Green Climate Fund Readiness Project

Market Assessment Report on Residential Refrigerators and Distribution Transformers

Zambia

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By

Basel Agency for Sustainable Energy (BASE), International Copper Association (ICA), and Southern African Development Community's (SADC) Centre for Renewable Energy and Energy Efficiency (SACREEE)

For

UNEP-CTCN GCF Readiness Project on "National framework for leapfrogging to Energy Efficient Appliances and Equipment in Namibia (Refrigerators and Distribution Transformers) through regulatory and financing mechanism"

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Abbreviations

BGFA	Beyond the Grid Fund for Africa
BGFZ	Beyond the Grid Fund for Zambia
COMESA	Common Market for Eastern and Southern Africa
CSO	Central Statistics Office
DoE	Department of Energy
DPs	Development Partners
DBZ	Development Bank of Zambia
EIA	Environmental Impact Assessment
EE	Energy Efficiency
ERB	Energy Regulation Board
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GEF	Green Climate Fund
GET FiT	Global Energy Transfer Feed-in Tariffs for Zambia
GRZ	Government of the Republic of Zambia
GW	Gigawatt (109 Watts) unit of electric power
IAEREP	Increased Access to Electricity and Renewable Energy Production
IPPs	Independent Power Producers
IRP	Integrated Resource Planning
KGL	Kafue Gorge Lower
KGRTC	Kafue Gorge Regional Training Centre
kWh	kilowatt hour
M^2	Square Meter
MEPS	Minimum Energy Performance Standards
MOE	Ministry of Energy
MT	Metric Ton
MW	Megawatt (106 Watts) unit of electric power
NDC	Nationally Determined Contributions
NDP	National Development Plan
NEP	National Energy Policy
OPPPI	Office for Promoting Private Power Investment
PPA	Power Purchase Agreement

PPP	Public-Private-Partnerships
PV	Photovoltaic
RE	Renewable Energy
SACREEE	Southern Africa Centre for Renewable Energy and Energy Efficiency
SADC	Southern Africa Development Community
ZABS	Zambia Bureau of Standards
ZEMA	Zambia Environmental Management Agency

1.0 Executive Summary

The network partners Basel Agency for Sustainable Energy (BASE), International Copper Association (ICA), and Southern African Development Community's (SADC) Centre for Renewable Energy and Energy Efficiency (SACREEE) are providing technical services for the implementation of a GCF Readiness project with Climate Technology Centre and Network (CTCN) through United Nations Environment Programme (UNEP) as implementing institution and United for Efficiency (U4E) as technical partner on national frameworks for leapfrogging to energy-efficient appliances and equipment in Zambia through regulatory and financing mechanisms. The primary objectives of the technical assistance project are to improve the country programming process regarding residential refrigerators and distribution transformers and strengthen the climate finance strategies and pipeline.

The readiness project aims to put in place mandatory Minimum Energy Performance Standards (MEPS) and a labeling scheme, which will create an enabling policy and regulatory environment for refrigerators and distribution transformers in Zambia. In addition, the project will include key components such as national policy roadmaps and enabling environments for the implementation of standards and labels, appropriate financing mechanisms to accelerate deployment of energy efficient refrigerators and distribution transformers and strengthened national capacity to develop standards and labels for other appliances in future.

This will transform the market to energy-efficient refrigerators and distribution transformers and ultimately reduce the strain on the electricity grid, increase disposable income for householders and potentially reduce greenhouse gases (GHG) emissions. The activities are being coordinated with similar GCF readiness projects in 7 additional Southern African countries (Botswana, Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zimbabwe) and also regional harmonization efforts, which are being coordinated by UNEP's United for Efficiency (U4E) initiative.

This market assessment report for residential refrigerators and distribution transformers was conducted with the main objective of informing the development and subsequent adoption of Minimum Energy Performance Standards (MEPS), labels, and financial mechanisms for the two products. The entire readiness project however is aimed at improving the country`s programming process regarding refrigerators and distribution transformers as well as strengthening the climate finance strategies and pipeline. The market assessment was informed by three types of surveys conducted for household refrigerators, their supply chain and distribution transformers respectively. This was conducted country wide with sample sizes of 200 for household refrigerators, 20 for the refrigerator supply chain and 10 for the distribution transformers. The exercise was carried out alongside desktop studies on the three areas.

The assessment revealed a number of findings that will be useful in progressing the readiness project for Zambia. Key features include the government`s awareness of the important role energy efficiency of the two products could play in the growth of the economy. To this end the government through the Ministry of Energy has put in place efforts to support the enactment of legal instrument that will help establish a framework to support the renewable energy and energy efficient sub-sector. The Zambia Renewable Energy Strategy and Action Plan (RESAP) is meant for the enhancement of the policy, legal and regulatory environment and capacity building for renewable energy. Zambia's RESAP provides a structured roadmap that will guide the development of the sector. Its ultimate goal is to significantly increase the uptake of renewable energy technologies in Zambia and contribute to economic growth and poverty reduction. The RESAP elaborates the activities to be undertaken to overcome the market barriers currently hindering the wide scale diffusion of renewable energy technologies (DTGlobal, 2021). Further to the RESAP is the Energy Efficiency strategy and Action Plan that is currently under development with support from the European Union under the Increased Access to Electricity and Renewable Energy Production Program (IAEREP) (EU, 2021).

The Ministry of Energy has further expanded and revised the National Energy Policy (NEP) of 2008 resulting in the revised NEP of 2019 and Electricity Act of 2019. The NEP of 2019 includes priority areas on renewable energy and energy efficiency. Its objective on Energy Efficiency is ***to promote efficient use of energy resources in order to conserve natural resources for the benefit of future generations.*** (GoZ, 2019)

The country has also demonstrated that transition to efficient refrigerators and distributional transformers would be supported by the already adopted technical standards that are in place through the national standards body, Zambia Bureau of standards. ZABS indicated that they have technical standards for both refrigerators and distributional transformers except these standards are not mandatory and the scope of these standards do not include aspects of product energy efficiency. Efforts to develop MEPS for lighting, lamps, electric motors, and solar water heaters are under way in the country but there is a lack of coordination to ensure an integrated and comprehensive approach. Product labels and financial mechanisms that could support this transition are non-

existent in Zambia as most financial institutions do not have programs that directly or indirectly seem to support or promote the use or manufacture of energy efficient refrigerators or distributional transformers.

The market outlook for both refrigerators and distribution transformers is attractive in Zambia in the sense that both products have attracted international market while creating appetite for local consumption. The refrigerator sector is hugely dependent on imports from South Africa, China, Zimbabwe, and Europe as a source of supply while the Distribution Transformer sector has both imports and local manufacturing base supporting the supply chain.

Estimated average price of a refrigerator based on the residential refrigerator survey was found to be approximately 440 USD[1] (7367 ZMW) and the market value estimated at around 33,000,000 USD (552,000,000 ZMW) in 2021. It's estimated that by 2030 the market value of refrigerators could be slightly above 43,000,000 USD (720,000,000 ZMW). The current total stock of refrigerators for 2021 was estimated to be around 790,000 refrigerators and this is expected to increase by about 30% by 2030. This was based on an economic model incorporating a replacement rate per year of 7% annually and an estimated 3.1% residential refrigerator market growth rate.

Zambia has an estimated total of 400 substations in the transmission system countrywide with each substation on average, having 1 or 2 power transformers with step-down capacities of 330/132kV or 132/33kV or 33/11kV. The power network in Zambia is owned and operated by ZESCO the national power utility. The power network is mostly distributed at the endpoints by pole mounted distribution transformers categorized by voltage levels between 66kV, 33kV and 11kV.

The market flow of transformers involve mainly importation from foreign countries namely China, South Africa and India. These imported transformers are then subjected to excise duty and VAT regulations by the Zambia Revenue Authority (ZRA). The Zambia Bureau of Standards and Energy Regulation Board (ERB) have a role to ensure adherence of imported transformers to technical specification though currently there are no mandatory standards for distribution transformers.

It is envisaged that the transformer market will double in a few years considering government`s ambitious electrification plans of universal electricity access goal (90% for urban areas and 51% for rural areas by 2030). This will of course see an increase in electricity demand which is hoped to spur the need for more efficient and quality transformer units. The electric appliances sector is also envisaged to grow as Zambia has positioned itself as a conduit(transit) for most goods coming from South Africa to other neighboring countries of Zambia or vice versa. Zambia does not only import refrigerators but also exports refrigerators, freezers and other refrigerating or freezing equipment to the neighboring countries with a value totaling 600,000 USD in 2020. This is expected to grow and with improved regulation and financial strategies it is hoped that the market will slowly transition to more efficient refrigerators. Discussions also on demand side management from the power utility end suggest that promoting more efficient electric household appliances would support initiatives of increased access as this will reduce residential demand and allow the power utility to connect more customers to the nation grid.

The report details all these aspects and highlights further some of the findings regarding types of refrigerator brands, common refrigerants, and energy efficient ratings of the various types of refrigerators. Further it highlights some of the identified barriers to the transition to efficient refrigerators and transformers, environmental and disposal aspects of both refrigerators and distribution transformers.

The overall finding of the market assessment is that, with a slight push from the donor community Zambia is poised to have a smooth transition to efficient refrigerators and distribution transformers. Over 120 refrigerators sampled out of 200 were A rated for energy efficiency, this is a good indicator that the market has already embraced energy efficiency products.

Technical assistance in the area of energy efficiency policy and regulation, fiscal and technical standards from the international community and development partners would help accelerate the adoption of energy efficient refrigerators and distributional transformers in the country. The government is already making efforts in creating an enabling environment to support this transition but also the market seems to be ready and willing to pay an extra cost for these efficient products. The aspect of affordability and awareness will also need to be addressed to ensure consented efforts and a buy in from the general public on the implementation of the GCF project.

[1] Unless otherwise stated, the exchange rate of USD 1= ZMW 16.74 is taken throughout the report

2.0 BACKGROUND AND INTRODUCTION

On 9th December 2016, Zambia ratified the Paris agreement on climate change. This followed the submission of the country`s plan for climate action known as the Nationally Determined Contributions (NDC). Renewable Energy and Energy Efficiency are one of the three programs which were identified as part of the mitigation component in the assessment undertaken as part of the intended nationally determined contributions.

As a means of implementing the climate action plan, Zambia is participating in the Green Climate Fund (GCF) Readiness and Preparatory Support Programme (the Readiness Programme) which supports country-driven initiatives by developing countries to strengthen their institutional capacities, governance mechanisms, and planning and programming frameworks towards a transformational long-term climate action agenda. Eight countries in Southern Africa[2] have embarked on the GCF Readiness projects on 'Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers. This is aimed at building and strengthening the countries energy efficiency policy and regulatory frameworks.

BASE in partnership with the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) and International Cooper Association (ICA) is providing technical services for the implementation of GCF Readiness projects in Malawi, Namibia, Zambia, and Zimbabwe through regulatory and financing mechanisms. The objectives of the technical assistance projects are to improve the country programming process on refrigerators and distribution transformers and strengthen climate finance strategies and pipeline.

The projects aim to put in place mandatory Minimum Energy Performance Standards (MEPS) and a labelling scheme, which will create an enabling policy and regulatory environment for refrigerators and distribution transformers in Zambia. In addition, the projects will include key components such as national policy roadmaps and enabling environments for the implementation of standards and labels, appropriate financing mechanisms to accelerate deployment of energy efficient refrigerators and distribution transformers and strengthened national capacity to develop standards and labels for other appliances in future.

This will transform markets to energy efficient refrigerators and distribution transformers and ultimately reduce the strain on the electricity grid, increase disposable income for householders and potentially reduce GHG emissions.

Based on the preliminary market research conducted by CTCN in Zambia (UNEP, 2019), five primary energy-consuming appliances and equipment were identified as lighting, air conditioning, refrigerators, motors and transformers. Refrigerators and distribution transformers were prioritized as focus products for the development of a national framework on energy efficiency. Distribution transformers were selected considering the growth of the electrification rate in Zambia from 35% in 2016 to 43% in 2019 (WorldBank, 2019) while refrigerators were selected due to their higher growth in the market resulting in increased energy demand.

Given the demonstrated political will by the Government of Zambia (GRZ) to increase access to electricity, Zambia stands to benefit from the deliverable of the project which include development and enforcement of national policy roadmaps for the promotion of higher efficiency refrigerators and distribution transformers, including Minimum Energy Performance Standards (MEPS), Highest Energy Performance Standards (HEPS), labelling scheme, consumer awareness, end-users' education, capacity building for custom and procurement officials, MV&E framework, as well as appropriate financing mechanisms and strategies to accelerate deployment of energy-efficient residential refrigerators and distribution transformers. These will contribute to the country`s efforts of universal energy access goal (90% for urban areas and 51% for rural areas by 2030) (GoZ, 2006). The GRZ, through the Vision 2030 and the 7th National Development Plan, recognises that access to affordable, reliable and sustainable energy is one of the main drivers for social and economic development.

Energy efficiency stands at the core of both reducing demand from the consumer end and facilitating increased access to reliable and sustainable electricity on the supply end. It remains a key aspect that will assist to improving energy access, especially in emerging economies where there is increasing energy demand. In combination with grid expansion and new clean energy generation, efficiency efforts can help to ensure that reliable power is provided to the maximum number of customers at a lower cost than would be required to increase generation alone.

Zambia's total population is expected to grow from 17.9 million in 2019 to 26.9 million by 2035 leading to an increase in the demand for energy services (GoZ, 2019). The energy sector therefore needs to put in place measures and interventions to meet the future demand. Zambia's overall national energy objectives are to promote sustainable national development by creating conditions that ensure the availability of adequate and reliable supply of a diverse energy mix at the least economic, social and environmental costs. These objectives are guided mainly by the National Energy Policy (NEP) 2019, Vision 2030, and National Development Plans. As part

[2] Botswana, Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia and Zimbabwe.

of its national energy strategy, Zambia emphasises the development and deployment of renewable energy and energy efficiency as well as increasing private sector participation in the energy sector. These national strategies have common goals-to facilitate universal energy access as well as to achieve key sustainable development goals. To facilitate wider diffusion of renewable energy and energy efficiency technologies, the NEP 2019 seeks to strengthen institutional capacity for research and development in renewable energy and energy efficiency, enhance coordination among key stakeholders for effective implementation of renewable energy and energy efficiency technologies, and aims to promote wider usage of these technologies.

Zambia is implementing energy efficiency initiatives which include promotion of efficient utilisation of energy services and switching to other alternative types of energy sources and technologies. Specific efforts have been on the development of energy performance standards developed for lighting, lamps, electric motors, and solar water heaters. However, these efforts need to be well coordinated and extended to other energy services. The absence of dedicated instruments such as building codes, and Minimum Energy Performance Standards has affected adoption of energy efficiency and conservation (GoZ, 2019). This project is expected to develop a national framework for leapfrogging to energy efficient products. The Project aims to develop national policy roadmaps for the promotion of higher efficiency refrigerators and distribution transformers, including Minimum Energy Performance Standards (MEPS), Highest Energy Performance Standards (HEPS), labelling scheme, consumer awareness, end-users' education, capacity building for custom officials and procurement officials, and MV&E framework, as well as appropriate financing mechanisms to accelerate deployment of energy-efficient residential refrigerators and distribution transformers.

Since 2020 Zambia has been part of an additional regional effort which is the harmonization of energy efficient policies on residential refrigerators and air conditioners. The countries of the Eastern African and South African regions are working together with the project partners SACREEEE, EACREEE and UNEP-U4E to develop harmonized MEPS and labelling. The project is particularly noteworthy in this context as it focusses on the same appliance as the national project for Zambia, namely on energy efficient refrigerators. As of August 2021, the regional MEPS had been drafted and are currently under review with the regional Technical Committees that had been formed for this purpose. Anteriorly, the project has also conducted a regional market assessment across both region and developed technical notes that include technical recommendations on the MEPS development. More information and the related documents can be accessed here. The MEPS and labels development for Zambia within the national GCF project will happen in synergy with the regional policies developed under this project.

3.0 METHODOLOGY AND APPROACH

3.1 This chapter presents the data collection methodology and approach used in the development of this market assessment repo**Objective and Scope**

The national market assessment for residential refrigerators[3] and distribution transformers was conducted with the objective to inform the development and subsequent adoption of national policy roadmaps for the promotion of higher efficiency refrigerators and distribution transformers, including Minimum Energy Performance Standards (MEPS), Highest Energy Performance Standards (HEPS), labelling scheme, consumer awareness, end-users' education, capacity building for custom officials and procurement officials, and MV&E framework, as well as appropriate financing mechanisms to accelerate deployment of energy-efficient residential refrigerators and distribution transformers.

The scope of this assessment was limited to the following sectors.

1. Consumers- to collect information on residential refrigerators and freezers.
2. Utilities- to gather information on distribution transformers.
3. Government ministries, energy efficiency entities, customs, standards, and regulatory bodies.
4. Private sector which included technology providers, manufacturers, local and regional distributors, local retailers, local consulting engineers and technicians.
5. Banks and financial institutions.

3.2 Existing Information Sources and Gaps

The study leveraged a number of information sources including stakeholder interviews and questionnaires for primary data on residential refrigerators, supply chain of refrigerators and distribution transformers. Several literatures were also reviewed for secondary data. Information on residential refrigerators and the supply chain of refrigerators was mainly gathered through the survey that was conducted. This information was found to be very helpful in understanding residential refrigerators' electricity consumption patterns and various related dynamics involved in the supply chain of refrigerators. Some of the challenges with the survey included delayed and/no responses from respondents and failure to disclose full information attributed to lack of awareness of the project. But also, some respondents particularly from the supply chain showed reluctance to answer questions in the questionnaire that were deemed market competitive. Furthermore, some companies indicated that they didn't have time to complete such long questionnaires due to their busy schedules.

Information gathered for the distribution transformers was both from interviews with stakeholders and literature review. This information was very difficult to collect as most of the relevant institution were not just willing to provide the information while others indicated they needed more time to gather the requested information. Zambia has a manufacturing base of distribution transformers, and it was expected that it would be easy to collect information on transformers but unfortunately this was not the case. Additionally, the country has no repository where information on distribution transformers manufactured, imported/exported, installed, or decommissioned could be recorded. Efforts to engage the power utility and the manufacturers proved less productive.

Secondary data was easy to collect with several documentations from relevant internet sites and government departments such as Department of Energy (DoE), Energy Regulation Board (ERB) and Central Statistics Office (CSO) helping. Several other sources were consulted for the same type of information and for data validation purposes.

3.3 Information Gathering Methodology

According to the guidance note, the activities that were planned to be conducted under the market assessment included the following:

- Collection of primary data through stakeholder outreach, identification, and interviews through a bottom-up approach for residential refrigerators and a hybrid approach (bottom-up and top-down) for distribution transformers.
- Collection of secondary data that is already in existence on the subject matter.
- Analysis, validation, and interpretation of data collected and

[3] Includes refrigerators, freezers, and refrigerator-freezers. In this document all of these three types are meant and referred to as "residential refrigerators" for simplicity.

- Compilation of the market assessment report.

Three types of surveys were conducted to assist in data collection for the market assessment. These included household surveys on residential refrigerators; supply chain of residential refrigerators and the distributional transformer survey. The sample sizes for all three surveys conducted were already predetermined by SACREEE based on the availability of resources as indicated in Table 1 below.

Table 1: Sample sizes of survey target groups

Target Group	Method of Data collection	Purpose of Sampling	Sample Size
Residential Households	Door to door survey	Household Refrigerators	200
Supply Chain (suppliers, retailers, importers, wholesalers)	Telephone calls, door to door visits, questionnaires, and interviews	Market landscape of Refrigerators	20
Utility, regional electricity distributors, suppliers, importers, retailers, engineering consulting firms	Telephone calls, door to door visits, questionnaires, and interviews	Distribution Transformers	10

The following section delivers a detailed methodology used in the data collection, including market segmentation and sample selection analysis.

Primary data collection for residential refrigerators

The data collection for residential refrigerators was conducted through door-to-door survey. The objective was to deliver the following information[4].

- General information on consumers including households, electricity consumption and household finances.
- Household user behaviours and preferences of residential refrigerators, through significant sampling from urban and rural areas – barriers and opportunities.
- Characteristics of the refrigeration equipment used (technology, performance, energy efficiency, capacity/volume, design/types, refrigerant, supply chain, age of equipment, upfront cost, operation and maintenance costs, etc.);
- Purchasing behaviours and preferences (brand new vs. second hand), as well as the financing options and incentives available for refrigerators – barriers and opportunities.
- Mapping the most popular refrigerator choices/sizes across various strata of the society.
- Estimation of the degree of sensitivity to the energy efficiency and climate-friendly refrigerants in relation to the cost of the equipment and.
- Total stock of refrigerators in use, and typical annual sales, market size, markets segments, and projections for the upcoming years. Disposal of old refrigerators.

The sampling methodology adopted for the survey was a random quantitative research approach. The sampling frame included the entire households. Firstly, a unit or cluster primary sampling unit was selected, which contains a number of households (dwelling units) and then a sample from those households (dwelling units) in that cluster was identified. The number of such clusters and the number of sampled households within each cluster was predetermined in such a way that the total number of sample households (sample size) was achieved. In this design only one member per household (the Head of Household) was interviewed.

The team of enumerators collected residential refrigerator data based on the geographical locations of the country. The project team kicked off by grouping households from 10 provinces. The provinces sampled are as depicted in Figure 1 below. The exercise targeted provincial centres because of their access to electricity through the national grid and it would be easy to locate households possessing refrigerators. Each enumerator randomly sampled 20 households from the provinces assigned. Enumerators were

[4] A Guidance Note from CTCN/UNEP was used in conducting the Market Assessment for energy efficient refrigerators and distribution transformers.

encouraged to add a 10% to the sample size assigned to cater for failed interviews due to people being absent from their homes and/or refusals. The exercise received in total 200 completed questionnaires.

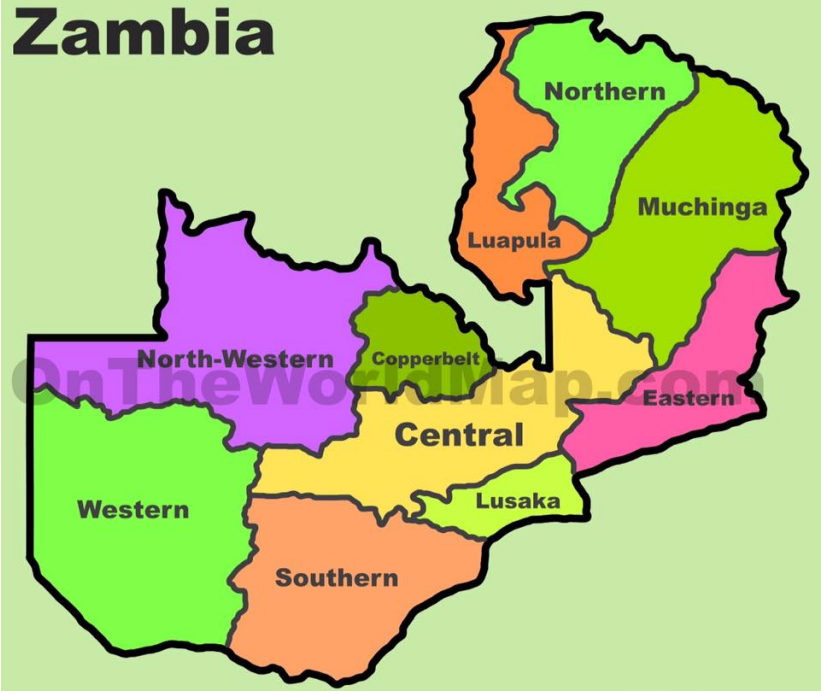


Figure 1: Map of Zambia with Provinces. Image Source: CSO

The table 2 below highlights the ten provinces and number of questionnaires administered.

