Green Climate Fund Readiness Project

Market Assessment Report on Residential Refrigerators and Distribution Transformers

Zimbabwe

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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 Zimbabwe (Refrigerators and Distribution Transformers) through regulatory and financing mechanism"

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Abbreviations and Acronyms

BASE	Basel Agency for Sustainable Energy
BCSDZ	Business Council for Sustainable Development-Zimbabwe
CO2eq	Carbon dioxide equivalent (emissions)
CoM	Chamber of Mines
CTCN	Climate Technology Centre and Network
CZI	Confederation of Zimbabwean Industries
DTs	Distribution transformers
EE	Energy Efficiency
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHGs	Green-house gases
Gg	Gigagram
GgCO2eq	Gigagram of carbon dioxide- equivalent
GJ	Gigajoule
GoZ	Government of Zimbabwe
GWh	Gigawatt-hour
ICA	International Copper Association
IDBZ	Infrastructure Development Bank of Zimbabwe
IEA	International Energy Agency
IMF	International Monetary Fund
Kg	kilogram

KII	Key Informant Interview
kVA	kilovoltampere
kW	kilowatt
KWh	kilowatt-hour
Kt	kilotonne
Ktoe	thousand tonnes of oil equivalent
kVA	kilovolt-ampere
L	litre
LPG	Liquefied Petroleum Gas
MD	Maximum Demand
MECTHI	Ministry of Environment, Climate, Tourism and Hospitality Industry
MoEPD	Ministry of Energy and Power Development
MRV	Monitoring, Reporting and Verification
MW	Megawatt
NDC	Nationally Determined Contribution
NDA	National Designated Authority
NDE	National Designated Entity
NEEA	National Energy Efficiency Audit
ODS	Ozone depleting substance
PRAZ	Procurement Regulatory Authority of Zimbabwe
PWG	Policy Working Group
RE	Renewable Energy
REF	Rural Energy Fund
REAZ	Renewable Energy Association of Zimbabwe
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SE4ALL	Sustainable energy for all
SDG	Sustainable Development Goal
SI	Statutory Instrument
TC-DT	Technical Committee – Distribution Transformer
TC-Ref	Technical Committee - Refrigeration

TJ	Terajoule
toe	tonnes of oil equivalent
t	tonne
U4E	United for Efficiency
UNEP	United Nations Environment Programme
USD	United States Dollar
ZELA	Zimbabwe Environmental Lawyers Association
ZENT	ZESA Enterprises
ZERA	Zimbabwe Energy Regulatory Authority
ZETDC	Zimbabwe Electricity Transmission and Distribution Company
ZNCC	Zimbabwe National Chamber of Commerce

1 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 Zimbabwe through regulatory and financing mechanisms. The objectives of the technical assistance project are to improve the country programming process regarding residential refrigerators and distribution transformers and strengthen climate finance strategies.

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 residential refrigerators and distribution transformers in Zimbabwe. 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 residential 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 residential 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, and Zambia) and also regional harmonisation efforts, which are being coordinated by UNEP's United for Efficiency (U4E) initiative.

The readiness project, which has been titled *"National framework for leapfrogging to Energy Efficient Appliances and Equipment in Zimbabwe (Refrigerators and Distribution Transformers) through regulatory and financing mechanism"*[1], is proposed for implementation by the government of Zimbabwe.

As part of the local market assessment, a comprehensive data collection exercise aimed at helping to inform the policy recommendations and the development of financing mechanisms that will be implemented jointly in Zimbabwe, was conducted. The exercise included a survey on household refrigerators and distribution transformers conducted in Zimbabwe during March-April 2021, as well as extensive desk studies and analyses. The purpose of the market assessment is to document and obtain data and information on energy efficiency status of residential refrigerators, on supply chain of residential refrigerators, and to obtain data and information on distribution transformers. Market assessments are essential for good policy development and governance. This market assessment report outlines the findings of the data collected and analysis on the use and demand of residential refrigerators and distribution transformers in Zimbabwe.

[1] https://www.ctc-n.org/technical-assistance/projects/leapfrogging-namibia-s-market-energy-efficient-refrigerators-and

1.1. Study Approach and Methodology

Specific data collection methods including desk studies (literature review), Key Informant Interviews (KIIs), a formal questionnaire survey, and the documentation through photography (especially for residential refrigerators) were used to collect both quantitative and qualitative data.

