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Presented by

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POLICY ASSESSMENT OF ENERGY EFFICIENCY ON FUTURE ENERGY DEMAND OF THE INDUSTRIAL SECTOR OF TANZANIA

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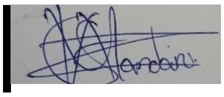
DECLARATION

I, Saada Awadhi Mandari hereby declare that this research thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

Signature: 

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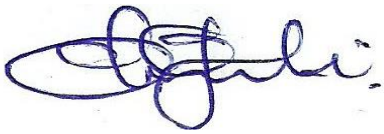
Signature: 

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DEDICATION

I am dedicating this research paper to my dearly loved father Mr. Awadhi Solomon Mandari who passed away 11 years ago which was 25th February 2010. It is because of his limitless love, support and constant push for me to become the best version of myself that brought me this far. I am also dedicating this research paper to my beloved son John Franklin Shaban. He is my ray of hope, source of inspiration and pillar of strength. He is the reason I have to attain my set goals.

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This work was made possible by the contributions and support of many individuals and institutions that I wish to express my heartfelt gratitude to all of them.

First and foremost, I am very thankful to GOD ALMIGHTY, for his blessings, and grace that has made this study possible.

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CONTENTS

ABSTRACT

Industrialization has been the main policy agenda for the 5th phase of the government of Tanzania. This is pivotal to realizing Tanzania's ambition to become a middle-income economy by 2025. Tanzania aims to become a semi-industrialized country by 2025, for which the contribution of manufacturing to the national economy must reach a minimum of 40% of the GDP. To achieve this, Tanzania aims to transform from being dominated by natural resource exploitation and extractive industries (agriculture, tourism, and mining), to becoming an economy with a broad and diverse base of manufacturing, processing and packaging industries, that will lead both the productive as well as the export trade sector. Energy is the vital fuel for economic and social development, and energy efficiency policies enhance development by raising the number of services got from every unit of energy utilized. The country's energy potential resources include hydro, natural gas, coal, and other renewable energies (solar, wind, biomass, geothermal). The country produces natural gas and coal mostly for electricity generations for domestic consumption and industrial applications. In a country like Tanzania where electricity tariff is very expensive (0.099 USD per KWH), the best solution in this case is for the industries to invest in the adoption of energy efficiency measure in order to reduce the cost of energy use. This study is both qualitative and quantitative to evaluate the impact of energy efficiency policies on future energy demand in the industrial sector of Tanzania. The study specifically focused on the industries' energy management systems, driving forces for improving energy efficiency, and barriers to energy efficiency. In order to gain an understanding on these issues, structured samples of questionnaire were administered to the industries while also conducting interviews in some industries where the concerned people dealing with energy issues were available. About 21 samples of questionnaire were administered and the surveyed industries were from 17 different categories as seen in the appendices. The results revealed that that energy audit is not being practiced in industries in Tanzania. Almost half of the respondents (40% of the respondents) said that they do not perform energy audits in the industries. Energy management practices were seen to be a myth in all the industries, while there are no policies in existence to promote the adoption of energy management practices. From the LEAP models, it was found that we can save up to 50% of the energy when using energy efficiency practices. A number of recommendations were also drawn from the study including the establishment of relevant energy institutions.

1. INTRODUCTION

1.1 Background Information

Energy is essential in achieving economic prosperity and improvement of social welfare. Therefore, for sustainable development we require adequate and reliable supply of energy with the ever-growing population. As countries develop and the economy grows there is always an associated increase in energy use (Reister, 1987). Tanzania being among the developing countries, its energy demand and the subsequent consumption is expected to increase as its economy and population grows (Tiris, 2005).

The sensible use of energy resources and technology to reduce the negative impacts of energy use and conserve energy involve the concept of energy efficiency. Energy efficiency is defined as a ratio between an output of performance, service, goods or energy, and an input of energy (EU, 2006). Hence, energy efficiency improvement basically refers to the reduction of energy input for a given activity.

Industries are among the four major sectors that consume primary energy which pose the need for the estimation of future energy demand for industrial sector. Other sectors consuming primary energy are transportation, residential and commercial. Tanzania's industrial sector has evolved through various stages since independence in 1961; from nascent and undiversified to state-led import substitution industrialization, and subsequently to de-industrialization under structural adjustment programmes and policy reforms. The current development agenda, however, has brought industrial development back to be one of the policy priorities (Msami and Wange, 2016).

The industrial sector of Tanzania is comprised of construction (50%), manufacturing (31%), mining (15%), electricity supply (3%), water supply, sewerage, and waste management (2%) as seen in the Figure 1.1.

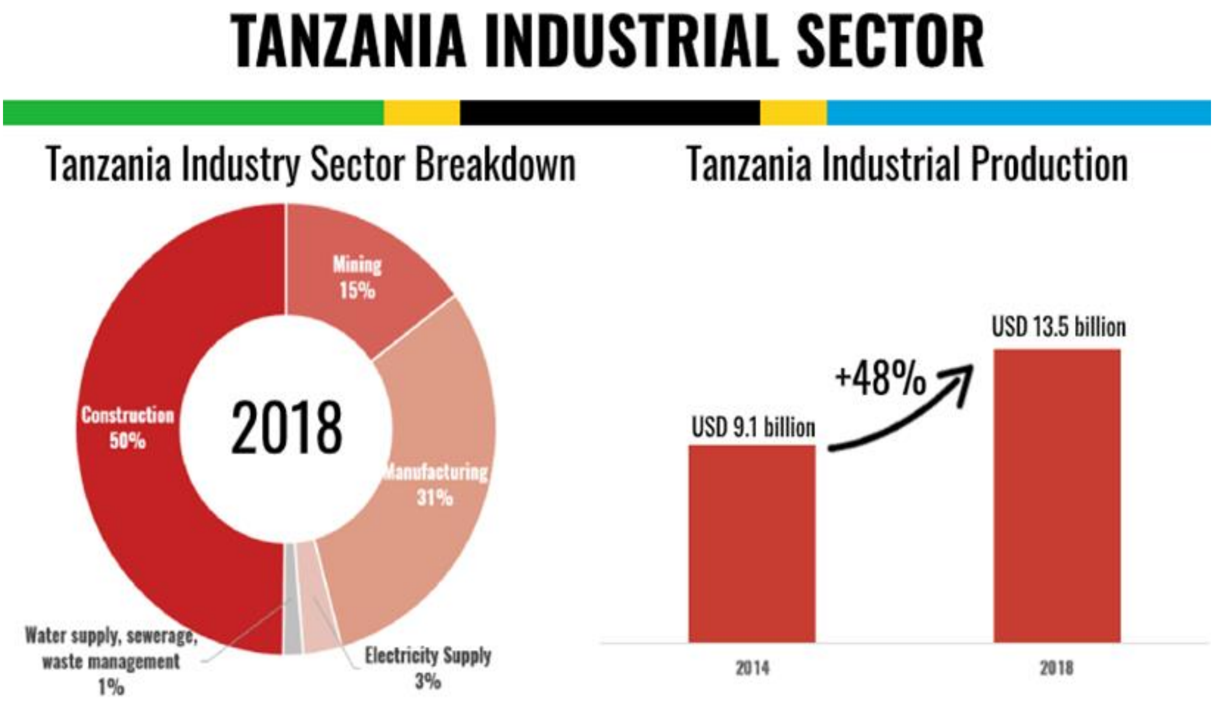


Fig 1.1. Tanzania Industrial Sector (https://www.tanzaniainvest.com/)

1.2 Problem Statement

With the world moving towards industrialization and Tanzania being a country looking into industrialization, there is a need to forecast energy demand for the industrial sector. Energy efficiency measures and practices for the industrial sector is important towards the estimation and forecasting of future demand for the sector.

1.3 Research Objectives

The aim of this research is to evaluate the impact of energy efficiency policies on future energy demand in the industrial sector of Tanzania. In achieving the aim, the specific objectives will be to:

1. evaluate energy resources, energy development, and associated policies,
2. develop long-term energy scenarios for industries,
3. forecast energy savings resulting from energy efficiency policies,
4. evaluate barriers to energy efficiency and energy conservation in industries,
5. recommend sustainable energy policy alternatives that can improve energy efficiency and conservation in industries.

1.4 Research Questions and the Working Hypothesis

This research will be centered on the following research questions:

1. How will energy demand in industries grow without the national energy efficiency policies and planning?
2. How does the intervention of energy efficiency policies impact the future energy demand in industries?

The following research sub-questions will also be of focus:

1. How is energy managed in industries in Tanzania?
2. Are there energy efficiency practices in industries in Tanzania?
3. Is there an energy efficiency gap in industries in Tanzania?
4. What are the barriers to adopting energy efficiency measures in industries in Tanzania?

The Hypothesis will be

1. There is no energy efficiency in Tanzania Industries.
2. Energy Consumption and Energy demand will increase with Business As Usual scenario.

1.5 Significance of the Study

This research aims at assessing policies for energy efficiency, while estimating future energy demand of the industrial sector of Tanzania. This will in turn assist in evaluating energy resources, energy development and associated policies, and develop long-term energy scenarios for industries. Moreover, the study will therefore forecast energy savings resulting from energy efficiency policies whilst evaluating barriers to energy efficiency and energy conservation in industries in Tanzania, and finally recommend sustainable energy policy alternatives that can improve energy efficiency and conservation in industries.

1.6 Scope of The Study

The scope of the study is to evaluate the impact of energy efficiency policies on future energy demand in the industrial sector of Tanzania. The study will evaluate energy resources and energy policies of Tanzania to determine loop holes and thus develop a long-term energy scenario for industries. From the shortcomings identified, there will be forecasting of energy savings resulting from energy efficiency policy, and recommendation of sustainable energy efficiency policy alternatives.

The study uses both qualitative and quantitative data, which are collected in a descriptive research design. It also involves primary and secondary data for the modelling and analysis and projection of a long-term industrial energy demand for Tanzania; population, national economic growth, sectorial value and energy intensities are the key drivers for the base year modelling. In the LEAP model framework, scenarios are based on detailed data of different types of energy consumed by the industrial sector using various types of fuels.

2. LITERATURE REVIEW

2.0 Introduction

This chapter presents an insight into the Tanzania energy sector, energy efficiency policies, the energy efficiency benefits, various energy forecasting models, their approach and classification. It also highlights some scholarly contributions in the energy economics literature which applied the LEAP model on various sectors in different countries of the world.

Energy is the vital fuel for economic and social development, and energy efficiency policies enhance development, by rising the number of activities services got from every unit of energy. Using energy efficiency can reduce demand, boost power capacity and the reserve margin. Executing energy efficiency practices can be thought of as adding a virtual power plant. (IEA, 2014b). There is a critical need to help developing countries meet their growing energy needs in order to maintain robust socioeconomic development. The recent volatility of oil prices and current projections show an increased reliance on oil and gas, and have collectively heightened concerns over energy security issues (IEA, 2014b).

Energy efficiency is rapidly becoming a critical policy tool a. round the world to help meet this substantial growth in energy. Evidence from the past 3–4 decades of experience around the world indicate that energy efficiency programs generally entail positive and multiple benefits for the government, energy consumers and the environment. (IEA, 2014b).

2.1.1 Key Terms and Concepts

The key terms related to energy efficiency and energy savings, which are used in this report, are defined as follows in Article 2 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency:

• **'Energy efficiency'** means the ratio of output of performance, service, goods or energy, to input of energy;

• **'Energy savings'** means an amount of saved energy determined by measuring and/or estimating consumption before and after implementation of an energy efficiency improvement measure, whilst ensuring normalization for external conditions that affect energy consumption;

• '**Energy efficiency improvement'** means an increase in energy efficiency as a result of technological, behavioral and/or economic changes;

• **'Energy service'** means the physical benefit, utility or good derived from a combination of energy with energy-efficient technology or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to result in verifiable and measurable or estimable energy efficiency improvement or primary energy savings;

Energy efficiency measures reduce the energy needed to produce the same quantity of goods and services or increase the output whilst keeping energy consumption constant. In addition to this direct contribution to improved competitiveness, energy efficiency measures provide indirect or 'non-energy benefits' that can increase the level of productivity. These include lower maintenance costs, higher levels of motivation, safer working conditions (IEA, 2012). The focus of this report is on end-use energy efficiency, ie measures that contribute to a reduction in energy demand, as opposed to measures that improve the efficiency of the energy supply chain.

Both direct and indirect energy efficiency benefits therefore affect competitiveness. Following Michael Porter from Harvard University, real competitiveness should be defined by productivity which in turn is a function of the value of goods and services (measured in price) and the degree of efficiency of their production (Porter 1990, see ECEEE 2013). In other words, productivity is defined by the relationship between the quantity of goods and services produced by a business or an economy and the quantity of labor, capital, energy, and other resources that are needed to produce those goods and services.

A commonly used measure in this context is the energy intensity of an economy which measures the energy consumption of an economy and its energy efficiency; it is the ratio between gross inland consumption of energy and gross domestic product. Energy intensity can therefore improve as a result of structural changes in an economy such as a lower share of energy-intensive manufacturing. Energy intensity can also be applied to individual sectors of an economy.

2.2 Demography of Tanzania

The United Republic of Tanzania (see Figure 2.1) is the largest country in East Africa with diverse ecosystems and climatic zones. It is endowed with abundant natural resources but is already showing vulnerabilities to climate change and extreme weather events, including droughts and floods. The mean temperature is projected to rise, and rainfall is expected to change its traditional patterns (African Development Bank Group, 2015).

Figure 2.1: Map of Tanzania (Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Feast-usa.com%2Fworld%2Ftanzania-map.html&psig=AOvVaw2z9j9lhYYmyKQPcOl0PDEB&ust=1636140719956000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCKDM0La5__MCFQAAAAAdAAAAABAE)

The population of Tanzania increased from 44.9 million in 2012 to 59,734,213 in 2020 (NBS, 2013; World Bank, 2020). The gross domestic product (GDP) of Tanzania has been growing steadily since 2000 at a rate of 7% annually. The highest and lowest growth rates of 7.8% and 6% were recorded in 2004 and 2009, respectively (BOT, 2012; NBS, 2012). The GDP per capita at current prices shows an increase in trend from US$ 306 in 2001 to US$ 1076.47 in 2020 (World Bank data, 2020). Figure 2.2 illustrates GDP growth rate from 2018 to 1st quarter 2021. . According to the World Bank Data, the GDP was 62.41 billion USD in 2020.

Tanzania's Vision 2025 estimates the country's GDP per capita to increase to 3000 USD per capita with growth rate of 8%, and this envisages that Tanzania will be a middle-income country by 2025.