Table 2: List of Provinces Sampled

Provinces	Provincial Centre	Number of Questionnaires
Lusaka	Lusaka	40
Copperbelt	Ndola and Kitwe	40
Central province	Kabwe	20
Southern province	Livingstone	20
Western Province	Mongu	20
Northwestern	Solwezi	20
Muchinga	Chinsali	20
Northern Province	Kasama	20
Eastern Province	Chipata	0
Luapula Province	Mansa	0

Due to lack of national awareness on the project and the data collection exercise, some enumerators experienced resistance from some homeowners in providing the information required in the questionnaire, despite the enumerators having been provided with MOE/SACREEE introduction letters and a flyer introducing the project. The whole project needed national sensitization program through various media platforms such as TV and Radio announcement and Newspapers adverts circulating the objectives, benefits and ultimate goal of the project.

Primary data collection for supply chain of residential refrigerators

The data collection for the supply chain on residential refrigerators was conducted through a door-to-door survey, telephone calls, questionnaires and interviews. The objective was to deliver the following information[5].

- Supply chains, including interaction with markets from the countries where the other GCF projects are implemented.

[5] A Guidance Note from CTCN/UNEP was used in conducting the Market Assessment for energy efficient refrigerators and distribution transformers.

- Brands and characteristics, including prices of products on the market with a specific focus on energy efficiency.
- Identification of manufacturers, distributors and retailers on the markets.
- Market appetite for new and used (second-hand) equipment as well as repairing facilities for both products.
-
- Stock and sales data (related to at least three to five years), market size and market segments, barriers and opportunities.
- Demand forecast and trends in sales, market projections for the upcoming years.
- For refrigerators: Identification and evaluation of the knowledge of refrigerators technicians in relation to refrigerants
- For distribution transformers: Use of distribution transformers in the mining industry/compliance with standards and consideration of energy efficiency in the specification of transformers to clients.

Table 3: Refrigerator Supply Chain Primary Data Collection Segments

Stakeholders for the Refrigerator Supply chain	Category of stakeholder
Southgate Investment Limited	Supplier/ Distributor
Hazida group of companies	Supplier/Distributor
Radian Stores limited	Supplier/Distributor
Game store	Supplier
Kohinoor	Supplier
HomePimp Limited	Supplier
Dergham Enterprise	Supplier
Shoppers World	Supplier
Zambia Bureau of Standards	Government Department/ National Standards Body
Zambia Development Agency	Government Department/ Investment Promotion
Zambia Compulsory Standards Agency	Government Department/ Regulator of Household appliances
Central Statistics Office	Government Department/ Statistics office
Zambia Association of Manufacturers	Association of Manufactures
Ministry of Finance	Government Ministry/ Customs
Ministry of National Planning and Development	Government Ministry/ National Economy
Zambia Revenue Authority	Government Department/ Customs
Consumer and Competition Commission	Government Department/ Consumer and Competition Authority
Ministry of Energy	Government Ministry/ Energy Efficiency
Energy Regulation Board	Government Department/Energy Regulator

Primary data collection on distribution transformers

The data collection for distribution transformers was conducted through door-to-door survey, telephone calls, questionnaires, and interviews. The objective was to deliver the following information[6]:

- Total stock of distribution transformer (by type) in use (i.e. single/three-phase liquid-filled, three-phase dry-type) and any other stock data;
- Characteristics of the distribution transformers used, rated power, technology, typical losses, typical lifetime.
- Purchasing behavior, procedures and rules, as well as the financing of transformers, including technical specifications for purchases (with the objective to map the adoption of LLCC (TOC) based procurement practices and preferences, loss specifications and to check the MV&E process). Moreover, including purchase preferences from local industry versus imports, local value addition (and technical and tariff barriers, if any);
- Refurbishment practices and end of life.
- Procurement of distribution transformers in relation to energy efficiency.
- Disposal practice of old transformers.
- PCB content (ppm) in liquid filled transformers.

[6] A Guidance Note from CTCN/UNEP was used in conducting the Market Assessment for energy efficient refrigerators and distribution transformers

- Load demand (per household income, per region), as well as the demand and supply side barriers.
- Financial reports, existing subsidies, electricity bill payment systems and processes, metering systems and processes, etc. and,
- General electricity situation of the country.

Table 4 displays the various stakeholders identified and contacted for data collection on the distribution transformers, indicating those that responded and those that did not, as well as the level of completeness of each questionnaire.

Table 4: Distribution Transformers Primary Data Collection Segments

Stakeholders for the Distribution Transformers	Category of Stakeholders
Elsewedy Transformers	Manufacture
Afrizam Electrical Limited	Assembler and Supplier
Tanelec Zambia Limited	Repairer and supplier
Marthinusen and Coutts,	Repairer and Supplier
Eugene Lottering	Repairer and Supplier
Energy Regulation Board	Government Department/ Regulator
ZESCO	National Power Utility
Copperbelt Energy Corporation	Private Power Utility
Lunsemfwa Hydro Power	Private Power Utility
Itezhi tezi Power station	Private Power Utility
Konkola Copper Mines	Copper Mine
Rural Electrification Authority	Government Department/ Rural Electrification
Ministry of Energy	Government Ministry / Energy
Zambia Revenue Authority	Government Department/ Customs
ZANACO Bank	Commercial Bank
Invest Trust Bank	Commercial Bank

Secondary data collection

Secondary data was collected using a desk study to assist with literature review of relevant energy efficiency issues related to residential refrigerators and distribution transformers. Sources used for the review included:

- Online databanks
- National Policy documents and legal instruments
- Peer reviewed articles (case studies, original research, reviews and short communication) in journals
- Official reports from organizations
- Books and academic reports (thesis, etc.)
- Newspaper articles and online stories from credible websites
- Information from online stores

Data analysis, validation, and interpretation

The data collected was entered into the IBM SPSS software for data cleaning, validation and where necessary the data was cross-checked through various sources to ensure consistency and data quality. A database was setup within the software for analysis of the data. The software requires that variables from the questionnaire used are defined to help in the interpretation of the data at point of analysis. Data from the household refrigerator survey formed the larger part of the data entered in the software while the other two surveys were more informative and not investigative.

3.4 Key Assumptions

The study was cognizant of the impact of the covid 19 pandemic on the Zambian economy and the energy sector in particular. However, the study assumed that no new legislations would affect the sector after the recently 2019 National Energy Policy (NEP) was enacted. This assumption was based on the fact that the new NEP was very comprehensive and forward looking. Furthermore, the study assumed that the energy sector would continue to experience growth especially the electrification rate would continue to grow based on the increased number of generation projects expected to contributed to the national installed capacity and electrification programs such as the Beyond the Grid Fund for Zambia (BGFZ), Global Energy Transfer Feed-in Tariffs for Zambia (GET FiT) and the Increased Access to Electricity and Renewable Energy Production (IAEREP).

4.0 Overview of the Country

4.1. Socio-economic Situation

The Republic of Zambia is a landlocked country in Southern Africa region surrounded by 8 countries: Democratic Republic of Congo to the north; Tanzania to the north-east; Malawi to the east; Mozambique; Zimbabwe; Botswana; and Namibia to the south; and Angola to the west. Table 5 below shows the current population statistics of Zambia which is at 18,819,883 based on Worldometer elaboration of the latest United Nations data (UN, 2021).

Table 5: Zambia Population Data

Year	Population	Urban Population	Rural Population	Density (p/Km2)	Yearly % Change
2020	18,383,955	8,336,381 (45%)	10,047,574 (55%)	25	2.93 %

According to the World Bank, Zambia is a resource-rich, lower-middle-income country: Zambia's Human Development Index (HDI) value for 2019 is 0.584 - in the mid-range of HDI rankings - positioning the country at 139 out of 188 countries and territories (CSO, 2021). In 2019 Gross Domestic Product (GDP) was 23.31 billion (WorldBank, 2019). The country has made significant socio-economic progress over the past two decades and achieved important average GDP growth of 7.4% between 2004 and 2014. However, since mid-2015, economic growth has slowed considerably to 2.9 percent. National economic performances are strongly related with the price of copper considering that copper mining is the most important activity and accounts for around 85% of country's exports. In 2015 Zambia faced a critical economic crisis due to the concomitance of the lowering of the price of copper and a strong energy crisis caused by a shortfall of rain. Today the situation has stabilized and macroeconomic outlooks for next years are positive and optimistic. The rapid and sustained growth achieved from the early 2000s to 2014 has been insufficiently inclusive and despite the doubling of GDP Zambia continues to deal with high unemployment rates as well as low revenues of its population.

Zambia's economy is heavily dependent on copper mining although the mining sector employs less than two percent of the population. The country has also been unlocking the potential of other sectors such as agriculture, manufacturing and tourism in a quest to reduce the dependency on copper, which tends to be vulnerable to international shocks. Like most countries in the Sub-Saharan region, Zambia in the early 2000s to about 2013 witnessed annual gross domestic product (GDP) growth of almost seven percent owing to among other factors, favourable commodity prices on the international market, significant foreign direct investments (FDI) in various sectors. However, the successes were short lived as the fall in commodity prices, which resulted in the depreciation of the Kwacha, which has currently breached the K22 mark to the United States dollar, drought, which resulted in the main electricity generation water sources recording low water levels and subsequently leading to power outages almost countrywide.

In 2019, economic growth declined significantly, from four percent (2018) to 1.4 percent. The services sector remained the country's key driver of growth, growing by 3.5 percent in 2019, but primary and secondary sectors decreased significantly**.** Most recently, COVID-19 (coronavirus) has exacerbated Zambia's macroeconomic vulnerabilities resulting in the country defaulting on its Eurobond interest payments thus further dampening investor confidence.

The supply chain breakdown in major trading partners such as China and South Africa which has been affected by the COVID-19 Pandemic is negatively affecting domestic production and consumption.

The Kwacha has depreciated by 30 percent since the beginning of the year, increasing external debt servicing costs and domestic inflationary pressures. Falling revenues and increased COVID-19-related spending will worsen in 2021 fiscal position and falling exports and capital. Inflows will put additional pressure on foreign exchange reserves. (The World Bank, 2021)

4.2. Energy (electricity) context

Zambia's electricity sub-sector comprises of the vertically Integrated Public Utility Company, ZESCO Limited, IPPs and Power Distribution Entities. These are responsible for the generation, transmission, distribution, and supply of electricity.

Access to electricity in Zambia, especially in rural areas, is dramatically low. The overall national electricity access rate, defined as connection rate to the grid, is around 38.9% (WorldBank, 2018) representing 67 % in urban areas, and only close to 4% in rural areas (WorldBank, 2018). Increasing access to energy is a key priority of the national development strategy and the government has set electrification targets at 90 % for urban areas and 51 % for rural zones by 2030 as highlighted in the figure 2 below. However, at the current pace, these targets are not expected to be achieved due to limited investment and macroeconomic growth.

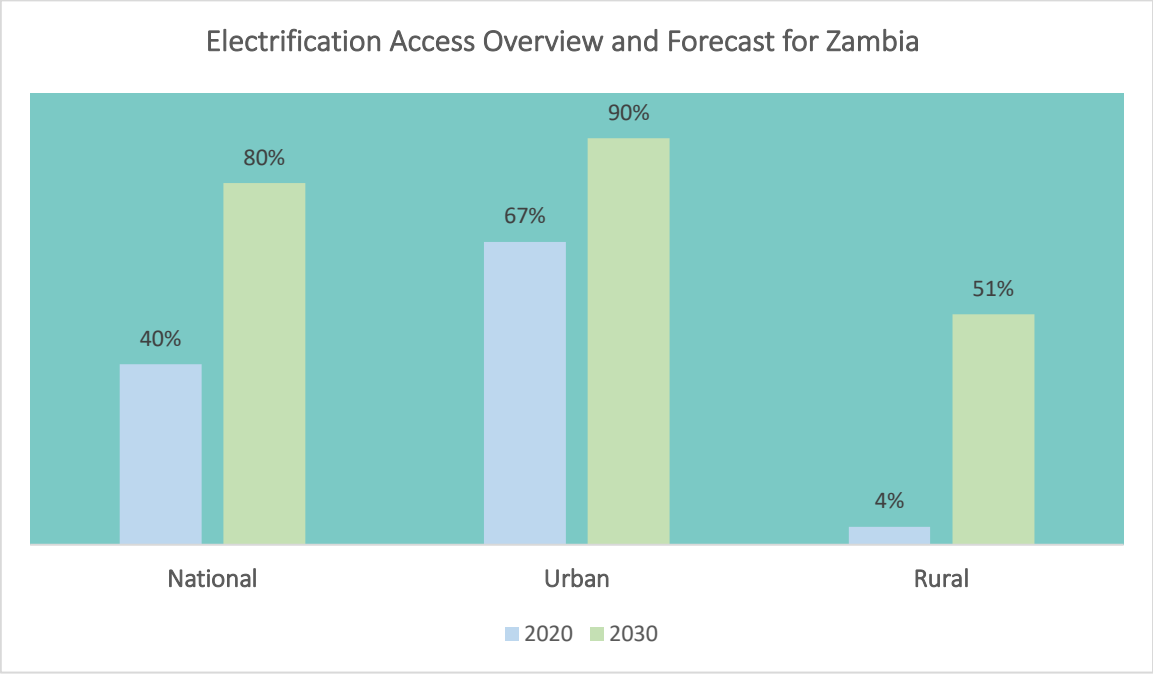


Figure 2: Electrification Access Overview for Zambia (source: NEP 2019)

Institutional and legal framework

The energy sector is efficiently managed through a policy framework that meets the ever-rising challenges not only in this sector but in the economy as a whole. The National Energy Policy 2019 (NEP 2019) builds on previous policies of 1994 and 2008 and is anchored on the Seventh National Development Plan (7NDP) and Vision 2030.

While the essence of the previous policy objectives remains valid, the social, political, environmental and economic situation has undergone significant changes. This has prompted the review of the 2008 Energy Policy and the formulation of the NEP 2019 which incorporates current developments not only in the energy sector and the entire economy but also the regional and international environment. Zambia is aspiring to become a middle-income economy by 2030 (GoZ, 2019). This entails formulating and implementing robust enabling policy measures that meet the energy demand of the future. The NEP 2019 therefore, is aimed at guiding the energy sector in the development of the electricity generation, transmission and distribution capacity.

In 1996, the Government of Zambia set a goal for universal electricity access for all Zambians by 2030 (GoZ, 2006). The electricity industry in Zambia has been undergoing restructuring since 1994. The main thrust of the reforms has been to liberalise and promote private investment in the industry, particularly in the area of generation. The amendment of the Electricity Act in 1995 abolished the statutory monopoly of ZESCO while the Energy Regulation Act of the same year established the Energy Regulation Board (ERB) as an independent regulator of the energy sector.

Currently, government's power sector reform strategy has focussed on the commercialisation of ZESCO, opening up to private investment and establishment of an independent regulator. The ERB and the Government continue to explore further means to promote investment and remove existing impediments to power sector investment in Zambia.

Energy has been identified as an important driving force behind economic development in Zambia, and the government has declared its commitment to developing and maintaining energy infrastructure and services. Some of the reforms that followed this government commitment included the enactment of the rural electrification Act which facilitated the establishment of the Rural Electrification Authority in 2003, The Amendments to both the Electricity and Energy regulation Acts in 2003, the formulation of the vision 2030 in 2006 (with a focus on electricity for all), the development of the grid code, revision of National Energy Policy and development of the Rural Master Plan and the Power Systems Development Plan in 2008. Because of these reforms the power sector has since been opening up to new IPPs for on-grid and off-grid transactions. GOZ expects to bring online additional MW of solar, hydro, and thermal power through.

Government has been implementing the NEP 2008 which expired in 2018. The Policy played an important role in providing guidance in the energy sector. The Policy endeavoured to attain overall macro–economic policy objectives of sustainable energy development and the creation of a market environment promoting increased private sector participation.

Over the years, dynamics and emerging issues in the energy sector, effects of climate change and advances in technology have necessitated the development of the NEP 2019 (GoZ, 2006).

The National Energy Policy (2019)

The National Energy Policy of 2019 (NEP 2019) supersedes the National Energy Policy of 2008 and is aligned with the Seventh National Development Plan (NDP7) and Vision 2030. While NEP 2019 has a general framework similar to NEP 2008, including facilitating the development of renewable energy, NEP 2019 takes cognisance of recent market developments and projected energy scenarios. Among key policy objective of NEP 2019 include:

- Strengthening the sector institutional capacity
- Strengthening the national energy sector regulatory framework, including off-grid systems
- Promoting efficient use of energy resources in order to conserve natural resources
- Promoting sustainable exploitation of biomass and alternative energy to wood fuel resources
- Increasing exploitation of renewable energy in order to diversify the energy mix
- Increasing access to electricity in order to improve the livelihoods of citizens
- Promoting private sector participation in the energy sector
- Promoting innovation, research and development in the energy sector
- Mainstreaming gender, climate change, and health and safety in the energy sector.

To facilitate wider diffusion of renewable energy technologies, the energy policy outlines three key policy measures; it seeks to strengthen institutional capacity for research and development in renewable energy and energy efficiency, enhance coordination among key stakeholders for effective implementation of renewable energy technologies, and aims to promote wider usage of renewable energy technologies. Further, the energy policy promotes gender mainstreaming in the energy sector to facilitate increased modern energy access and poverty reduction among vulnerable groups, especially women and children.

The country's energy legal framework sector is currently governed by four (4) major statutes namely, The Energy Regulation Act; the Electricity Act; the Petroleum Act; and the Rural Electrification Act. The Energy Regulation Act established the Energy Regulation Board, as a body corporate, whose primary role is to license entities that intend to produce energy. The Electricity Act provides for the regulation of generation, transmission, distribution and supply of electricity. The Petroleum Act provides for the importation, conveyancing and storage of petroleum and other inflammable oils. The Rural Electrification Act established the Rural Electrification Authority whose primary role is to provide electricity to rural areas of Zambia.

In 2019, the national installed capacity of electricity increased to 2,981.31MW from 2,898.23 MW in 2018, representing a 2.86 percent increase (ZESCO, 2020). This was mainly attributed to the commissioning of the 54.3 MW Bangweulu and 34 MW Ngonye solar power plants. Additionally, standard micro grids for solar (0.067 MW) were also commissioned. Meanwhile, ZESCO decommissioned 5.28 MW diesel power plants as follows: Kabompo (2 MW); Zambezi (1.36 MW); Mufumbwe (0.8 MW); Lukulu (0.32); and Chavuma (0.8 MW). The decommissioning was mainly on account of connecting the districts to the national grid. Despite the increase in the national installed capacity, the generation sent out declined from 16,189 GWh in 2018 to 15,040 GWh in 2019, reflecting a 7.1 percent decline. This was due to the poor rainfall pattern recorded in the 2018/2019 rainy season and led to ZESCO to carry out demand load management in the second half of the year. Consequently, according to ZSA, the electricity sector experienced negative growth of 4.9 percent and contributed -0.1 percent to the national GDP in the first three quarters of 2019 (ERB, 2019) (USAID, 2020). Although there are pockets of private sector activity in generation, transmission, and distribution, the vast majority of power in Zambia is operated by ZESCO the vertically integrated state-owned utility (USAID, 2020). The utility is wholly state-owned through the Industrial Development Corporation (IDC), the holding company for the majority of state-owned enterprises in Zambia. ZESCO owns and operates over 90 % of the generation, transmission, and distribution assets in the country and supplies electricity to all grid-connected consumers, with the exception of some mining consumers in the Copperbelt Province, which are served by the Copperbelt Energy Corporation (CEC), a private company that purchases bulk power from ZESCO for onward supply to the mines. The power utility (ZESCO) is under the jurisdiction of the Ministry of Energy (MoE) and operates based on the policies established by MoE.

With 40% of the water resources in the Southern African Development Community (SADC), is in Zambia and Zambia has about 6,000 MW unexploited hydropower potential, while only about 2,800MW (45%) has been developed.

There are no utility-scale wind power projects implemented in Zambia. However, there are a few investors who are carrying out feasibility studies of wind power in Zambia. One such investor is Mphepo Power, a Zambian renewable energy company, focussed on the development of wind power in Eastern Province in collaboration with a local community trust and three renewable energy companies: Oswald and Kapata, Western Renewable Power, and Buffalo Energy. Mphepo Power has a number of sites across Eastern Province. The first planned site, called Unika I, is near Katete and has a planned capacity between 150 and 300 MW. The company has plans to construct other similarly sized wind plants at its sites elsewhere in Eastern Province. Currently, Mphepo Power is finalising the feasibility study for the Project, including wind measurements, IFC Standard Environmental and Social Impact Assessment, and engineering designs. Construction is anticipated to begin in the second half of 2021, with commercial operations starting in 2023 (mphepopower, 2021).

Zambia first experienced load shedding in 2008 was due to demand for power outracing the installed capacity at the time, and Government through ZESCO Limited had to work round the clock to increase generation. At the time, Kariba Hydro Power Station had four machines, which collectively produced 600 megawatts (MW), Kafue Gorge had six machines, which produced 900MW and Victoria Falls had an installed capacity of 108MW.

This necessitated the need to expand power generation under the power rehabilitation programme resulting in Kariba Hydro Power Station increasing generation to 720MW and later to 1080MW. Kafue Gorge increased to 990MW and expansion of mini hydro stations across the country and the exploration of greenfield projects such as the 120 MW Itezhi-Tezhi project, which is a public private partnership with Tata Africa Group.

Years of investments in hydropower projects such as the expansion of the Kariba North Bank Hydro Power Station and Kafue Gorge helped to improve power supply until about 2015, when the country and other countries in SADC were hit by drought. With Zambia and other countries mainly being dependent on hydro power, the drought affected power generation resulting in a deficit of 810 MW (DailyMail, 2020).

Zambia's electricity generation mix is predominantly hydro, accounting for 80.45 percent of installed capacity as of 2019. The remainder of the generation mix comprised of coal (10.06%); Heavy Fuel Oils (HFO)(3.69%); diesel (2.80%); and solar (2.99%) (see figure 3 below) (ERB, 2019).

