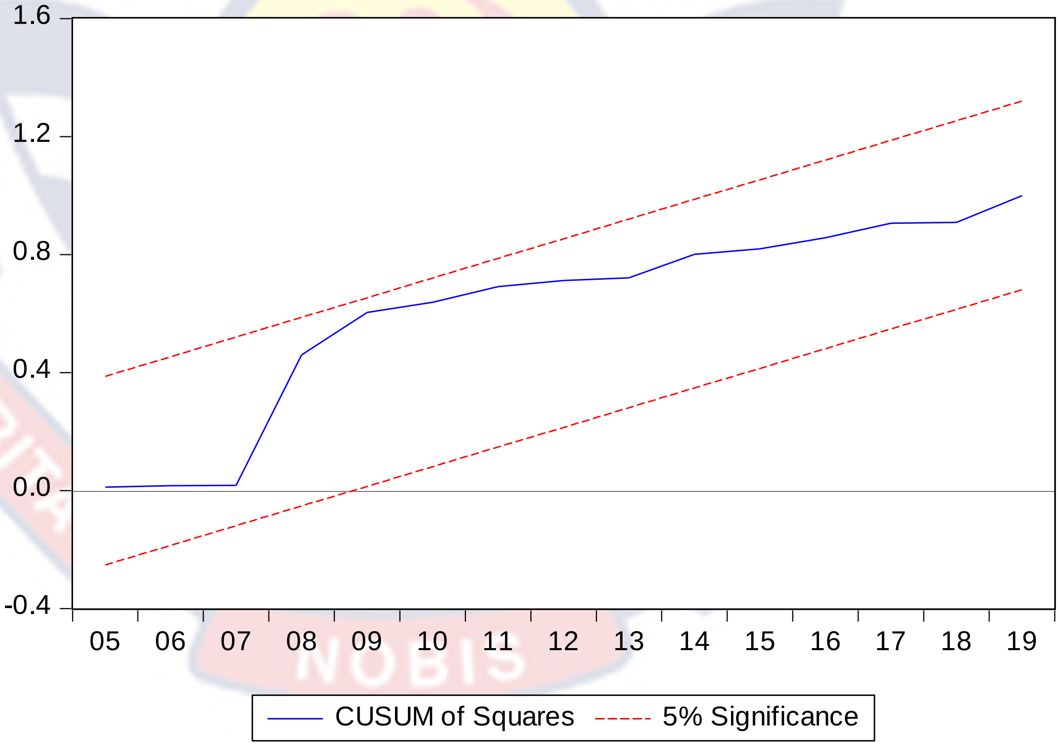

Figure 6.9: Cusum of Squares for Effect of Energy Usage on Agric Sector
Source: Asafo (2024)

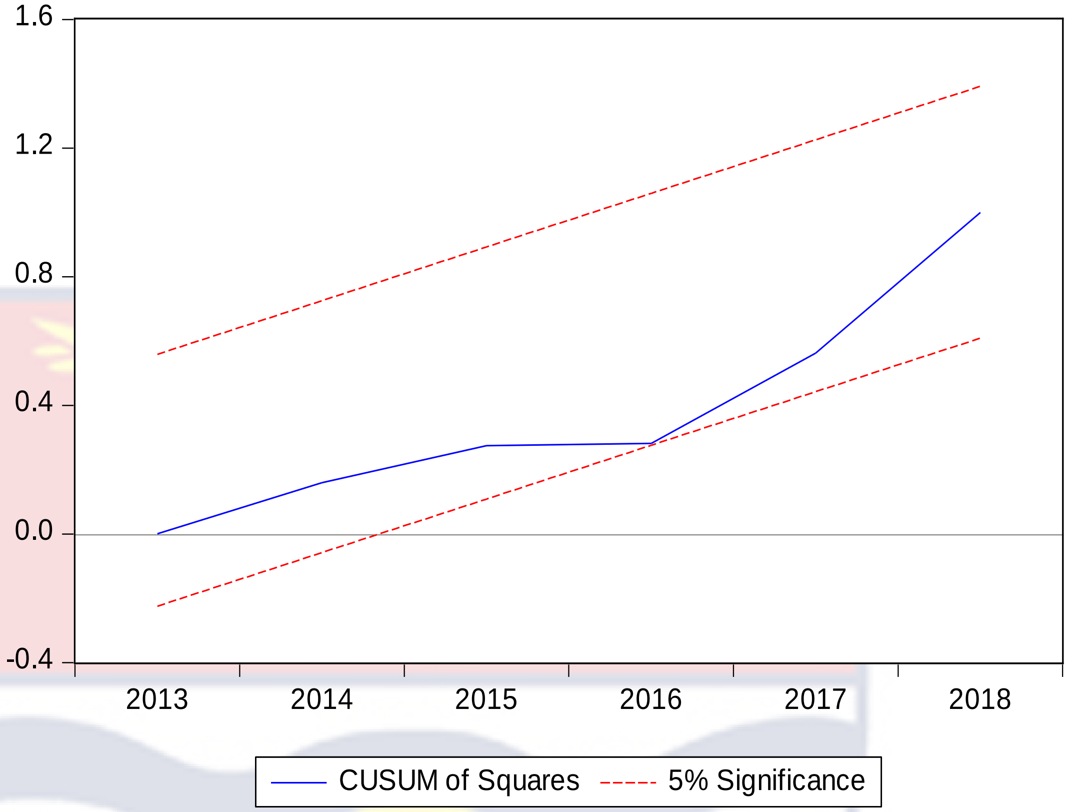

Figure 6.10: Cusum for Effect of Energy Security on Service Sector
Source: Asafo (2024)

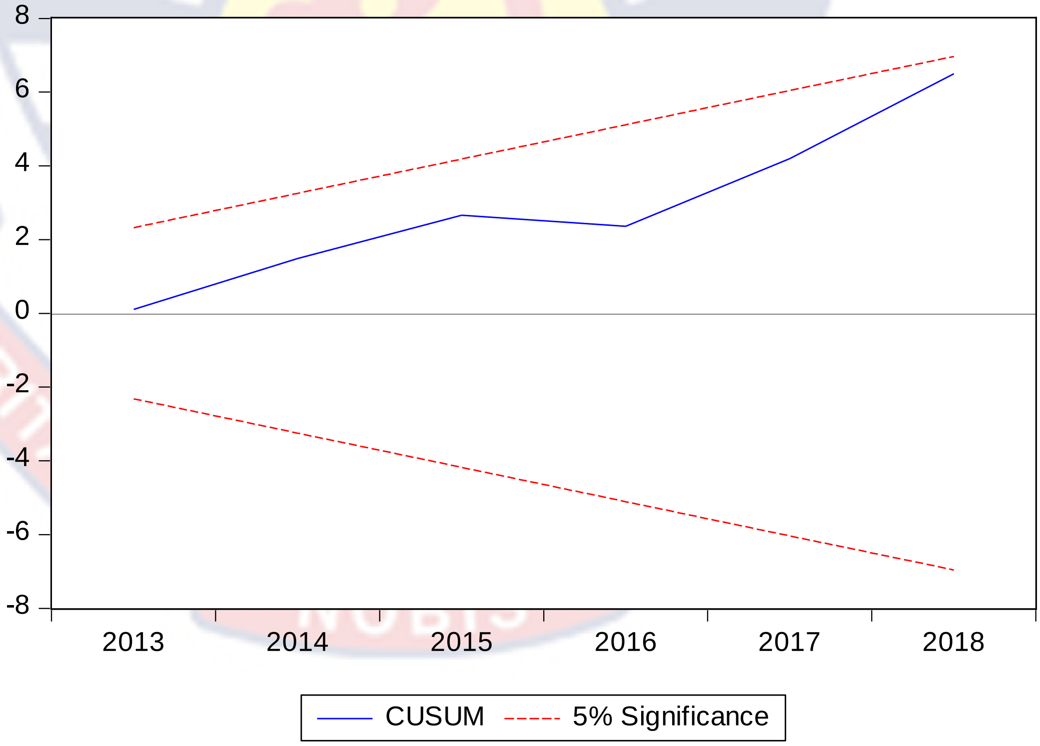

Figure 6.11: Cusum of Squares for Effect of Energy Security on Service Sector
Source: Asafo (2024)