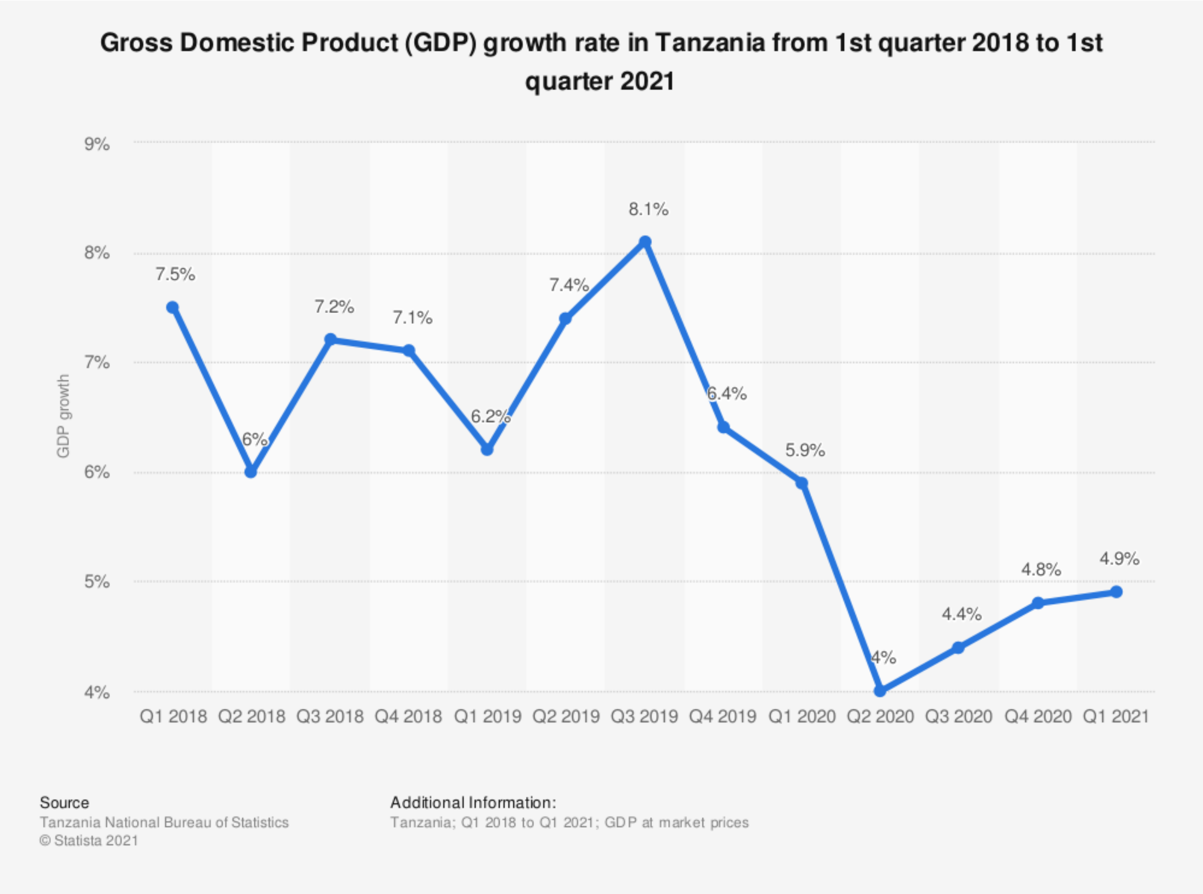


Figure 2.2: GDP growth rate 2018 – 2021(Source: Statista.com)

2.3 Industrialization in Tanzania

Industrialization has been the main policy agenda for the 5th Phase of Government. This is considered pivotal to realising Tanzania's ambition to become a middle-income economy by 2025 (Kweka, 2018). Industrialisation plays a critical role in economic development (Martorano et al., 2017). Tanzania's industrial sector has evolved through various stages since independence in 1961; from nascent and undiversified to state-led import substitution industrialization, and subsequently to de-industrialization under structural adjustment programmes and policy reforms (Msami and Wangwe, 2016). The current development agenda, however, has brought industrial development back to be one of the policy priorities.

In Tanzania, industrialization has been characterized by shifts in roles of the state and private sector; starting with largely private sector driven industrial development up to the mid-1960s as reflected in the First Five-year Development Plan (1964–1969), shifting to largely state driven industrial development from 1967 to the mid-1980s as reflected in the Second and Third Five-year Plans (1969–1974 and 1976–1981). It shifted back to private sector driven industrialization after 1986 as reflected in the Economic Recovery Programme (ERP) of 1986–1989, and the Economic and Social Action Programme of 1989–1992 in which liberalization and privatization were practiced followed by initiatives to revert back to industrialization as a development agenda from the mid-1990s as indicated in the Sustainable Industrial Development Programme of 1996–2020, and the Integrated Industrial Development of 2011.

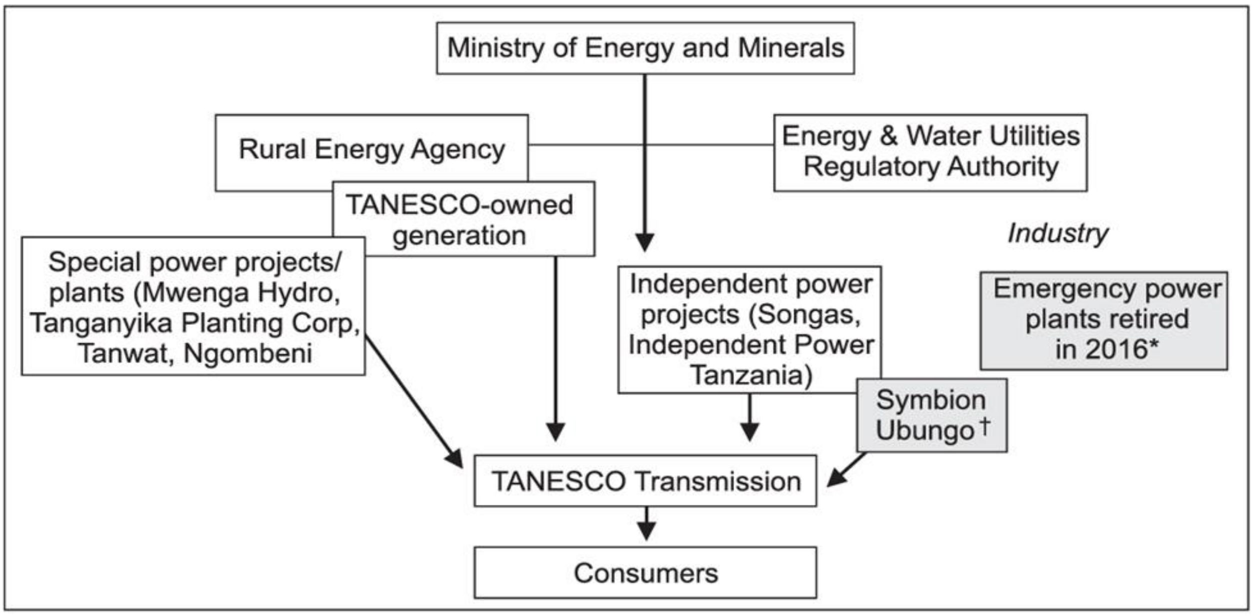
Tanzania aims to become a semi-industrialized country by 2025, for which the contribution of manufacturing to the national economy must reach a minimum of 40% of the GDP. To achieve this, Tanzania aims to transform from being dominated by natural resource exploitation activities and extractive industries (agriculture, tourism, and mining), to becoming an economy with a broad and diverse base of manufacturing, processing and packaging industries, that will lead both the productive as well as the export trade sector.

2.4 The Energy Sector in Tanzania

Tanzania has been endowed with numerous energy resources ranging from renewable to non-renewable. Tanzania's energy potential resources include hydro, natural gas, coal, and other renewable energies (solar, wind, biomass, geothermal). The country produces natural gas and coal for domestic consumption mostly in electricity generations and industrial applications, and does not produce crude oil. Total primary energy supply of Tanzania is estimated to be more than 22 million tonnes of oil equivalent (MTOE) (Wilson, 2010; Bauner et al., 2012). Primary energy supply is composed of biomass at approximately 90% of the total supply (MEM, 2013). The rest of primary energy supply is represented by 7– 8% from oil products and 1– 2% from electricity (Mwakapugi et al., 2010; MEM, 2013).

Despite the abundant resources for modern energy, 84% of a total 25.968 million tons of oil equivalent (MTOE) of the total primary energy supply in 2017 was from biomass (mainly firewood and charcoal), while other energy sources include petroleum (11%), natural gas (2.8%), hydro (0.7%) and coal (0.6%) (International Energy Agency, 2017). These proportions are a direct indicator of the country's level of development (African Development Bank Group, 2015).

High consumption of biomass is attributed to the low per capita income and limited investment in alternative energy supplies (Monela et al., 1999). The country's dependence on biomass has reached an annual yield of 40 million m^3 while annual sustainable yield is estimated at 24.3 million m^3 (Mwihava, 2010). Experience shows that biomass energy will remain a dominant source of energy, at least in the medium term. More efforts will thus be needed to ensure sustainability of biomass supply (United Nations Framework Convention on Climate Change, 2012). In Tanzania the energy sector is under the Ministry of Energy (formerly referred to as Ministry of Energy and Minerals (MEM) before 2017). Figure 2.3 shows the flow diagram of Tanzania's energy sector.



Notes:

* All EPPs phased out as of 2016. TANESCO = Tanzania Electric Supply Company

† Symbion Ubungo signed PPA in 2016 though at the time of writing no power was being purchased, as discussed in subsequent sections.

Figure 2.3: Energy Sector of Tanzania (Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.semanticscholar.org%2Fpaper%2FA-review-of-private-investment-in-Tanzania%2527s-power-Eberhard-Gratwick%2F476477bfaa65f3d030aa61c81db78251d4fca6d4&psig=AOvVaw2WxLj-rBf4_Rr_c8RlB-q5&ust=1636140927923000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCIDFw4u6__MCFQAAAAAdAAAAABAD)

2.4.1 Convectional Energy Resources and Potential

Conventional resources, also known as non-renewable resources are sources of energy that cannot be renewed or replenished. They include coal, natural gas and petroleum (oil).

2.4.1.1 Fossil Fuel

As much as Tanzania has profuse renewable resources that mostly remains unexploited, it has fossil fuels include coal and Natural gas. In 2008, Tanzania exploited 21,383 TJ of natural gas and 90 kt of coal. The regions in Tanzania that are rich in coal include Songea (Ngaka Coal mines) in large quantity followed by Mbeya (Kiwira Coal mines) and Rukwa. The country has coal reserves of a total of 1.9 billion tons.

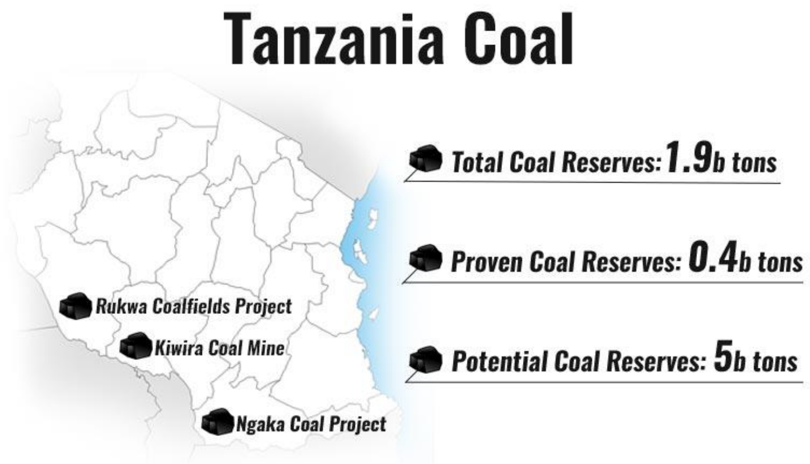


Figure 2.4. Map showing potential coal areas in Tanzania (Source: Tanzania Invest)

Figure 2.5 Kiwira Coal Mines – Mbeya region (Source: thecitizen.co.tz)

The gas is used mainly for power generation (84%), the rest is used by the domestic industry (IEA). Tanzania has a large potential of natural gas, the reservoir of more than 50 trillion cubic feet. The majority of this reservoirs are on the shores of Indian Ocean. The regions in Tanzanian that are rich in natural gas include Lindi and Mtwara. Electricity generated in Tanzania by thermal power stations sums to more than 1000MW. There are 13 stations that have been constructed and which sum to 1170.5MW as seen in table 2.1 and figure 2.6 shows on eof the thermal power plant in Ubungo Tanzania.

Figure 2.6. Songas Thermal Power Station which uses Natural gas fuel (Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fsweetcrudereports.com%2Fge-to-upgrade-gas-turbines-at-songas-ubungo-power-plant-in-tanzania%2F&psig=AOvVaw1Jo3ZYQcGwXxYPjqjnJWkm&ust=1636141410747000&source=images&cd=vfe&ved=2ahUKEwi2yv7tu__zAhUS8xoKHZAwDwoQr4kDegUIARCqAQ)

Tanzania does not have own oil resources and imports are currently only able to cover 70% of the total demand. The main consumer of oil products is the transport sector (URT Website).

Table 2.1: List of Thermal power plants in Tanzania

Thermal Power Station	**Community**	**Fuel Type**	**Capacity**	**Year Completed**	**Owner**
PAP Diesel Power Station	Dar es Salaam	Diesel	100	2002	PAP
Ubungo I Thermal power Station	Dar es Salaam	Natural gas	100	2007	Tanesco
Ubungo II Thermal Power Station	Dar es Salaam	Natural gas	120	2011	Symbion Power Ltd
Tegeta Thermal Power Station	Dar es Salaam	Natural gas	45	2011	Tanesco
Mtwara Thermal Power Station	Mtwara	Natural gas	18	2008	Tanesco
Somanga Thermal Power Station	Songas	Natural gas	7.5	2010	Tanesco
Dodoma Thermal Power Station	Dodoma	Diesel	55	2011	Symbion Power Ltd
Songas Thermal Power Station	Dar es Salaam	Natural gas	180	2004	Songas Power Ltd
Arusha Thermal Power Station	Arusha	Diesel	50	2012	Symbion Power Ltd
Nyakato Diesel Power Station	Mahango	Heavy Fuel Oil	60	2013	Tanesco
Kinyerezi I Thermal Power Station	Kingerezi	Natural gas or Jet Oil	150	2015	Tanesco
Kinyerezi II Thermal Power Station	Kinyerezi	Natural gas	240	2018	Tanesco
Dangote Industries Tanzania Thermal Power Station	Mtwara	Natural gas	45	2018	Dangote Industries Tanzania Ltd

2.4.2 Renewable Energy Resources and Potential

Tanzania has vast renewable energy sources such as biomass, solar, hydropower, geothermal, biogas, wind, tidal, and waves (MEM, 2017). These sources are important for decentralized renewable energy technologies that are found to be environmentally friendly, and which nurture the isolated nature of the settlements (Sarakikya, 2015). Despite their necessity, renewable energy sources are given low priority by both government and households. They are important to users in local households in the countryside, where most people depend on the use of charcoal, firewood, and cow dung as their major sources of energy.