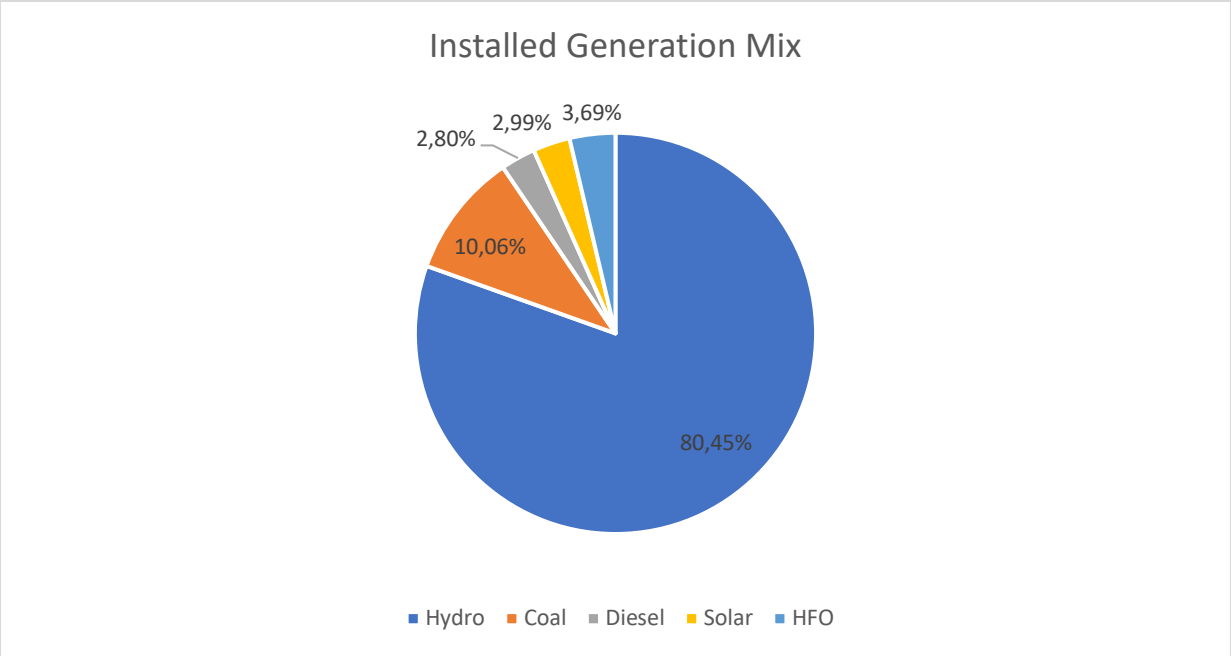


Figure 3: Installed Generation Mix (source; Energy Sector Report 2019)

The national peak demand for 2019 stood at around 2,925 MW although the installed capacity of about 2,900 MW, following the partial coming on stream of the Kafue Gorge Lower (KGL), which is ZESCO's flagship project which adds to the current installed capacity about 750 MW (ERB, 2019).

With the addition of KGL, the country's installed capacity will be 3,731.310 MW. This means that the country will continue to meet its growing energy needs. Therefore, the addition of KGL means that we are ahead in meeting the country's growing demand for a secure and sustainable future.

With an assumption of 150MW growth in peak demand, Zambia's electricity demand is expected to double in 2030 due to an increased population. Figure 4 below highlights the historical and forecast demand against installed capacities.

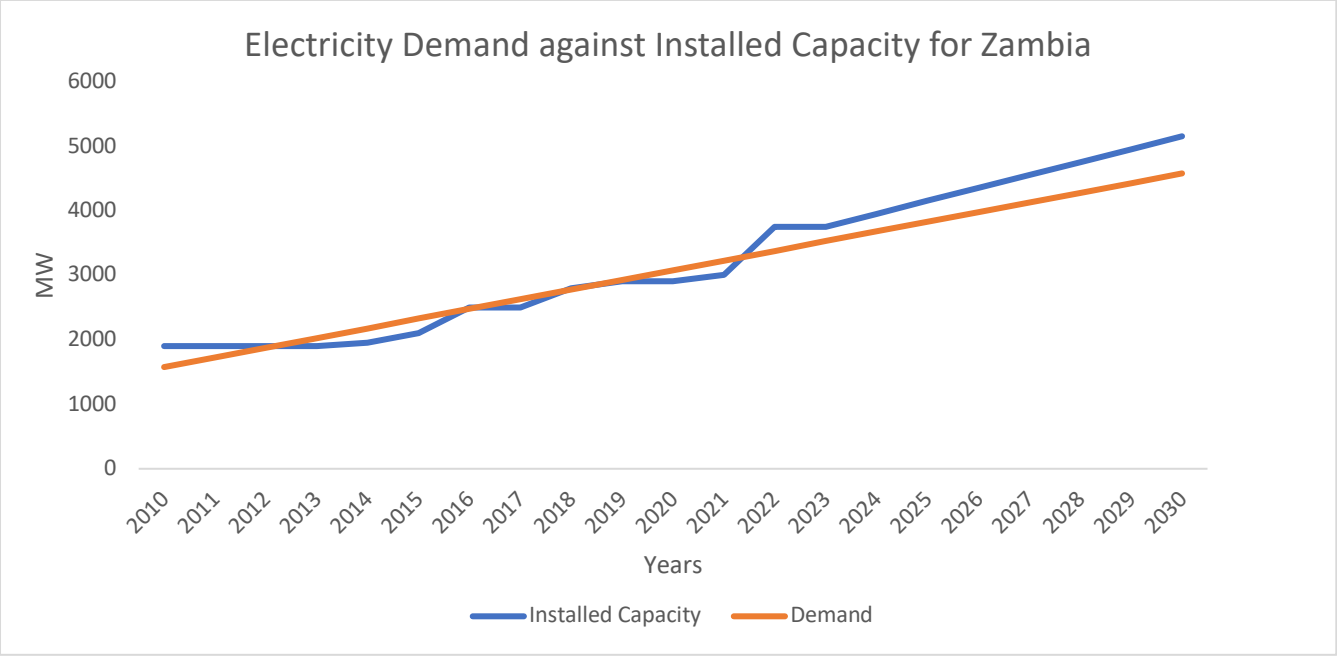


Figure 4: Electricity Demand against Installed Capacity for Zambia (Source; Zesco)

In addition to water reserves, Zambia has abundant renewable and non-renewable energy resources, including:

- Industrial minerals such as coal
- Agricultural land to support biofuels.
- Ample forest for biomass
- Abundant wind for wind energy
- Long and intense hours of annual sunlight to support solar energy generation (IEA, 2014).

The national power utility, ZESCO is also investing in alternative power generation infrastructure such as solar, wind, and thermal to mitigate any future power deficits that may arise due to inadequate rainfall. Notable, among the renewable energy projects is the planned development of 600MW of solar energy in three districts at 200MW each between ZESCO and Power China at a cost of US$548 million. Zambia's electricity generation mix is predominantly hydro, accounting for 80.45 percent of installed capacity as of 2019. The remainder of the generation mix comprised of coal (10.06%); HFO (3.69%); diesel (2.80%); and solar (2.99%). The table 6 below shows the current installed power generation capacity and mix for Zambia.

Table 6: Installed power generation capacity (ERB, 2019)

Company	Station	Technology	Installed Capacity (MW)	% Contribution
Renewables				
ZESCO Limited	Kafue Gorge	Hydro	990	33.2%
	Kariba North	Hydro	720	24.2%
	Kariba North Extension	Hydro	360	12.1%
	Victoria Falls	Hydro	108	3.6%
	Lunzua River	Hydro	14.80	0.5%

	Lusiwasi	Hydro	12	0.4%
	Chishimba Falls	Hydro	6	0.2%
	Musonda Falls	Hydro	10	0.3%
	Shiwang'andu	Hydro	1	0.03%
Itezhi-tezhi Power Corporation	Itezhi-tezhi	Hydro	120	4.0%
Zengamina Limited	Ikelengi	Hydro	0.70	0.02%
Lunsemfwa Hydro Power Co	Mulungushi	Hydro	32	1.1%
	Lunsemfwa	Hydro	24	0.8%
	Total	**Hydro**	**2,398.50**	**80.5%**
Rural Electrification Authority	Samfya	Solar	0.06	0.002%
Copperbelt Energy Corporation	Kitwe	Solar	1	0.03%
Muhanya Solar Limited	Sinda Village	Solar	0.03	0.001%
Ngonye Power Limited	LSMFEZ	Solar	34	1.1%
Bangweulu Power Company Ltd	LSMFEZ	Solar	54	1.8%
Solera Power	Luangwa bridge	Solar	0.01	0.0003%
Standard Microgrid	Kafue	Solar	0.02	0.001%
Mugurameno	Chirundu	Solar	0.01	0.0003%
	Total Solar	**Solar**	**89.13**	**3.0%**
Coal				
Maamba Collieries Limited	Maamba	Coal	300	10.1%
	Total	**Coal**	**300**	**10.1%**
Petroleum-based fuels				
Copperbelt Energy Corporation	Luano	Diesel	40	1.3%
	Bancroft	Diesel	20	0.7%
	Kankoyo	Diesel	10	0.3%
	Maclaren	Diesel	10	0.3%
ZESCO Limited	Luangwa	Diesel	2.60	0.1%
	Shang'ombo	Diesel	1	0.03%
	Total	**Diesel**	**83.60**	**2.8%**
Ndola Energy	Ndola	HFO	110	3.7%
	Total	**HFO**	**110**	**3.7%**
GRAND TOTAL			**2,981.23**	**100.0%**

Zambia is also interconnected with the neighboring countries by the Southern African Power Pool (SAPP). The organization created in 1995 is playing a key role for the energy sector of Southern African region. The SAPP has twelve country members (Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania and Zambia) represented by their utility company. Its aim is to optimize the use of available energy sources in the region and enhance energy exchange between countries by promoting an interconnected regional power market. The table 7 below highlights Zambia exports and imports for the years 2017, 2018, 2019 & 2020.

Table 7: ZESCO`s Imports and Exports for January - December 2017, 2018, 2019 & 2020 (ERB, 2020)

ZESCO's ELECTRICITY EXPORTS AND IMPORTS								
	2017		2018		2019		2020	
Month	Exports (GWh)	Imports (GWh)	Exports (GWh)	Imports (GWh)	Exports (GWh)	Imports (GWh)	Exports (GWh)	Imports (GWh)
January	64.40	114.64	92.55	61.67	81.84	1.28	84.05	62.88
February	67.96	65.22	63.67	55.97	86.26	1.19	80.92	46.66
March	91.11	56.29	77.61	22.13	87.17	1.24	114.34	5.21
April	111.05	41.44	130.58	0.86	57.16	1.38	110.17	2.28
May	122.03	58.10	97.22	1.01	49.16	1.56	119.70	1.38
June	97.56	58.82	93.39	1.35	81.99	10.60	110.22	1.43
July	89.23	60.37	143.73	0.64	88.54	22.33	116.09	1.48
August	76.91	57.65	128.87	1.23	80.35	24.79	119.95	1.47
September	83.65	63.19	124.09	1.86	78.00	25.25	117.13	1.41
October	85.73	64.40	104.73	2.84	91.58	1.38	118.25	1.37
November	87.07	58.80	83.23	1.04	93.95	20.23	120.60	3.10
December	86.22	54.02	85.81	1.63	99.56	86.93	128.11	1.26
Total	**1,062.92**	**752.94**	**1,225.48**	**152.23**	**975.56**	**198.16**	**1,339.53**	**129.94**

Electrification Tariffs

Electricity tariffs in Zambia have historically been subsidized, leading to a challenging commercial environment for private developers, as well as for ZESCO. Currently, it is estimated that ZESCO loses over K1.8bn in revenue through subsidies to residential consumer (CUTS, 2020)

On 26th February 2019 the Energy Regulation Board (ERB) received an application from ZESCO Limited proposing upward adjustments of electricity tariffs and connection charges for domestic consumers (i.e. excluding mining, exports and Power Purchase Agreement (PPA) based customers) by weighted average increases of 113 percent and 213 percent respectively. According to public notice issued by ERB, ZESCO Limited specifically, proposed to increase electricity tariff per customer category, which was granted by the Energy Regulation Board. Table 8 below shows the approved and effective tariffs for the different categories. All residential customers (metered residential) use prepaid meters while all customers in the maximum demand category (with demand above 16kVA) are on postpaid metering system.

Table 8: ERB effective approved electricity tariffs as of 30th June 2020

Customer category	Tariff components	Approved Tariffs as at 30th June 2019	Approved Tariffs as at 30th June 2020
1. METERED RESIDENTIAL (Prepaid) (capacity 15 kVA)			
R1 – Consumption from 1 - 100 kWh in a month	Energy charge/kWh	0.15	0.47
R2 – Consumption between 101kWh - 300 kWh in a month	Energy charge/kWh	0.89	0.85
R3 – Consumption above 300kWh	Energy charge/kWh	Nil	1.94
	Fixed Monthly Charge	18.23	Abolished
2. Commercial Tariffs (capacity 15kVA)			
C1 – Consumption up to 200kWh	Energy charge/kWh	0.54	1.07
C2 – Consumption above 200kWh	Energy charge/kWh	Nil	1.85
	Fixed Monthly Charge	96.41	Abolished
3. Social Services			
Schools, Hospital, Orphanages, churches, water pumping & street lighting	Energy charge K/kWh	0.49	1.19
	Fixed Monthly Charge	83.84	203.73
4. Maximum Demand Tariffs			
MD1- Capacity between 16 - 300 kVA	MD Charge (K/kVA/Month)	24.45	42.79
	Energy Charge (K/kWh)	0.35	0.61
	Fixed Monthly Charge (K/Month)	239.44	419.02
	Off Peak MD Charge (K/KVA/Month)	12.22	21.39
	Off Peak Energy Charge (K/kWh)	0.26	0.46
	Peak MD Charge (K/KVA/Month)	30.56	53.48
	Peak Energy Charge (K/kWh)	0.44	0.77
MD2- Capacity 301 to 2,000 kVA	MD Charge (K/kVA/Month)	45.73	80.03
	Energy Charge (K/kWh)	0.3	0.53
	Fixed Monthly Charge (K/Month)	478.84	837.97
	Off Peak MD Charge (K/KVA/Month)	22.87	40.01
	Off Peak Energy Charge (K/kWh)	0.23	0.39
	Peak MD Charge (K/KVA/Month)	57.17	100.03
	Peak Energy Charge (K/kWh)	0.37	0.66
MD3- Capacity 2,001 to 7,500kVA	MD Charge (K/KVA/Month)	73.06	126.39
	Energy Charge (K/kWh)	0.25	0.43
	Fixed Monthly Charge (K/Month)	1,014.55	1,755.17
	Off Peak MD Charge (K/KVA/Month)	36.52	63.2
	Off Peak Energy Charge (K/kWh)	0.18	0.32
	Peak MD Charge (K/KVA/Month)	91.33	157.99
	Peak Energy Charge (K/kWh)	0.3	0.54
MD4-Capacity 7500kVA to 25,000 kVA	MD Charge (K/KVA/Month)	73.47	127.39
	Energy Charge (K/kWh)	0.21	0.36
	Fixed Monthly Charge (K/Month)	2,029.13	3,510.39
	Off Peak MD Charge (K/KVA/Month)	36.73	63.55
	Off Peak Energy Charge (K/kWh)	0.16	0.27
	Peak MD Charge (K/KVA/Month)	91.84	158.88
	Peak Energy Charge (K/kWh)	0.25	0.45
Bulk Distributors tariff	Maximum Demand customers - MD Charge/KVA/month	Nil	58.6
(Purchasers of Power for distribution)	Retail customers – Energy charge / kWh	Nil	0.49
NOTE; The above tariffs are:-			
(a) Exclusive of 3% Government excise duty			
(b) Exclusive of 16% Value Added Tax (VAT)			

Source: Statistical bulletin, January -June 2020, ERB (2020).

The power utility justified the upward tariff application as being necessitated by the prevailing macro-economic conditions, need for system and customer base expansion, rising cost of generating power from ZESCO's own power plants and Independent Power Producers (IPPs) and rising cost of connecting customers to the grid. The connection fees for customers vary depending on the category of the customer. The power utility has no fixed fees as this is only determined after doing an assessment of the location and projected demand of a particular customer.

Furthermore, in its application, ZESCO proposed the introduction of a bulk power distribution tariff and proposed to cap maximum demand capacity to 10MVA from the current 25MVA with ZESCO projected to raise K16,056 million in the first full year of implementation of the proposed tariffs. The various tariff categories are as highlighted below in Table 9.

Table 9: Customer Base and Category for ZESCO

Tariff Category	June 2019	June 2020
Residential	894,829	929,281
Maximum Demand	8,398	8,562
Commercial	77,365	81,722
Agriculture	814	825
Social	10,941	11,428
Total	992,347	1,031,818

Source: Statistical bulletin, January -June 2020, ERB (2020).

It is important to note that in 2014, Zambia had the lowest tariffs in sub-Saharan Africa, with the average Zambian tariff only 38 percent of the median one (Trimble et al. 2016). This was made possible because ZESCO's variable cost of energy generation was minimal.

Almost all energy came from renewable hydropower which has no marginal cost associated with generation. On top of this, until the addition of the Maamba Coal Power Plant to the grid in 2016, the costs of ZESCO's large power plants had been fully amortized.

This policy represented a transfer of welfare to end-consumers then at the expense of end-consumers now. For today's consumers, it is now apparent that adequate investment in maintenance and new energy generation projects were not being made.

After the last major electricity crises of 2015 and 2016, ZESCO revised its tariffs upwards twice in 2017 (ZESCO Ltd 2017). The reasons given included the rising cost of generation and the need for system expansion (Energy Regulation Board of Zambia 2019a).

Peak electricity demand

Approximately 70% of the country's electricity demand is driven by its mining sector, which benefits from highly subsidized electricity rates. Growth in electricity demand has been estimated at between 150 MW and 200 MW per year (Zambiainvest, 2020). The Mining Sector is the largest consumer of electricity with an estimated 51.1 percent while the consumption for the domestic sector stands at 33.2 percent. Figure 5 below shows the consumption of electricity by sector.

At household level, an estimated 67.3 percent of households in urban areas and about 4.4 percent of households in rural areas have access to electricity, translating into 39.4 percent at national level (GoZ, 2019). Measuring access has been a challenge due to the absence of an agreed framework for measuring energy access. In addition, the government recognizes that the current electrification approach faces several challenges and needs to be reviewed to make it more sustainable if the country is to achieve the desired electrification goals. A planned, systematic approach is necessary for effective implementation of access for all.

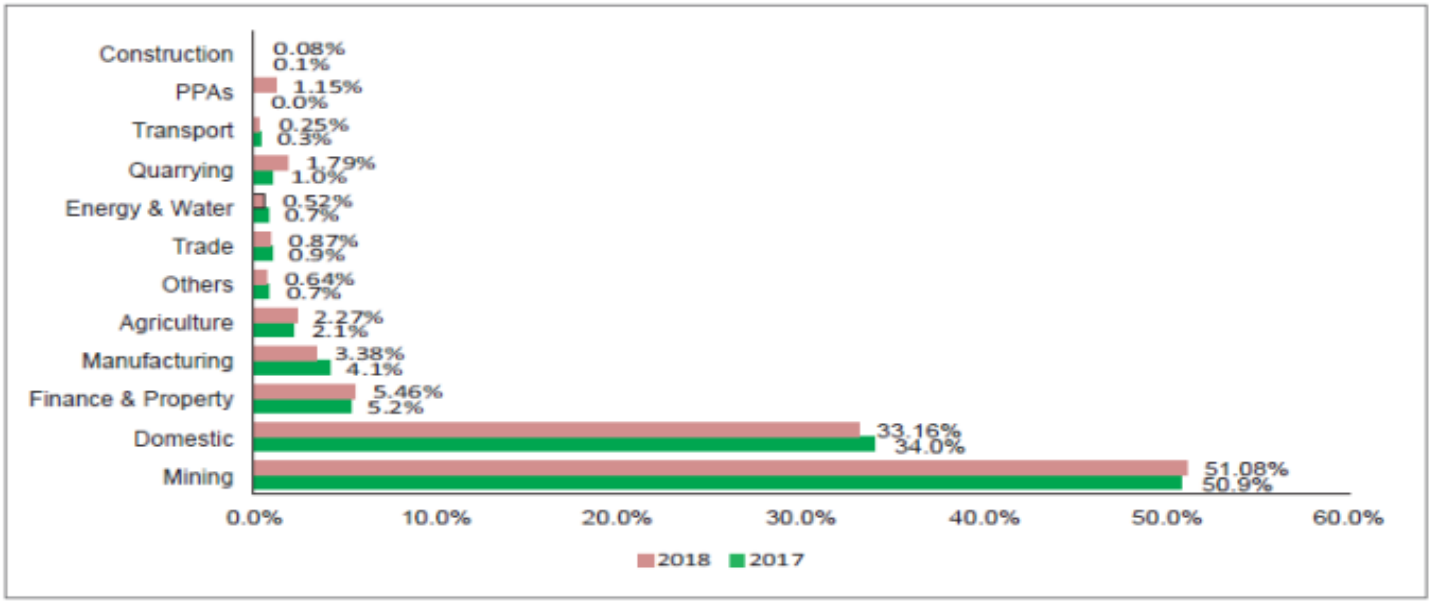


Figure 5:Electricity Consumption by Economic Sub-Sector, ERB Statistical Bulletin 2018

Voltage levels - System voltage for single and three phase voltage system

ZESCO owns and operates over 90 percent of the generation, transmission, and distribution assets in the country and supplies electricity to all grid-connected consumers in all the 10 Provinces of Zambia, with transmission and distribution lines of 9,975 km. The remaining network is owned by Copperbelt Energy Corporation. Table 10 below highlights the three different voltage levels for the Zambia Electricity Network.

Table 10: Voltage Levels

Type	Voltage Range	Application
Single Phase	220-240	Domestic
Three Phase	380-400	Distribution
Other	11kv-33kv	Industrial

The transmission grid is a highway for electricity delivery across the country and also forms part of the regional grid used for power exchange with other countries. The ZESCO transmission grid comprises transmission lines and substations at 330 kV, 220 kV, 132 kV and 66 kV voltage levels. The backbone of the grid is built on a robust 330 kV system from the southern part of the country where the major generating stations are located through Lusaka and Central provinces to the Copperbelt see figure 6 below of the country`s power network system. Copperbelt Energy Corporation (CEC) network consists of 246 km of 220 kV lines (7.5 percent of Zambia's HV network), 678 km of 66 kV lines, and 41 substations. CEC's network assets in Zambia include 36 percent of the 142 km 220 kV line that connects the grid in Zambia to the DRC border.