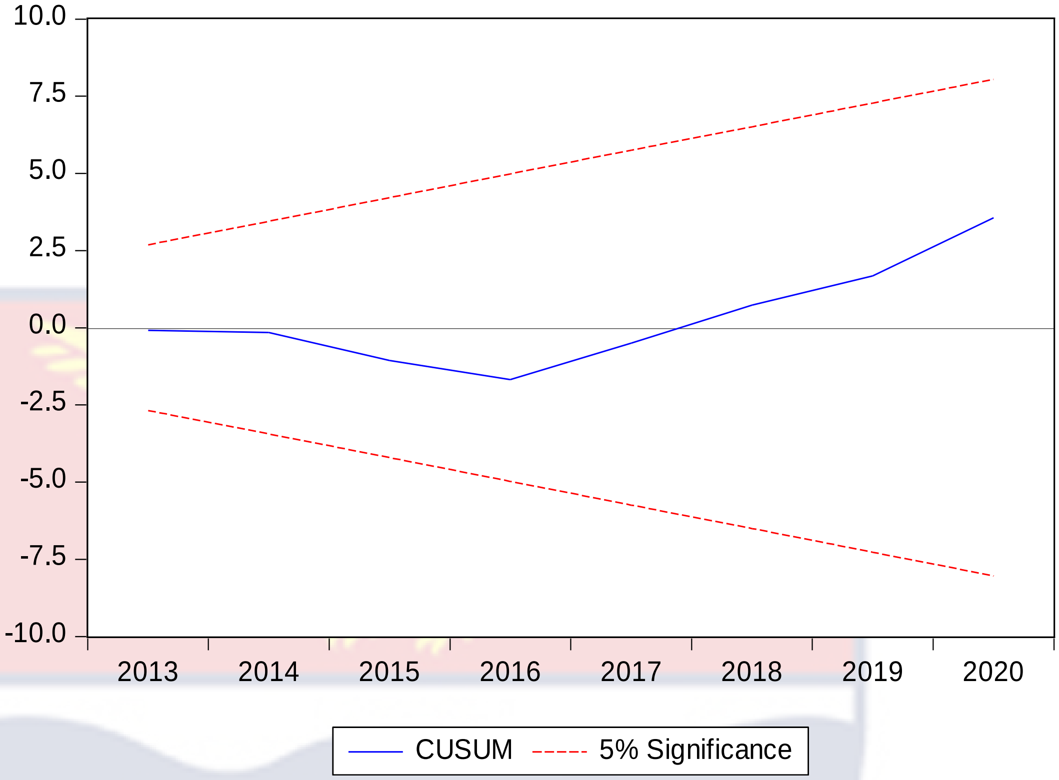

Figure 6.12: Cusum for Effect of Energy Security on Industrial Sector
Source: Asafo (2024)

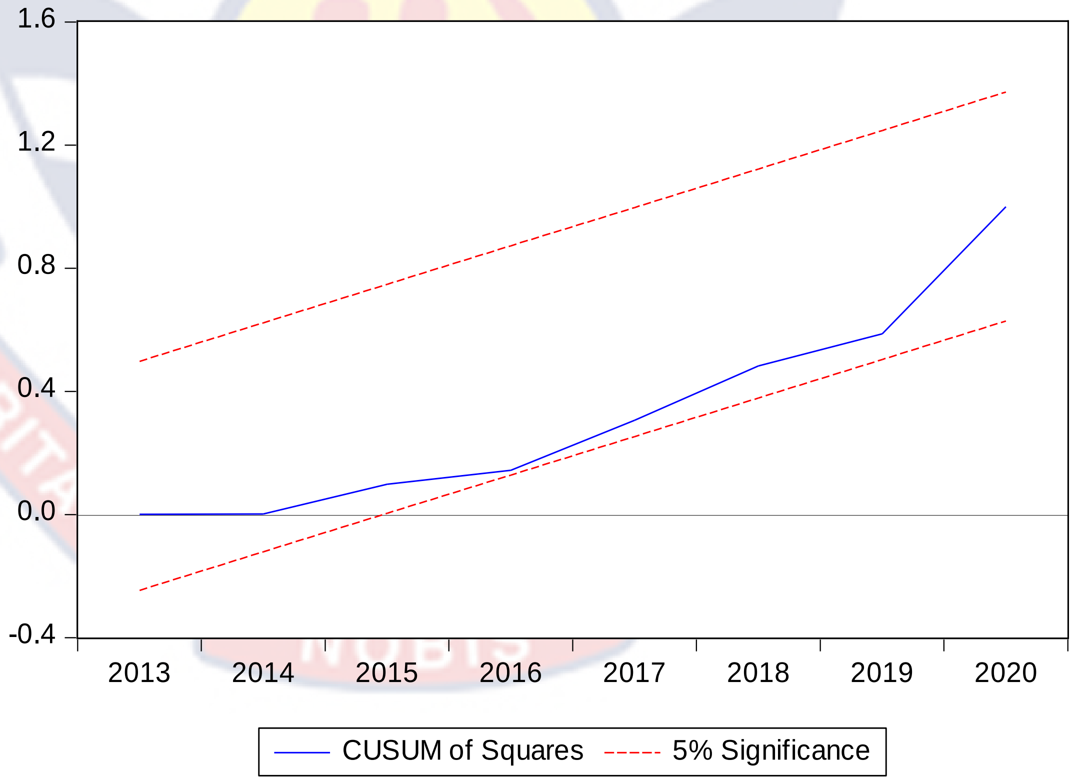

Figure 6.13: Cusum of Squares for Effect of Energy Security on Industrial Sector
Source: Asafo (2024)

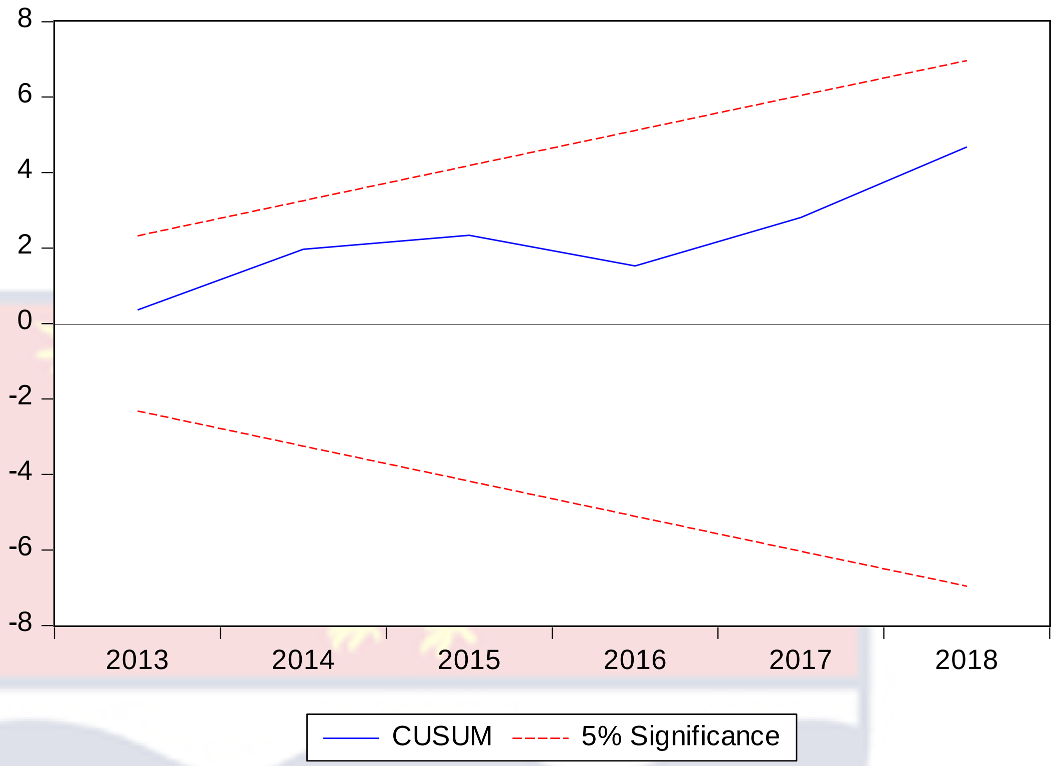

Figure 6.14: Cusum for Effect of Energy Security on Agric Sector
Source: Asafo (2024)