2.4.2.1 Hydropower

Hydropower is the most widely-utilized renewable energy source in the world (Obadiah etal,2018). It contributes about 1000 GW (Otsuki, 2017), and supply over 16% of the global net electricity production (REN21, 2016) and with over 65% of the world's power generated from renewable energy resources (Gupta, 2014). Currently, hydropower constitutes over 45% of the total power generated in Tanzania (Obadiah etal,2018). It has customarily played a notable role with an installed capacity of 561 MW, which is approximately one-third of total installed power capacity of 2612 MW (International Hydropower Association, 2017). Tanzania has potential hydropower capacity of over 3.173 GW as shown in Table 1. This pushed the country to plan for further energy development, but due to challenges such as weak transmission infrastructure, this sector is still in a poor state (Sergi et al., 2018). Tanzania has nine (9) hydropower stations as seen in Table 2.2. Hydropower dominated the power industry of Tanzania, until recently that natural gas took over.

Table 2.2: Hydropower Stations in Tanzania

No	Hydroelectric Station	Region	River	Capacity MW	Year Completed
1	Mtera Power Station	Dodoma	Rufiji	80	1979
2	Kihansi Power Station	Morogoro	Kihansi	180	2000
3	Nyumba ya Mungu Power station	Kilimanjaro	Mt Kilimanjaro streams	8	1967
4	Kidatu Power station	Morogoro	Rufiji	204	1976
5	Pangani Power Station	Tanga	Pangani	68	1994
6	Hale Power Station	Tanga	Pangani	21	1964
7	Kikongwe Power Station	Ruvuma	Ruhuhu	300	2025 Exp
8	Songwe Power station	Mbeya	Songwe	180	2022 Exp
9	Stiegler's Gorge Power Station	Morogoro	Rufiji	2,100	2021 Exp

2.4.2.2 Wind

Wind is the second most applied renewable energy source in the world with the total installed capacity of 539.123 GW in 2017 (GWEC, 2017), and an annual growth of 12.6% (Wind Energy and Electric Vehicle Review, 2017) (Figure 2.7). Currently, in Tanzania, the expansion of community interest in wind electricity generation is prejudiced by factors such as an increase in oil costs, a long hydropower drought, and increased demand for power, influenced by high population growth. Tanzania has areas of high wind potential that cover more than 10% of its land (Tanzania Invest, 2015). In Tanzania, a lot regions are being assessed for their wind potential. The Ministry of Energy, in collaboration with Tanzania Petroleum Development Corporation, Renewable Energy Association, and Tanzania Electric Supply Company Limited (Dar es Salaam, Tanzania) is conducting wind energy resource assessments in Mkumbara (Tanga region), Karatu (Manyara region), Gomvu (Dar es Salaam region), Timbe (Mtwara region), Makambako (Iringa region), Mgagao (Kilimanjaro region), Kititimo (Singida region), and Usevya (Katavi region). Renewable Energy Association is supporting wind measurements on Mafia Island (coastal region) (Herscowitz et al., 2017).

Figure 2.7. Prospective windmill power plant in Tanzania (Source: Construction review)

2.4.2.3 Solar

Globally, the total installed capacity of solar power was about 405 GW at the end of 2017. In Tanzania, solar energy is used as a source of power through photovoltaic technology for access to electricity by 24.7% of the households. Potential solar energy resources are found in the central parts of the country (Sarakikya, 2015). This is shown in Figure 2.8. There are high solar resources with sunshine durations ranging from 2800 to 3500 h/year and global horizontal radiation of 4–7 kWh/m^2/day (AFDB, 2015). According to the World Bank, Tanzania has a solar energy potential greater than that of Spain, and wind energy potential greater than that of the US State of California (Tanzania Invest, 2015). With such a great potential for solar energy resources, Tanzania is naturally appropriate for producing solar energy as a feasible alternative source for modern energy supply and rural electrification. Currently, solar energy resources in Tanzania are used in different parts such as solar thermal for heating and drying, while photovoltaic is used for lighting, water pumps, refrigeration purposes, and telecommunication (Sarakikya, 2015). The regions of Lindi, Njombe, Mtwara, Katavi, and Ruvuma lead in the use of solar power electricity in Tanzania (The Citizen, 2017). Currently, there are more than 1,000,000 solar-powered homes in Tanzania, with solar photovoltaic panels ranging from 10 to 100 kW per home (USAID, 2017). Different types of solar technologies exist, with diverse market and technological solutions for each one of them.

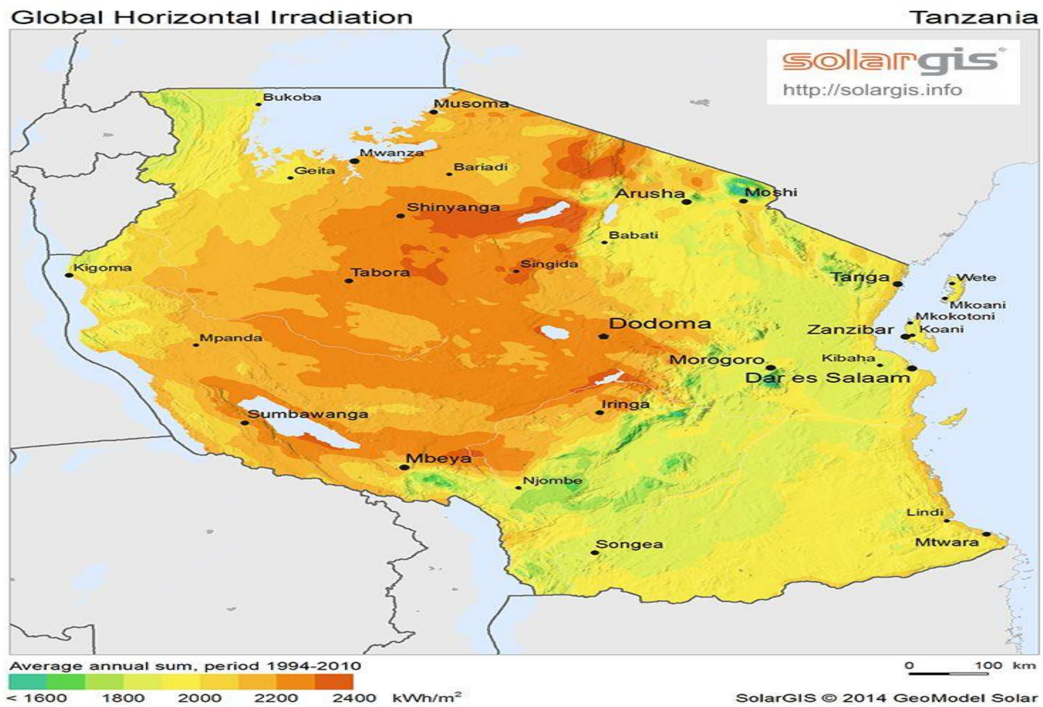


Figure 2.8. Map showing solar capacity in Tanzania regions (Source: smartsolar-tanzania.com)

2.4.2.4 Biofuel

Biopower is among the most potent types of renewable energy. Biopower can be found as biomass (biofuels and biodiesel), and, currently, it contributes over 83 GW globally. In Tanzania, biomass is the largest energy source (Martin et al., 2009) (see Figure 2.9). It is predominantly utilized in the domestic sector. More than 1 million people engage in charcoal production and supply (Figure 2.10). Demand for firewood and charcoal is dominated by the countryside and urban areas, respectively. For instance, Dar es Salaam city and other urban centers remain the largest charcoal consumers. Biomass are harvested traditionally from forests. The harvesting is unsustainable due to factors such as weak law enforcement, low awareness, and high poverty levels (Muhumuza et al., 2013). In Tanzania, most of the biomass resources are mainly from forests, agricultural residue, animal dung, and solid industrial waste. Residents of urban Tanzania consume an average of 93.6 to 180 kg of charcoal per person per year. However, the number is predicted to increase to 2.8 million hectares by 2030 because of high population growth (Msuya et al., 2011). Government loses about US$100 million in revenue annually. Currently, about 18 MW of grid power is generated from biomass, whereby the agro-industry is estimated to generate its own electric power of 58 MW. At present, the Tanzanian sugar industry produces around 290,000 tonnes of sugar per year in around 40,000 hectares of dedicated land, leaving slightly less than a million tonnes of bagasse (IFAD, 2015). This bagasse can be utilized to generate power.

Liquid biofuels can be either biodiesel or ethanol, whereby the latter is mostly produced from feedstock containing a significant amount of sugar from sugarcane or starch from maize/wheat. Biodiesel is produced from vegetable oil (Mshandete, 2011). Tanzania is endowed with vast potential of biofuel resources, which can produce energy due to good geographic and climatic conditions for growing a broad range of biofuel crops such as Jatropha, cotton, sugar cane, palm oil, and soya bean. Most of the plants, which provides unique potential for biofuel, is Jatropha. Jatropha is currently well promoted in Tanzania.

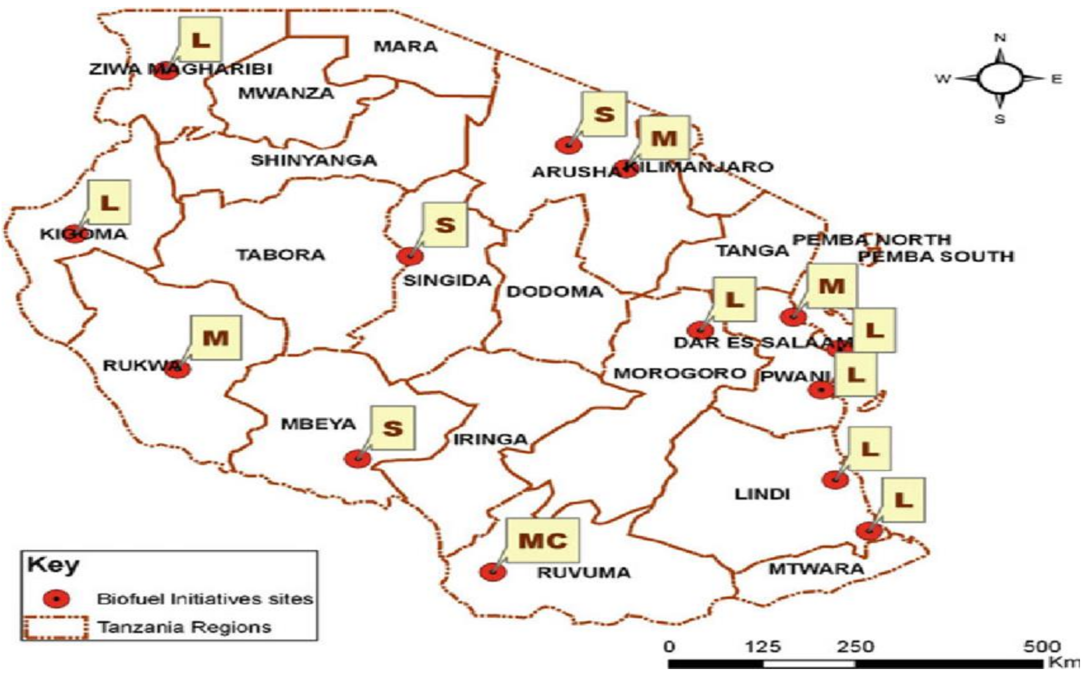


Figure 2.9: A Map for potential biofuel sites across regions in Tanzania (Source: researchgate.net)

Figure 2.10: Charcoal as source of biomass (Source: thecitizen.co.tz)

2.4.2.5 Geothermal

Geothermal power is ranked as the fifth biggest renewable energy source. The installed power production capacity from geothermal sources is about 13.438 GW in 2016 (BP, 2017). One-third of the geothermal energy resources provides electricity generation, and the remaining two-thirds are used for direct heat generation. Tanzania has exploitable geothermal energy resources; however, the resource is yet to be exhaustively quantified. Assessments of geothermal energy resources began in 1976, and, currently, Tanzania has about a total of 5000 MW capacity, which can be produced by geothermal energy resources (MEM, 2018), with most prospects located in the East African Rift System (AFDB, 2015). In Tanzania, prospect for geothermal are grouped into main three zones, namely the: (i) northeastern zone covering regions of Mara, Kilimanjaro, and Arusha, (ii) southwestern zone with regions of Rukwa and Mbeya, and (iii) eastern coastal belt zone in Rufiji Basin, which is related with rifting and magmatic intrusions (ESI Africa, 2016). There is an ongoing project of a new geothermal plant in Runge Mbeya in Lake Ngozi (Figure 2.11) which is expected to yield 200 MW and will be completed by 2025.

Figure 2.11. Lake Ngozi Geothermal Plant (Source: Construction review online)

2.4.3 Electricity Access and Electricity Prices in Tanzania

Electricity access in Tanzania increased from 13% in 2008 to 32% in 2017 (IEA). About 35.56% of Tanzania's population had access to electricity by 2018, whereby the rural electrification access was 18.84% and urban electrification rate was 68.355% (World Bank, 2018). The access to clean fuel and technologies for cooking was 2.16% by 2016 (World Bank, 2016). The Government of Tanzania is currently implementing a national energy policy, the National Rural Electrification Program (2013–2022), whose goal is to increase the country's overall electricity access of the population from 36% in 2014 to 50% by 2025, and to at least 75% by 2033.

Tanzania's power supply company TANESCO distinguishes between customers for setting its electricity and fuel prices. The price of electricity for geothermal is 0.099 USD per kWh for households and 0.102 USD for businesses which includes all components of the electricity bill such as the cost of power, distribution and taxes (Global Petrol Prices, 2020). The Energy and Water Utilities Regulatory Authority (EWURA) is the institution for regulation of electricity tariffs in Tanzania.

2.4.3.1 Residential

In Tanzania, the price of electricity is 0.099 USD per kWh for households which includes all components of the electricity bill such as the cost of power, distribution and taxes. For comparison, the average price of electricity in the world for that period is 0.137 USD per kWh for households. For households, the displayed number is calculated at the average annual level of household electricity consumption (Global Petrol Prices, 2021).

2.4.3.2 Commercial

In Tanzania, the price of electricity for businesses is 0.102 USD per kWh for which includes all components of the electricity bill such as the cost of power, distribution and taxes. For comparison, the average price of electricity in the world for that period is 0.122 USD for businesses. For businesses, the displayed data point uses 1,000,000 kWh annual consumption (Global Petrol Prices, 2021).