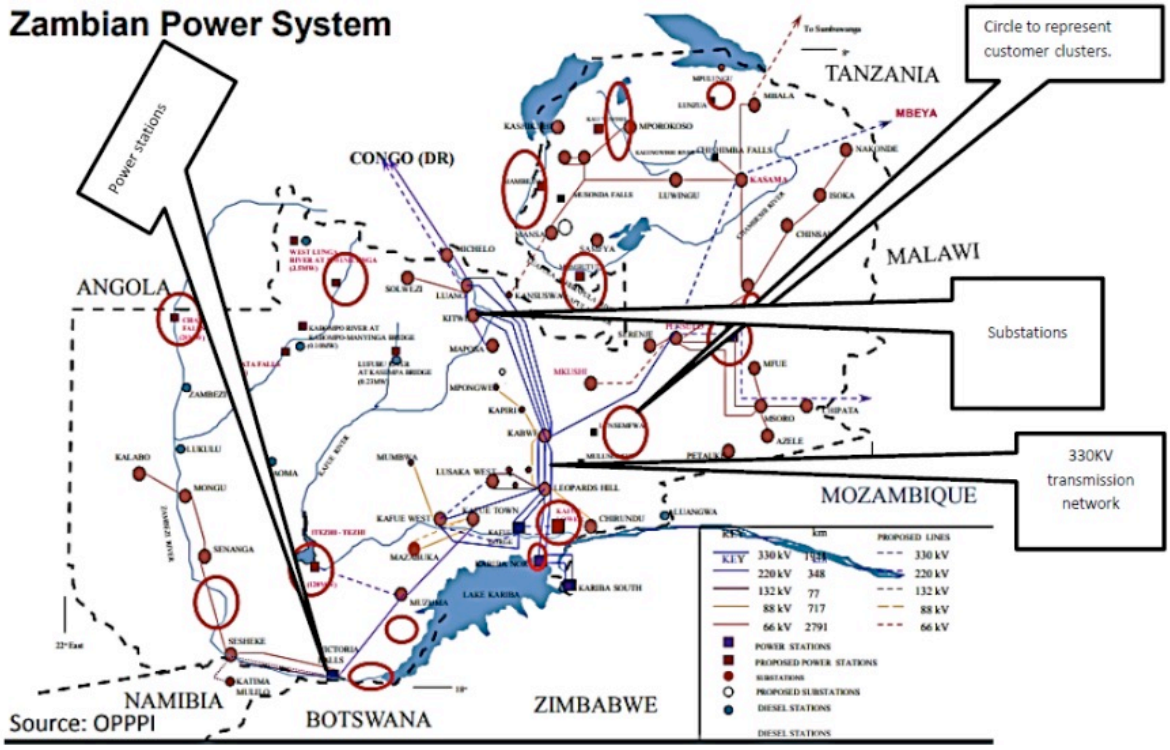


Figure 6: Zambia`s Power Network System (ERB, 2019)

Demand forecast

The customer base is expected to continue growing with an average of 6000 connections per month. However, ZESCO limited has continued to invest to meet the projected demand. With the addition of Kafue Gorge Lower (KGL), the country will have an installed capacity of above 3700MW by 2022 against the peak demand of 3300MW. This means that, with the current and future investments, ZESCO limited has projected adequate capacity to meet increased demand. Zambia's electricity demand is expected to double in 2030 to above 4500MW with an expected installation capacity of above 5,500MW (get-invest, 2020).

ZESCO limited has continued to invest in infrastructure development for inclusive growth. Investments in new power stations is a step in ensuring that today's energy needs are met without sacrificing the needs of the future. That is the meaning of sustainability. Additionally, ZESCO limited recognizes the challenges of hydro power generation which is susceptible to weather fluctuations such as droughts. Considering this, ZESCO has continued to invest in renewable energy such as Solar, Wind, and Thermal power energy. This is to ensure a rich energy mix that is mutually reinforcing (ZESCO, 2020).

The most important measure in the energy balance of Zambia is the total consumption of 11.04 billion kWh of electric energy per year. Per capita this is an average of 646 kWh. Zambia could provide itself completely with self-produced energy. The total production of all electric energy producing facilities is 12 billion kWh, which is 105% of the country's own usage. Despite this, Zambia is trading energy with foreign countries. Along with pure consumptions the production, imports, and exports play an important role. Other energy sources such as natural gas or crude oil are also used (Worlddata, 2019).

Zambia demand for energy has been rising due to robust GDP growth of more than 6% per year for the past decade in the country, particularly in the mining, manufacturing and agriculture sectors. According to the Zambia Development Agency (ZDA), the demand for electricity in the country has been growing at an average of about 3%, or between 150 and 200 MW, annually based on historical data ar (ZDA, 2021). Figure 7 below shows the percentage of total energy consumption by sector.

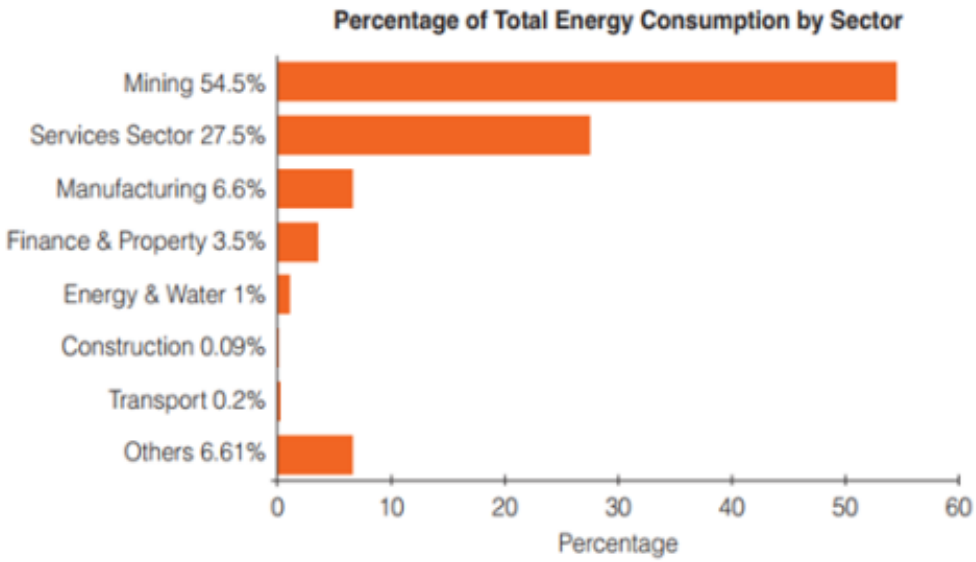


Figure 7: Percentage of Total Energy Consumption by Sector (ZDA, 2021)

5.0 Market Assessment on Residential Refrigerators

5.1 Supply Chain

5.1.1 Summary of Suppliers, end users, officials, and other stakeholders

The Zambian market is dominated by refrigerator products from different countries. Most companies in this sector import these products and retail them to the end users. The most prominent suppliers include Hazida, Radian and Southgate. Table 11 below highlights the summary of residential refrigerator suppliers with the related brands and other stakeholders involved in the supply chain. The other stakeholders key to the sector includes the Zambia Bureau of Standards who are mandated with ensuring quality of the products and the Zambia Revenue Authority who are responsible of customs issues.

Table 11:Summery of Supply Chain in Zambia

Stakeholders for the Refrigerator Supply chain	Related Brands	Category of stakeholder
Southgate Investment Limited	Hisense, KIC, Samsung	Importer/Supplier/ Distributor
Hazida group of companies	Defy, Groundig, Beko, Hisense	Importer/Supplier/Distributor
Radian Stores limited	LG, Hitach, Defy, Hisense, SPJ	Importer/ Supplier/Distributor
Game store	Hisense, LG, KIC, Samsung, Defy,	Importer/Supplier
Kohinoor	LG, KIC, Samsung, Defy, Capri	Supplier
HomePimp Limited	Hisense, LG, KIC, Samsung, Defy	Supplier
Dergham Enterprise	Hisense, LG, KIC, Samsung, Defy	Supplier
Shoppers World	Hisense, LG, KIC, Samsung, Defy, Capri, SPJ	Supplier
Zambia Bureau of Standards	N/A	Government Department/ National Standards Body
Zambia Development Agency	N/A	Government Department/ Investment Promotion
Zambia Compulsory Standards Agency	N/A	Government Department/ Regulator of Household appliances
Central Statistics Office	N/A	Government Department/ Statistics office
Zambia Association of Manufacturers	N/A	Association of Manufactures
Ministry of Finance	N/A	Government Ministry/ Customs
Ministry of National Planning and Development	N/A	Government Ministry/ National Economy
Zambia Revenue Authority	N/A	Government Department/ Customs
Consumer and Competition Commission	N/A	Government Department/ Consumer and Competition Authority
Ministry of Energy	N/A	Government Ministry/ Energy Efficiency
Energy Regulation Board	N/A	Government Department/Energy Regulator

5.1.2 Manufacturing of Refrigerating Appliances

Zambia currently does not manufacture any type of refrigerators. All refrigerator appliances in the country are imported from different countries around the globe. Table. 12 below summarizes the various refrigerator brands sourced from various parts of the world. The market is comprised of a number of brands from the various manufacturers across the globe. South Africa currently has the largest share of tthe Zambian refrigerator market of 76% (21 million US$) followed by China with a share of 5.47% (1.54 million US$) (UN, 2021). The survey revealed that the refrigerator products from the two countries dominate the market. Zimbabwe also exports into the Zambian Market with its Capri brand manufactured in Zimbabwe.

Table 12: List of Refrigerator Brands and Country of Origin of Import (source is from Supply Chain Survey)

Branda Name	Country of Origin of Import
Defy	South Africa
Hisense	South Africa, China
KIC	South Africa
Samsung	China, South Africa, Turkey
Cool master	South Africa
LG	South Africa, China
Capri	Zimbabwe
Meiling	China
Sharp	South Africa, China
Hitachi	China
Fussion	China
Thunderbolt	China
Aftron	China
Bosch	China

The top trading partners with Zambia with regards to import of "Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines include

- South Africa with a share of 76% (21 million US$)
- China with a share of 5.47% (1.54 million US$)
- Turkey with a share of 4.5% (1.27 million US$)
- India with a share of 4.18% (1.18 million US$)
- United Arab Emirates with a share of 2.26% (640 thousand US$)
- Mexico with a share of 1.22% (347 thousand US$)
- Netherlands with a share of 1.07% (305 thousand US$)
- Zimbabwe with a share of 1% (284 thousand US$)
- Poland - 145 thousand US$
- Egypt - 140 thousand US$

Imports of refrigerators to Zambia reached 3.68% of total imports to Zambia in 2020 (equivalent to $766 million in 2020). The share of purchases in total imports refrigerators to Zambia increased by 0.606 p.p[7]. compared to 2019 (it was 3.08% in 2019, and imports of refrigerators to Zambia accounted for $1.13 billion) (TrendyEconomy, 2021). This reduction could be attributed to reduced imports experienced as a result of COVID 19 pandemic. Table 13 below shows the percentage import share of related refrigerator appliances.

Table 13: Percentage Import share of Related Refrigerators Appliances

Description	Percentage share
Freezers of the chest type	34% (9.62 million US$)
Refrigerating/freezing equip	16.6% (4.71 million US$)
Combined refrigerator-freezers, fitted with separate ext. doors,	10.8% (3.07 million US$
Refrigerators, h-hold. type, compression-type, elec./other	9.11% (2.57 million US$
Household-type refrigerators	6.22% (1.76 million US$)
Freezers of the upright type	6.02% (1.7 million US$
Compression-type refrigerating/freezing equip. whose condensers are heat exchangers	0.901% (255 thousand US$

Zambia`s Imports from South Africa of Refrigerators, Freezers, Heat Pumps was US$21.58 Million during 2020, according to the United Nations COMTRADE database on international trade (UN, 2020). Zambia Imports from South Africa of Refrigerators, Freezers, Heat Pumps - data, historical chart and statistics as of April of 2021 is shown in the figure 8 below.

[7] p.p is the percentage point unit which is the arithmetic difference of two percentages.

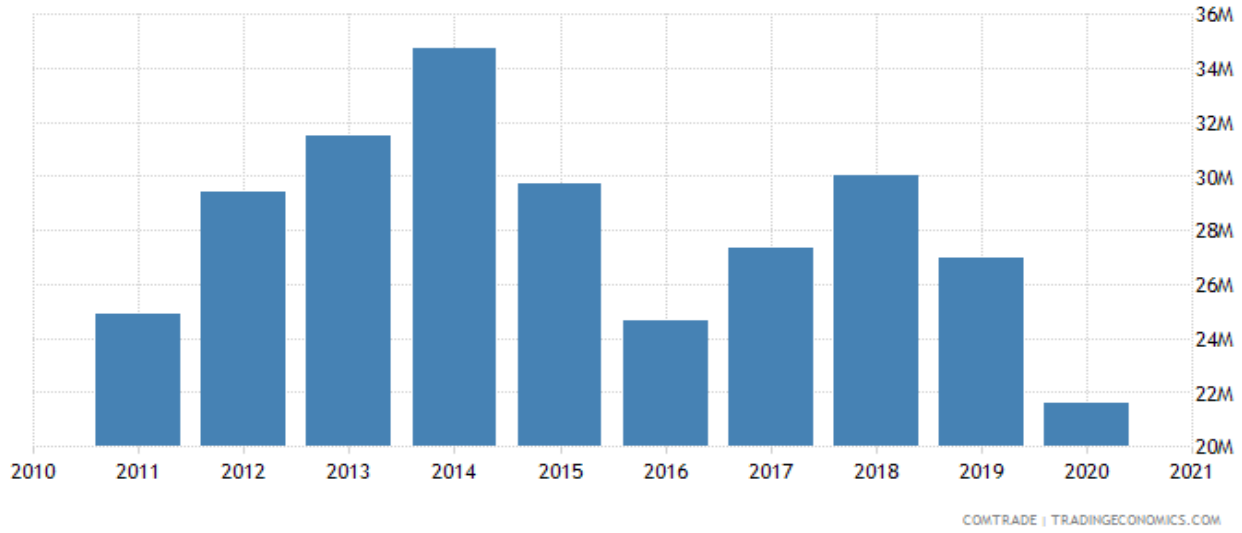


Figure 8: Zambia Imports from South Africa of Refrigerators, Freezers, Heat Pumps

5.1.3 Overview of the supply chain for refrigerators in Zambia

The market supply chain for refrigerators in Zambia is based on the imports. All refrigerators sold are imported, with no refrigerator manufactures, the Zambian Market is dominated by distributors who import from the various countries around the globe. The market model is shown below in figure 9. The Importer either sells to the consumer (end-user) at retail or wholesale prices based on their business model.

Importer	Wholesaler	Retailers	Consumers
• Southgate Investment Limited • Hazida group of companies • Radian Stores limited • Game store	• Southgate Investment Limited • Hazida group of companies • Radian Stores limited • Game store	• Southgate Investment Limited • Hazida group of companies • Radian Stores limited • Game store • Kohinoor • HomePimp Limited • Dergham Enterprise • Shoppers World	• Residential Homes • Restaurants • Hotels, Lodges • Bars

Figure 9: Distribution Channel of Refrigerators in Zambia

Zambia does not only import refrigerators but also exports to the neighbouring countries. The value of exports "Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machine" from Zambia totalled $600 thousand in 2020. Sales went up by 768% compared to 2019: exports also went up by $531 thousand. Exports amounted to 0.007% of total exports from Zambia (cumulative merchandise exports from Zambia totalled $ 7.8 billion in 2020). The share of Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machine in total exports from Zambia increased by 0.006 p.p. compared to 2019 (it was 0% in 2019 and cumulative exports from Zambia were equal to $ 7.02 billion) (TrendyEconomy, 2021). Top export destinations of "Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines." from Zambia in 2020 included.

- Tanzania with a share of 36% (220 thousand US$)
- Dem. Rep. Congo with a share of 33% (200 thousand US$)
- Zimbabwe with a share of 18.3% (110 thousand US$)
- Rwanda with a share of 8.22% (49 thousand US$)
- South Africa with a share of 2.77% (16.6 thousand US$)

- Mozambique - 1.92 thousand US$
- Malawi - 1.14 thousand US$

The exports structure of these appliances from Zambia in 2020 represented by the following main commodity groups (TrendyEconomy, 2021): looked as shown in the table 14 below.

Table 14: Percentage Export share of Related Refrigerators Appliances (TrendyEconomy, 2021)

Description	Percentage share
Refrigerating/freezing equip	31% (187 thousand US$)
Refrigerating/freezing chests	21% (127 thousand US$)
Parts of the refrigerating/freezing equip. & heat pumps	16.4% (98 thousand US$)
Freezers of the chest type,	16% (96 thousand US$)
Freezers of the upright type	6.31% (37 thousand US$)
Household-type refrigerators	1.41% (8.48 thousand US$)
Refrigerators, h-hold. type, compression-type	0.227% (1.36 thousand US$)
Combined refrigerator-freezers, fitted with separate ext. doors	0.216% (1.3 thousand US$)

Refrigerants

Refrigerants of low global warming potentials (GWPs) of ≤150 are required by regulations as working fluids in domestic refrigeration systems (Bolayi, 2020). The international community have insisted on the use of refrigerants that have less GWP and zero ozone depletion potential. Figure 10 below shows the list of the refrigerants used in most refrigerators in Zambia as observed from the results of the survey. R600a and R134a were found to be the most used refrigerants. This is consistent with the requirements of the Environmental Protection and Pollution Control Act. The two different refrigerants are R600a (Isobutane) and R134a (tetrafluoroethene). R134a is zero ozone depletion layer and high global warming and R600a is zero ozone depletion layer and negligible global warming (Qureshi & Bhatt, 2012). The high usage of R600a in most refrigerators clearly demonstrates Zambia`s commitment to ensuring usage of zero ozone depleting substances as well as negligible global warming potential.

Zambia being a Party to the Vienna Convention has met one of the major Montreal Protocol's objectives which demands that each Party establishes and operationalise control measures in the production and consumption of Ozone Depleting Substances (ODS). Zambia has in place regulations which provide for the control of production of and trade in any controlled substance or any other substance likely to deplete the ozone layer. "Controlled substance" means a substance set out in column II of the First Schedule to the Environmental Protection and Pollution Control Act (Ozone Depleting Substances) Regulations, 2000 (S.I. No. 27 of 2000). The regulations stipulate that a person shall not produce or conduct any activity likely to produce any controlled substance or any other substance likely to deplete the ozone layer or emit into the open air any controlled substance likely to result in adverse effects.

Zambia through the Zambia Compulsory Standards Agency (ZCSA) mandated to check imports of electrical appliances have listed refrigerators as a compulsory product. This means that all refrigerators imported into the country are subject to inspections and should meet ZS 106 'Safety of Household and Similar Electrical Appliances' Specifications. The scope of the standard provides key import conditions of refrigerators and other electrical appliances imported into the country. Some of the factors checked on imported electrical appliances include marking and instructions, protection against access to live parts, power input and current.

Figure 10: List of Refrigerants used in Zambia as informed by the survey (Source; Residential Refrigerators Survey 2021).

5.1.4 Best-selling equipment

The survey indicated that defy was the best-selling equipment on the market. The figure 11 below shows the list of refrigerator brands from the best-selling brand to the least sold based on the data collected from the residential and supply chain survey. The survey also revealed that the refrigerator-freezer was the most sold type of refrigerator as shown in the figure 12 below showing the most sold refrigerator type.

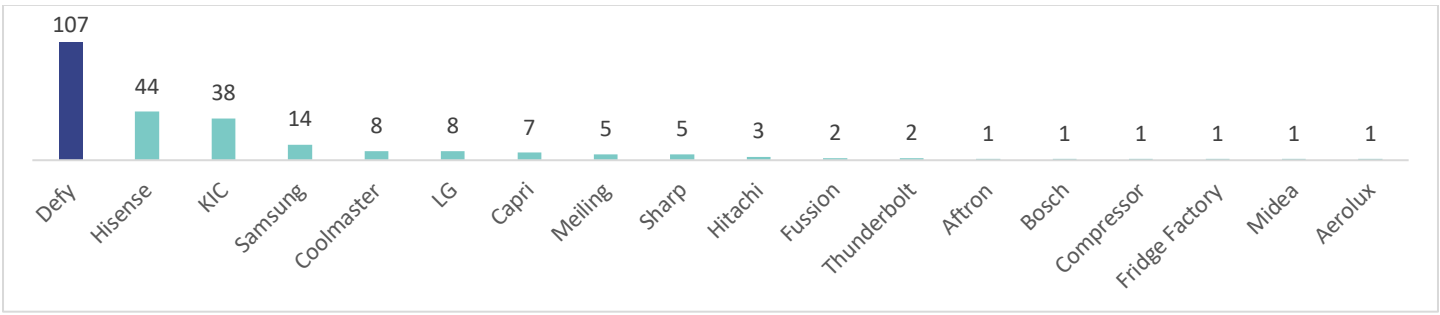


Figure 11: List of Most Sold Refrigerator Brands. (Source; Residential Refrigerators Survey 2021)

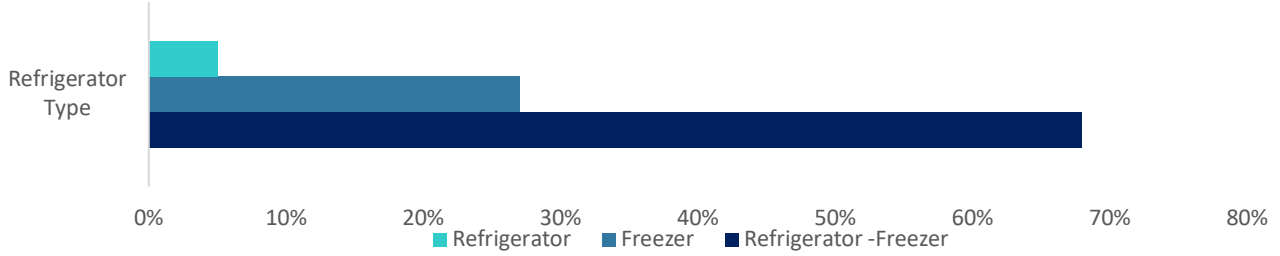


Figure 12: Most Sold Refrigerator Type (Source; Residential Refrigerators Survey 2021)

5.1.5 Barriers to the sale of efficient residential refrigerators

From out of the 201 participants interviewed in the household survey, 97 percent of the participants indicated that they were unaware of any energy efficiency and labelling policies or schemes in Zambia and the driver of most of the sales was observed to be related to appliance pricing and affordability. Energy efficiency was not a factor though most distributors have appreciated the growing number of energy efficient appliance but were quick to mention that most sales were as a result of pricing and affordability.

Therefore, based on both the residential refrigerators and supply chain interviews, the barriers to the sale of efficient residential refrigerators were more related to the lack of awareness on efficient refrigerators and its benefits, as well as the high prices related to the efficient refrigerators. The efficient refrigerators fetched a higher price compared to the ordinary refrigerators, approximately

30% higher making it difficult for most consumers to afford. Most consumers face financial challenges and could not afford to buy a new refrigerator. Those that could afford, it was found that they would still be influenced by the price of the appliance rather than its energy efficiency rating. It still remains important for awareness campaigns regarding energy efficient appliances to be strengthened. With a national EE framework in place, distributors will be compelled to import refrigerator appliance that comply to minimum energy performance standards and labelling. This will eventually be expected to trickle down to the end-users.