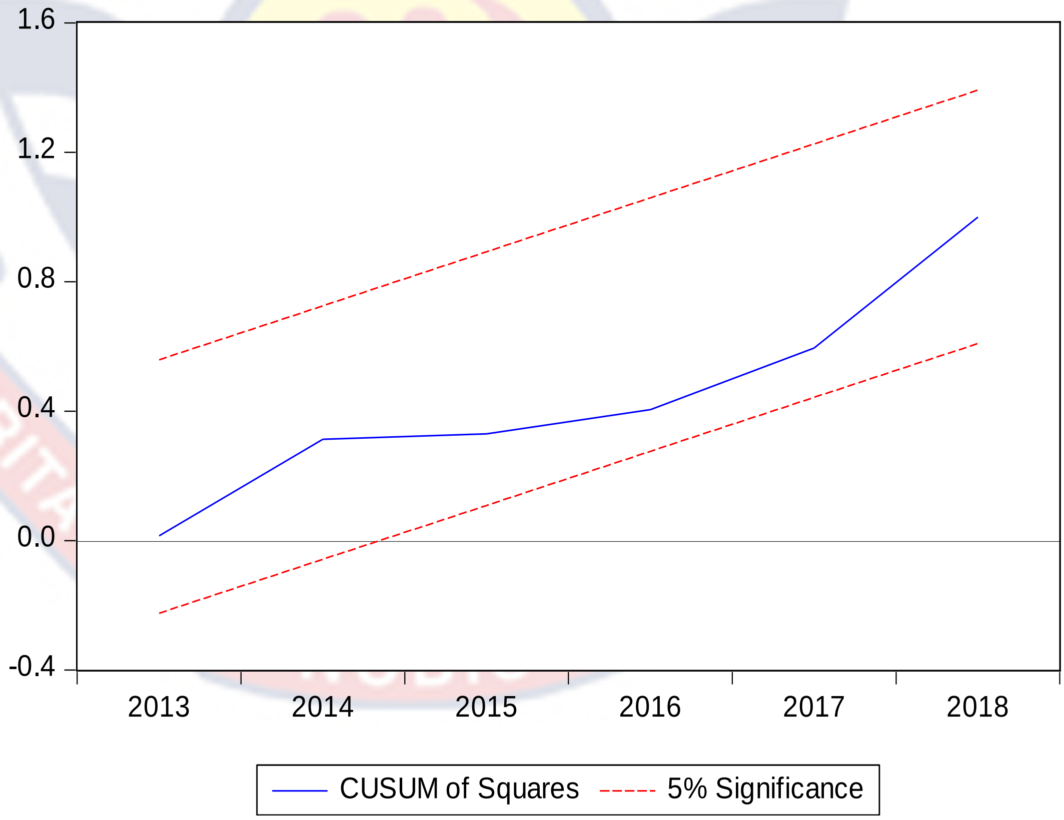

Figure 6.15: Cusum of Squares for Effect of Energy Security on Agric Sector
Source: Asafo (2024)

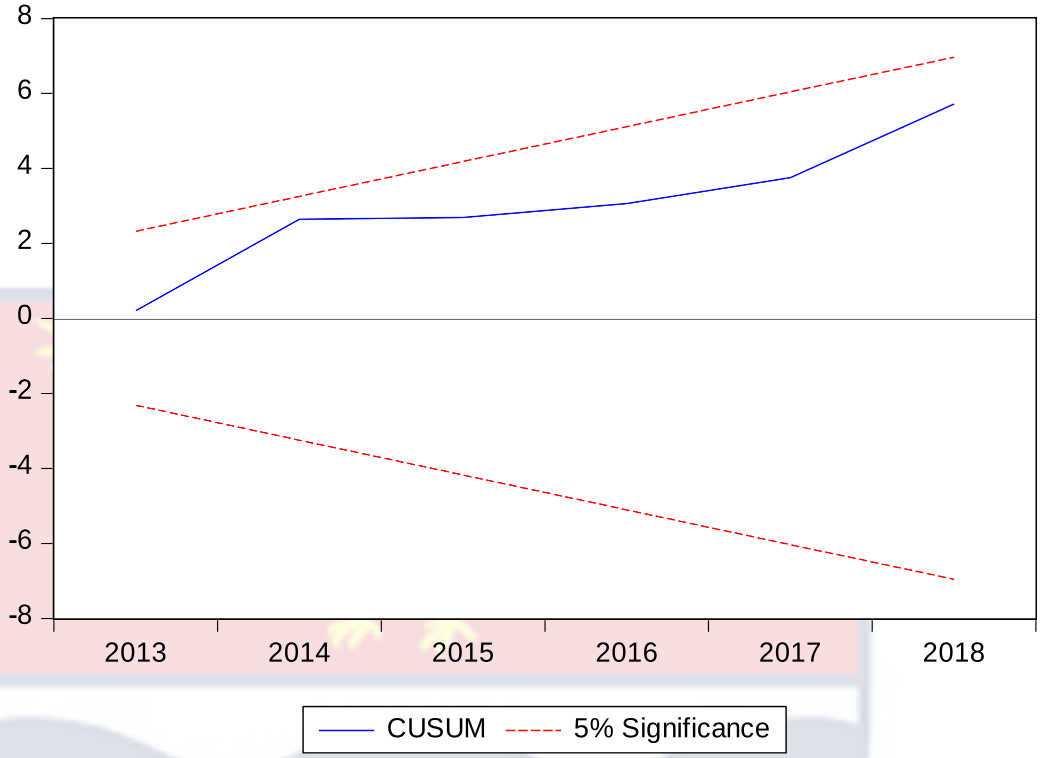

Figure 6. 16: Cusum for Effect of Energy Humanization on Service Sector
Source: Asafo (2024)

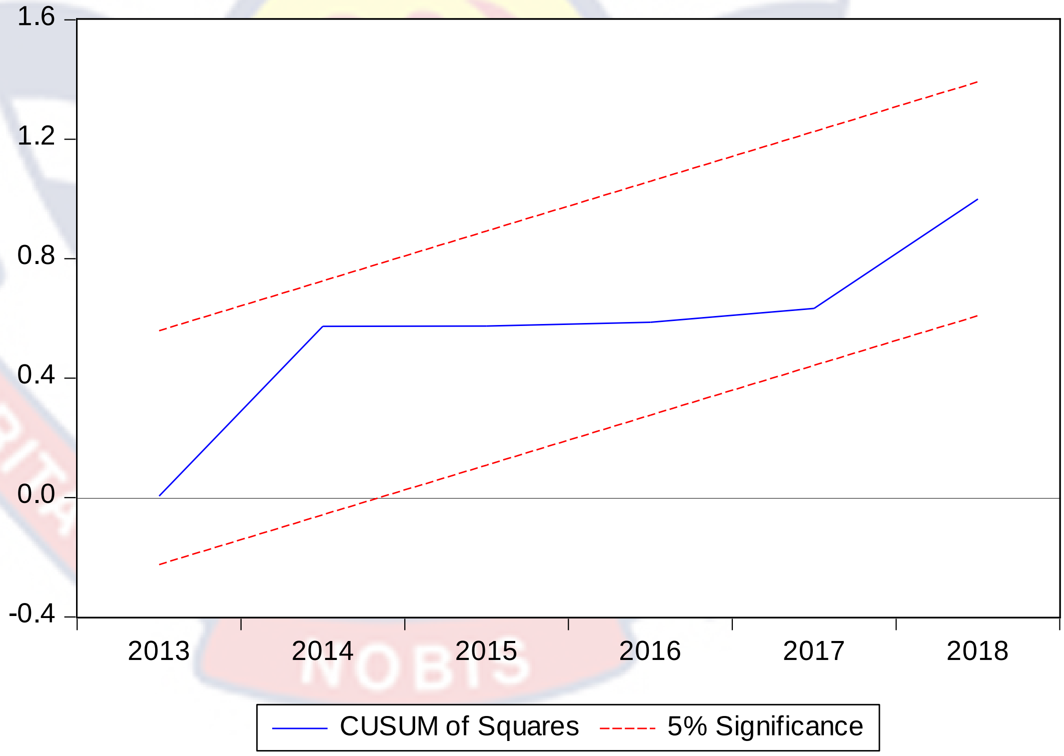

Figure 6. 17: Cusum of Squares for Effect of Energy Humanization on Service Sector
Source: Asafo (2024)