2.4.3.2 Industrial

The pricing of the industrial sector in Tanzania is considered the same as the one for commercial because they are considered businesses. Therefore, the price for electricity for industries is 0.102 USD per kWh for which includes all components of the electricity bill such as the cost of power, distribution and taxes. For comparison, the average price of electricity in the world for that period is 0.122 USD for businesses.

2.5 Energy Policy in Tanzania

The Government of Tanzania launched the first National Energy Policy in 1992. To cope with increasing activities in the energy sector and accommodate public sector reform objectives, a new National Energy Policy was released in 2003. Despite several interventions in the past decades, the energy sector has been facing some challenges embedded in policy, legal, regulatory and institutional frameworks. The National Energy Policy (NEP) 2015 aimed to "unlock challenges prevalent with the energy sector, improve performance and spur prudent and optimal use of the energy resources for the benefit of the present and future generations" (Policy Road Map, 2019). The country's national plans have followed, leading to plans for the liberalization and growth of Tanzania's energy markets.

The establishment of the Rural Energy Act in 2005, created the autonomous Rural Energy Board, with a mandate to electrify rural areas of Tanzania with projects producing less than 10 MW. Another important national level plan is the Electricity Act of 2009, which will lead to plans for unbundling of the state owned and controlled TANESCO utility, often cited as a major impediment to the growth of an efficient and resilient electrical sector in Tanzania. Currently the progress of the NEPs is highlighted in the drafting of the National Energy Plan and National Energy Policy 2015 by the Government of Tanzania.

2.5.1 Framework for Renewable Energy Policy in Tanzania

Tanzania has drafted renewable energy policies so as to shift dependence from hydropower which is many times affected by draught and weather patterns and petroleum that have been affected by price fluctuation to solar, wind, biogas and other biomass which are renewable (Sarakikya, 2015). However, the uptake rate of these renewable energy technologies is low because of financial limits, poor/low awareness, poor or no coordination between the Government, non-Governmental organizations and private sectors. Existing renewable energy policies should be coherent and the current practice should be gaged so as to upgrade the adoption rate of renewable technologies in Tanzania.

2.5.2 Framework for Energy Efficiency Policy in Tanzania

In 2015 Tanzania's National Energy Policy set a goal on Energy Efficiency and Conservation. It contemplates on how to improve Energy Efficiency in energy production, transformation, transmission, transport and energy end-use. The policy recognizes that Energy Efficiency have the potential to reduce capital investment needed to provide additional energy. In order to achieve this goal, The Government of Tanzania shall:

(i) Facilitate establishment of standards and code of practice for energy management;

(ii) Ensure energy uses are benchmarked to industry prudent practices

(iii) Facilitate efficient biomass conversion and end-use technologies

(iv) Ensure integration of energy efficiency aspects in housing policies and building codes (NEP, 2015).

2.6 Energy Planning Tools

Energy system models are developed and applied in a wide variety of energy planning and policy making activities and they provide support at all three planning levels (Hoffman & Wood, 1999). The energy models are used to project future energy demand and supply of a country or a region. Energy models often utilize scenario analysis to investigate the different assumptions about the technical, social or economic conditions under consideration. They are also used to simulate policy and technology choices that may influence future energy demand and supply, and hence investments in energy systems. (Herbst et al., 2012).

Predictive models are used to forecast energy supply and/or demand and attendant effects over a particular time horizon. According to Hoffman and Wood (1999), most models have both normative and predictive capability, and a partition of models into these classes can be misleading. Therefore, energy models represent a more or less simplified picture of the real energy system and the real economy; at best they provide a good approximation of today's reality (Howells, 2013).

2.6.1 Numerical Energy Planning and Modelling Tools

The impacts of energy efficiency policy have received a political push regarding to the sustainable development perspective (Goldemberg and Johansson, 2004). Policy evaluation research is commonly, though not exclusively, concerned with the simulation and modelling of the impacts of different policy instruments for increased energy efficiency. In past decades, we have seen an increased use of bottom-up energy models in policy- making to evaluate ex-ante the energy, economic, and environmental impacts of energy efficiency policy instruments.

Energy efficiency scenarios are developed in national and international contexts to explore and evaluate different policy designs and visions of how energy will or should be generated, distributed and used in the future. These scenarios are often developed using bottom-up modelling tools that, only to a limited extent, take into account decentralised decision-making frameworks, such as household decisions regarding energy-efficient technologies (Hourcade et al., 2006). Uncertainties associated with energy models and scenarios can be distinguished between "data uncertainties", "modeling uncertainties" and "completeness uncertainties" (Functowicz & Ravetz, 1990). The uncertainties of outputs with respect to its input (e.g. gross domestic product (GDP)) are assessed in sensitivity analyses, showing how robust model outputs are (DEA, et al., 2013).

However, policy and technology choices induce a dilemma in the choices of energy models. “Energy models can simulate sector specific future energy supply and demand including impacts on economic growth, employment or foreign trade. Energy models have specific advantages and limitations of which modellers, policy makers and users are often not sufficiently aware of the result” (Böhringer, C., 1998). A large number of modeling approaches are developed depending on their intended use (data analysis, forecasting, optimization, simulation, estimation of parameters), target groups (research communities, policy makers, utility companies), the information available (useful energy, energy demand data on final energy, sector wise energy demand), regional (national regional multinational) and conceptual framework (top-down, bottom-up)

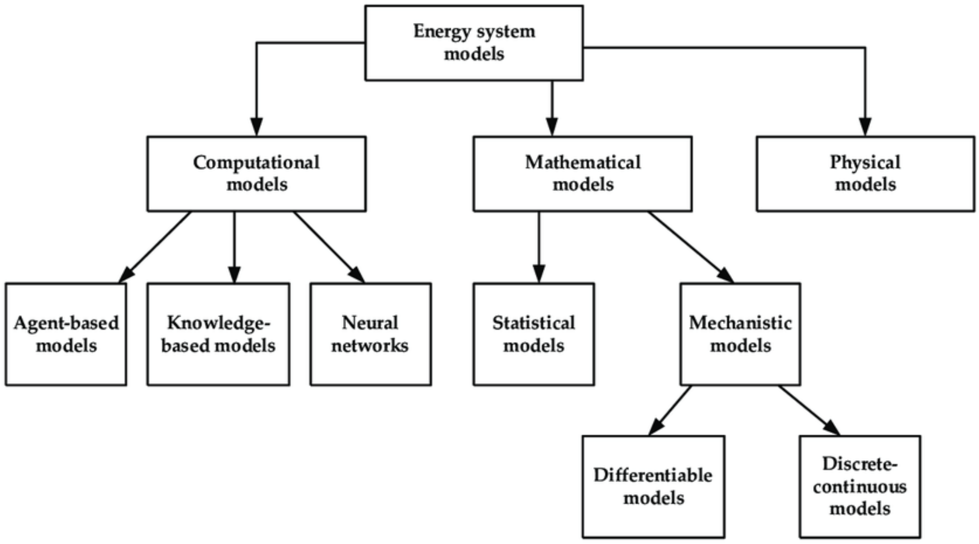


Figure 2.13: Energy models approach (Source: researchgate.net)

2.6.2 Energy Demand Models

Policy making in the energy sector is strongly influenced by models designed to forecast the effects of policies on energy demand, energy related pollution and economic output. The high capital intensity of the sectors are reasonable grounds for the application of simulation and optimization algorithms. Internationally, the global warming concern has been stimulating the energy modellers to develop more sophisticated energy models and climate change assessment models. Energy models represent a more or less simplified version of the real economy. At best they provide a good approximation of today’s reality. Most of the energy models comprise the following main processing features:

- Principle: Simulation and optimization

- Approach: sectoral ("top-down") or technology-oriented ("bottom-up")
- Structure: point model (reduced to the consideration of production and demand without power restrictions) or extended model (including grid considerations)
- Period: long-term study (typical input variables: years of integral power generation or work) or short-term resource planning (use of existing or specified power plants typical input: load profile and power) (Pandey, 2002).

The purpose of using energy models in scenario analysis is the most commonly used parameter for model choice and relates to the different factors to organize large amounts of data, to provide framework for testing hypothesis and to reflect understandable form of complex systems (Heaps, 2011). The increasing energy demand and environmental concerns have led to the creation of a number of energy models which can be classified in two major categories (Rivers and Jacard, 2005).

The two major approaches for energy sector mitigation assessment models are:

Top-down models describe the energy system in aggregate relationships derived empirically from historical data.

- Important where GH mitigation activities will cause substantial changes to an economy
- Assume competitive equilibrium and optimizing behavior in consumers and producers
- Examine general impact of GHG mitigation on the economy
- Typically examine variables such as GDP, imports, exports, employment, public finances, etc.
- Can be used in conjunction with bottom-up approaches to help check consistency; such as energy sector investment requirements from bottom-up energy models used in macroeconomic assessment to iteratively check the GDP forecasts driving the energy model (UNFCCC, 2005).

Bottom-up models which determine the financially optimized (cheapest) way based on available technologies and processes. Bottom-up energy models use highly disaggregated data on specific technologies such as estimated cost of energy technologies. This would make it possible to produce detailed and fair energy use projections by type and sectors, typically to identify least-cost configurations (Wilson et al 1993). Bottom-up energy models are categorized as: optimization models, simulation Models and accounting Frameworks.

2.7 Leap Model

Long-range Energy Alternatives Planning (LEAP) was developed by the Stockholm Environment Institute. It is an integrated modelling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy (Community for Energy, 2009). LEAP functions using an annual time-step, and the time horizon can extend for an unlimited number of years (typically between 20 and 50 years). LEAP supports a number of different modelling methodologies: on the demand side these range from bottom-up end-use accounting techniques, to top-down macro-economic modelling.

LEAP's modelling capabilities operate at two basic conceptual levels. At one level, LEAP's built-in calculations handle all of the "non-controversial" energy, emissions and cost-benefit accounting calculations. At the second level, users enter spreadsheet-like expressions that can be used to specify time-varying data or to create a wide variety of sophisticated multi-variable models, thus enabling econometric and simulation approaches to be embedded within LEAP's entire accounting framework. Overall, LEAP can simulate all sectors and all technologies within an energy system.

2.7.1 Various Application of LEAP Model

The LEAP model can be used in different applications especially as a software for Climate Change Mitigation assessment and Energy policy analysis. Moreover, LEAP is a unified modeling tool that can be used to track energy consumption, production and resource extraction in all sectors of an economy of a nation. It can be used to account for both energy sector and non-energy sector greenhouse gas (GHG) emission sources and sinks (SEI, 2012).

LEAP as a database, it provides a comprehensive system for maintaining energy information; as a forecasting tool, it enables the user to make projections of energy supply and demand over a long-term planning horizon; as a policy analysis tool, it simulates and assesses the effects - physical, economic, and environmental of alternative energy programs, investments, and actions (Aminata, 2005)

3.0 MATERIALS AND METHODS

This chapter describes the study area along with the demographics such as population, Gross domestic product which totals up to the country's economy and the general situation of the industrial sector in the study area. It also defines the research design and methodology that was deployed for gathering and analyzing data. The sample size that was used to come up with the findings. Moreover, this chapter expounds on the model used and scenarios that were deployed to reach the results, recommendations and conclusion.

3.1 Introduction

This study used both qualitative and quantitative data, which were collected in a descriptive research design. It describes dependent and independent variables, as well as the evaluation of the relationship between independent and dependent variables in terms of percentages. It also involves primary and secondary data. For the modelling and analysis of a long-term industrial energy demand projection for Tanzania, population, national economic growth, sectorial value and energy intensities are key drivers for the base year modelling. In the LEAP model framework, scenarios are based on detailed data on different types of energy consumed by the industrial sector using various types of fuels. In this research, scenarios have been created to develop long-term energy plans and to understand industrial energy demand in Tanzania. The Research Framework of LEAP Model is shown in Figure 3.1.

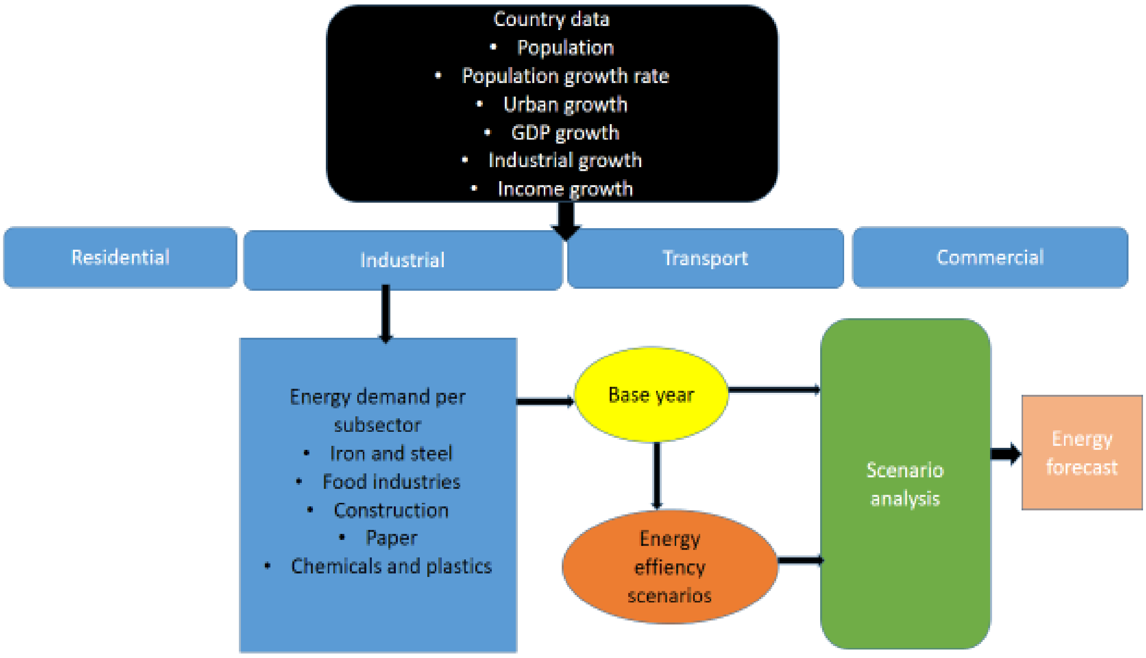


Figure 3.1: The Research Framework of LEAP Model (Source: SEI)

3.2 Study Area

3.2.1 Geographical Description

The United Republic of Tanzania is the largest country in East Africa with diverse ecosystems and climatic zones. It is bordered with eight other countries which include Kenya, Uganda, Rwanda, Burundi, Zambia, Democratic Republic of Congo, Malawi and Mozambique together with the Indian Ocean. Tanzania is endowed with abundant natural resources but is already showing vulnerabilities to climate change and extreme weather events, including droughts and floods. The mean temperature is projected to rise, and rainfall is expected to change its traditional patterns (African Development Bank Group, 2015).