5.2 Demand

5.2.1 General Consumer Information

A total of 200 households participated in the household refrigerator survey and out of these, 53 percent were female headed households and 47 percent male headed household, while the youngest among the participants was aged 19 and the oldest, 69 years, this is illustrated in figure 13 below. Most participants fall in the 30 to 39 years old category and within this category, there are more women than men. The lowest age category consists of participants aged between 60 and 69 years old.

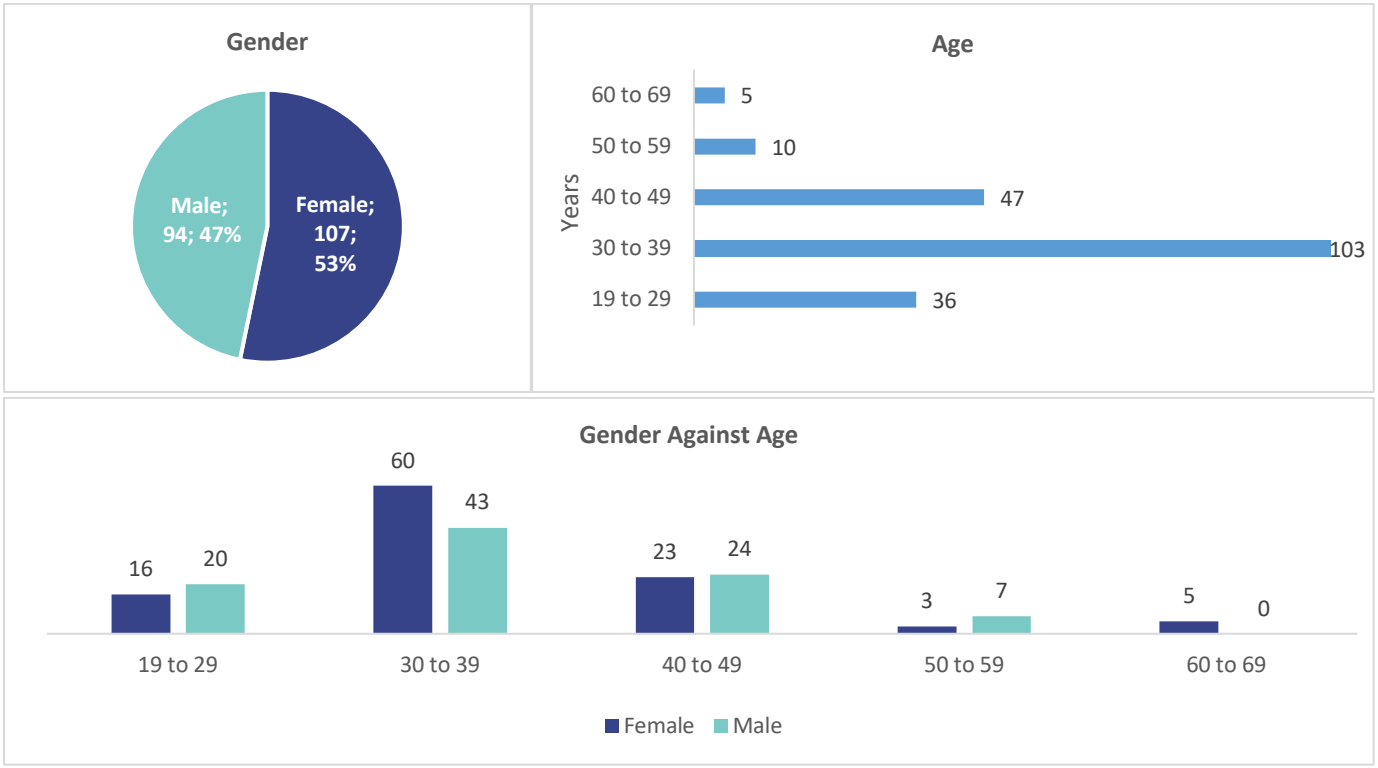


Figure 13: Gender and Age Statistics of Survey Participants

The survey also revealed that 76 percent of the participants lived in rented houses compared to 24 percent who lived in owned houses as figure 14 below shows. Further from a gender perspective it was found that more men than women owned houses which could be attributed to levels of employment and income earned, however, this is by a very small margin.

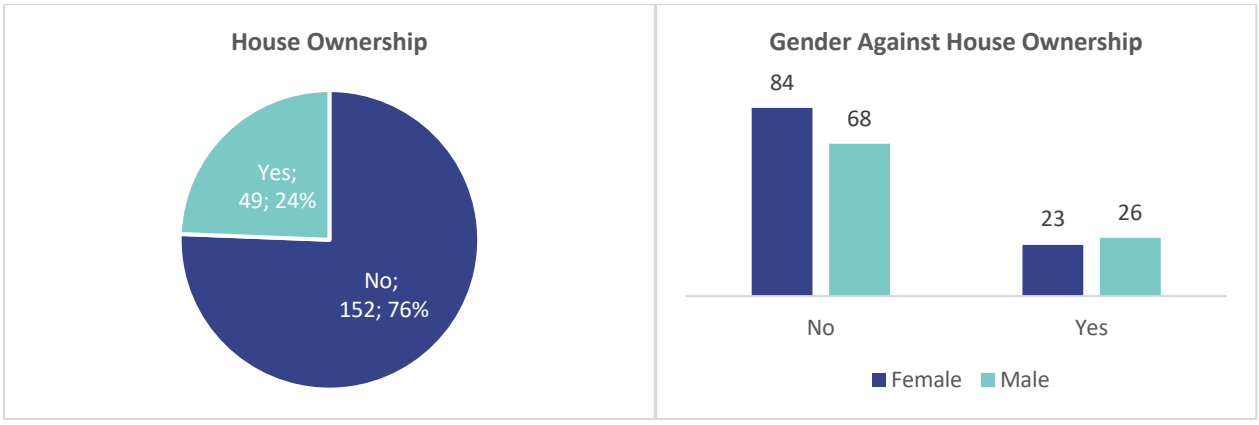


Figure 14: Gender against House Ownership of Survey Participants

Figure 15 below indicates that the highest number of households consisted of 4 members and the lowest only had between 9 and 10 members. Most of the households consisted of 4 to 7 members, it was the common range while households with 7 or more members was the least common among the participants. Majority of the male headed households consisted of 4 members, whereas the female headed households consisted of 3 members. Male headed households showed a higher number of household members compared to female headed household members.

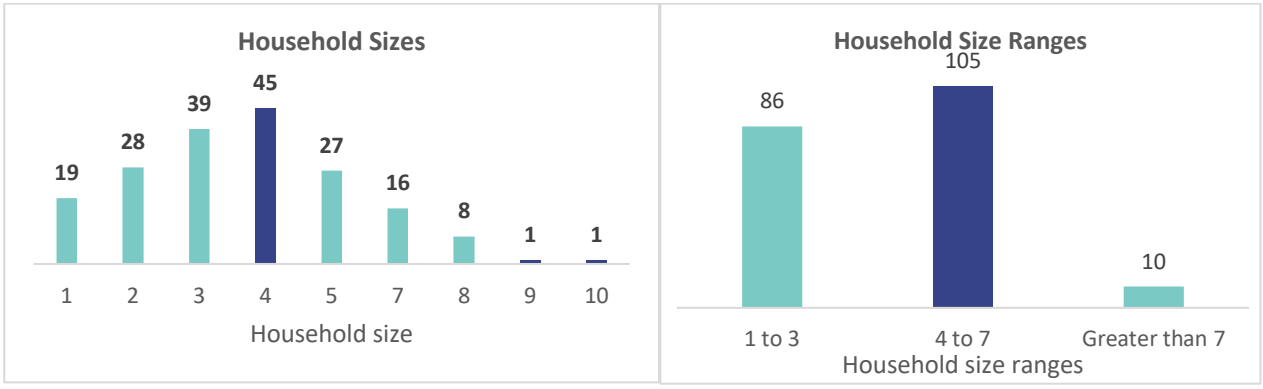


Figure 15: Household Size Ranges

Regarding the house type among the participant, it was found that most of the participants owned or lived in 3-bedroom apartments and these families mainly consisted of 4 to 7 members as indicated in figure 16 below. It was also observed that most female headed households owned or lived in 2-bedroom apartments and male headed households lived in 3-bedroom apartments.

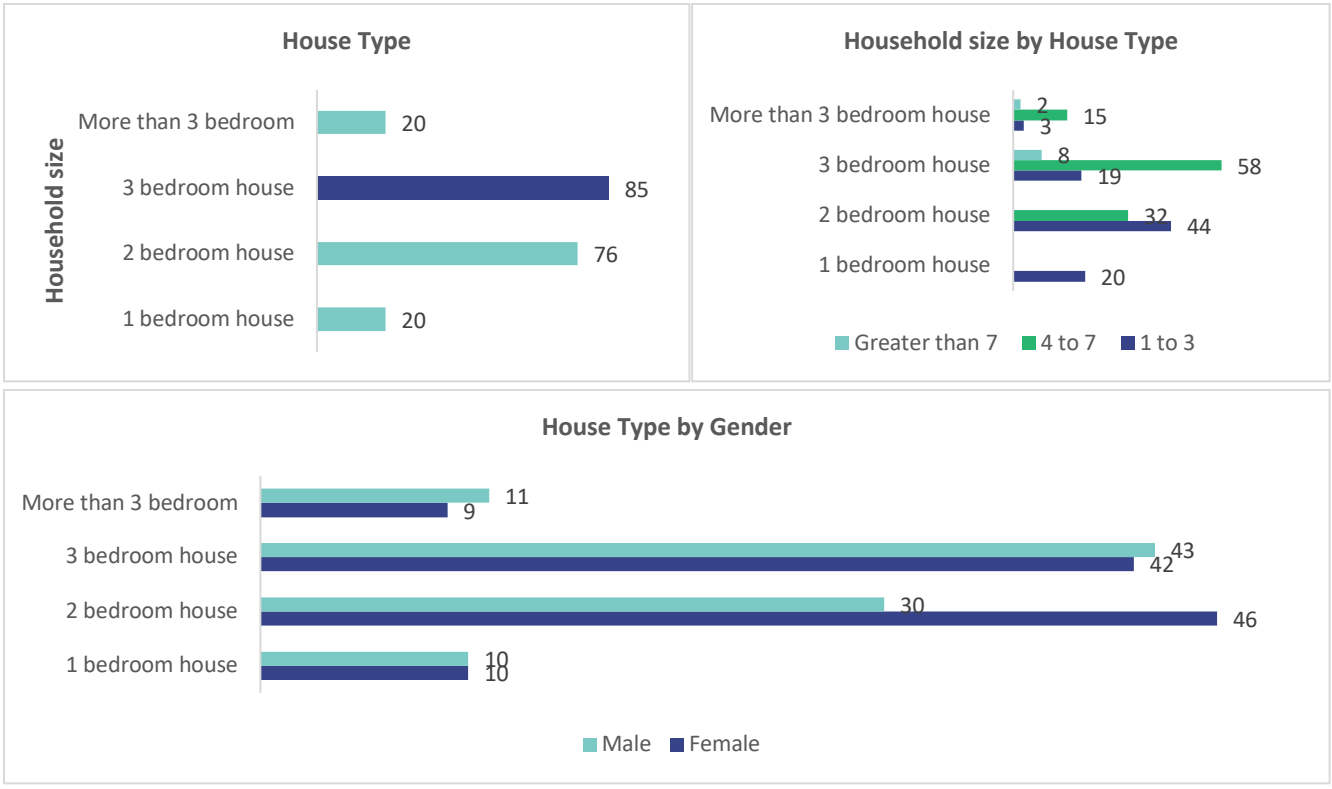


Figure 16: House Sizes, Types against Gender

The average annual income of the participants ranged between $1,000 (17, 000 ZMW) and $28,636 USD (479, 468 ZMW). Majority of the participants earned between $1,000 (17, 000 ZMW) and $8,181 USD (136, 979 ZMW) per year. Both the minimum and maximum average income is lowest among women compared to that of men as indicate in the table 15 below.

Table 15:Ranges of Annual Income of Participants

Gender	No. of Participants	Minimum Annual Income USD $[8]	Maximum Annual Income USD $
Female	107	1,000	22,727
Male	94	2,000	28,636
All	**201**	**1,000**	**28,363**

Also, a comparison of the employment type indicates that the self-employed (amongst public and private) have the highest 'minimum annual average' income but the lowest 'maximum annual average income'. The public sector has the highest maximum average annual income, and the private sector has the lowest average income. Most of the participants work for either the private or public sector. This also applies for both genders. However, more women than men are self-employed as shown in the table 16 below.

Table 16: Employment Against Gender of Participants

Employment Type	Gender	No. of Participants	Minimum Average Annual Income USD $	Maximum Average Annual Income USD $
Private	Female = 36 Male = 39	75	1,000	22,727
Public	Female = 38 Male = 35	73	1,636	28,636
Self Employed	Female = 33 Male = 20	53	1,727	11,363

5.2.2 Level of financial inclusion

As traditional banks continue to downsize, as they struggle to grow their revenues and close more of their brick-and-mortar branches, a close substitute and now considered as a viable future alternative in mobile money has continued to march ahead, mobile money is putting out more agents and post growth numbers that are jaw dropping. And this was confirmed in Zambia by Bank of Zambia that digital financial services in the country have recorded significant growth with mobile money payments posting an annual average growth of 126% in value from $ 89 million USD processed in 2015 to $2.23 USD billion processed in 2019 (BOZ, 2019).

The number of active mobile money wallets have increased over time as at end of 2019, about 14 million mobile money wallets were registered and about 4.9 million were actively transacting, representing 34% of the total registered mobile money wallets. This has also brought about the opportunity to easily get short term loans and repay with lowest interest rates. Some financial institutions have also provided for easy repayments of loans through mobile money.

The digital financial services landscape in Zambia has changed quite dramatically as the usage of digital channels for the delivery of payment and financial services has grown considerably.

The majority of commercial banks have developed and deployed mobile applications that their customers use to access financial services adding that e-money issuers are capitalizing on smart and ordinary feature mobile phones to offer financial services.

The Zambian Business Times – ZBT with sources at both Banks and Mobile money players has confirmed that though banks are offering some way to inter-operate and facilitate bank to e-wallet and Vice-versa, the situation on the ground is that there are more funds flowing from banks to mobile wallets than the other way round (BOZ, 2019).

He added that the performance of other electronic payment streams such as Electronic Funds Transfer – EFT equally recorded remarkable growth, posting annual average growth of 35% in value from $938 million USD processed in 2015 to $ 3 billion USD processed in 2019.

"From these statistics, it can clearly be demonstrated that there is great potential in Zambia to have more people financially included through digital channels and ultimately in the digital economy.

[8] Exchange rate of $1 USD to K22 ZMW was used.

Even more relevant today primarily because given the current situation with the Covid-19 pandemic, digitalization has offered an opportunity for contactless business continuity, rapid and systematic data collection and efficiency, informed and transparent resources allocation.

Mobile money players have continued to expand their service offering with most companies with a high number of blue-collar workers opting to use mobile money to process their payroll payments. Person to person payments is today seeing more growth and actively cannibalizing the payments space once considered a preserve of banks. Out of the 201 participants from the household refrigerator survey, 12 participants did not have bank accounts as indicated in figure 17 below. Also, most of the participants (11 participants) without bank accounts were self-employed. The majority that had bank accounts, and in particular banked with ZANACO. More women compared to men banked with ZANACO and the majority of self-employed participants and those working in the public sector also banked with ZANACO. The majority of those working in the private sector had bank accounts with FNB.

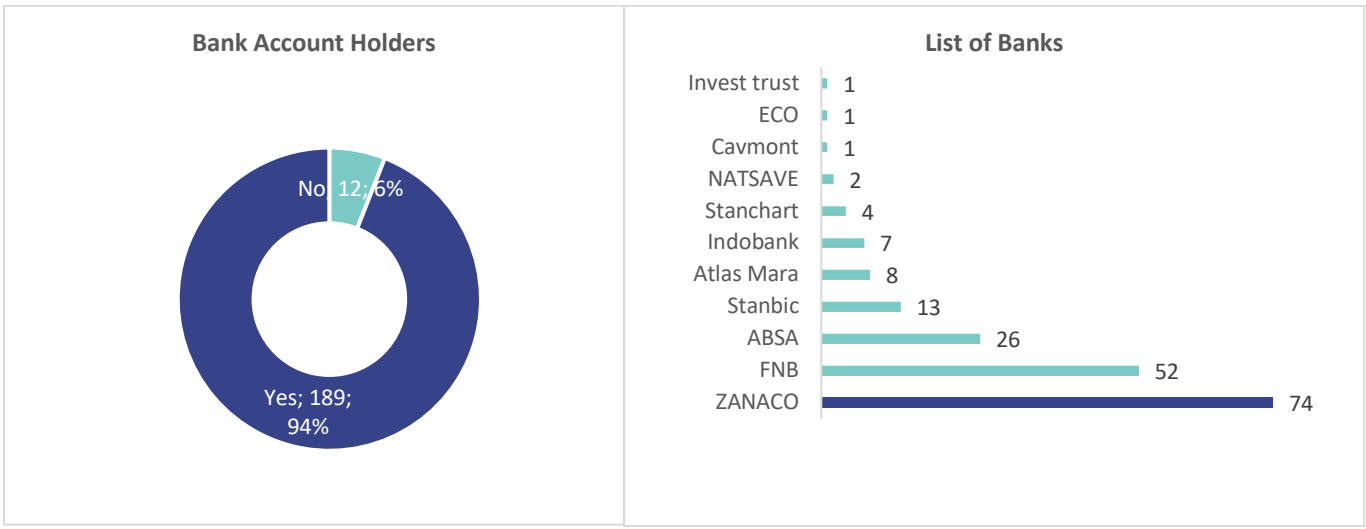
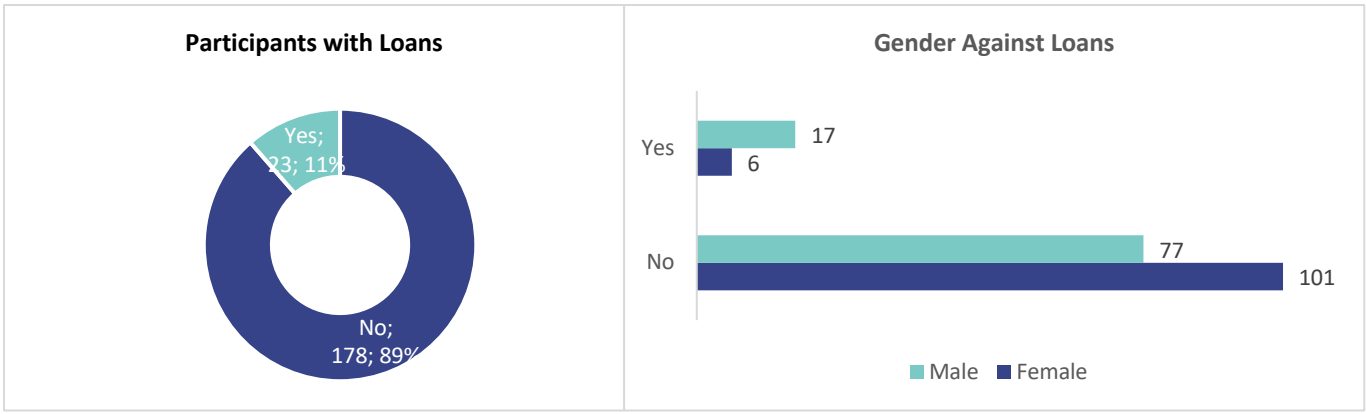


Figure 17: Bank Account Holders and List of Banks

The survey also revealed that only 11 percent of the participants obtained loans and most of them were men (17 men and 6 women) as indicated in figure 18 below. Most of the participants obtained loans from ABSA, with interest ranging between 24 and 28 percent per annum. The highest interest loan was from Stanbic bank at (37%/Yr.). Among those that obtained loans, 15 out of 23 find the loan conditions favourable. On the other hand, majority of those without loans find the loan conditions unfavourable.



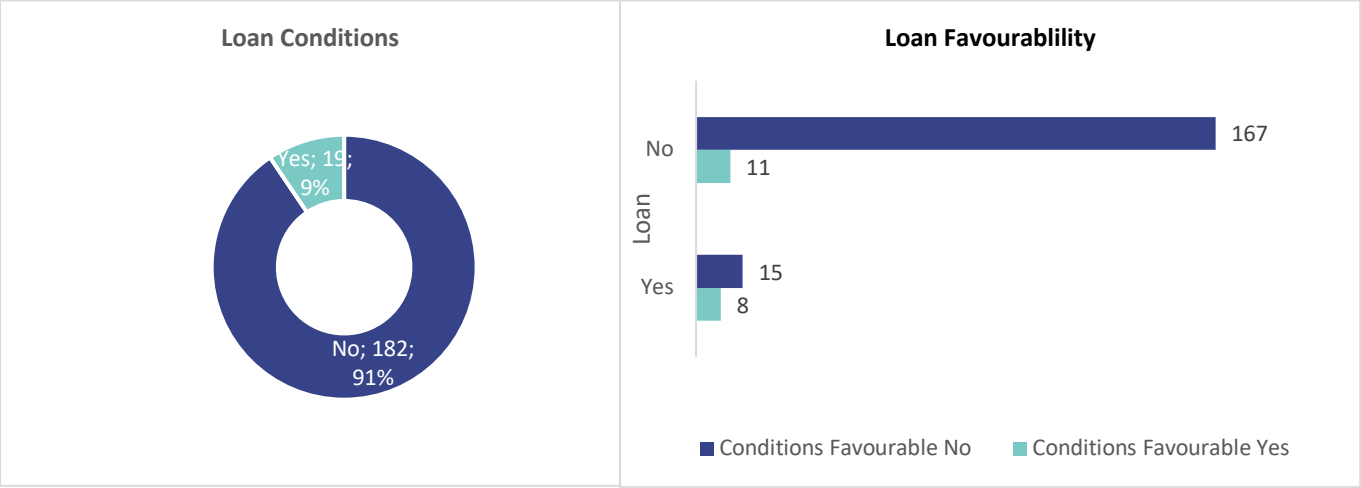


Figure 18: Loans and related issues

5.2.3 Current expenditure on electricity

All the households sampled had a prepaid electricity meter, in fact all residential customers have prepaid meters in Zambia except for maximum demand customers consuming 16kVA or more. These also involves split meters mounted on electricity poles which are usually utilized by more than one household. The payment method for electricity units has evolved over the years with the emergency of mobile money technology. Most of the purchase of electricity units are done through mobile money platforms related bank platforms. This is convenient for most consumers who can purchase electricity units from the comfort of their homes. From the survey we found that the lowest average electricity purchase made per month was 70 units while the highest electricity purchase was 2000 units. Majority of participants spent less than 500 units every month on electricity purchase, and this group has household size ranging from 1 to 7 members. Those that spend between 1500 units and 2000 units have a household size above 7 members. Figure 19 below shows the electricity units purchased per month.