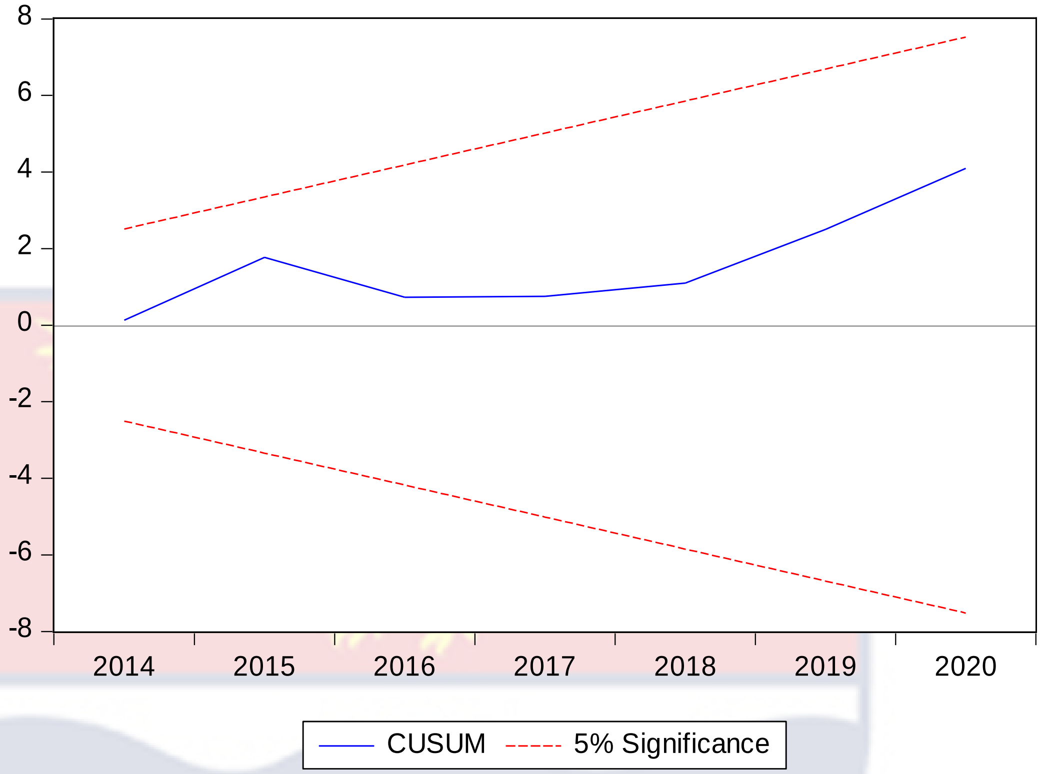

Figure 6. 18: Cusum for Effect of Energy Humanization on Industrial Sector
Source: Asafo (2024)

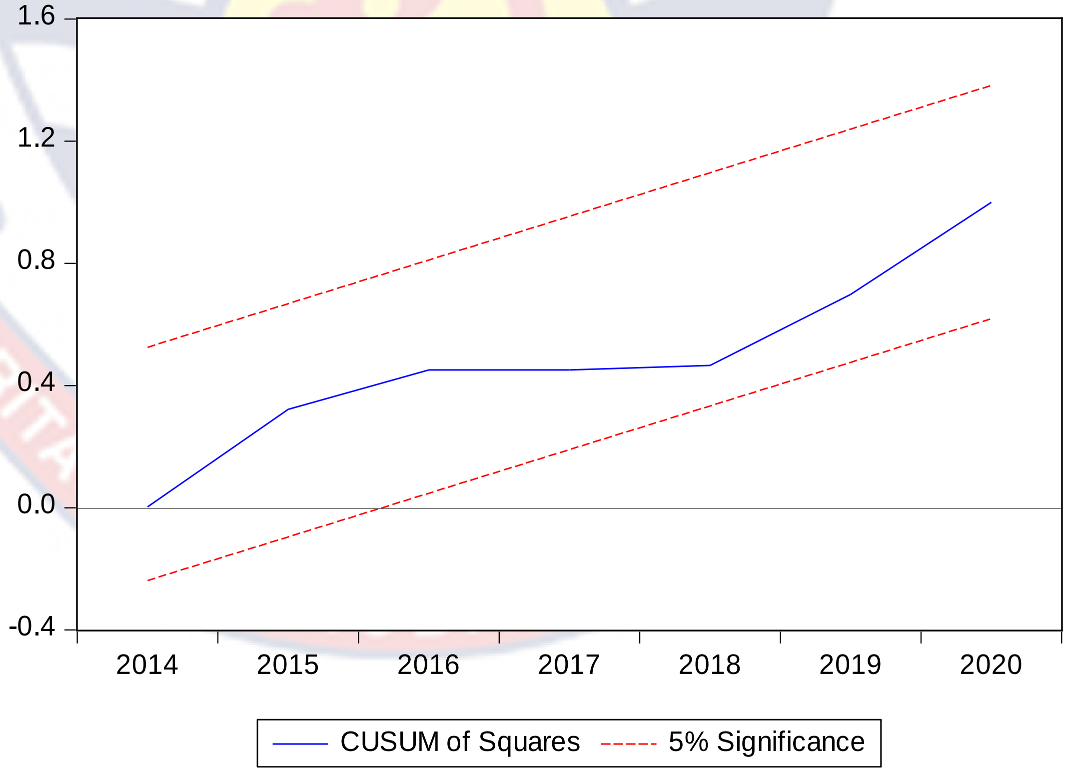

Figure 6.19: Cusum of Squares for Effect of Energy Humanization on Industrial Sector
Source: Asafo (2024)

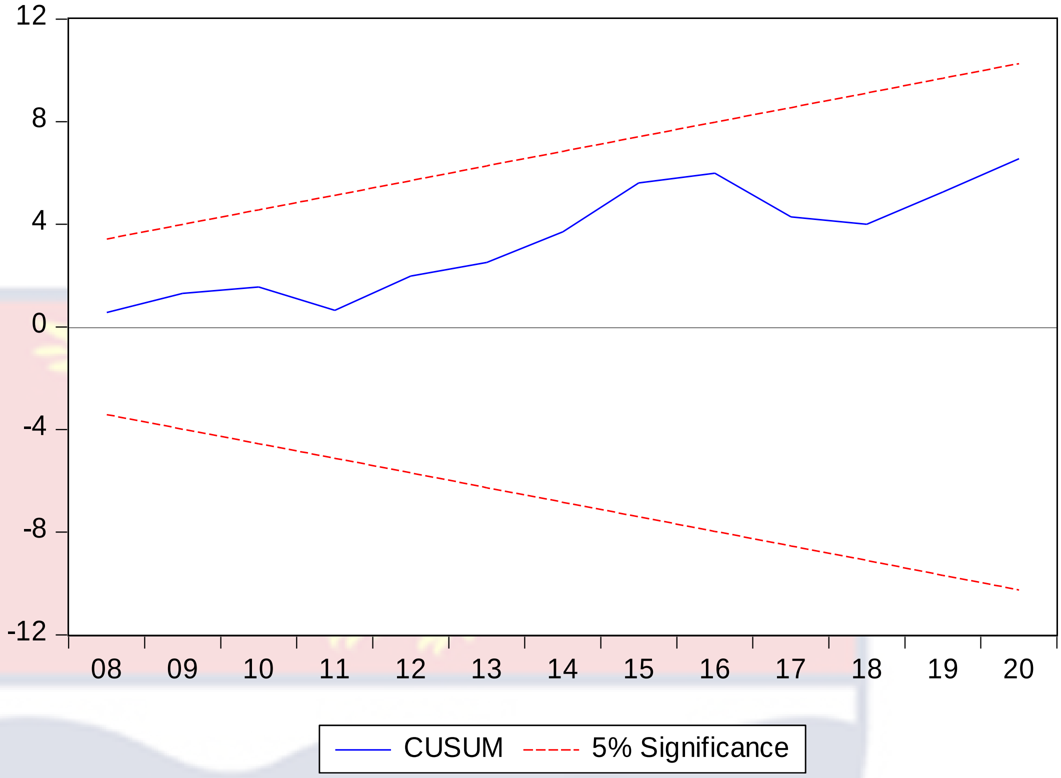

Figure 6. 20: Cusum for Effect of Energy Humanization on Agric Sector
Source: Asafo (2024)