Figure 3.2: Map of Tanzania (Source: researchgate.net)

3.2.2 Population

The current population of Tanzania as per worldometer is 61,883,986 people dispersed in 31 regions speaking more than 120 languages. The population is rising at ab rate of 2.9% yearly it is forecasted to grow to 83,900,000 by 2040 (MEM, 2016).

3.2.3 The Economy

Tanzania had a Gross domestic product (GDP) of 62.45 billion US dollar which is approximately to 0.06% of the world's economy as per the official data from the World Bank and projections from trading Economy (World bank, 2020). Tanzania economy expanded by 4.9% in the first quarter of 2021 whereas mining and quarrying had the highest contribution to the Tanzania Gross Domestic Product (GDP) growth (Faria, 2020). Tanzania's Vision 2025 estimates that the country's GDP per capita to increase to 3000 USD per capita with growth rate of 8% and envisages that Tanzania will be a middle-income country by 2025.

3.2.4 The Industrial Sector

As Tanzania gears towards its vision of becoming a middle-income economy by 2025, the National Five-Year Development Plan 2016/17–2020/21 (FYDP II), published in 2016, identifies industrialization as the main policy objective and key driver of economic transformation (Kweka, 2018). According to a recent budget speech by the Minister of Industry, Trade and Investment, about 3,306 industries have been established since the 5th Phase Government came to power (Daily news, February 2018). The industrial sector of Tanzania is comprised of construction (50%), manufacturing (31%), mining (15%), electricity supply (3%), water supply, sewerage, and waste management (2%) as seen in the below figure.

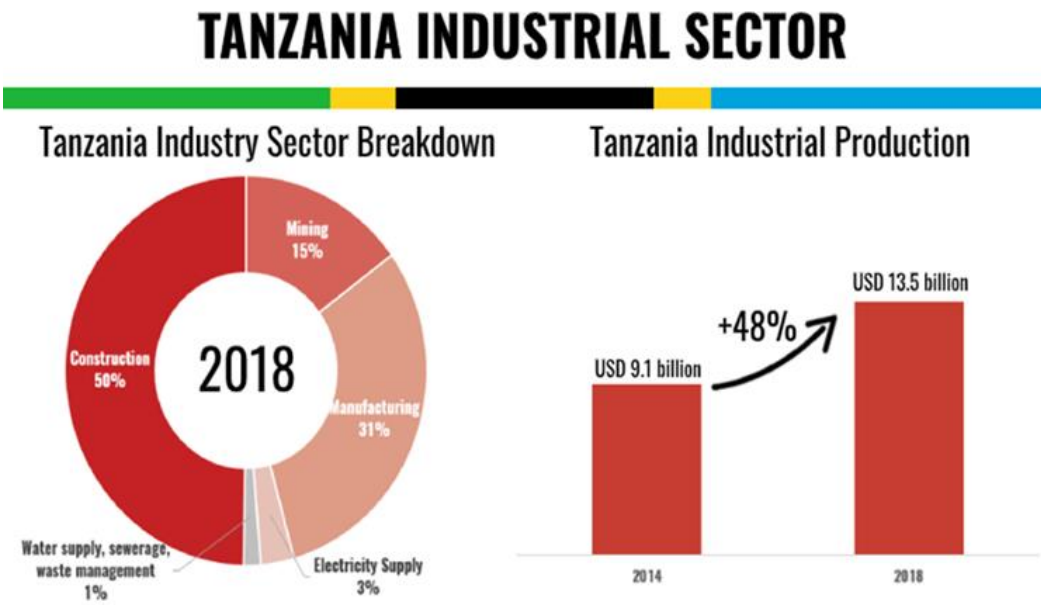


Figure 3.3: The industrial sector breakdown (Source: Tanzania Invest)

3.3 Research Design

3.3.1 Sampling Determination

Singh and Masuku (2013) stated different strategies of determining sample size which include using a census for a small population, using sample size of a similar study, using published tables and using formulas to calculate sample size. The work of Sekaran and Bougie (2016), showed that a business research study should have a sample size of between 30 to 500 participants. In a similar study, Hanafizadeh et al., (2019) recommended a sample size of less than 50.

The CTI Directory 2015 divided the industries in Tanzania into 17 sectors as shown in the Table 3.1. From Table 3.1, we have a total sum of 381 industries. The samples size determination was 5.5% of the industries, and which is 21 industries.

Table 3.1: Tanzania's Industry by Sector (source: SEI)

S/N	Industry By Sector	Number of Industries
1	Building and Construction	17
2	Chemical and Chemical products	34
3	Energy, Electrical (Machinery, Equipment services) &Electronics	16
4	Finance, Insurance, Real Estate & Consultancy	27
5	Food, Beverage and Tobacco	69
6	Hospitality and Training	17
7	Leather products and footwear	7
8	Metal and Metal products	36
9	Mineral products	20
10	Motor vehicles and accessories	7
11	Paper, Paper products, Printing, Publishing and packing materials	38
12	Pharmaceuticals and Medical Equipment	4
13	Plastic and rubber Products	45
14	Several	6
15	Textiles and apparels	12
16	Timber and wood products	9
17	Transport, Storage & Communication	17
	Total	381

3.3.2 Data Collection

The study involved both primary and secondary data. The sample of the study were the different industries in Tanzania while primary data were from questionnaire, and secondary data from data tanks, statistical bodies and literature. From the CTI Directory, 17 industrial sectors were defined. There was a random selection of industries from all the 17 industrial sectors of Tanzania to a total of 21samples from the different regions of Tanzania. A questionnaire survey was constructed and distributed to participants in Tanzanian industries and the ministry responsible for Energy in Tanzania. The participation in the survey was voluntary, and respondents were required to provide consent upon completion. The survey had a total of 12 questions (see questionnaire in Appendix).

In order to feed the required input data into the simulation tool, LEAP-relevant data were collected mostly from survey and government agencies such as Tanzania National Electric Supply Company (TANESCO), Energy and Water utilities (EWURA), Petroleum Upstream Regulatory Authority (PURA), Rural Energy Agency (REA), National Bureau of Statistics (NBS), Ministry of Energy and Minerals, and Tanzania Petroleum Development Corporation (TPDC).

For economic parameters such as national Energy Consumption per Sector, GDP, GDP per capita, GDP growth rate and GDP by city, data were taken from reports of the World Bank, International Energy Agency (IEA) and Ministry of Finance. Most of the required data for the application of the LEAP model were available for the base year. However, for some input parameters, either the official data was not available, or it had not been updated. In such cases, either an assumption was made based on information available from previous years or data was collected from reports and publications.

3.3.3 Statistical Analysis

After the completion of data collection process, the questionnaire samples which were returned after being completely filled were edited, coded, and thereafter entries made into Statistical Package for Social Sciences (SPSS version 25.1). Preprocessing is conducted to change the row data to be able to use it in further modelling tool. The preprocessing is conducted by first filling the raw data in SPSS and MS Excel, before the data is analyzed. The value was used for further analysis and forecasting.

3.4 Scenario Description and Assumption

3.4.1 The Model

The LEAP (Long-range Energy Alternative Planning System) model is a static energy - economy - environment model developed by the Stockholm Environment Institute in Boston, USA since 1980 (Winarno, 2006). LEAP is a widely-used tool for energy policy analyst and climate change mitigation assessment (Heaps, 2013). The software can be used to created models in countries or regions. The structure of LEAP is flexible; the user will design energy, economic and environmental models. Energy demand or energy supply is calculated by summing up the energy consumption and supply of each type of activity. Leap provides four main modules used in energy modeling. They are key assumptions, demand, transformation, and resources (Perwez etal,2015). Key assumptions module consists of data such as population size, population growth, nominal GDP (Gross Domestic Product), GDP growth, number of household customers and other parameters. Demand module consists of four sectors, they are household, industry, business and public. Figure 3.4 describes how LEAP works. Demographic data, energy scenario (assumptions) and macroeconomic data are the variables which conducted the energy demand. Energy transformation and supply energy depends on demand necessities. Finally, an environmental and cost-benefit analyst could be achieved in the process

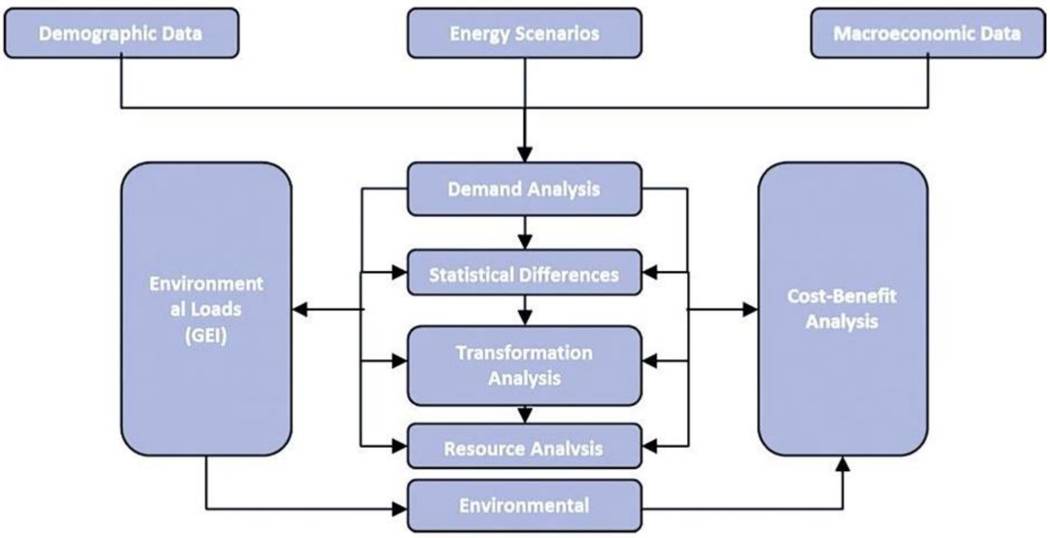


Figure 3.2: LEAP Model (Source: SEI)

3.4.2 Demand Analysis

Demand analysis is a disaggregated, end-use based approach for modeling the requirements for final energy consumption in an Area in a specific time.

3.4.3 Computations of Energy Demand

Energy demand can also be energy intensity defined as the total amount of energy consumption per unit of gross domestic product (GDP) (Indonesia NEP,2014). Economic, demographic and energy-use information can be applied to construct alternative scenarios that examine how total and disaggregated consumption of final fuels evolve over time in all sectors of the economy. Costs and environmental implications of each scenario can be examined. Energy demand analysis is also the starting point for conducting integrated energy analysis, since all Transformation and Resource calculations are driven by the levels of final demand calculated in your demand analysis.

The energy demand is calculated by the model MAED as a function of a scenario of possible development. MAED calculates the total energy demand for each end-use category, aggregating the economic sectors into four main "energy consumer" sectors: Industry (including Agriculture, Construction, Mining and Manufacturing), Transportation, Service and Household. At the same time, it provides a systematic accounting framework for evaluating the effect on the energy demand of any change of economic nature or in the standard of living of the population (IAEA,2006). In a final energy demand analysis, energy demand is calculated as the product of the total activity level and energy intensity at each given technology branch. Energy demand is calculated for the Current Accounts year and for each future year in each scenario. In other words:

$$D_{b,s,t} = TA_{b,s,t} \times EI_{b,s,t} \quad (1)$$

where D is energy demand, TA is total activity, EI is energy intensity, b is the branch, s is scenario and t is year (ranging from the base year [0] to the end year). Note that all scenarios evolve from the same Current Accounts data, so that when t=0, the above equation can be written as:

$$D_{b,0} = TA_{b,0} \times EI_{b,0} \quad (2)$$

The energy demand calculated for each technology branch is uniquely identified with a particular fuel. Thus, in calculating all technology branches, LEAP also calculates the total final energy demand from each fuel.

The total activity level for a technology is the product of the activity levels in all branches from the technology branch back up to the original Demand branch. In other words:

$$TA_{b,s,t} = A_{b',s,t} \times A_{b'',s,t} \times A_{b''',s,t} \times \ldots \quad (3)$$

Where Ab is the activity level in a particular branch b, b' is the parent of branch b, b" is the grandparent, etc. Note that those branches marked as having "No data" as well as the top level "Demand" branch are treated as having an activity level of 1. The activity level values of other branches with percentage units (e.g., percent shares or percent saturations) are always divided by 100 to yield a fractional value from zero to one in the calculations.

3.4.4 Data Requirement for LEAP Model

LEAP is a very general-purpose software tool, which can be used to build a wide variety of different models of energy systems. LEAP's initial data requirements are relatively simple compared to other energy modelling approaches because many parts of the software (LEAP) are optional such as s the Transformation (energy supply) analysis, pollution and GHG emissions analysis, costing analysis, and non-energy sector GHG accounting.

Equally as important, data requirements will depend enormously on whether you develop an aggregate, top-down data set, which describes total consumption of the fuels in each major sector, or a disaggregated, bottom-up data set that examines how fuels are consumed in the various devices and end-uses in each different subsector of the economy. The type of data required for analysis on the LEAP model is described below and can be found in Heaps (2006).

3.4.4.1 Demographic Data

This generally includes data of a nation such as National population data, urbanization rates, Average household sizes, population growth rate, and urbanization growth rates. In some other cases data like population by region, male/female population, age structure of population may be needed for modelling purposes. All this are filled into the "Key Assumption" of the data tree in the LEAP model.

3.4.4.2 Economic Data

This is data associated to economics of a certain nation which includes GDP/GNP data, Value added by sector/subsector, Average income levels, Interest rates and Inflation rates. Other useful data in this data category include Employment/unemployment statistics, Investment/national saving rate, LEAP may also be linked to energy sector analysis for a broader macro-economic analysis or macroeconomic model.

3.4.4.3 General Energy Data

This is basically data for the National energy balances with data on energy consumption and production by sector or subsector in an economy. Most of these data are found in National statistical bodies or agencies or Energy related agencies as the country case may be. If the data are not available in the country, they may be available from the International Energy Agency (IEA) published energy statistics. National energy policies and plans, annual statistical reports with information on production, consumption, etc., of oil, natural gas, coal, charcoal, LPG, CNG, and other relevant fuel and any previously published integrated energy plans or GHG mitigation assessments for the country are also part of the general data that is required by LEAP software.

3.4.4.4 Demand Data

•Activity Levels: In LEAP's demand analysis, works by forecasting future energy consumption as the product of two factors: activity levels and energy intensities. Activity levels are simply a measure of the economic activity in a sector, and you can choose what data to use for this purpose. For example, in the household sector the user may choose to use the number of households as the activity level, in the cement industry you might use tonnes of cement production, and in the transport sectors you may choose to use tonne-kms (for freight transport) and passenger-kms (for passenger transport). The user will need to collect data describing the current, historical and future projections of whatever data the user chooses to use for his/her Activity Level variables. The user may need to consult national statistical reports or contact governmental or academic organizations working in specific sectors (industry, commerce, transport, households, etc.)