For the residential refrigerator survey, the local experts, with the assistance of SACREEE, engaged ten enumerators for the household survey, trained them on basic refrigeration and the use of the household questionnaire and flyer. The survey was restricted to the urban centres and the ten enumerators were selected from Harare (6), Bulawayo (2), Gweru (1) and Mutare (1) in line with population. The agreed minimum sample was 200 households. Pilot data was used to check the consistency of the information collected. The pilot data was also analysed to check for consistency and data completeness before embarking on the actual data collection. The field primary data was collected over five days. A total of 226 household interviews were conducted by the ten enumerators. The market survey was conducted during the COVID-19 pandemic, thus presenting limitations to the study since some interviews were done virtually and the respondents were asked to take photographs of their refrigerators including the nameplates and send to the interviewer.

For the residential refrigerator and distribution transformer supply chain study the local experts, in consultation with the two focal points for the project (Climate Change Scientist, GCF National Alternate Focal Point & CTCN NDE Focal Point from the Ministry of Environment, Climate, Tourism and Hospitality Industry and the Principal Energy Department Officer from the Ministry of Energy and Power Development), developed a list of stakeholders that would be consulted. These stakeholders included Ministries and Government Departments, industry (private sector), refrigerator manufacturers and distributors, transformer manufacturers and distributors, financial institutions, consumer associations, and non-utility companies running own grids. To collect data from these stakeholders the local experts used the harmonised data collection questionnaire developed by UNEP's U4E initiative, in addition to virtual and physical meetings. More than 50 questionnaires were sent out and 21 responses were received.

The primary data from the household survey and the supply chain actor consultations, and the secondary data from literature review was processed, analysed and written in a report for submission to SACREEE and BASE. The major findings of the market assessment are given in section 1.2.

1.2. Market assessment results

1.2.1. Residential refrigerators

The best-selling locally manufactured refrigerator brand was CAPRI, followed by IMPERIAL. The DEFY, SAMSUNG, KIC and HISENSE dominated the refrigerator imports. Tetrafluroethane (R134a) was the mostly used refrigerant during the period 2010-2015, while iso-butane(R600a) was the mostly used refrigerant in refrigerators manufactured during the period 2015-2020, indicating a transition from unfriendly refrigerants. However, the results showed that the shift from R134a to R600a by the local manufacturers was slower than their foreign counterparts.

The refrigerator-freezer is the most preferred refrigerator type and it contributed 69% of the refrigerators, followed by the freezers at 28%. The refrigerators ranged from 60L to 265L and the maximum price was USD338. The refrigerator-freezers ranged from 75L to 730L and their energy consumption range was 193-635 kWh per year The distributors of residential refrigerators indicated that the refrigerators ranging from 150L to 275L had the highest sales, and the household survey results showed that the refrigerators in the range 150-275L contributed 58% of the studied refrigerators. About 95% of the interviewed households are on a prepayment metering system while the remaining 5% are on a conventional metering system, and 71% of the households pay less than USD35 per month for electricity.,

More than 90% of the residential refrigerator purchases were done using own capital, 7.8% through hire purchase, 0.4% through a bank loan and 1.3% through other means. There was no case of leasing. The survey results show that the most considered factors when purchasing a refrigerator were functionality, quality and price while energy and access to financing were 9th and 11th respectively on a list of 12 factors.

The locally manufactured residential refrigerators were 37% of the refrigerator stock in 2021, 55% of which were the frost-free type. The percentage of the more energy-efficient refrigerators were projected in this market assessment to be 66% in 2030 and 79% by 2040 under business-as-usual (Market Assessment, 2021). The projected slow penetration of more energy-efficient refrigerators in Zimbabwe justifies the framework to leap-frog to more energy-efficient refrigerators, which will be expected to save 5.5 GWh and 6.4 GWh in 2030 and 2040, respectively.

1.2.2. Distribution transformers

The supply chain survey indicated that Zimbabwe Electricity Transmission and Distribution Company (ZETDC) has a DT stock of around 20,000 as of 2020 and purchases around 2,000 transformers per year. ZESA Enterprises (ZENT) sells around 1,500 transformers per year with ZETDC and REF being the major customers. The trade statistics show that Zimbabwe is a net importer of transformers. In 2020 the exports of transformers were only 0.4% of imports.

The stock of the distribution transformers is projected to rise to around 80,000 in 2030 and 160,000 in 2040, while the market size would be expected to rise from 25,000 in 2021 to 70,000 in 2030 and 160,000 in 2040. The distribution transformer market value is expected to be USD50 million in 2021, USD160 million in 2030 and USD350 million in 2040, electricity demand being the major driver for distribution transformer installations contributing 83% to 90% of the market. According to this market assessment annual potential energy savings ranging from 100 GWh to 160 GWh in 2030 and from 200 GWh to 320 GWh in 2040 can be achieved through the use of more energy-efficient transformers, avoiding greenhouse gas emissions of up to 70 GgCO2eq in 2030 and 140 GgCO2eq in 2040.