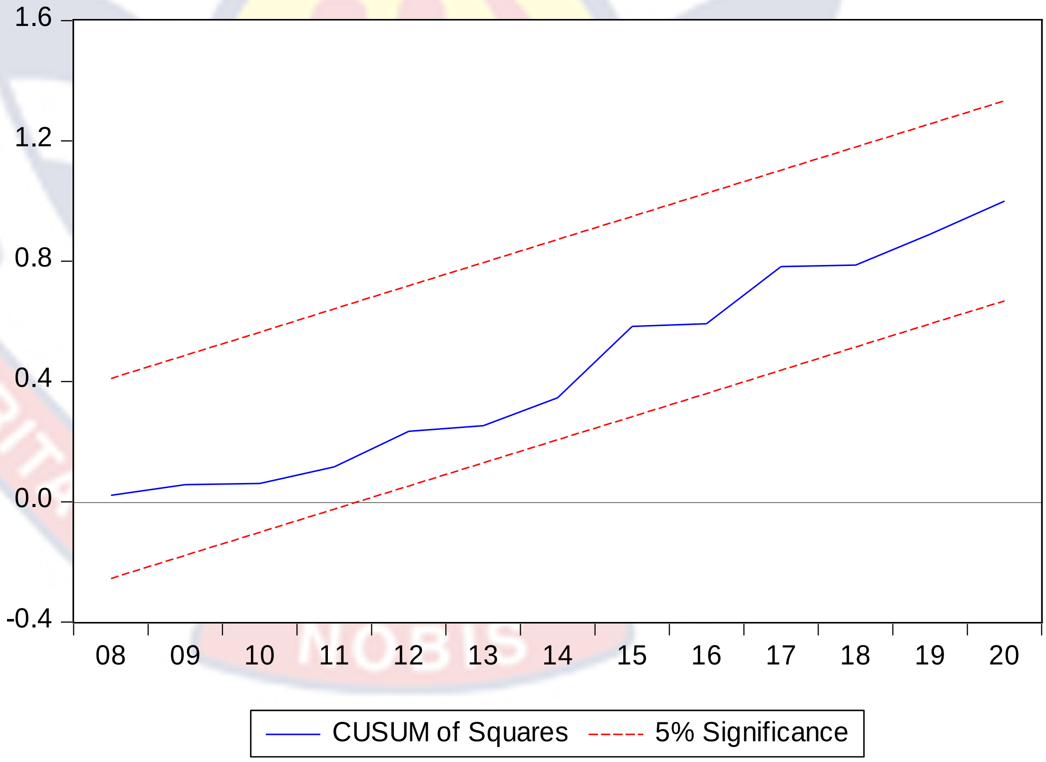

Figure 6. 21: Cusum of Squares for Effect of Energy Humanization on Agric Sector
Source: Asafo (2024)

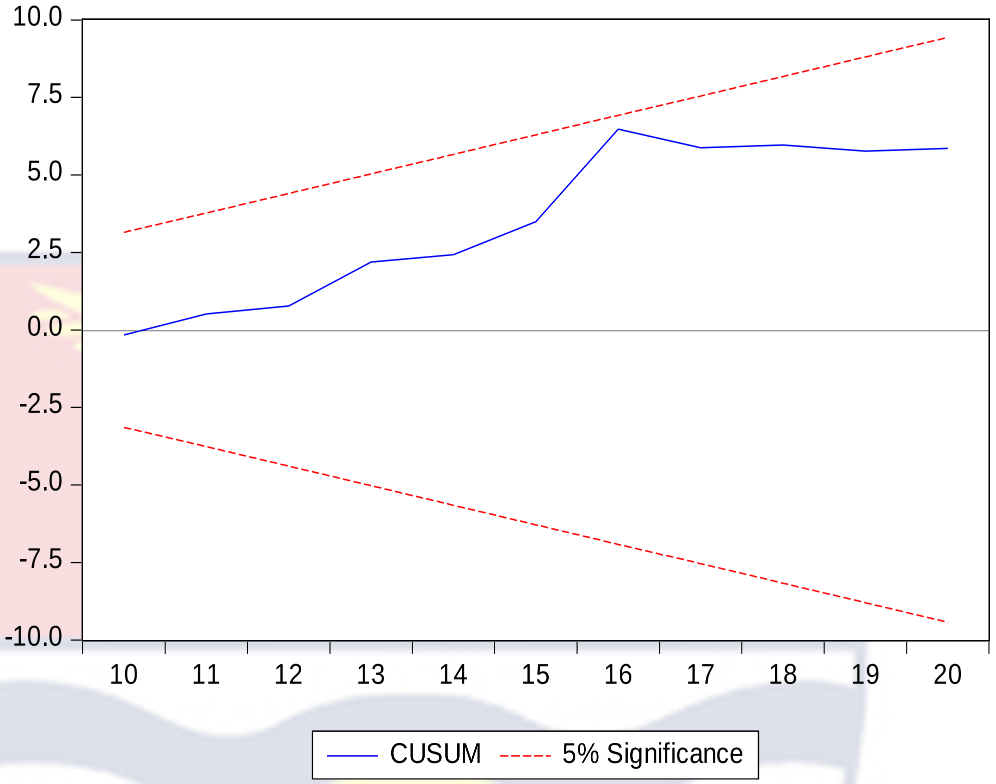

Figure 6. 22: Cusum for Moderating Role of Economic Institutions in the Energy Humanization - Service Sector Growth Relationship
Source: Asafo (2024)

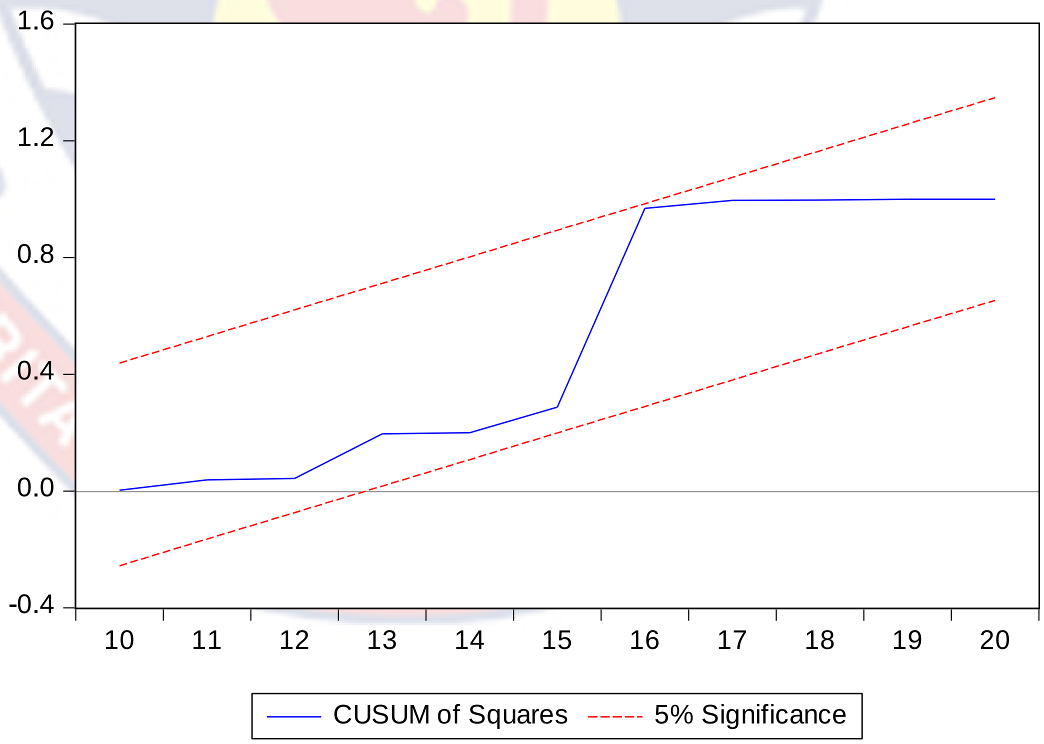

Figure 6. 23: Cusum of Squares for Moderating Role of Economic Institutions in the Energy Humanization - Service Sector Growth Relationship
Source: Asafo (2024)