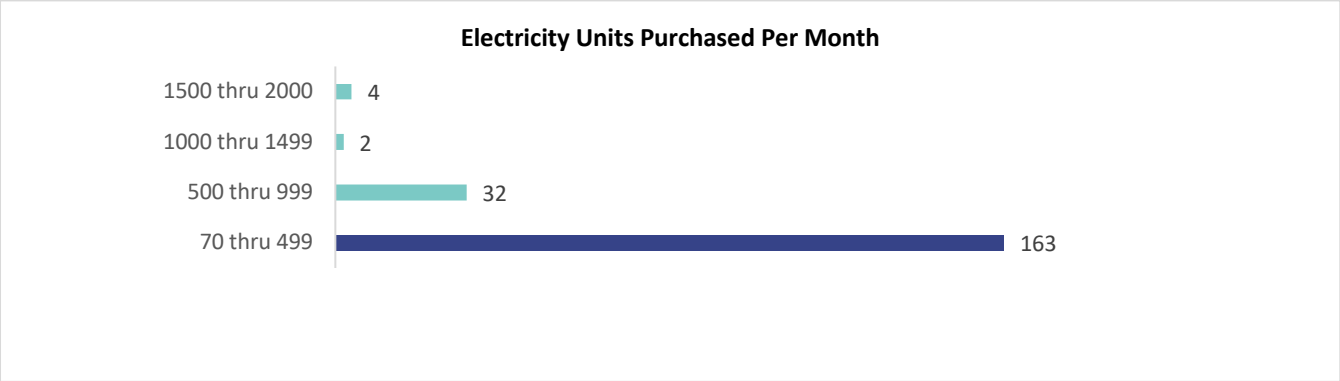


Figure 19: Electricity units purchased per month. (Source: Residential refrigerators survey)

5.2.4 Ownership refrigerating equipment

From the 201 sampled households, a total number of 249 appliances were observed. Most participants owned Refrigerator-Freezer's type. The most common brand observed among the participants was the Defy brand and from the 107 Defy appliances observed a total of 59 were Refrigerator-Freezer types. 48 participants were found to have more one residential refrigerator as the majority had only one residential refrigerator.

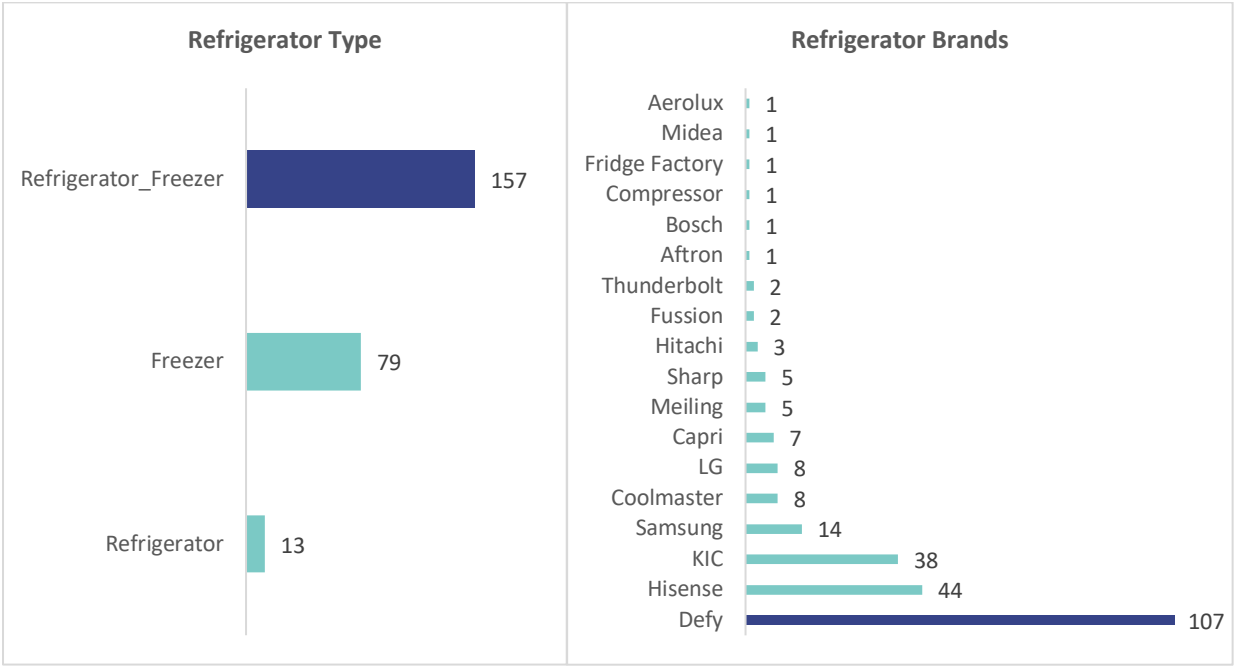


Figure 20: Refrigerator Type and Brands

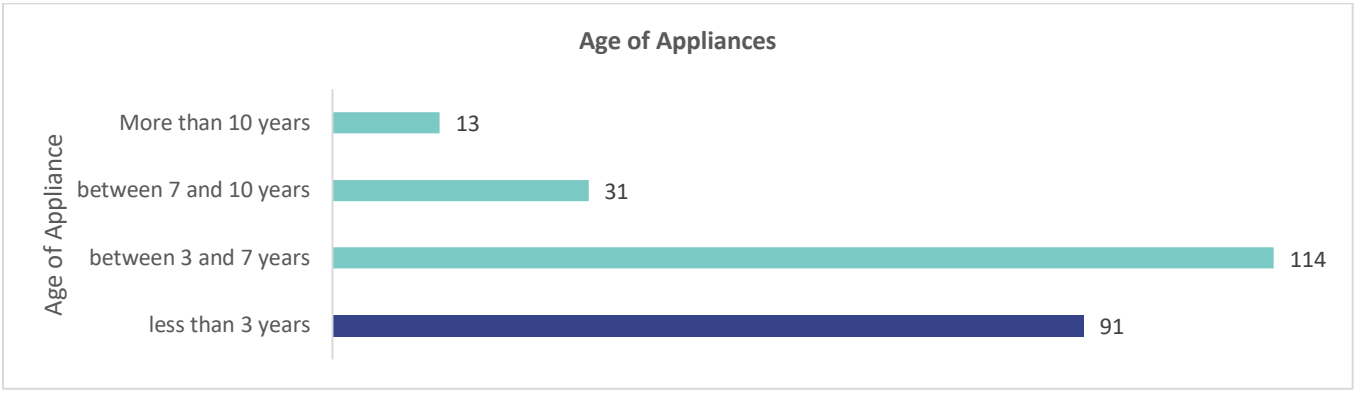


Figure 21: Age of Appliances Surveyed

The survey revealed that 114 appliances from the 249 sampled had been in use for 3 to 7 years. This formed the largest category followed by those that have been in use for less than 3 years. Further it was observed that most participants purchased new appliances compared to only 20 percent who purchased second-hand appliances and it was also found that of the new products purchased a majority were Defy brand products and was also a Refrigerator-Freezer types as indicated in figure 22 below.

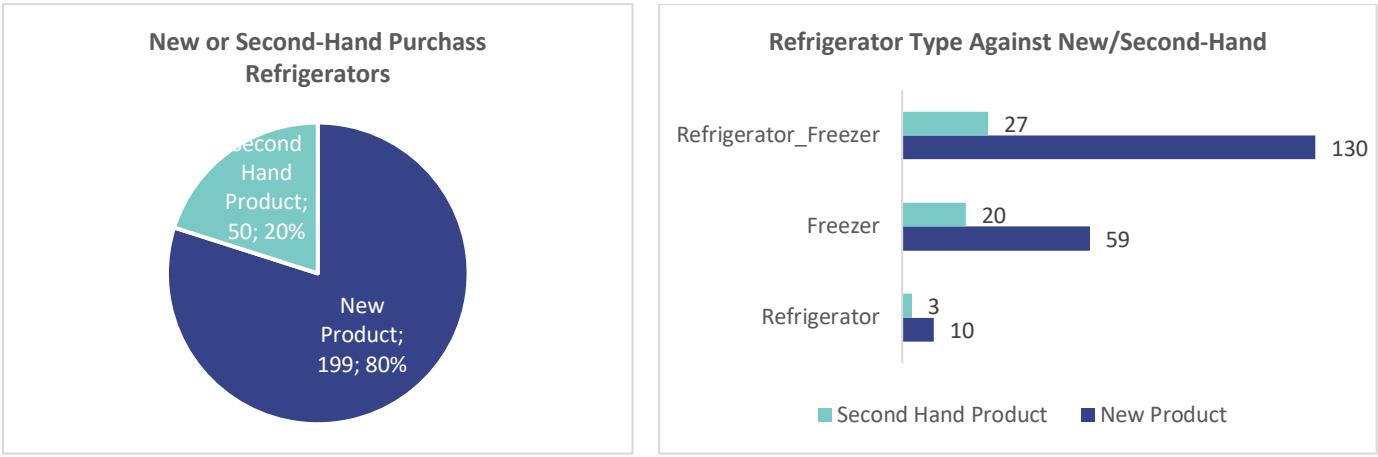


Figure 22: Refrigerator type against New or Second Hand

The lowest purchasing price for a refrigerator appliance was found to be $ 63.6 USD (1, 055 ZMW), and this was an LG brand appliance. The highest purchase price was $ 818.8 USD (13,709 ZMW) a Fridge Factory brand appliance. The most-costly among the residential refrigerator types are the Refrigerator-Freezers and less costly are the Freezers. Also, as expected, second-hand appliances were purchased at a much lower price compared to the purchase price of the new appliances. It was also found that 92 percent of the participants would prefer to own a new energy efficient refrigerator, refrigerator-freezer or freezer than leasing one.

Majority of the surveyed refrigerating appliances use the direct cool technology, as are most of the Defy, Hisense and KIC refrigerating appliances. Also, among the refrigerating appliance types, most Refrigerator-Freezers were employing the direct cool technology as can be seen in the figure 23 below. The figure 23 also highlights that 201 (81%) of all the refrigerators sampled employed the direct cool technology type and amongst these most of them were refrigerator-freezer type. Direct cool technology is less expensive in production and in operation, as it consumes less energy. This justifies the high number of refrigerators employing the technology.

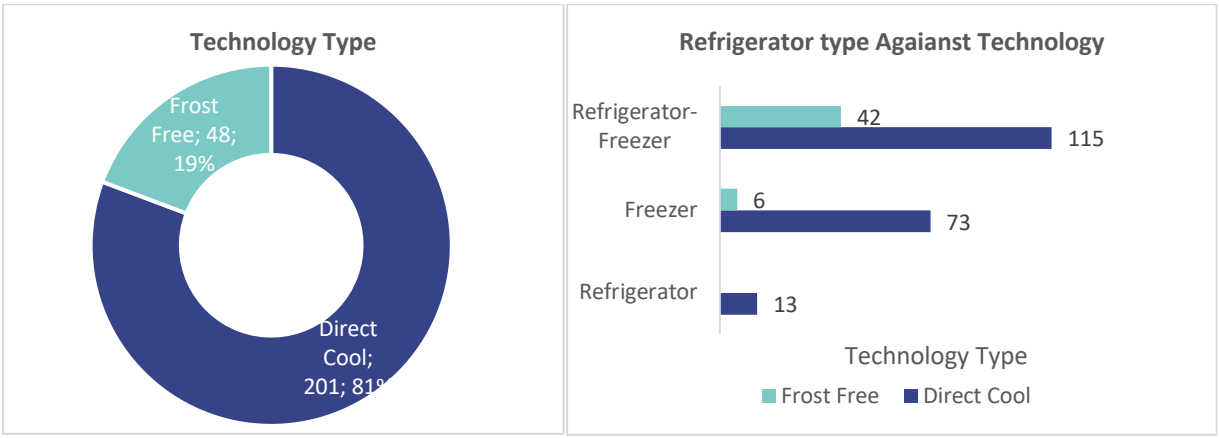


Figure 23: Direct and Frost-Free Technology (Source: Residential Refrigerator Survey)

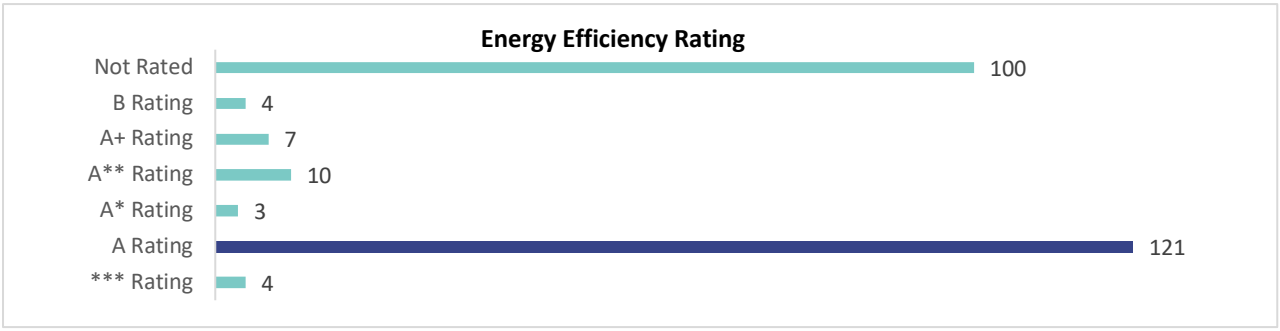


Figure 24: Energy Efficiency Rating (Source: Residential Refrigerator Survey)

From the sample of 249 refrigerators, 100 of them were found to have not been energy efficiency rated while a total of 121 refrigerators were A rated of which a majority were the Defy, Hisense and KIC refrigerators. Figure 24 above shows the various energy efficiency rating. These brands come A efficiency rated from source which is mainly South Africa. No deliberate policy or regulation requires that these appliances are checked for energy efficiency at the border entry. Most A rated appliances power rating ranged between 61 to 240 kWh of energy consumption. Among those that were not rated, the power rating ranged between 181 and 240 kWh for most of them. Regards awareness of energy efficiency, 97 percent (194) of the participants indicated that they were unaware of any energy efficiency and labelling policies or schemes in Zambia.

Figure 25 below shows some of the desired features of equipment, Quality, Warranty and Brand were the topmost features that most participants considered of high importance when acquiring a residential refrigerator. The same features were also the most preferred among women. As for men, the three most important features were quality, the price of the equipment and the brand. One key finding is that most participants do not consider access to financing as key feature when purchasing a residential refrigerator. This is also the case for energy consumption.

Apart from the list that was provided, very few participants had other features that they would consider when purchasing a residential refrigerator, however, specifics of what those features would be were not obtained.

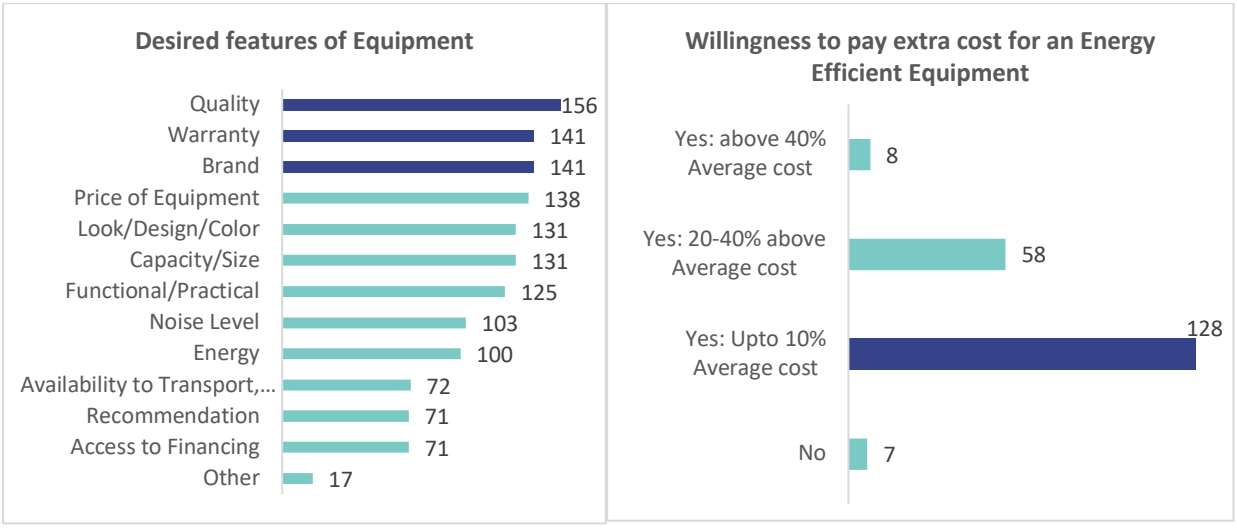


Figure 25: Desired Equipment Features and Willingness to Pay (Source: Residential Refrigerator Survey)

Further it was observed from figure 25 above that most participants were willing to pay an extra cost of up to 10% of the average cost for an energy efficient refrigerator whereas only 7 participants out of the 200 were unwilling to pay extra. An encouraging prospect especially that the project is promoting energy-efficient appliances. This is a key indicator in understanding the current market landscape.

The participants' willingness to pay for an energy efficient appliance is there though a number of them are not willing to pay more than a ten percent of the average cost of the appliance. This will form a baseline of the future planned activities to try and increase advocacy and sensitization campaigns aiming at enriching and educating people about the benefits of energy efficiency.

5.2.5 Desired features of equipment

It was observed that the desired feature of the refrigerator was the number of doors. Besides the number of doors on the refrigerator, consumers were also particularly interested in the brand of the refrigerator.

5.2.6 Consumer preference on purchase of a refrigerator

The residential refrigerator survey further indicated that most consumers preferred to buy brands when it came to consumer preference. Though the price of the equipment was crucial, most of the consumers were inclined to the brand of the refrigerator. The brand of the refrigerator was in a way associated with durability and operational efficiency.

5.2.7 Barriers to the purchase of efficient refrigerators

Based on the survey results it is safe to conclude that the Zambian market could grow even beyond the current state. Most participants indicated the desire for quality products, warranty and brand as their preferred factors that could influence their purchase of a residential refrigerator. Quality has been a major issue in Zambia especially that the country has no manufacturing base of refrigerators, and all of these appliances are imported from the various countries around the globe. But quality of course would come with a cost and ultimately most of the people would not be able to afford quality expensive refrigerators. The conversation therefore shifts back to affordability as the country is struggling financially with most of its people leaving below the poverty line (World Bank, 2018).

Lack of finances to afford new and efficient refrigerators were the highest rated barrier because even if quality products were available, very few Zambians would still be able to afford the product and even for the few that would afford, issues of energy efficiency would not be a major factor to influence the ability to purchase. Therefore, to rate the barriers, lack of finances to afford a new efficient refrigerator would be regarded the largest barrier followed by capacity and least would be awareness. Of course, it is expected that more people would purchase efficient refrigerators if they were aware of it. In this context you want to assume that the few would have the financial capability to purchase a refrigerator and would therefore be influenced by the energy efficient status of the refrigerator. But more would need to be done from the policy level to try and promote efficient refrigerators from the energy management front. Understanding that an efficient refrigerator would reduce energy consumption which in turn would save money for the end-user would be more of an appropriate message to disseminate

5.3 Equipment Stock and Projections

To establish the stock levels of residential refrigerators in Zambia, an economic model was utilized, and an assessment was done based on two key assumptions of the market.

1. Households will be replacing residential refrigerators due to end of life. The end of life of a refrigerator based on secondary data was set to be 15 years. This yielded a replacement rate of 7% per annum.
2. Households will acquire new residential refrigerators due to economic opportunities.

Several factors were considered as well in the economic model such as the refrigerator market growth of 3.1 % for Zambia and the average price of the residential refrigerator obtained from the residential refrigerator survey. The table 17 below shows the total stock of refrigerators and market value projections of refrigerators in Zambia until 2030.

Table 17: Total Stock and Market Projects for Zambia (Source; Market Assessment Economic Model 2021)

Years	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of residential refrigerators replaced (end-lifetime)	50,000	52,000	54,000	55,000	57,000	59,000	61,000	63,000	65,000	67,000
Additional number of residential refrigerators acquired (market growth)	23,000	24,000	25,000	25,000	26,000	27,000	28,000	29,000	30,000	31,000
Total market size for	74, 000	76, 000	79, 000	81, 000	84, 000	86, 000	89, 000	92, 000	95, 000	98, 000

residential refrigerators										
Total market value for residential refrigerators (USD)	32, 000, 000	33, 000, 000	34, 000, 000	36, 000, 000	37, 000, 000	38, 000, 000	39, 000, 000	40, 000, 000	42, 000, 000	43, 000, 000
Total stock of residential refrigerators	787, 000	811, 000	837, 000	863, 000	889, 000	917, 000	945, 000	975, 000	1,000,000	1,000,000

The projections indicate a steady growth in both the market size and value of residential refrigerators. The market value is expected to grow above 43,000,000 USD (720,000,000 ZMW) by 2030 while the market size is expected to be slightly below 100,000 residential refrigerators by 2030 as indicate in figures 26 and 27 below.