1.3. Role of financial institutions

The household refrigerator survey showed that only 54 % of interviewees were formally employed and about 70% of them were in the low-income bracket of less than USD7,100 per year. Less than 1% of the interviewees purchased a residential refrigerator using a bank loan, as 91% used own capital, and around 8% used hire purchase facility. There was no case of leasing although 4% of

the respondents said they would prefer leasing compared with 96% who preferred owning the refrigerator.

Financial institutions are now having appetite for energy infrastructure investments, which will go a long way in improving electricity access and hence demand for refrigerators and transformers. These financial institutions may consider providing loans to those willing to purchase more efficient appliances and with the capacity to pay back. According to the assessment, the majority of consumers have bank accounts.

1.4. Possible barriers to energy-efficient residential refrigerators and distribution transformers

- The manufacturers and distributors of refrigerators strongly believe that in the future, consumers will consider energy efficiency when making refrigerator purchasing decisions. However, low demand resulting from low disposable income by consumers is a subject of concern.
- Lack of awareness of the benefits of energy-efficient and environmentally friendly refrigerators by policy makers and consumers
- Lack of technical skills in the industry in the future as a result of brain drain, ineffective apprentice training program would be barriers to the penetration of more energy-efficient technologies

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

Some of the stakeholders that were consulted made some recommendations that may enhance the opportunities to transform the market toward more energy-efficient distribution transformers.

- The Ministry of Industry and Commerce and Bureau Veritas can assist with Consignment Based Conformity Assessment for transformers.
- The grid is owned and maintained by ZETDC and because of this, financial institutions hardly finance the purchase of transformers. The financial institutions may fund REF's electrification projects, e.g. the electrical reticulation between the transformer and the new residential households.
- The asset register of transformers should be accessible to all stakeholders who need it.
- Training on green procurement for both public and private institutions would be necessary

1.5. Conclusion

The market assessment enabled the establishment of the country's baselines for the residential refrigerators and distribution transformers in terms of stock, market size and market values and how these parameters are likely to change with time, under predicted conditions. The market assessment will help the Government of Zimbabwe (GoZ)

understand current stock of residential refrigerators and distribution transformers and projected growth, electricity saving potential and the analysis of the regional context. The GoZ is encouraged to form the Policy Working Group (PWG) that will develop the national policy roadmap for refrigerators and the national policy roadmap for distribution transformers. The national policy roadmaps must include the following:

- Minimum Energy Performance Standards (MEPS) and Higher Energy Performance Standards (HEPS)
- Labelling options and decide on labelling scheme
- Enabling policy and regulatory environment for residential refrigerators and distribution transformers in Southern Africa
- Appropriate financing mechanisms to accelerate deployment of energy efficient residential refrigerators and distribution transformers in Zimbabwe
- End-users' awareness campaign
- Public consultations
- Monitoring Verifications & Evaluation plan

In addition to guiding the development of the above-described activities, the PWG will oversee the work of the technical committee for refrigerators (TC-Ref) and of the technical committee for distribution transformers (TC-DT).

2 Background and Introduction

Eight countries in the Southern African Development Community (SADC)[2] have embarked on Green Climate Fund (GCF) Readiness projects on "Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers". The implementation of the projects is primarily led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme (UNEP)'s United for Efficiency (U4E) initiative as technical partner.

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 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 residential refrigerators and distribution transformers and strengthen climate finance strategies.

The projects aim to put in place mandatory Minimum Energy Performance Standards (MEPS), Higher Energy Performance Standards (HEPS) and a labelling scheme, which will create an enabling policy and regulatory environment for residential refrigerators and distribution transformers in Southern Africa. 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 residential 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 residential refrigerators and distribution transformers and ultimately reduce the strain on the electricity grid, increase disposable income for households and potentially reduce GHG emissions.

The first activity within the projects was to conduct a market assessment of energy efficient residential refrigerators (i.e. refrigerator, refrigerator-freezer, freezer) and distribution transformers (i.e. 5 kVA to 3150 kVA). Market assessments have long been recognised as a key driver for good policy development and governance to inform the adequate measures. This document outlines the findings of the market assessment with the aim to inform the development of national policy roadmaps for the promotion of higher efficiency residential refrigerators and DTs, including MEPS-HEPS, labelling scheme, consumer awareness end-users' education, capacity building for custom and procurement officials and local manufacturers, MV&E frameworks, and financial mechanisms, adopted by the government.