•Energy intensity data is often very hard to come by. If the user is preparing an aggregate analysis, he/she will likely be able to use combine their activity level data with national energy consumption statistics and energy balances to calculate historical energy intensity values by sector and by fuel.

In other words, for historical data, energy intensity = total energy consumption/activity level. For your forward-looking scenarios you will instead use LEAP to calculate the total energy consumption by projecting the energy intensity and activity level. That is: total energy consumption = energy intensity x activity level.

•Other useful sources of energy demand data include recent social surveys or energy consumption surveys that analyze how energy is consumed in different sectors of the economy, and reports from utilities and private companies on sales of different energy forms (electricity, natural gas, oil products). If possible, the user should try to get data disaggregated by sector and by consumer category.

If the user is creating a more detailed analysis, he/she will likely also need information on the stocks, technical characteristics (efficiency, specific fuel consumption), costs and environmental loadings of major energy consuming devices in different sectors. For example, if the user wants to focus on road transport energy use you would need data describing the stocks and sales of vehicles; there fuel economy, and some estimate of their average on-road life expectancy.

3.4.4.5 Transformation Data

In general, a transformation analysis requires that you prepare a complete picture of how energy is extracted, converted and transported in your energy system. This requires data on the flows of energy into and out of major processes, as well as information on the efficiency, costs (capital, operating and maintenance and fuel costs) and environmental loadings associated with each major process.

• Electric sector: In general, you will need data describing the current and historical installed capacities (MW), efficiencies, costs (capital, operating and maintenance and fuel costs) and actual dispatch (MW-HR) of the various types of electric generating plants in your country. You will also need information on the seasonal load shape for your electric system and the maximum availability and dispatch priority of each different type of power plant. Capacity expansion plans, if they exist, can be very useful for establishing forecasts of how the electric system is likely to evolve in the future. In addition to collecting data on generation, you should also collect data describing transmission and distribution losses including both technical and non-technical losses. In many countries, combined heat and power (CHP) production is becoming increasingly important. You may wish to analyze this sector separately from the dedicated electric generation sector. For this sector your data should include the production efficiencies of both electricity and heat. In many countries, rural electrification is a key issue, so you may wish to collect relevant data describing rural electrification rates for different geographic regions.

• Oil Refining: If oil refining is an important sector, you will need to collect data on the different products produced by your refineries, the efficiency and the capacity of the refineries.

• Extraction sectors: If extraction sectors such as coal mining or oil and gas production are important, you will need data describing the efficiency and capacity of these sectors as well as information on the fuels produced and the energy consumed during extraction.

• Renewables: Renewable energy is becoming increasingly important in many countries and may be an important focus of any GHG mitigation analysis. Collect data describing the current installed capacities, efficiencies, costs and expansion plans for any relevant renewables such as wind, geothermal, municipal solid waste, solar, etc.

• Biomass: If wood or other biomass fuels are important in your country try to collect whatever data is available on the consumption and production of those fuels. Woodfuel surveys can be an important source of data for estimating the sustainability of production of wood fuels.

• Other Sectors: Other conversion sectors that may be important include charcoal making, ethanol production and synthetic fuel production from coal.

3.4.4.6 Environmental Data

• For a first cut GHG mitigation assessment you may be able to rely on the basic "Tier 1" emission factors published by the IPCC (and included in LEAP). However, as you refine your analysis you may wish to collect local emission factors estimate that reflect the fuel and technology characteristics of devices used in your country. For example, cars in your country may have particular emissions characteristics. It is particularly important to have data on the chemical composition of the fuels used in your country as this can be used to refine the emission factor estimates from different devices.

• The IPCC's online EFDB database is a key source of data on emission factors.

3.4.4.7 Fuel Data

LEAP includes a good default list of fuel and their characteristics (energy content, chemical composition) that should meet the needs of most studies. However, be sure to adjust the energy, carbon and sulfur contents in this list to reflect the characteristics of the fuels used in your country. In particular, the characteristics of coal and biomass fuels vary greatly between (and even within) countries and uses. In addition to their physical characteristics, you will also require data describing the production costs of any primary fuels produced in the country and the import and export costs of any relevant fuels.

3.4.5 Reason for Selecting the LEAP Model

The LEAP model has some advantages compared to other known models. These advantages were the basis for the collection of the model as seen below.

1. Work scope: The LEAP model can work over a wide range of scope unlike other models it is a tool that can create models of different energy systems. LEAP model is able to work its way up from energy extractions, processing, conversion, transmission, up to end-use consumption by demand devices, under a range of assumptions. LEAP also includes a range of optional specialized methodologies including stock-turnover modeling for areas such as transport planning. On the supply side, LEAP provides a range of accounting, simulation and optimization methodologies that are powerful enough for modeling electric sector generation and capacity expansion planning.
2. Time factor for modelling - LEAP is intended as a medium- to long-term modeling tool. Most of its calculations occur on an annual time-step, and the time horizon can extend for an unlimited number of years. Studies typically include both a historical period known as the Current Accounts, in which the model is run to test its ability to replicate known statistical data, as well as multiple forward-looking scenarios.
3. Technology and Environmental Data (TED): the LEAP model is integrated with TED databases which gives users information regarding technical characteristics, cost, and environmental effects of energy technologies.
4. Policy analysis: with LEAP, an energy policy analyst can develop and evaluate alternative scenarios by comparing the energy requirement, social costs and benefits, and their environmental impacts. LEAP is designed around the concept of scenario analysis. Scenarios are self-consistent storylines of how an energy system might evolve over time. This approach allows policy makers to assess the impact of an individual policy as well as the interactions that occur when multiple policies and measures are combined. For example, the benefits of appliance efficiency standards combined with a renewable portfolio standard might be less than the sum of the benefits of the two measures considered separately.
5. Graphical interface: The LEAP’s interface is user-friendly, rich in technical specifications and end-use details.

6. Data characteristics: the LEAP uses a flexible data structure which can be a Top-Down or Bottom-Up approach depending on the data available, or even decoupling approach.

3.5 Scenarios

3.4.1 Business as Usual (BAU) Scenario

The Business as Usual scenario is how Tanzania industries operate currently in the absence of Energy efficiency policies and mechanisms.

- The industrial percentage shares of manufacturing industries, Mining industries and other industries in Tanzania are 31%, 15% and 64% respectively. Where the manufacturing industries, mining industries and other industries will grow at a yearly rate of 4.5%, 6.9%, and 2% respectively (MFP, 2016)
- The manufacturing industry dominates the energy consumption in industries followed by Mining industries and the last being a combination of all other industries.
- Process heating and Motive power being the two process that consume energy in Industries.
- Manufacturing industries use electricity at high ratio compared to other energy sources while Mining industries use more Diesel as compared to electricity. The other industries use a combination of other fuel but mostly electricity.
- Industrial Electrification at 75% at 2035 (Power System Plan, 2010)
- Electricity makes up only 0.6% of total energy consumption in Tanzania (http://www.tanzania.go.tz/energyf.html).
- The energy use in Tanzania industries is 1362GWh (IEA,2016)

3.4.2 Energy Efficiency (EE) Scenarios

The energy efficiency practices that need to be adopted include facility management and maintenance whereas the machinery used are on regular basis checked for maintenance purposes so as to figure out energy efficiency losses.

Technical skills and awareness training are other forms of energy efficiency practices whereby there is adequate trainings to both the industrial workers on energy efficiency practices. Technical skills and access to related resources to quantify energy savings is also important for energy efficiency in industries, for example when facility managers have technical skills and resources to quantify energy saved thus energy efficiency practices.

- The use of primary energy to produce useful energy

The energy used should not just be wasted but instead help producing energy (e.g heat energy) that could be used to perform other activities. When considering the whole global economy Cullen et al. (2011) concluded that the existing economy could run on 73% less energy by applying known engineering best practice to passive systems that transform energy into services such as buildings. They also estimated the energy reduction potential in conversion devices to be 85% without any reduction in service levels. They concluded that globally, we use 475 exajoules (EJ) of primary energy resources (oil, coal, biomass, renewables and nuclear) to provide 55 EJ of useful energy services (motion, heat, cooling, light and sound). This means that globally we have achieved an overall energy efficiency of just 11% (Fawkes et al., 2016)

- Use of alternative energy such as Geothermal energy

Alternative energy such as geothermal energy and other clean energy should be use in industries so as to reduce the dependency on electricity and natural gas which is the case for Tanzanian industries presently.

- Having strong and effective energy efficiency policy for Industries

Having a strong and effective industrial energy efficiency policy are in three categories: economic, enhanced energy security and reduction in environmental impact. The evidence for the benefits in all three categories is growing. As well as helping to create employment and growth, improving energy efficiency is a cheaper option than energy supply alternatives, whether conventional or renewable.

Based on these findings, industrial energy efficiency in developed and developing countries can be improved considerably by applying existing and economic technologies and improved management. Taking the estimated industrial energy consumption of 4,871 mtoe in 2035 and a conservative 20% energy savings potential, 974 mtoe could be saved (Fawkes et al., 2016)

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the data collection the industrial sector of Tanzania.

4.2 Industrial Energy Consumption

The data collection on energy consumption in Tanzanian industries are based on quantitative and qualitative data. The data gave some highlights and robust insights, focusing on energy sources, fuel consumption costs, and energy use/technologies.

The characterization of the respondents consisted of industries with employees ranging from 10 being the least, and the highest being 2100. The names of the industries were not mentioned to keep the data private and confidential. The annual turnover for most industries were seen to be from 100-500 million Tanzanian shillings, while few ranging over a billion Tanzania shillings; we found three companies out of the sample space are having annual turnover of more than a Trillion Tanzania Shillings.

Based on analysis of the questionnaire, the source of energy mostly used in Tanzanian industries is basically electricity. One company out of the respondents claimed to be using both thermal and electricity while the rest mentioned only electricity as the source of energy. This is shown in Figure 4.1.

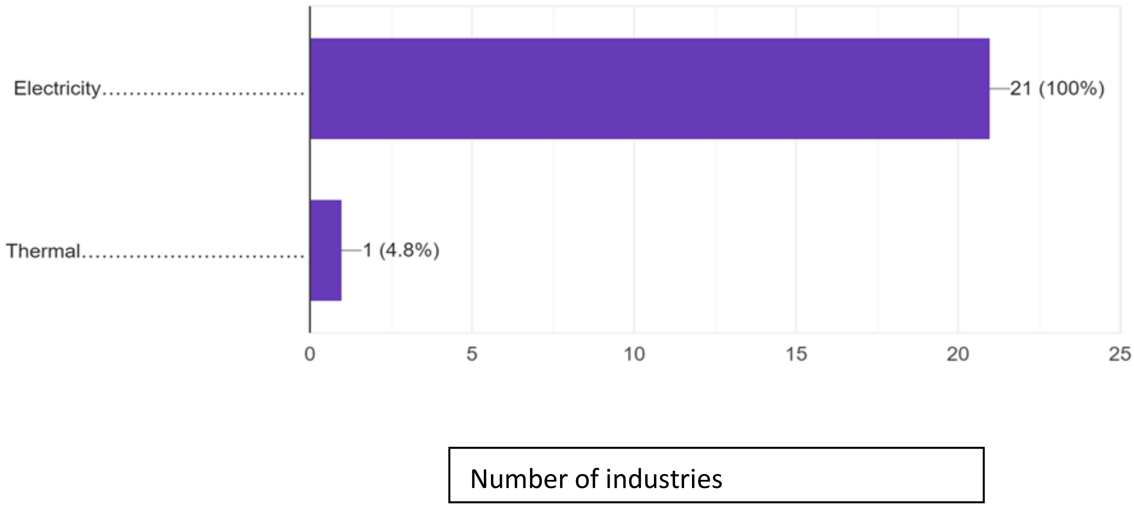


Figure 4.1: Sources of energy used by industries

The data further raised questions on why there are few industries using thermal type of energy, even with the high number of thermal plants that are in the country which sum to 1220.5MW as shown in Table 2.1.

The only industry that was using electrical and thermal energy was Dangote industry which has its own power plant. Dangote Industry has a natural-gas powered thermal power plant with capacity of 45 MW (60,000 hp), in Tanzania. The rest of the industries from the survey were only using electricity as the source of energy.

In this research, it was also found that majority of the industries (i.e., 14/21 which equals 66.67%) from the survey, are having electrical energy metered on the whole site, while 19% (i.e., four industries) of the respondents' have metered energy on the building, and remaining 14.33% (3 industries) have meter energy on the individual equipment (Figure 4.2).

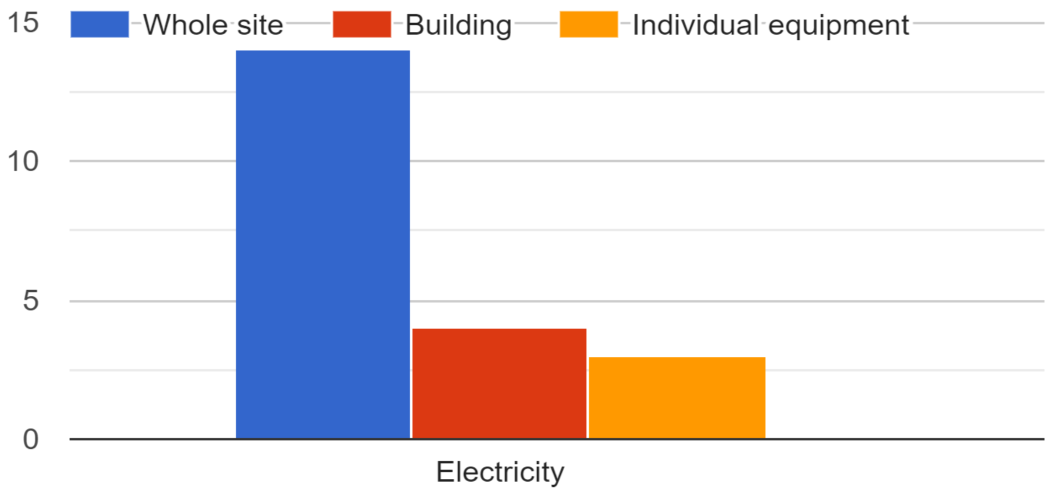


Figure 4.2: Energy metering in industries

Furthermore, we assessed how the energy is frequently being recorded, and if they monitor trends in energy consumption as an energy efficiency practice. About 18 out of 21 respondents totaling 85.7% responded that they record energy on a monthly basis, and the remaining 3 out of 21 respondents (i.e., 14.3%), said they record energy on a weekly basis. The frequent recording of energy is important to monitor trends in consumption, although from the research we found that even with the energy recording that was done by all respondents, 23.8% representing 5 industries, were not monitoring trends in energy consumption (Figure 4.3).