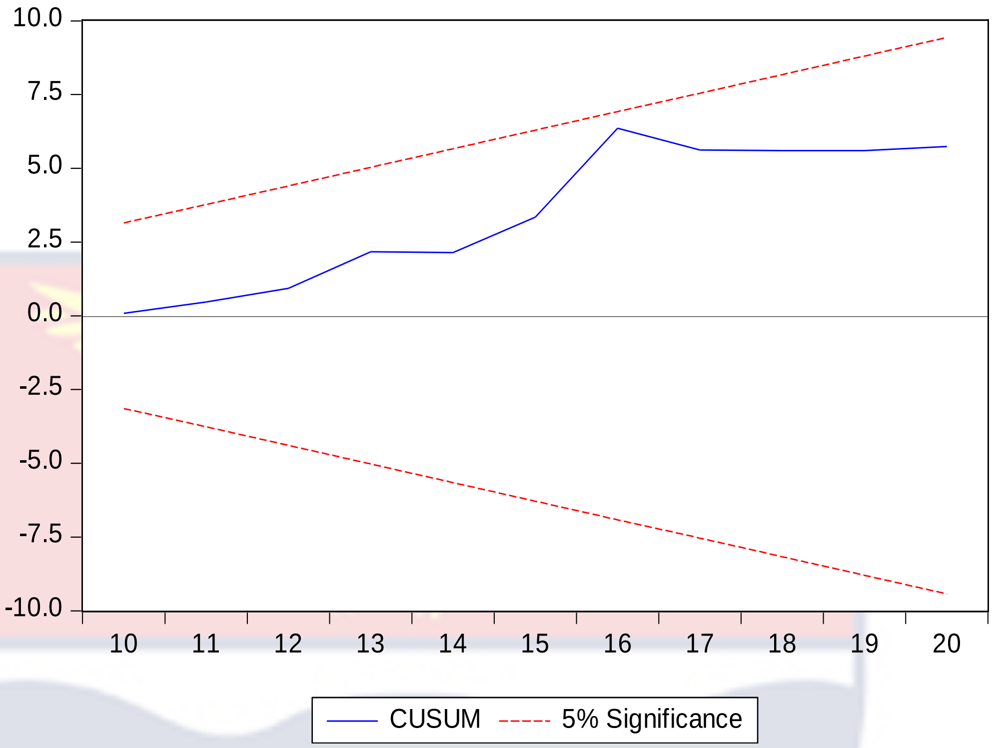

Figure 6. 24: Cusum for Moderating Role of Economic Institutions in the Energy Humanization - Industrial Sector Growth Relationship
Source: Asafo (2024)

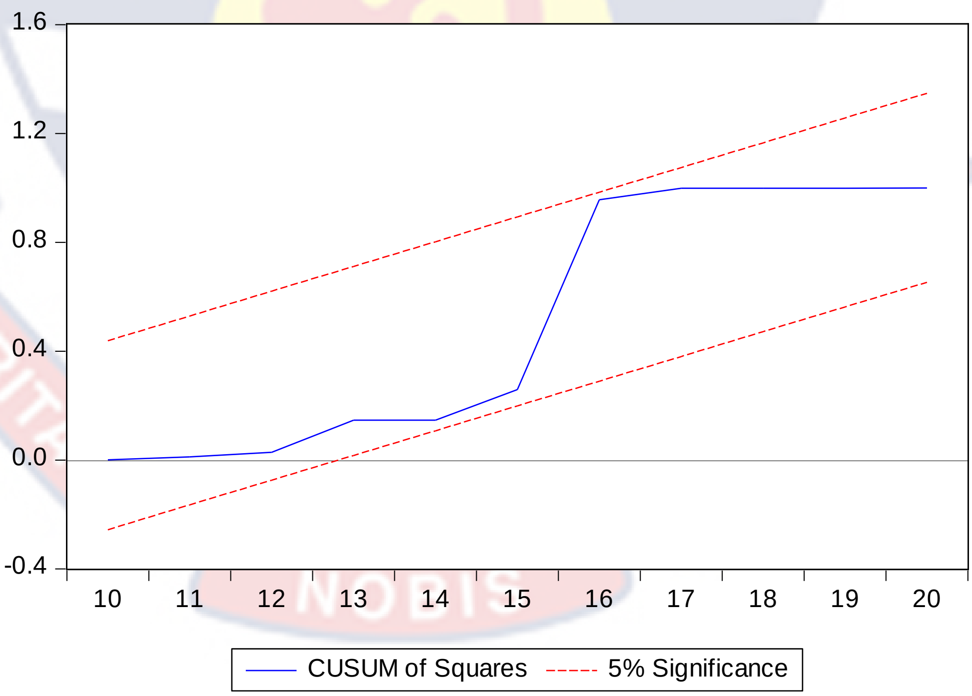

Figure 6. 25: Cusum of Squares for Moderating Role of Economic Institutions in the Energy Humanization - Industrial Sector Growth Relationship
Source: Asafo (2024)

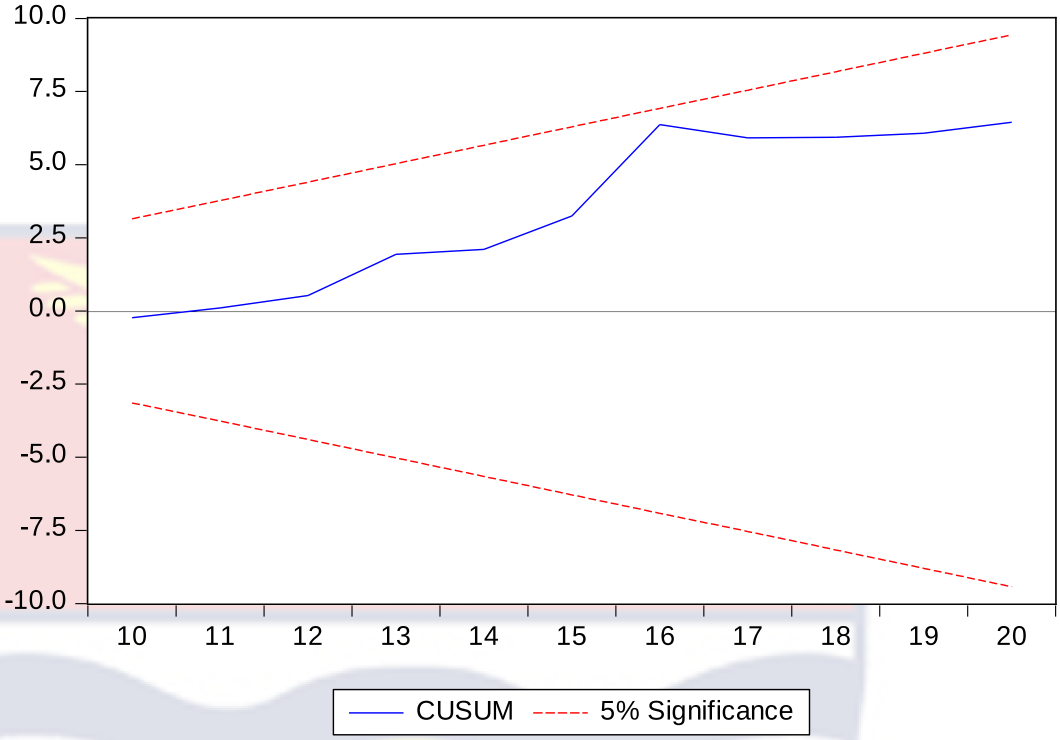

Figure 6.26: Cusum for Moderating Role of Economic Institutions in the Energy Humanization - Agric Sector Growth Relationship
Source: Asafo (2024)

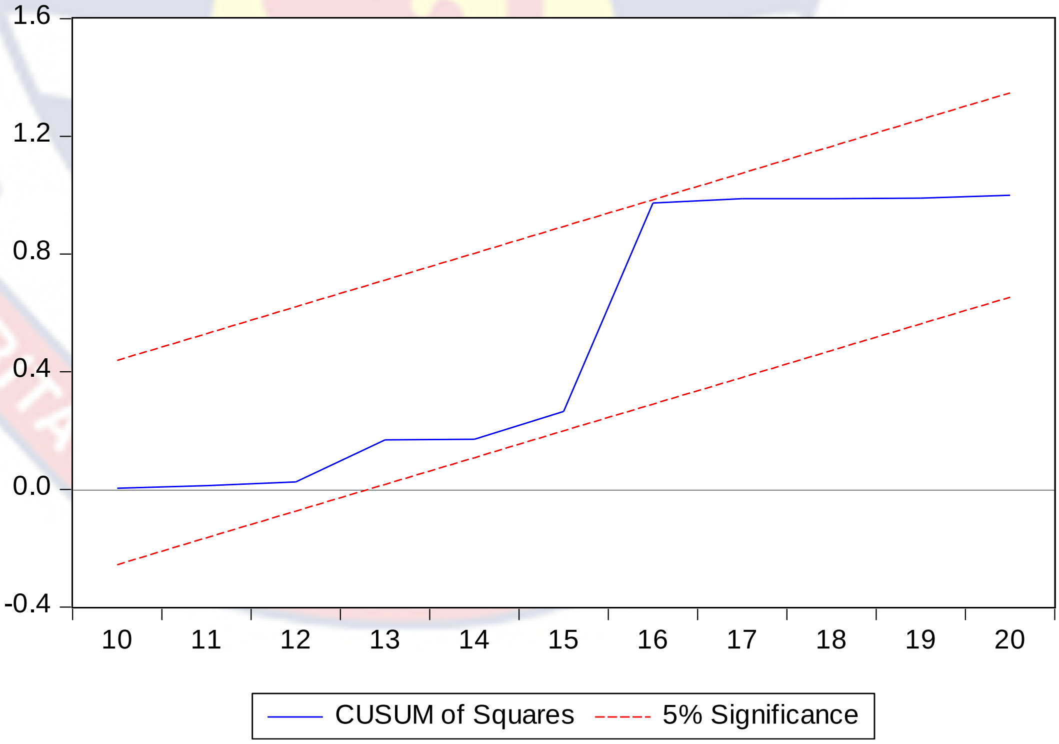

Figure 6. 27: Cusum of Squares for Moderating Role of Economic Institutions in the Energy Humanization - Agric Sector Growth Relationship
Source: Asafo (2024)