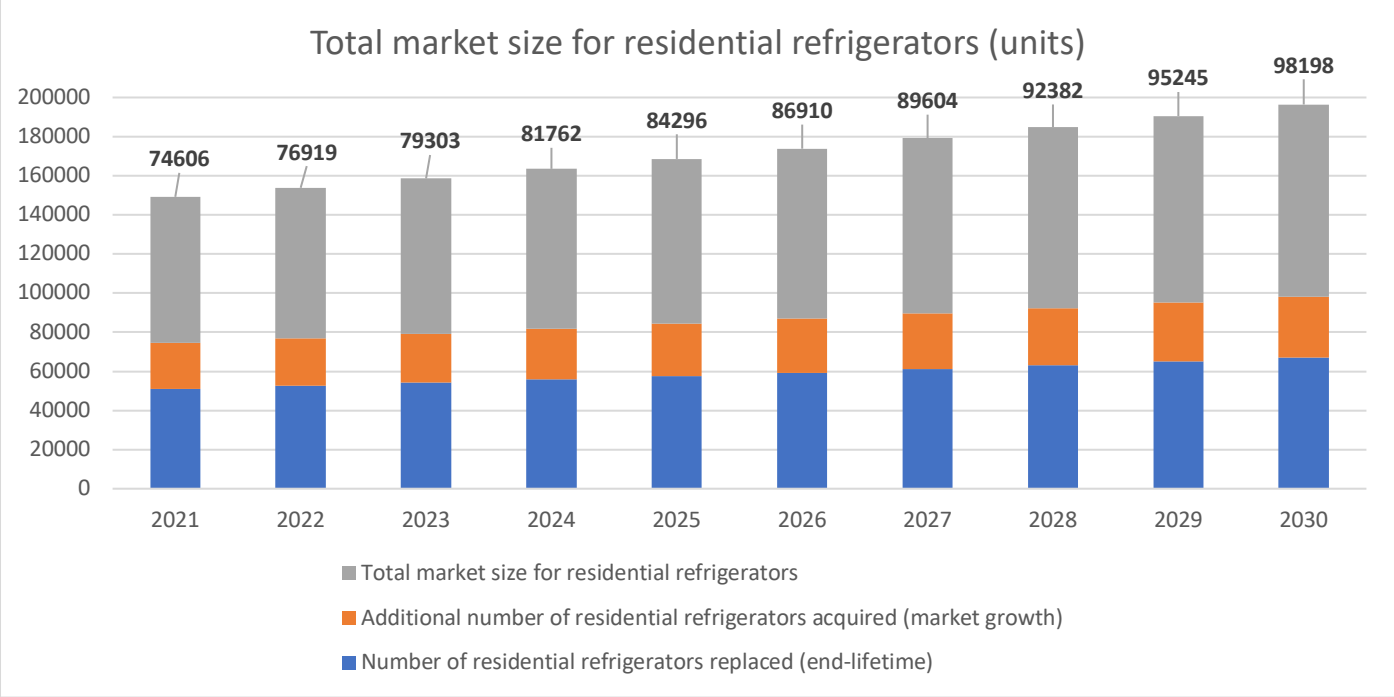


Figure 26: Total market size for residential refrigerators (Market Assessment Economic Model 2021)

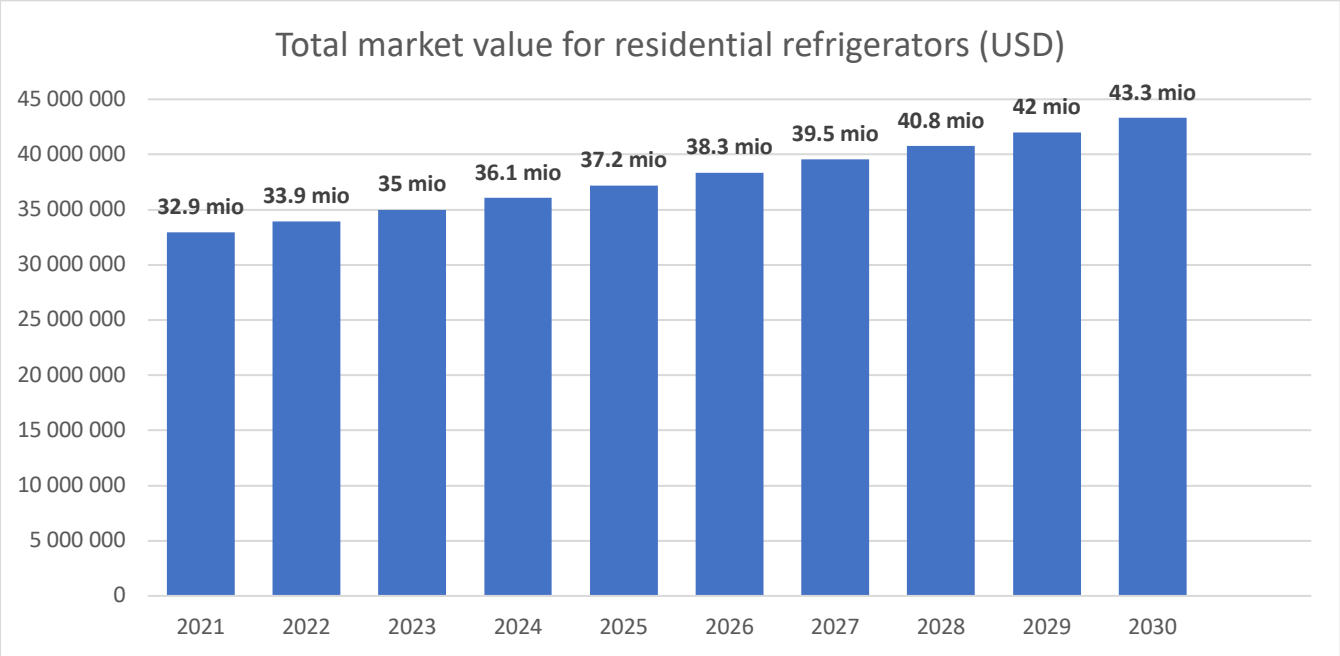
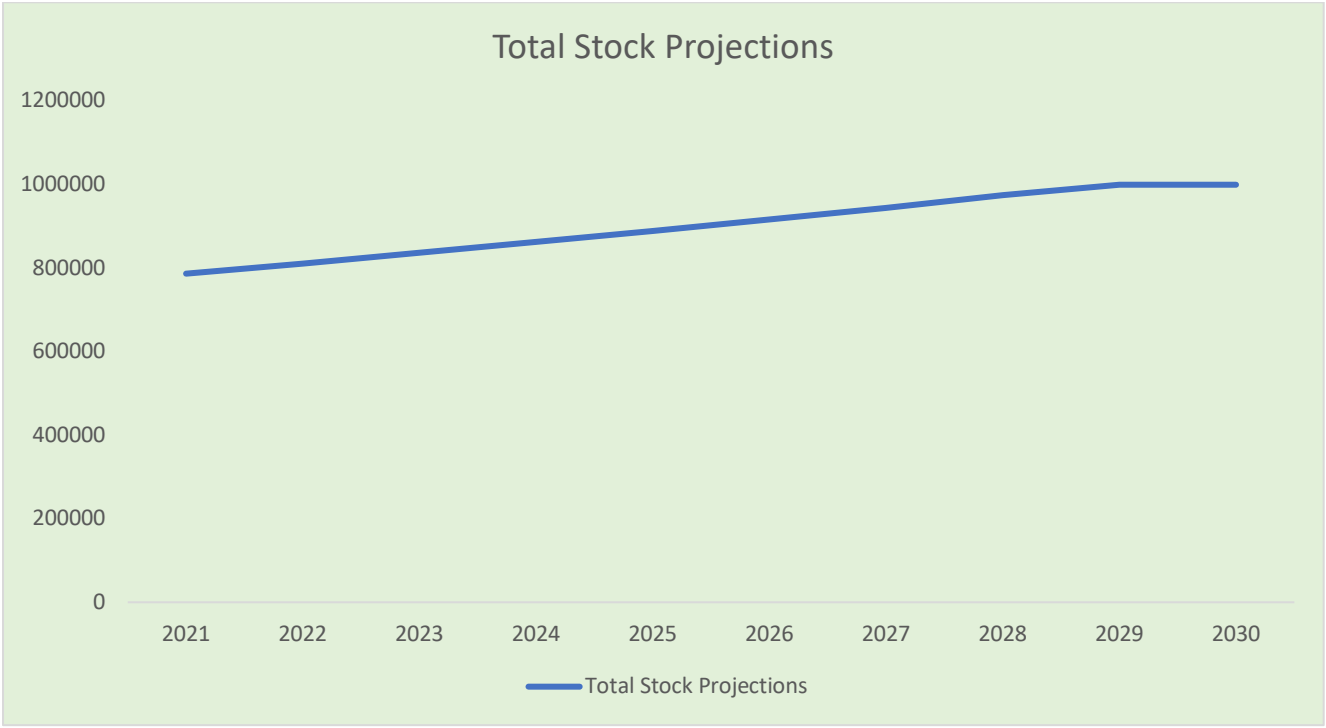


Figure 27: Total market value for residential refrigerators (USD) (Market Assessment Economic Model 2021)



5.3.1 Summary of residential refrigerators in the market based on household demand

The survey focused mainly on the refrigerator- freezer, freezer and refrigerator appliances with the number of doors as a physical feature to be assessed. The type of refrigerants used was also assessed to check the level of compliance with permitted refrigerants. The Zambian market is dominated by the refrigerator-freezer appliance which vary in the number of doors. The survey also revealed that the most used refrigerant was R600a and are still the most used.

Table 18: Refrigerator Types with Physical Features (Residential Refrigerator Survey)

Product Types	Physical Feature (No. of Doors)	Average Annual Energy Consumption kWh	Refrigerants
Refrigerator-Freezer	1 Door 2 Doors 3 Doors 4 Doors	1376.88	R130a, R134a, R500a, R600a
Freezer	1 door 2 doors	1567.35	R130a, R134a, R600a
Refrigerator	1 door 2 doors	1321.78	R134a, R600a

The average volume corresponding to below average annual energy consumption was found to be 346 liters corresponding to 112kWh. However, no correlation was established between the size of the volume of the refrigerator and the annual energy consumption.

5.3.2 Technology trends and market projections

The household refrigerators and freezers market are segmented by the types of refrigerators and freezers as well as distribution channels. The type of refrigerators is classified in terms of side-by-side doors, bottom doors, double and single doors. From the survey conducted, majority of the refrigerators sampled were double doors. The refrigerators comprise both direct cool and frost free.

Further the market trends are also influenced by the distribution channels available in a particular market. Zambia`s refrigerator supply chain involves only suppliers and distributors as there is no manufacturing base. All refrigerators and freezers are imported into the country and distributed by various distributers segmented by brand types.

Market projections using the economic model projects a growth in the market size by an estimated 32% by 2030.

5.4 **Policies and Programme Landscape**

5.4.1. Current and planned refrigerator policies and programs

The country has put in place the National Energy Policy of 2019 and in the policy energy efficiency is highlighted as the first fuel. Besides, the country is implementing energy efficiency initiatives which include promotion of efficient utilisation of energy services and switching to other alternative types of energy sources and technologies. Specific efforts have been on the development of energy performance standards developed for lighting, lamps, electric motors, and solar water heaters. However, these efforts need to be well coordinated and extended to other energy services. The absence of dedicated instruments such as building codes, and Minimum Energy Performance Standards has affected adoption of EE and conservation. An energy efficiency strategy is in draft form and could be completed by end of 2021. Specific policies or programs for refrigerators are not yet in place.

5.4.2. Status of electronic-waste management in the country

Electronic-waste volumes have been growing with no clear sustainable management and disposal system in the country. However, the Zambia Environmental Agency (ZEMA) have put in a place a statutory Instrument SI 65 which attempts to address the issue as it provides for extended producers responsibility. The country has seen a sharp increase especially in ICT e-waste and this has been a huge concern for the ICT regulator. Efforts to develop national standards and procedures for handling e-waste are underway being championed by the ICT regulator, ZEMA and ZABS. Zambia is bound by the SADC Protocol on Energy 1996, which states that: “energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications”. The handling of removed equipment is addressed in the Environmental Management Act 10 of 2008 and related regulations.

5.4.3. Stakeholder perspectives on opportunities and barriers to transform the market toward more energy-efficient and climate-friendly refrigerators.

A number of stakeholders interacted with expressed optimized of the transformation of the sector except most of them still feel there is need for a high-level intervention from the policy side. Zambia currently has nothing in place that would mandate or motivate someone to import or purchase an efficient refrigerator and the level of awareness on the benefits of energy efficient

refrigerators in the country is very low. The country has in place the Environmental Protection and Pollution Control Act for Ozone Depleting Substances which provides for the control of production of and trade in any controlled substance or any other substance likely to deplete the ozone layer. However, willingness to pay for an energy efficient refrigerator indicates that with a proper structure in place adoption of energy efficient refrigerator appliance would be possible. From the supply chain end, most distributors expressed willingness and desire to continue supplying latest energy efficient refrigerators but were quick to mention that most end users are more concerned of the price of the product and not its energy efficiency state. Zambia`s market is dependent on imports and this has huge impact on the quality and efficient state of the product coming. With deliberate law and enforcement of MEPS in place the market would respond in ensuring quality and energy efficient products are allowed in the country. Most end-user also expressed willingness to purchase efficient refrigerators, but this was not the factor that would influence them to but the product. Affordability still remains a challenge for most of the people in Zambia and pricing of the product still place a big role in determining the influence to purchase a product.

5.5 Existing Financial Institutions and financing instruments for appliances

Currently there are no known financial mechanism that have been put in place to promote the adoption of efficient refrigerators. The participants surveyed indicated that most of their banks do not have provisions for such arrangement and most of the participant did not find getting a loan to purchase a refrigerator attractive. Mode of purchase of refrigerators was mostly through own capital e.g. bank or cash. The list of financial institutions surveyed include, ZANACO, FNB, Standard Chartered, Investrust, Stanbic, ABSA, ATLAS, Cavmont, Ecobank Zambia, Indo-Bank and NATSAVE Banks.

5.6 Embedding and dependencies of the national refrigerator market in the regional context

Zambia has no manufacturing base for refrigerators, and thus has been dependent on the neighboring countries for imports of refrigerators. The Zambian market has been seen to grow over the past years with a lot of future prospects. Zambia as a member of SADC has benefited from the regions rich manufacturing base. This is evident from the 76% (21 million US$) import share of refrigerators in 2020 from South Africa alone and 1% (284 thousand US$) share from Zimbabwe. This has stabilized the market in Zambia and ensured the steady growth of the market. Other markets include parts of Asia and Europe. The national refrigerator market therefore has strong dependency on both regional and international market. This is exciting for the relationship with Zimbabwe who is also actively participating in the GCF project as this would see an increase in trade volumes of refrigerators due to reduced technical barriers to trade (TBTs). This is true also for the export potential of the country especially with neighbouring countries participating in the GCF Project.

6.0 Market Assessment on Distribution Transformers

6.1. Supply

6.1.1. Summary of suppliers, government officials and other stakeholders

The supply of distribution transformers in Zambia is mainly dependent on the buyer of the transformer. Predominantly the power utilities, mining companies and related industry are active in the procurement of distribution transformers. The supply chain involves both locally manufactured and imported transformers. Key suppliers include newly registered AFRIZAM electrical limited in partnership with Rongzhong of China who are currently supplying the Zambian market with Electrical Equipment such as Sub Stations, Switch Cabinets, Switch Gear, Transformers and Fuses. The company has plans to build a state-of-the-art manufacturing plant in Zambia to supplement the products they are supplying with those to be manufactured. Tanelec Zambia Limited on the other hand was incorporated in Zambia in 2013 and has been in operations in the Zambian mining services industry for over 20 years offering servicing and repair of distribution transformers. Tanelec Zambia is predominantly engaged in supply of transformer parts and repair of the transformers. Table 19 below highlights the Summary of suppliers, government officials and other stakeholders.

Table 19:Summary of suppliers, government officials and other stakeholders

Suppliers/Manufacturer	Type of Transformers and Related Services	Other Stakeholders and Government Officials
1. Elsewedy Transformers 2. Afrizam Electrical Limited 3. Tanelec Zambia Limited 4. Marthinusen and Coutts, 5. Eugene Lottering	1. Distribution transformers up to 36 kVA 2. Oil Immersed distribution transformers from 25 KVA up to 4000 KVA with a primary voltage up to 33 KV. 3. Range of compact substations 4. Total service package for distribution transformers 5. Fuse, Switch cabinets, Switch Gear, Substations, Transformer services 6. Repair and reconditioning of Transformers	1. Energy Regulation Board 2. Ministry of Energy 3. Rural Electrification Authority 4. ZESCO 5. Konkola Copper Mine 6. Copperbelt Energy Corporation 7. Itezhi tezi Power station 8. Lunsemfwa Hydro Power 9. Mopani Copper Mines

6.1.2. Overview of the supply chain, including finished products and major components like core, winding, insulation, etc.

Zambia has an estimated total of 400 substations in the transmission system countrywide with each substation on average, having 1 or 2 power transformers with step-down capacities of 330/132kV or 132/33kV or 33/11kV while in the distribution system there are close to 19,400 distribution transformers with a step-down capacity of 33/0.4kV and 11/0.4kV. ZESCO the electricity utility company is responsible for operations and maintenance of these transformers on the network. It has since partnered with an Egyptian firm Elsewedy Electric which has since been manufacturing and in some cases repairing transformers for ZESCO for the past few years.

The power network in Zambia is owned and operated by ZESCO the national power utility. The power network is mostly distributed at the endpoints by pole mounted distribution transformers, some of them dating back to the mid 1900's. The distribution system in Zambia is categorized by voltage levels between 66kV, 33kV and 11kV.

The local market for transformers and switchgear is expected to continue growing with the country`s ambitious plans to expand and improve the electricity grid network system and integrate electricity from renewable energy sources through programs such as Renewable Energy Feed-In Tariff (REFIT). Also, under the Euro Bond Financed projects, the government of the Republic of Zambia (GRZ) allocated USD 69 million from the USD750 million Euro bond proceeds towards the rehabilitation and expansion of the distribution network infrastructure (LusakaTimes, 2014). The scope of works under this component includes the construction of new substations, upgrading of existing substation, replacement of obsolete switch gear and upgrading of the high-voltage underground cables in major towns. These and many other programs are expected to drive the market for transformers and switchgears in Zambia.

Elsewedy Electric is an Egyptian company based in Ndola, Zambia positioned as a local manufacturer of distribution transformer ranging Up to 250 MVA and up to 220 kV class including Oil immersed distribution transformers, cast resin transformers, in addition to offering modular solutions and transformer services in maintenance and installations. The 20,000 m^2 factory in Ndola, Zambia is ISO-certified and offers a one-stop shop for transformers and substation needs. All Elsewedy substations meet IEC 60076 series of international standards.

Most transformers in the SADC region are either manufactured in, or distributed by, South African companies. The same is true for transformers in Zambia with roughly 69% coming from South Africa. Strong business ties along with competitive pricing have resulted in an increase in market share from both India and China.

6.2. Demand

6.2.1 Assessment of main purchasers of distribution transformers

Costs of energy efficient transformers are still significantly higher than standard efficiency units and the relatively low cost of electricity combined with a general acceptance of system losses results in the very slow adoption of energy efficient transformers in Zambia. The main buyers of distribution transformers in Zambia include ZESCO, Copperbelt Energy Corporation and Mining Firms. Specifications considered include Primary and Secondary Voltage, Power rating, Cooling, Vector group, impedance and mode of mounting and termination. ZESCO procure their distribution transformers through public Invitation to Bids while the Copperbelt Energy Corporation and the Mining Industries procure through private requests for competing quotations. Public Tenders are advertised in the public media and qualifying bidders apply requesting to supply the units in the case of ZESCO. For the private power utilities and Mining Firm usually they will request for quotation from private suppliers and the lowest priced bid supplies the units. The flow diagram below in figure 28 is a correct representation of the movement of transformers in Zambian market. Foreign entities mainly from China, South Africa and India export transformers to Zambia which are subjected to excise duty and VAT regulations by the Zambia Revenue Authority (ZRA) while the Zambia Bureau of Standards and Energy Regulation Board (ERB) ensure conformity to technical specifications.

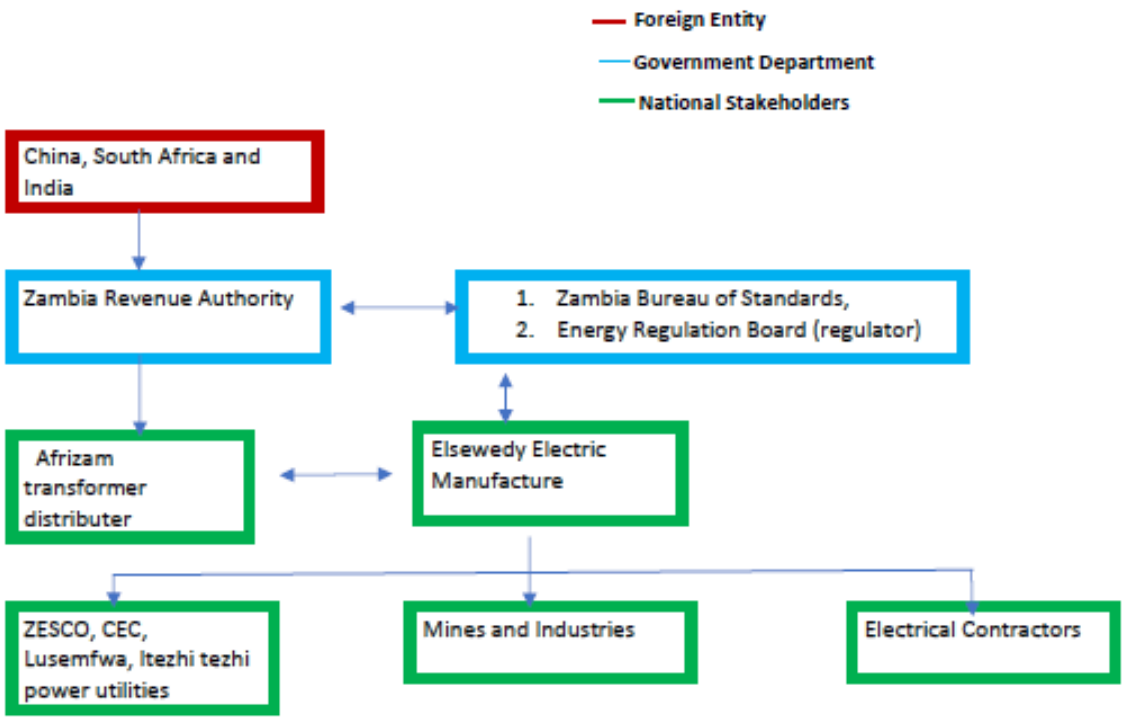


Figure 28:Flow diagram of Movement of Transformers in Zambia

The mounting setup include pole mount especially for domestic distribution system transformer less than 500kVA and Pad mount is applicable to transformers above 500kVA owing to the weight for this rating category. With Elsewedy Electric coming on the market in collaboration with ZESCO to manufacture distribution transformers, it has become fairly easy for the national power utility

in Zambia to procure these units. The table 20 below shows some of the application of transformers with their kVA rating and expected service life.

Table 20 Typical service life of distribution transformers, grouped according to their kVA rating (KCM 2021)

kVA rating of Distribution Transformer	Application sector (*e.g.* Utility, Industrial, Commercial)	Typical Service Life (in years)
Small (1-100 kVA)	Utility, Mining and Processing	10 -25 years
Medium (101-1000 kVA)	Utility, Mining and Processing	25-30 years
Large (1001-XXXX kVA)	Utility, Mining and Processing	Over 30 years

6.2.2 Technical standards and regulations for distribution transformers in public utility/ies

Zambia through the Energy Regulation Board has put in place the Power Distribution Grid Code (ERB, 2018) designed to provide clear procedures for both planning and operational purposes to ensure efficient development, operation and maintenance of a co-ordinated and economical power distribution system and also to promote grid integration of renewable energy technologies. The Distribution Grid Code seeks to avoid undue discrimination between Distribution Network Service Providers (DNSPs) and other categories of participants (ERB, 2018). It further promotes the use of both international and national technical standards for distribution transformers. The country does not have in place a labelling scheme in to differentiate between the performances of transformers.