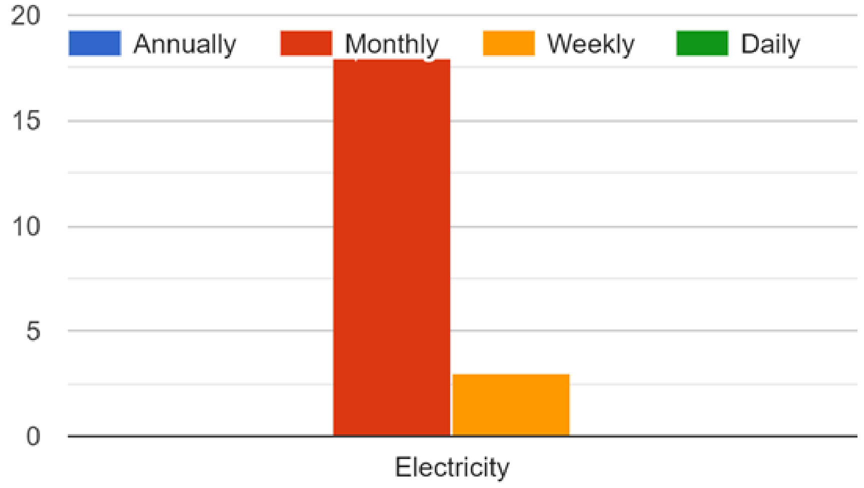


Figure 4.3: The frequency of energy recording

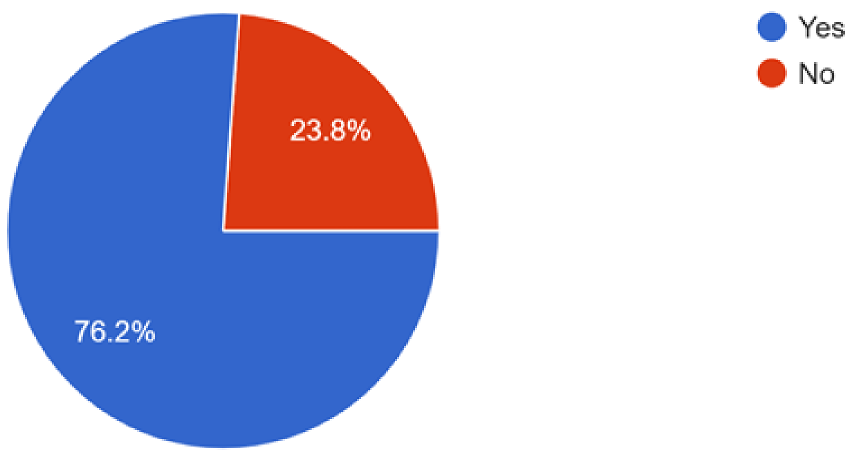


Figure 4.4: Respondents on whether energy recording is important

Energy audit is vital as an energy efficiency measures that reveals usage patterns, identify waste, over-expenditure, thereby making one to adopt energy efficiency mechanisms and practices. The questionnaire survey revealed that energy audit is not largely practiced in industries in Tanzania, because almost half of the respondents i.e., 40% of the respondents said that they do not perform energy audits in their respective companies. Energy management and energy policies for industries were also seen to be a myth as they were not practiced by majority of the respondents. About 71.4% i.e., 15 out of 21 respondents did not have energy policy for their industry, and only 6 respondents which 28.6% had energy policies for their respective industries. This is shown in Figure 4.5.

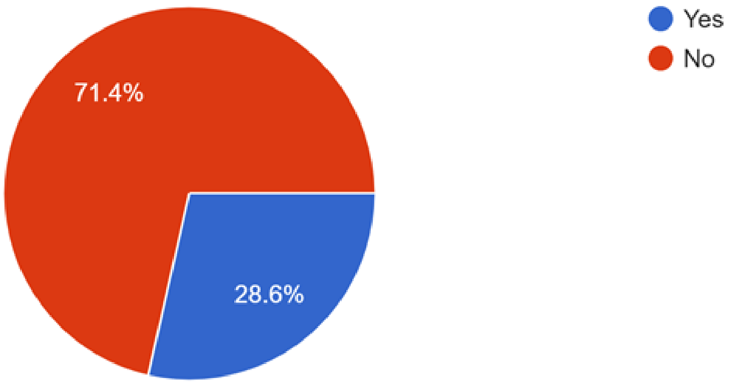


Figure 4.5: Respondents on Energy Audit

4.3 Results on Scenarios and Forecasting

4.3.1 Business As Usual (BAU)

In the Business As Usual scenario (BAU), factors such as growth in the different industrial sectors and projections of electricity and geothermal energy were considered. Simulations that were run by LEAP software showed energy consumption by the type of industries by 2040, being 4.7958 Terajoules for the industrial sector. Table 4.1 shows the total energy consumption in an interval of 5years. The lowest increment was in the year 2015-2020 which was 180.4 thousand GJ, while the highest increment is observed to be between the year 2030-2035 at 663.2 thousand GJ in a period of 5 years, which gives about 132.64 thousands GJ per year.

Table 4.1: Total final Energy by different industries at BAU

Energy Demand Final Units						
Scenario: Business As Usual						
Branch: Demand\Industries						
Units: Thousand Gigajoules						
Fuel	2015	2020	2025	2030	2035	2040
Electricity	2,135.8	2,211.4	2,307.9	2,431.4	2,851.0	3,118.9
Natural Gas	208.8	260.2	324.2	404.0	503.5	627.4
Diesel	133.2	185.9	259.5	362.3	505.8	706.1
LPG	340.4	340.4	340.4	340.4	340.4	340.4
Geothermal	-	0.6	1.2	1.8	2.4	3.0
Total	2,818.1	2,998.5	3,233.2	3,539.9	4,203.1	4,795.8

Throughout the years the energy consumption for manufacturing industries continues to rise, followed by the mining sector, and lastly the other industries as shown in Figure 4.6. The demand side management report of 2014, states that ICF also estimates that higher levels of consumption occur in sub-sectors such as mining and cement production, whereas cement industry is part of the 4-manufacturing industry.

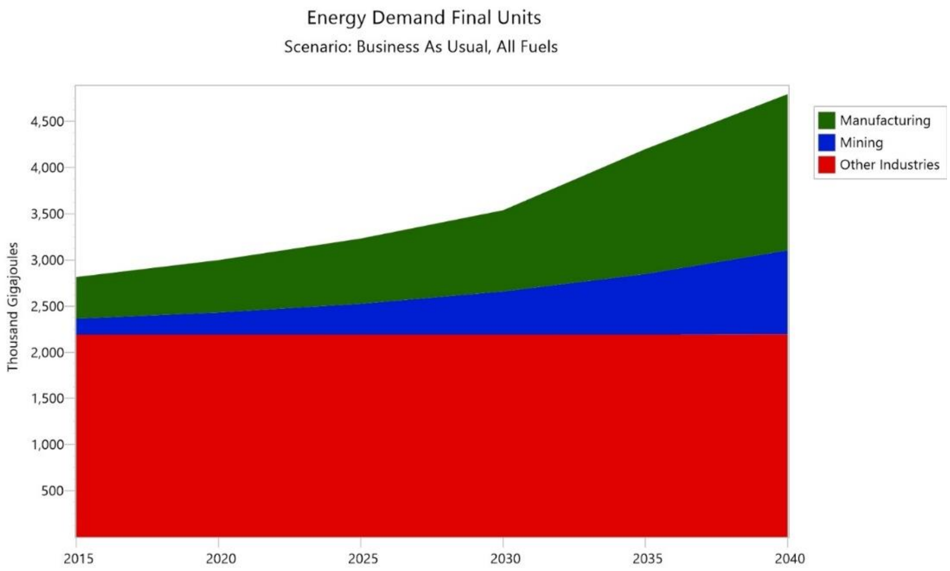


Figure 4.6: Area graph for energy consumption in BAU scenario

The fuel that is mostly used is electricity in both the base year and final year is shown in Figure 4.7. Other energy types such as natural gas, LPG and diesel, continue to be on the rise over time; but diesel is found to exceed natural gas and LPG.

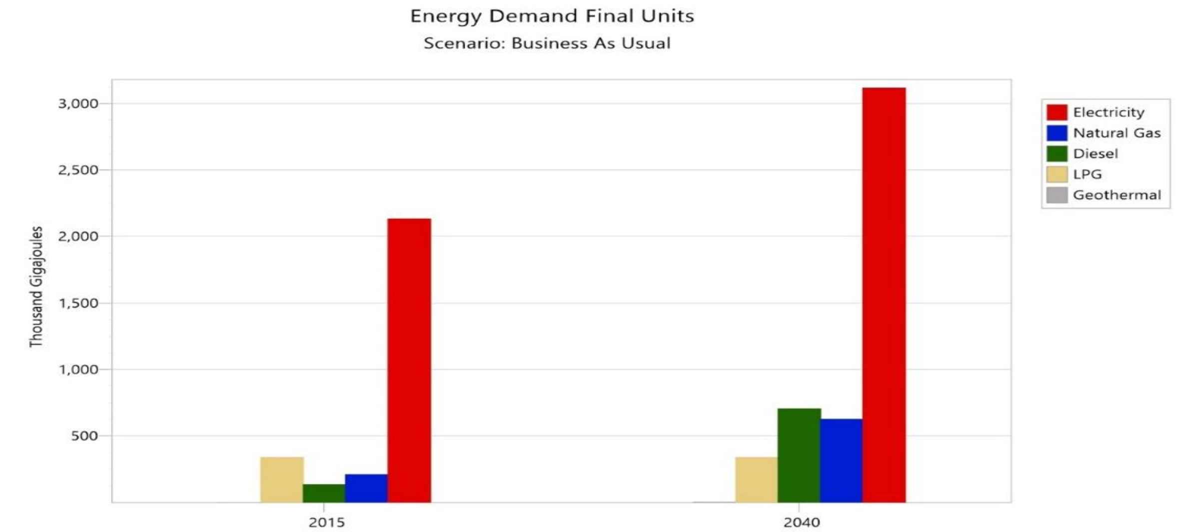


Figure 4.7: Energy consumption in BAU scenario per specific fuel

4.3.2 Energy Efficiency (EE) Scenario

In the energy efficiency (EE) scenario, the assumption was derived from the best practices and case studies for the industrial energy efficiency improvement. The work of Fawkes et al., (2016) expressed that the conservation of energy up to 20% is possible by 2035. With energy efficiency practices in place, the energy consumption is seen to be decreasing as we move towards the final year 2040. In 2015 the total energy consumption is shown to be 2818.1 thousand GJ whereas in 2040 it is 2.172 TeraJoules, thus bringing a difference of 645.8 thousand GJ from 2015 to 2040. Table 4.2 shows the total energy consumption in industries in Tanzania, with energy efficiency practices in place.

Table 4.2: Total final Energy by different industries at EE scenario

Energy Demand Final Units						
Scenario: Energy Efficient Scenario						
Branch: Demand\Industries						
Units: Thousand Gigajoules						
Fuel	2015	2020	2025	2030	2035	2040
Electricity	2,135.8	1,987.4	1,849.3	1,720.8	1,601.2	1,490.0
Natural Gas	208.8	208.8	208.8	208.8	208.8	208.8
Diesel	133.2	133.2	133.2	133.2	133.2	133.2
LPG	340.4	340.4	340.4	340.4	340.4	340.4
Geothermal	-	-	-	-	-	-
Total	2,818.1	2,669.7	2,531.7	2,403.2	2,283.6	2,172.3

The consumption of energy in EE scenario continues to fall as we move from the base year 2015 to the final year 2040. Manufacturing industry is seen to consume a lot of energy in a similar way with the BAU scenario. Mining follows suit with much lower consumption as compared to manufacturing industry, while other industries gave a much lower energy consumption, as compared to the two aforementioned industries (Figure 4.8).

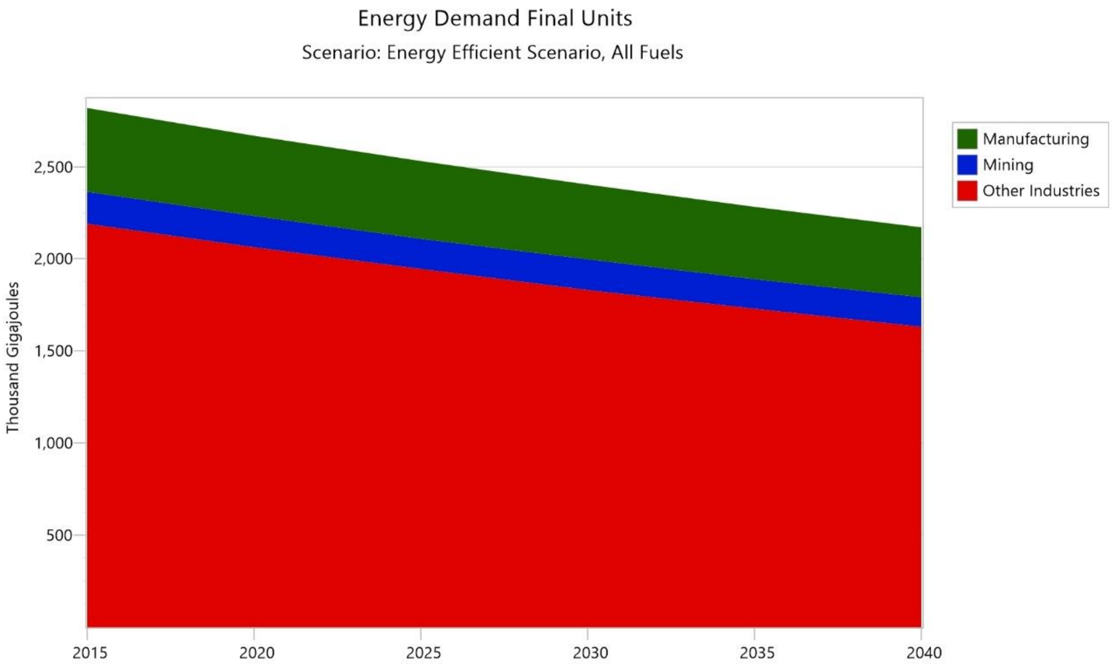


Figure 4.8: Area graph for energy consumption in EE scenario

The fuel mostly used in industries is electricity followed by LPG, natural gas and diesel in that order. The electricity decreases by a factor of 1.43% yearly up to 2035, resulting in exactly 20% in line with the assumption by Fawkes et al., (2016). This is shown in Figure 4.9.