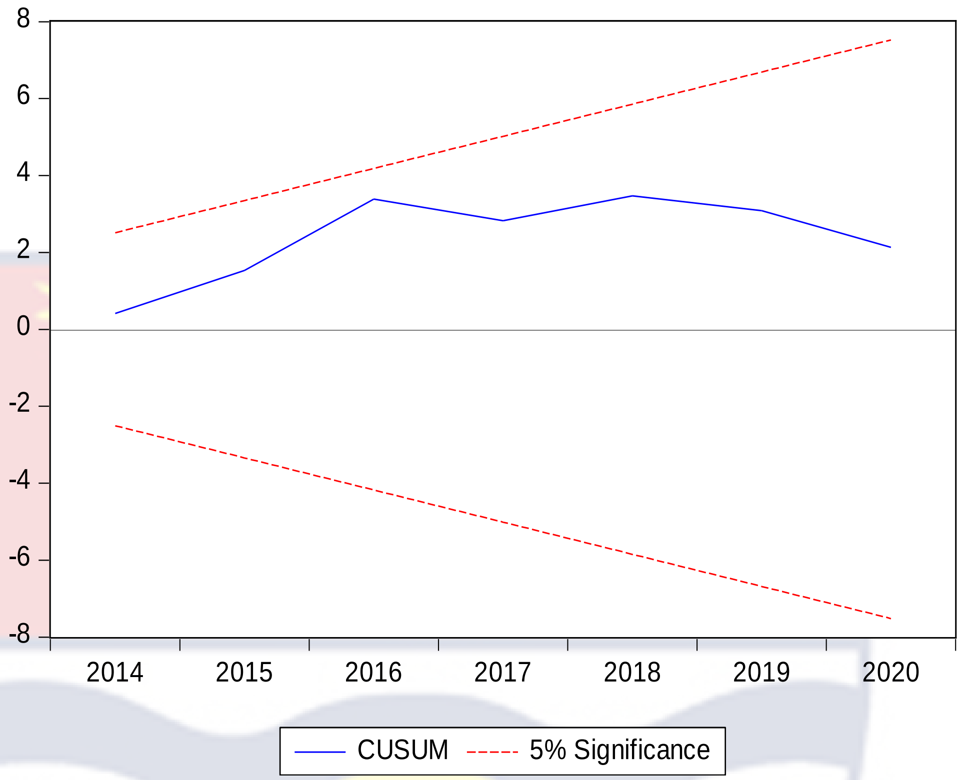

Figure 6.28: Cusum for Moderating Role of Political Economic Institutions in the Energy Humanization - Service Sector Growth Relationship

Source: Asafo (2024)

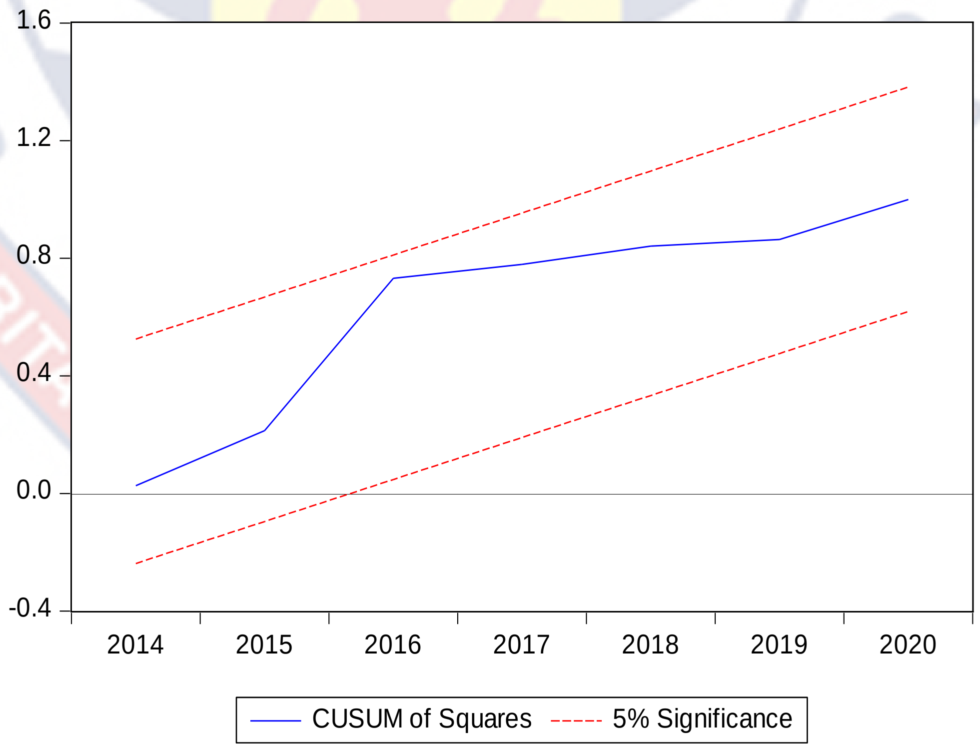

Figure 6. 29: Cusum of Squares for Moderating Role of Political Economic Institutions in the Energy Humanization - Service Sector Growth Relationship

Source: Asafo (2024)

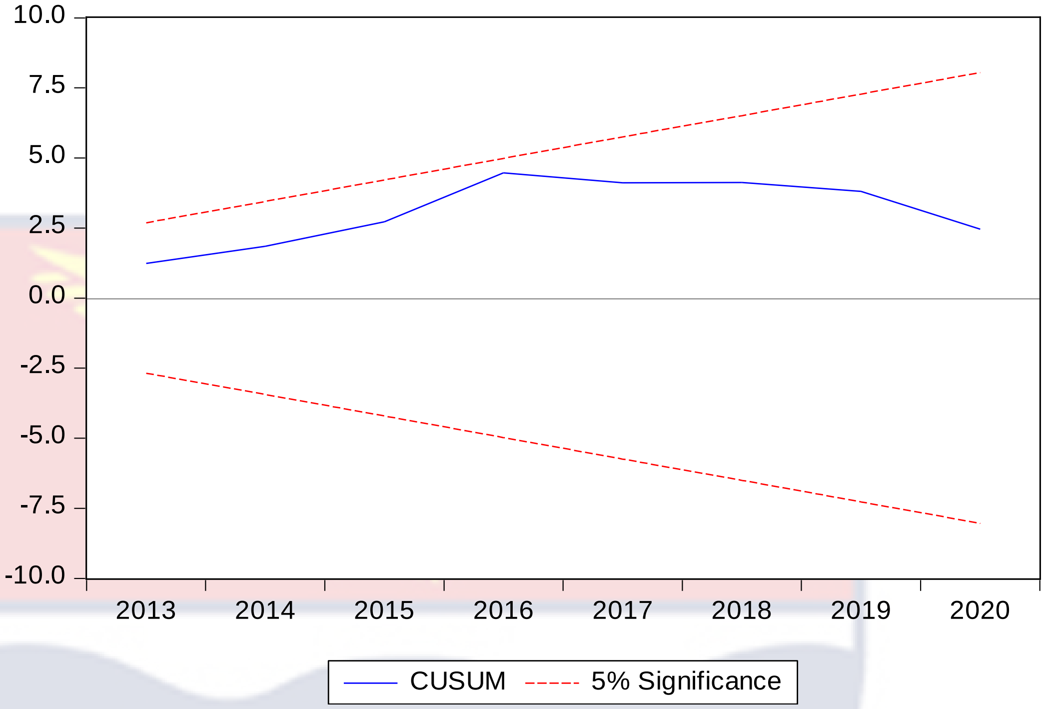

Figure 6.30: Cusum for Moderating Role of Political Economic Institutions in the Energy Humanization - Industrial Sector Growth Relationship