Since 2020 Zimbabwe 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 Zimbabwe, 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

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

technical recommendations on the MEPS development. More information and the related documents can be accessed here. The MEPS and labels development for Namibia within the national GCF project will happen in synergy with the regional policies developed under this project.

3 Methodology and Approach

3.1 Objectives and scope

The market assessment for Zimbabwe was conducted for residential refrigerators and distribution transformers to inform the development and subsequent adoption of MEPS, labels standards and financial mechanisms for these appliances. The scope of the assessment includes households, supply chains and stakeholders' knowledge and use of residential refrigerators and distribution transformers. Sections 3.1.1-3.1.5 give the stakeholders and their characteristics considered in the market assessment.

3.1.1 Households Survey

- Household user behaviors of residential refrigerators through random sampling from the four selected urban areas Harare, Bulawayo, Gweru and Mutare.
- Refrigerator types (refrigerator, refrigerator-freezer, and freezers)
- Characteristics of the refrigeration equipment used (technology, performance, energy efficiency, capacity/volume, design/types, refrigerant, supply chain, etc.)
- Purchasing behaviour, as well as the financing options and incentives available for refrigerators
- Mapping the most popular refrigerator choice/size 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.
- Total stock of refrigerators in use and typical annual sales

Zimbabwe is a landlocked country located in southern Africa, between the Zambezi and Limpopo Rivers. The capital and largest city is Harare, other major cities including Bulawayo, Mutare, Gweru, and Masvingo (Figure 1). The four cities contributed 74% of the total urban population in 2012 (Zimstat, 2013, p15, Table 3.3) with Harare contributing 66%, followed by Bulawayo at 22% as shown in Figure 2.

Figure 1: Zimbabwean map showing the major cities (Source: CIA World Factbook, 2020)

In line with the population of the four major cities, a total of 10 enumerators were engaged to obtain the responses for the household. Table 1. shows the number of enumerators assigned to each city.

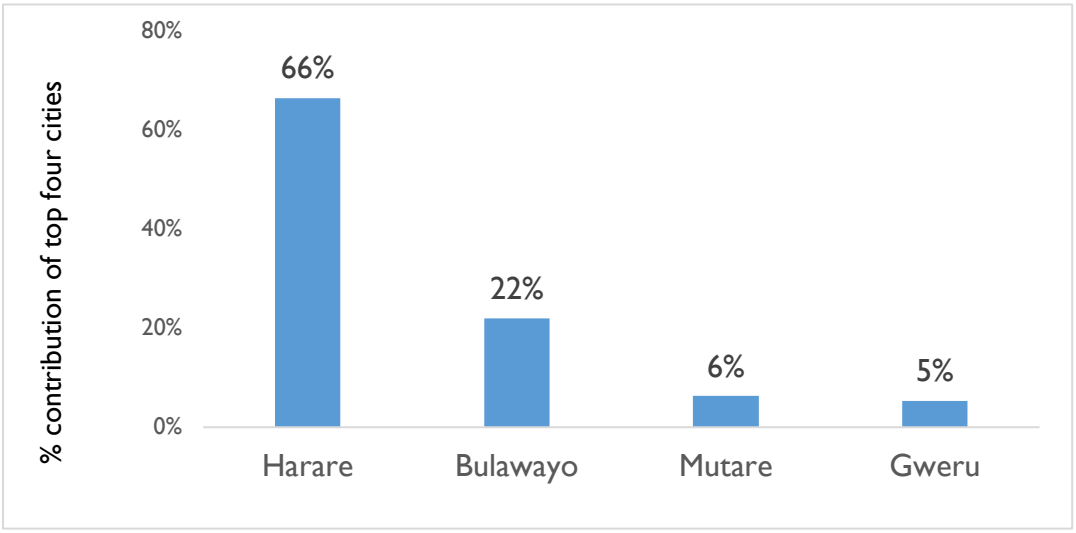

Figure 2: Relative contribution of the four major cities (Source: Zimstat, 2013, p15)

Table 1: Percentage of population of major cities and the number of enumerators assigned to each city for the household survey (Source: Zimstat, 2013)

City/Urban centre	% population	Number of enumerators
Harare	49%	6
Bulawayo	16%	2
Mutare	5%	1
Gweru	4%	1
Rest	26%	

3.1.2 Utilities

- Total stock of distribution transformer (by type) in use (single/three-phase liquid-filled, three-phase dry-type)
- Characteristics of the distribution transformers used, size, technology, typical losses, typical lifetime
- Purchasing behavior, as well as the financing of transformers
- Refurbishment practices and end of life
- Any other stock data
- Procurement of distribution transformers in relation to energy efficiency.