Zambia has no mandatory energy performance standards for distribution transformers but utility standard procurement specifications in some cases are in place for distribution transformers, such as maximum losses or minimum efficiency applying the South Africa Standards in most case the SANS 780 on Distribution transformers especially that most private firms procure these transformers from South Africa. The IEC-60076 series which includes safety standards for power transformers and other IEC related standards have also been adopted through the National standards body ZABS.

Transformers and switchgears typically serve as the end points for transmission lines originating from generating switchyards, and they provide the electrical power for circuits that feed distribution stations. They therefore make an integral part to the long-term safety, reliability and integrity of the electric system and enable large blocks of energy to be moved to load centers. Table 21 below highlights technical standards both national, regional and international that are used in Zambia to ensure quality, safety and continuous performance of these strategic facilities. These technical standards are also essential in designing, procurement and constructing, and maintenance of power infrastructures.

Table 21: List Adopted Standards on Transformers and Related

Sl	Standard	Title of the Standard	Status
1.	IEC 60694:1,2,3,4,5,6,7,8	Low Voltage Switchgear and control gear	Adopted by Zambia
2.	IEC 62271-1:2017	The whole Series of Standards on High voltage Switchgears	Adopted by Zambia
3.	IEC 60439-1,2,3,4,5:	Low Voltage Switchgears	Adopted by Zambia
4.	IEC 62626-1:2014:	Low-voltage switchgear and control gear	Adopted by Zambia
5.	SANS 725:2010/IEEE 80:2000	IEEE guide for safety in a.c. substation grounding	Adopted by Zambia
6.	IEC 60044-7, 8:1999:	Instrument transformers Part 7 and 8	Adopted by Zambia
7.	IEC 60076-2, 3, 4, 5, 6, 7, 8,9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 57	Power Transformers	Adopted by Zambia

8.	COMESA 310-1,2,3:2010	Convertor transformers	Adopted by Zambia

6.2.3 Electrical connection regulations/rated frequency for distribution transformers applicable to private MV users

The distribution grid code is applicable in this regard. The Code is implemented as a license condition and provides a general description of the technical connection requirements for large embedded generating systems including some basic rules for net metering. The Code further seeks to avoid undue discrimination between Distribution Network Service Providers (DNSPs) and other participants.

6.3. Equipment stock and projections

6.3.1. Data on available distribution transformers in the market

The power utility companies are the largest consumer of distribution transformers, followed by the Mining Firms and other related industries. The survey was able to establish from the data collected through the questionnaire that the power utility has over 400 substations with way above 19,000 distribution transformers on the network. It is anticipated that this number could even be more if stock in the power utilities warehouses across the country was considered. Besides the power utility two firms are involved in the manufacture and assemble of distribution transformers and unfortunately, we could not establish the exact number of being manufactured, assembled or repaired. What is, however, evident is that the stock of distribution transformers is on the rise in the country with the increased economic activities giving rise to increase in electricity demand. The mines and other commercial industries have also installed a number of distribution transformers within their premises.

The government through its electrification plan and the rural electrification authority have spelled out the country`s ambitions of increasing access to electricity by 2030 (GoZ, 2019). This will mean extension of the national electricity grid and installation of more distribution transformers on the network. This therefore gives an idea of the projected demand for transformers in Zambia. Because of the various planned electrification programs in the country, it is anticipated that the demand for transformers will grow further. The country has also an ambitious target of becoming a middle-income country by 2030 (GoZ, 2006) and this will require a lot of investment in the energy sector including the installation of distribution transformers to support the expansion and upgrading of urban cities infrastructure and the corresponding bursting urban population.

Distribution Transformer Savings Assessment

The savings assessment approach in this report is based on the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) proposed Country Savings Assessments Methodology. Here the scope for distribution Transformers is based on 3 types of DTs which are considered as the most representative of the overall market: three-phase liquid-filled, three-phase dry-type and single-phase liquid filled.

The assessment also takes into consideration three scenarios as defined based on the levels derived from the UNEP United for Efficiency Model Regulation Guidelines. The scenarios are:

- Business as usual scenario – no policy intervention. It is assumed in all markets that the stock and sales of distribution transformers have losses in line with those assumed in the CENELEC harmonization research for the development of the EU standards. In this scenario, these are losses are assumed to remain the same throughout the period of the analysis.
- The Minimum and High Ambition Scenario: There will be two policy scenarios to show the savings possible from regulating at two levels of stringency. These will see Minimum Energy Performance Standards (MEPS) set as level 1 and level 2 as defined in the Model Regulation Guidelines.

Several other factors considered include product lifetime of 20 years and the analysis timeline of 2020 – 2040. Under the BAU scenario the number of transformers and energy consumption is expected to increase overtime, this is due to increased losses. The graph in figure 29 shows the expected stock of distribution transformers under the BAU Scenario.

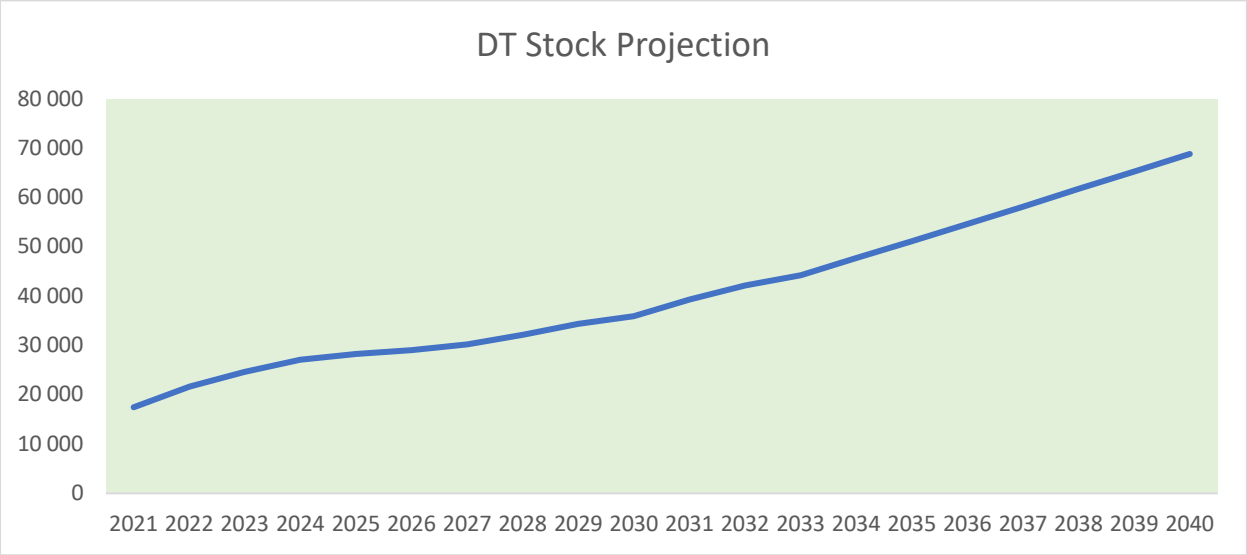


Figure 29: DT Stock Projection under BAU Scenario

Table 22 shows the expected losses for the three scenarios for the year 2021, 2030 and 2040.

Table 22: Expected Loss for 2030 and 2040 for the Three Scenarios

Three Scenarios	2021	2030	2040
BAU Total losses (kWh)	166,170,998	364,657,590	718,945,251
Level 1 Total losses (kWh)	120,126,637	263,614,533	519,732,542
Level 2Total losses (kWh)	91,335,112	200,432,339	395,164,895

Further the graph in figure 30 demonstrates the trend in the varying expected losses for the three scenarios for a period of 20 years. Level 2 scenario clear shows significant reduced losses.

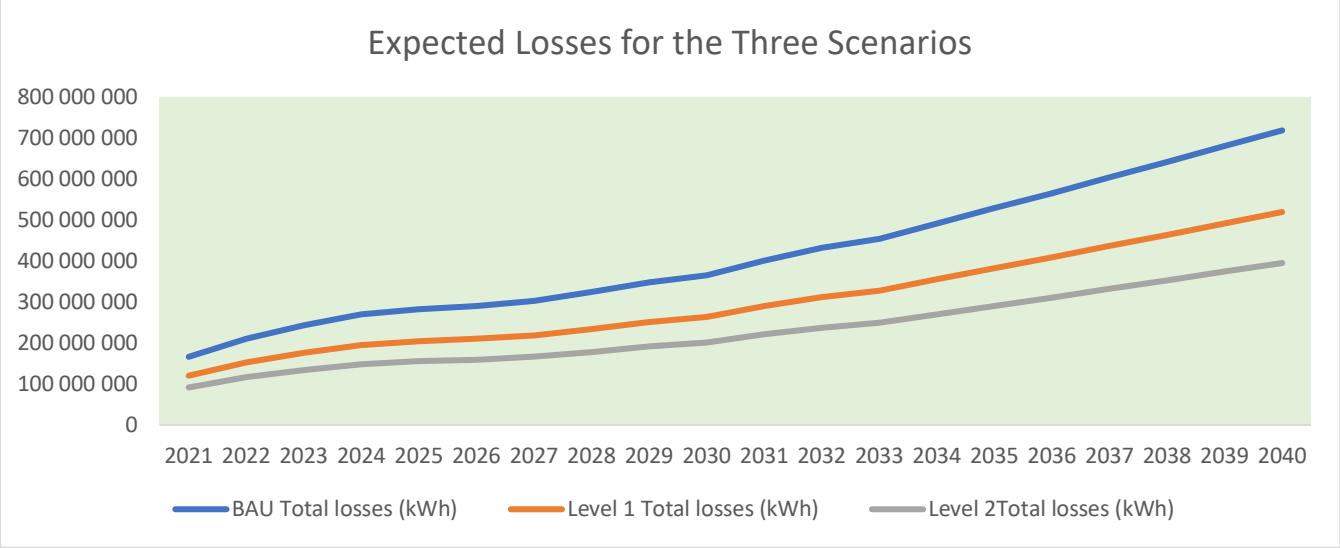


Figure 30:Trend of Losses from the three Scenarios

The assessment also reviews both the energy and GHG emission savings as indicate in the table 23 based on Level 1 and Level 2 Minimum Energy Performance Standards.

Table 23: Energy and GHG Emission Savings

Energy and GHG Emission Savings	2030	2040
Energy savings (Level 1 or Minimum Ambition scenario) GWh	101	199
Energy savings (Level 2 or High Ambition scenario) GWh	164	324
GHG emissions savings (Level 1 or Minimum Ambition scenario) GgCO2eq	44	87
GHG emissions savings (Level 2 or High Ambition scenario) GgCO2eq	72	141

6.3.2. Technology trends and market projections

The DT market in Zambia is segmented by Insulation type (Oil-filled and Dry-type), Mounting type (Pad-Mounted, Pole Mounted and Underground vault) and by the Phase (Three Phase and Single Phase). These define the market of DT in Zambia. Advancement in the technology capability of a particular DT usually will give it more advantages over the other. Currently the market has seen advanced DTs such as the Pad-mounted with self-protected fuses with backup high energy to protect against transformer overload and secondary faults as well as the Pole mounted transformers which are reasonably small in size and can be mounted easily on electricity poles.

Electrification rates ambitions of 80% national electrification by 2030 (GoZ, 2006) for Zambia are expected to motivate a growth in the demand for DT in the market. Zambia has put in place a number of electrification projects that will see the national grid extended and a number of load centers established. Further the rapidly increasing industrial and infrastructural development activities, are also expected to drive the market.

6.4. Policies and programme landscape

6.4.1 Current and planned electrification policies and programs

Programmes such as voluntary programmes, tax breaks, procurement specifications, labelling, or other incentives that promote energy-efficient units are not available in Zambia. The government however in the National Energy Policy of 2019 has expressed enthusiasm to promote the energy efficiency sector through drafting a strategy that would culminate into an action plan with activities to put in place fiscal incentive for energy efficient related equipment. A draft technical report has since been produced on the baseline analysis for the Zambia Renewable Energy Strategy and Action Plan with a view to enhancement of the Policy, Legal and regulatory environment and capacity building for renewable energy and energy efficiency sectors (DTGlobal, 2021). Besides this the only known promotor of energy-efficient transformers is the EU –Africa Infrastructure Trust Fund. Created in 2007 by the European Commission and European Union Member States, the EU-Africa Infrastructure Trust Fund (EU-AITF) was the first EU "blending instrument" with the objective of promoting infrastructure projects in Sub-Saharan Africa with a regional impact (EUAfrica, 2019). Up until 2019, the EU-AITF offered grant support from two different envelopes, The Regional envelope promoting regional infrastructure projects (energy, transport, water, ICT): cross-border projects or national projects with a demonstrable regional impact on two or more countries and the SE4ALL envelope supporting regional, national and local energy projects targeting SE4ALL objectives to ensure universal access to modern energy services, to double the global rate of improvement in energy efficiency and to double the share of renewable energy in the global energy mix.

The Rural Electrification Master Plan (REMP) has set ambitious targets for increasing access to electricity by 2030. The Plan has identified a total of 1,217 Growth Centers in rural areas throughout the country which will be the target for electrification during the period 2008 to 2030. The Master Plan targets to increase the electrification rate in rural areas from the current 3% to 51% by the year 2030. The total investment required to achieve this target over the same period is USD 1.1 billion. This translates into an

annual expenditure of USD 50million. The growth centers are planned to be electrified using three principal methods of electrification, namely grid extension (extending the existing national grid), Stand-alone electricity systems supplied from renewable sources such as Mini Hydro Power Stations and Biomass Generation and Solar Energy.

6.4.2 Environmental regulations for oil-filled transformers and current program status)

In cases where these are encountered various disposal methods are employed such as outsource experts for incineration of PCB contaminated oil and in some case handled with care through personnel wearing the right PPE and all oil safely drained into recommended seal containers for export disposal to an international environmental organization that carries out the remove of PCB oil contained materials. In the case of ZESCO, it has embedded in the standard for oil filled transformers to have NO PCB content and all PCB from old transformers was collected and shipped to Norway for disposal.

To avoid PCBs utilities and industry receiving distribution transformers test every new transformer or transformer oil procured for PCBs at receipt and ensure they receive a comprehensive Material Safety Data Sheet from the Supplier/Manufacturer. Some typical refurbishment methods for transformers are listed in the table 23 below.

Table 24: Refurbishment methods for transformers (KCM 2021)

Type of transformer refurbishment	For refurbished transformers, is this common, sometimes, seldom or never done?	Which kVA ratings are most often refurbished?
Drain and replace oil	It is common	100kVA 4000kVA
Sandblast and repaint tank	sometimes	100kVA 4000kVA
Change bushings, fuses, arrestors	sometimes	100kVA 4000kVA
Change the tank	seldom	100kVA 4000kVA
Replace one phase	seldom	100kVA 4000kVA
Replace more than one phase	seldom	100kVA 4000kVA
(Other – please describe)		

6.4.3 Stakeholder perspectives on opportunities and barriers to transform the market toward more energy-efficient distribution transformers.

A number of barriers still exist in the market that are hindering a full transformation to more energy efficient distribution transformers. Some of these barriers include limited access to information (customer unaware of savings opportunities) and limited access to financing. The issue of "who is going to pay" for the cost of more efficient units still arises and this is a significant barrier to this transformation.

Increasing demand for energy access and the need for more reliable and improved power network system on the other hand provides opportunities for power utilities to invest in efficient distribution transformers as these units could reduce the cost of power distribution through reduced losses. Therefore, the concerns still remain on the level of awareness and cost related to implement such programs. The government role cannot be over emphasized because having a policy framework that supports investment in this sector could attract foreign investment and help promote more efficient units on the market.

6.5. Utility's procurement specifications

ZESCO Limited invites sealed bids through Open International Competitive Bidding process for the supply and delivery of Substation Equipment, bidding is conducted in line with the national procurement procedures specified in the Public Procurement Act of 2008 and the Public Procurement Regulations of 2011. The bid usually specifies a schedule of requirements for each particular bid with relevant technical standards to be met.

Utility standard procurement specifications in some cases are in place for distribution transformers, such as maximum losses or minimum efficiency applying the South Africa Standards in most case the SANS 780 on Distribution transformers especially that most private firms procure these transformers from South Africa. The IEC-60076 series which includes safety standards for power transformers and other IEC related standards have also been adopted through the National standards body ZABS.

6.6. Financial environment and government procurement for both replacements and network expansion

This is available through the rural electrification authority mainly looking at the extension of the national grid. Government limited budget in most cases is supplemented by donor aid. A number of programs including the Increased Access to Electricity and

Renewable Energy Production (IAEREP) programme aimed at increasing access to clean, reliable and affordable energy through promotion of use of renewable energy (RE) and energy efficiency (EE) technologies. The programme is being implemented through three parallel lines of action which include support to public institutions to develop and/or revise the legal and regulatory framework for deployment of renewable energies and energy efficiency in Zambia, building capacity of both public and private organization's involved in the deployment of renewable energy and energy efficiency and providing early stage seed finance in the form of grant funding, through this call for proposal, for stimulating the emergence of sustainable business models for energy services to promote the use of renewable energy and energy efficiency at national level and incentivize private sector participation in the rural electrification programme.

6.7. Embedding and dependencies of the national distribution transformer market in the context of the region

Zambia is currently partially dependent on local manufacturers and suppliers. Of course, imports from other countries like China and South Africa come into the country as well, as a means of supply. The National Power Utility, however, has a memorandum of understanding with a local manufacture Elsewedy Electric of Egypt to manufacture distribution transformers and this has lessened ZESCO's dependency on imported units. Going forward, if energy efficiency policy measures are put in place and implemented, Zambia stands to benefit in the export of efficient distribution transformers to neighbouring countries like Malawi, Zimbabwe and Namibia who are all engaged in this Green Climate Fund (GCF) Readiness and Preparatory Support Programme

7.0 Conclusions

Zambia is implementing energy efficiency initiatives which include promotion of efficient utilization of energy services and switching to other alternative types of energy sources and technologies. Specific efforts have been on the development of energy performance standards developed for lighting, electric motors, and solar water heaters. However, there is no dedicated instruments such as building codes, and Minimum Energy Performance Standards, Highest Energy Performance Standards (HEPS), labelling schemes or clear policy or financial strategies to support these efforts for energy-efficient residential refrigerators and distribution transformers.

The government of Zambia in the National Energy Policy of 2019 has expressed enthusiasm to promote the energy efficiency sector through drafting a strategy that would culminate into an action plan and a possible legislation. The Renewable Energy Strategy and Action Plan (RESAP) has the ultimate goal to significantly increase the uptake of renewable energy and energy efficient technologies in Zambia and contribute to economic growth and poverty reduction. The strategy and action plan elaborates the activities to be undertaken to overcome the market barriers currently hindering the widescale diffusion of renewable energy and energy efficient technologies. The market assessment has revealed that the government of Zambia has demonstrated political will to formalize the energy efficient space with several efforts in place and it is hoped that the GCF project will help give a push to see relevant policy and legislation enacted to regulate and promote energy efficiency in the country.

A number of technical standards and regulations are available in the country for the two products, i.e residential refrigerators and distribution transformers though they are not mandatory. The Zambia Compulsory Agency is responsible for regulating household electrical appliances including residential refrigerators and they do inspect time to time but mostly looking at the safety of the products and not the performance of the products. This will need to be expanded and include a deliberate technical standard that will address the issues of product performance with regards to energy efficiency and quality of the product. Distribution transformer technical standards are also available mainly IEC and SANS standards adopted but not mandatory. For transformers, mostly it's the buyers (utilities, mines, industry) that define which technical specification a supplier should meet to supply the distribution transformers. There will be a need to have a policy framework that will cascade down to regulation encompassing technical standards to ensure quality, efficient and sustainable products supply, for both residential refrigerators and distribution transformers. This should be complimented with labeling schemes and deliberate programs to support sustainable financial mechanisms that could eliminate the lack of affordability issues.

Market outlook for power transformers in the coming years is very promising for Zambia. Demand for transformers will see a strong growth driven by renewable additions, replacements and generation capacity additions for increasing electrification in Zambia and the region. This growth will be experienced across mostly distribution voltage segments. The increased inflow of investment for power infrastructure in Zambia clearly demonstrates that the country has a ready market for generating stations, substation, transformers, switchgears, overhead lines and related equipment to support the electrification programs that the government has put in place.

The country has a challenge on the channels to the market especially on the supply chain of residential refrigerators, with lack of manufacturing base, the supply of residential refrigerators is limited to imports only. This is a challenge when it comes to ensuring that only quality and efficient product come into the country. From the survey it is clear that the solution to residential refrigerator market supply chain is to address the awareness level and affordability issues.

Based on the economic model, the market value for refrigerators is expected to grow above 43,000,000 USD (720,000,000 ZMW) by 2030 while the market size is expected to be slightly below 100,000 refrigerators by 2030. The economic model took into consideration an annual market growth rate of 3.1% based on the historical average GDP for Zambia.

For the case of distribution transformers, Zambia has already a manufacturing base that is collaborating with the national power utility. Therefore, it becomes easy to control quality and efficiency. It is also hoped that with the increased demand for energy, the power utility will need more efficient distribution transformers and therefore this will have a deliberate effect on the local manufacturer and imports. Going forward, it's okay to say that distribution transformer units could gain a level of efficiency that

GCF program is looking at much earlier than residential refrigerators because of the fact that Zambia already has a manufacturing base which can easily be influenced to embed quality and efficiency issues in their production process.

The aspect of waste disposal of the two products was found to be a big issue as Zambia has no legal instrument that mandates anyone to dispose products in an environmental and safe way. The Zambia Environmental Management Agency advised that each manufacturer/supplier/distributor/retailer are given the owners responsibility to dispose of waste. In the case of distribution transformers, the mines and the power utility confirmed that they are very cautious with disposal of these units due to possible PCBs while for residential refrigerators the country has nothing that guides on the disposal. Going forward this could be integrated in the development of the national policy roadmaps and financing mechanism as a component.

8.0 Annexes:

Overview/List of data sources

Government Consultations through Phone calls and Questionnaire.

1. Ministry of Energy
2. Zambia Central Statistics
3. Zambia Bureau of Standards
4. Zambia Revenue Authority
5. Ministry of Finance
6. Zambia Development Agency
7. Zambia Compulsory Standards Agency
8. Energy Regulation Board
9. Zambia Environmental Management Agency
10. ZESCO

Private Sector Consultations through phone calls and questionnaires

1. Zambia Association of Manufacturers
2. Zambia Bankers Association
3. Konkola Copper Mines
4. Elsewedy Electrical Limited
5. Afrizam Electrical Limited
6. Radian Stores
7. Game Stores
8. Clearing Agents
9. Various Banks
10. Various Refrigerator Suppliers

Internet Searches

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5. https://www.worldometers.info/world-population/zambia-population
6. https://www.usaid.gov/powerafrica/zambia
7. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZM
8. https://www.zambiainvest.com/energy
9. www.zesco.com

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