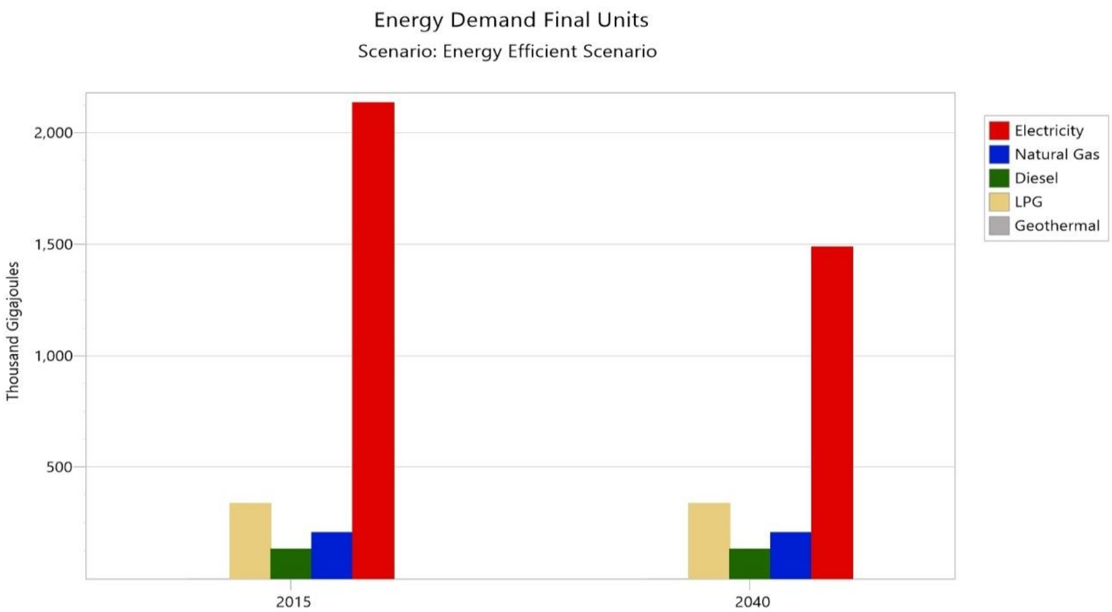


Figure 4.9: Energy consumption in EE scenario per specific fuel

4.4 Energy savings resulting from Energy efficiency practices

From the analysis above for the BAU and EE scenarios, we tend to see that with BAU, the energy consumption is directly proportional to years progressively. On the other hand, it is different with the EE scenario whereby there is decrease in energy consumption with increasing years as shown in Figure 4.10. The difference between the two graphs is the total energy saved in adopting energy efficiency practices. The analysis showed that 2.6235 TeraJoules will be saved when adopting EE scenario, and which is more than 50% energy savings.

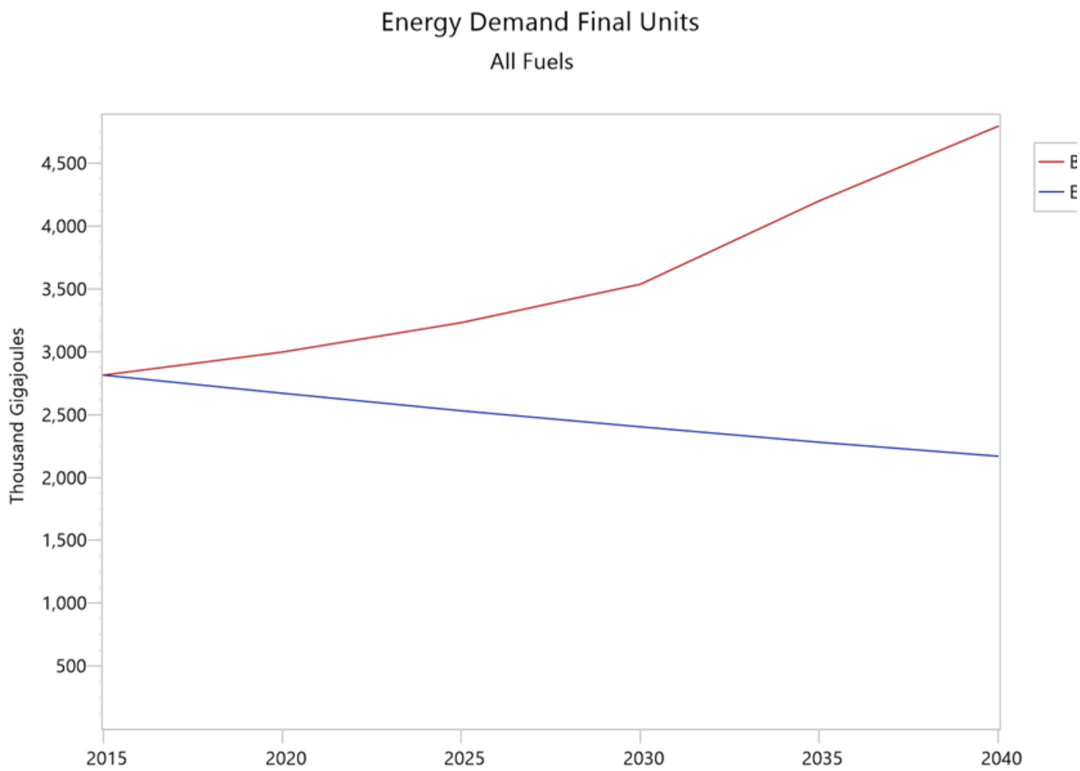


Figure 4.10: Energy demand at BAU and EE scenarios

4.5 Barriers to energy efficiency and energy conservation in industries

An interview conducted with the different energy managers and experts' association leaders in their respective fields, revealed the different strategies aiming at enhancing EE in Tanzanian industries. From interviews, different barriers and drivers have been found during research as seen below:

4.5.1 Barriers

1. **Policy barrier**: Despite the energy efficiency campaign on energy efficiency and energy efficiency practices, the government of Tanzania has not implemented a dedicated energy efficiency policy. They neither have the general nor the specific for the different sectors energy efficiency policy, thus making it difficult for citizens and industries to practice energy efficiency.
2. **Informational barriers**: These barriers relate to the dissemination of information regarding EE among all stakeholders throughout the EE supply chain, from policy makers to end-users. People have to be informed about EE technologies and their advantages. A special focus has to be given to information and communication activities with the aim of raising awareness about EE technologies, their benefits and the roles of energy efficient users' behavior. Taking an example of the questionnaire survey we got to discover that a lot of industries do not follow EE practices and the main reason being ignorance of energy efficiency.
3. **Institutional barriers**: The Tanzania Energy Supply Company (TANESCO) is the sole institution with the significant role of electricity supply in the country. There is no institution that is responsible for energy efficiency practices, thus becoming so difficult to enhance and regulate energy efficiency practices. Nevertheless, for energy efficiency activities to be effective in a country, there should be a dedicated institution or agency/body in a suitable part of the government structure with a leading mandate and a suitable budget to work as the energy efficiency champion and flagship leader. The lead energy efficiency institution or agency must have the right mix of suitably skilled human resources with adequate funding to effectively fulfil its role. While being an active participant in developing the practical aspects of energy efficiency policies and managing suitable energy efficiency programmes and projects, it would also have a leading role in conducting energy efficiency training and awareness campaigns

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study assessed the impact of energy efficiency policies on future energy demand in Tanzania's industrial sector. The results showed that four energy sources dominate the industrial sector and are: electricity, diesel, natural gas and LPG. It is worth noting that Tanzania has potential of other energy sources such as geothermal, but yet to be exploited to its full potential thereby creating dependence on the aforementioned sources. The study evaluated the forecast of energy consumption based up on various scenarios. The analysis results with a BAU scenario shows that as the result of the growth of the industrial sector, the demand for energy is increasing very fast, while the energy supply is declining due to inefficient utilizations.

The demand of energy sources especially electricity is increasing, and analyses show that the total energy demand in 2040 will be 4,795.8 thousand GJ on BAU scenario and total energy demand of 2,172.3 thousand GJ on EE scenarios. At EE scenario, the electricity decreases by a factor of 1.43% yearly up to 2035. The limitation of the study is uncertainty and lack of consistent past historical data while the few studies previously conducted could not reveal energy consumption in the different industrial sub-sectors.

5.2 Recommendations

In order to promote energy efficiency practices in industries thereby minimizing energy losses, the following should be done:

1. Similar studies in the future may focus more on obtaining past historical data, if possible. The study could be conducted over years using primary data, to forecast the future energy consumption accurately.
2. Energy institutions in the country should promote awareness of energy savings to the people. It must be emphasized that many industries may not understand the technicalities in saving a unit of energy.
3. For energy savings, more and better data and information are needed on energy end-use and the usage of energy-consuming products. It would be important to develop a database of EE indicators for Tanzania, for data availability.
4. Effective implementation of policy and legislation on EE practices for industries.

5. Establishment of institutions that develop and promote EE policies. The creation of a dedicated energy efficiency institution or agency with a suitable mix of skilled professional staff, empowered with readily available fundings, will be a key component in any effective long-term energy efficiency policies in Tanzania.

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APPENDIX 1

Questionnaire for thesis work on energy efficiency practices and industrial energy management– a case study of Kenyan industries.

Please, be assured that any information provided will be treated confidentially.

1. **The company**

Number of employees (approximate)……………………………………………

Annual turnover (approximation)……………………………………………….

2. **Type of energy used**

Please tick the type of energy used in your company

Electricity……………………………………………

……………………..

Thermal……………………………………………………………………………

3. **Annual energy use**

Please indicate your company's approximate annual consumption of:

Fuel…………………………………………………………………………………

Electricity……………………………………………………………………...

(Please indicate units)

Please indicate your company's approximate annual expenditure on:

Fuel……………………………………………………………………………….

Electricity…………………………………………………………………………

4. **Energy information systems**

At what level is energy generally metered?

	Whole site	Building	Individual equipment
Electricity			
Steam/hot water			

How frequent is energy use generally recorded?

	Annually	Monthly	Weekly	Daily
Electricity				
Steam/hot water				

	Yes	No
Do you monitor trends in energy consumption?		
Are consumption records adjusted to energy price change?		
Is a monitoring and targeting scheme employed?		
Is energy performance advised to staff?		
Is consumption compared with benchmarks?		
Have you conducted energy audits?		

5. Energy management profile

i. Does your company have an explicit energy policy?

Yes [ ] No [ ]

ii. If yes, is the top management of your company committed to the energy policy?

Yes [ ] No [ ]

iii. If yes, is the energy policy fully integrated into your company's operation?

Yes [ ] No[ ]

iv. Does your company have an implicit energy policy?

Yes [ ] No [ ]

i. If yes, please state the related system or policy

……………………………………………………………………………………………

……………………………………………………………………………………

v. If yes, is the top management of your company fully committed to the energy policy?

Yes [ ] No [ ]

vi. If yes, is the energy policy fully integrated into your company's operation?

Yes [ ] No [ ]

vii. If yes, what is the level of awareness among staffs in the company?

High [ ] No [ ]

viii. Does your company have an energy management system?

Yes [ ] No [ ]

ix. If yes, name and comment on the features of the energy management system

……………………………………………………………………………………………
……………………………………………………………………………………

6. Energy efficiency opportunities

i. There exist cost-effective energy efficiency measures at my company, which can be implemented and considered profitable according to the company's investment criteria

Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know

ii. What is the estimated payback time for investing in the energy efficiency measures at the current energy price?

No idea	<1yr	<2yrs	<3yrs	>3yrs

7. Information sources

How useful do you consider the following sources to be as regards to information on energy efficiency measures?

	Excellent (1)	Good (0.75)	Average (0.5)	Poor (0.25)	Don't use (0)
Colleagues within the company					
Colleagues within the sector					
Sector organization					

Written sources of information such as journals					
Information from power companies					
Conferences and seminars					
Energy audit reports					
Energy commission (ERC)					
Equipment manufacturer					

8. **Measures**

The following table lists some common measures for reducing energy consumption. Please indicate the extent to which your company has implemented each measure by assigning it a number on a scale from 0 (not implemented) to 1 (extensively implemented).

Measures	0	0.25	0.5	0.75	1
Good house keeping					
System optimization					
Staff capacity building and training					
Adoption of energy management system					

9. **Others**

Please indicate any other major energy efficiency measures that you have implemented but which are not indicated above:

……
…………………………………………………

………………………………

10. Barriers to energy efficiency improvement

……
………

11. Studies by researchers identify energy efficiency measures which are cost-efficient but which are not implemented. According to the aggregated experience in your company, how do you value the following factors impact on the implementation of cost-effective energy efficiency measures at your company?

	Often important (1)	Sometimes important (0.5)	Rarely important (0)
High initial cost			
Inadequate budget funding			
Other priorities on expenditure			
Production based priorities			
Inadequate technical skills			
Beauracracy			
Lack of submetering			
Inadequate staff capacity building & training			
Inadequate information on energy efficiency opportunities			

Do you have any further comments on barriers to energy efficiency improvement?

………………………………………………………………………………………………………
……………………………………………………………………………………………

Do you have any further comments on driving forces for energy efficiency improvement?

………………………………………………………………………………………………………

……………………………………………………………………………………………

10. Driving forces for energy efficiency improvement

Successful industrial energy management is characterized by a number of factors, external as well as internal. According to the aggregated experience in your company, how do you value the following factors impact on the implementation of cost-effective energy efficiency measures at your company?

Barriers	Often important (1)	Sometimes important (0.5)	Rarely important (0)
Cost reduction by lowering energy use			
Increase production			
Institution requirements e.g audits, energy management regulation,2012			
Recognition as green company e.g Energy Efficiency awards			
Threat of rising energy prices			
Investor's interest in Energy Efficiency			
Operation reliability and control			
Avoidance of capital expenditure			
International competition			
Government incentives			
General energy advices through seminars, journals, booklets etc			

Thank you very much for completing this questionnaire.

APPENDIX 2

List of Industries in Tanzania by Sectors According to CTI Directory 2015

S/N	INDUSTRY BY SECTOR	NUMBER OF INDUSTRIES
1	Building and Construction	17
2	Chemical and Chemical products	34
3	Energy, Electrical (Machinery, Equipment services) &Electronics	16
4	Finance, Insurance, Real Estate & Consultancy	27
5	Food, Beverage and Tobacco	69
6	Hospitality and Training	17
7	Leather products and footwear	7
8	Metal and Metal products	36
9	Mineral products	20
10	Motor vehicles and accessories	7
11	Paper, Paper products, Printing, Publishing and packing materials	38
12	Pharmaceuticals and Medical Equipment	4
13	Plastic and rubber Products	45
14	Several	6
15	Textiles and apparels	12
16	Timber and wood products	9
17	Transport, Storage & Communication	17
	Total	381