Source: Asafo (2024)

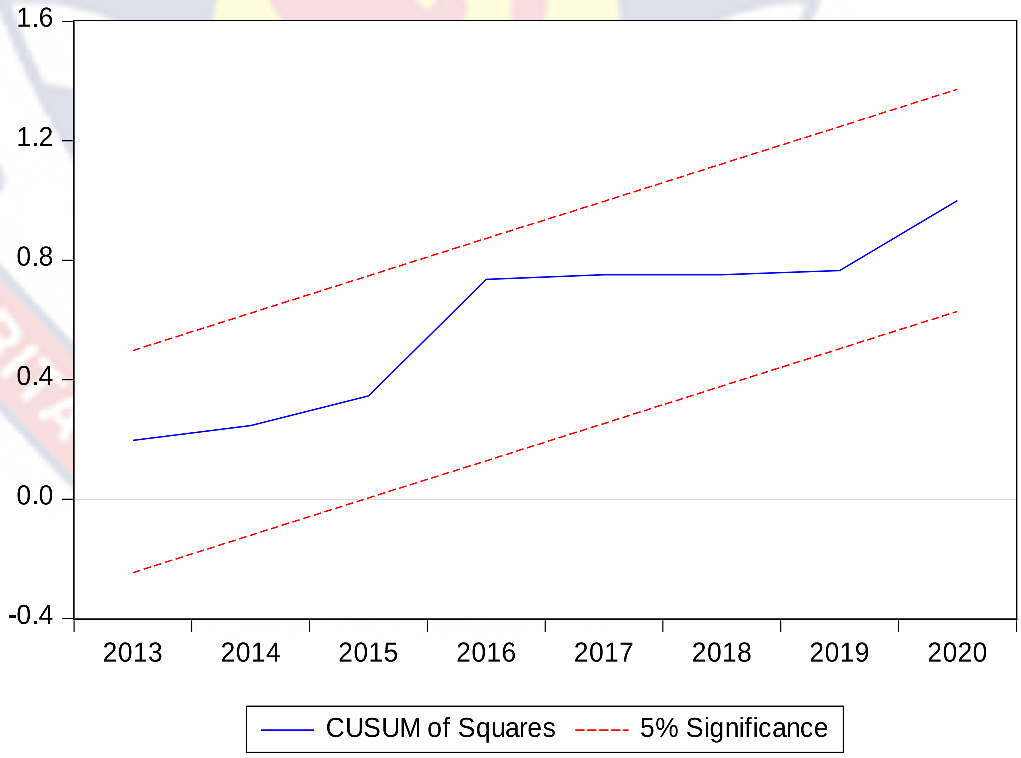

Figure 6.31: Cusum of Squares for Moderating Role of Political Economic Institutions in the Energy Humanization - Industrial Sector Growth Relationship

Source: Asafo (2024)

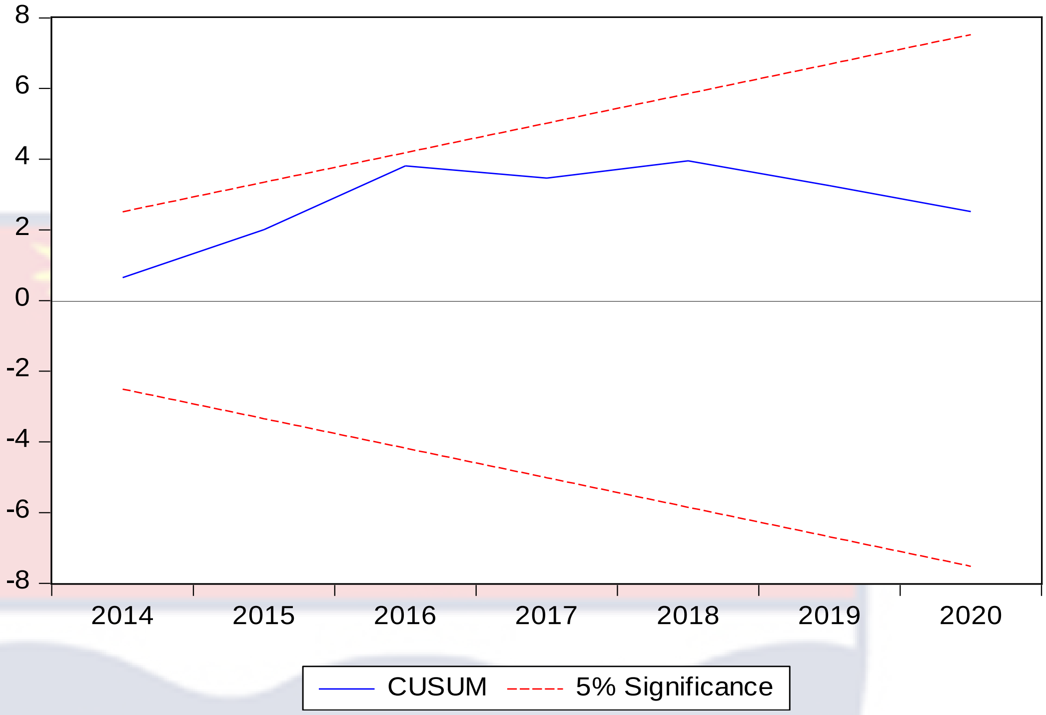

Figure 6.32: Cusum for Moderating Role of Political Economic Institutions in the Energy Humanization - Agric Sector Growth Relationship

Source: Asafo (2024)

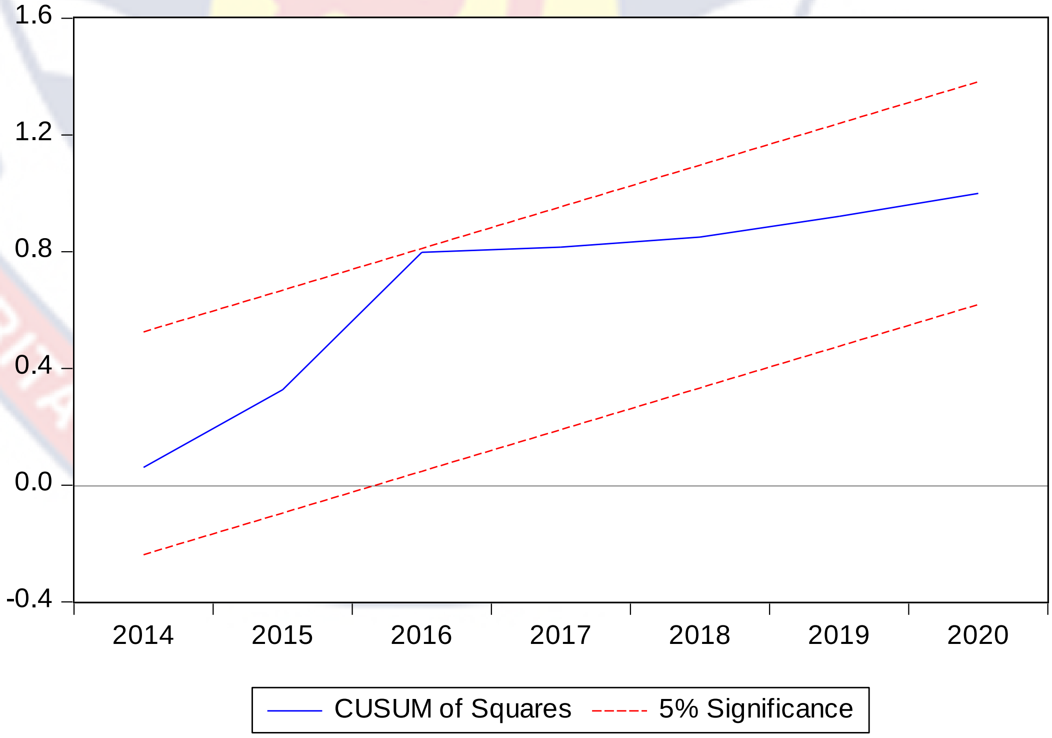

Figure 6.33: Cusum of Squares for Moderating Role of Political Economic Institutions in the Energy Humanization - Agric Sector Growth Relationship

Source: Asafo (2024)