3.1.3 Government ministries, energy efficiency entities, customs, standards and regulatory bodies

- General electricity situation of the country (electrification rates (urban and rural), maximum electricity demand, total electricity consumption by sector, demand forecast etc.)
- National energy policies in place (e.g., regulatory policy, import tax relief/duty, subsidy/financing, labelling, or other information programme)
- Regional, municipal, utility or other entity offering programmes to promote efficient cooling
- Product Registration Systems
- Bodies responsible for testing of products
- Stock and sales data (including imports/exports)
- Demand forecast and trends in sales
- General environment policies and regulations on refrigeration and distribution transformers
- Waste management, including electronic-waste collection mechanisms
- Funding mechanism & operation of rural electrification programs/network maintenance

3.1.4 Private Sector

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

- 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
- Information on service technicians (skillset evaluation, training and certification, etc.)
- Stock and sales data
- Demand forecast and trends in sales
- For refrigerators: Identification and evaluation of the knowledge of refrigerators technicians
- For distribution transformers: Use of distribution transformers in the mining industry.

3.1.5 Banks and financial institutions

- General financing channels/mechanisms for refrigerators and distribution transformers
- Offers particularly related to cooling equipment credits or credits for utilities
- Evaluation of the offers in relation to energy efficiency

3.2 Existing information sources and gaps

The literature review conducted by the local experts showed that Zimbabwe is putting measures in place to ensure that both urban and rural households have access to electricity under the SE4ALL programme. The electricity access of the rural households was 20% in 2019 while that of the urban households was 85% (World Bank, 2019). Among its SE4ALL targets, Zimbabwe aims to have 35% of the rural households have electricity for lighting, TV, phone charging, etc. powered by solar home systems with more than 70 W capacity by 2030 (at Tier 2). Demography studies (2017 Inter Censal Demography Report) show the number of urban and rural households that use electricity for cooking. However, electricity uses for appliances such as light bulbs and refrigerators are not available. It is important to know the residential refrigerator population, energy consumption and energy efficiency levels.

Literature also shows that the country is struggling to meet demand of electricity and also experiences power supply interruptions as a result of faults in the transmission and distribution networks, in which distribution transformers are very important appliances. The national statistics do not indicate the distribution transformer population. Information on residential refrigerators and distribution transformers would go a long way in energy demand planning. The Standards Association of Zimbabwe (SAZ) has four standards on residential refrigerators and ten on distribution transformers. The extent to which these standards are applied is unknown.

3.3 Information gathering methodology

The data gathering approach for residential refrigerators and distribution transformers included:

- Mapping of stakeholders

- Engaging the Climate Change Management Department (through the NDE) and the Ministry of Energy and Power Developing (through the Focal Point) to provide information about the project, including the stakeholder mapping that was done during the development of the project.
- Refining survey questionnaires
- Continuously working with the above-mentioned focal points throughout the project
- Consulting the focal points of ministries, Government departments, private sector, manufacturers and distributors of residential refrigerators and distribution transformers, financial institutions, consumer associations, and auto-producers for information on refrigerators and transformers. Auto-producers are industrial establishments that produce electricity and use much of it within its unit and sell the balance to users outside the unit.
- Engaging professionals who are highly qualified and experienced in research who would gather data for the residential refrigerators
- Using both virtual and physical meetings to gather data and information from some manufacturers and distributors of household refrigerators and distribution transformers

The market assessment study used both quantitative and qualitative data collection techniques. The advantage of this is that each complementary data collection method contributed information which could have been missed by adopting only one perspective, bringing triangulation which results in authentic analysis. Data collection methods adopted for the market assessment study entailed desk studies; key informant interviews (KIIs) from institutional stakeholders; individual interviews; voice recordings of the interviews in some cases, and photographs of refrigerators as necessary to collect both quantitative and qualitative data. The methods used employed and ensured that all ethical considerations were conducted prior to data collection. Market assessment study tools, methodology and findings were reviewed and approved by SACREEE prior to use for the study. Details of the market assessment steps are as discussed below:

a. Review of background material and market assessment tools

   This stage was a desk study and involved the review of relevant documents including the approved GCF Readiness proposal and work-plan. Information collected at this stage were used to enrich the data collection. The desk study also included research on the Internet.

b. Stakeholder consultations

   Secondary data was gathered by the Policy and Communications experts through desk reviews. KIIs on institutions were guided by pre-prepared questionnaires. Where key informants were not readily available for physical interviews, the consultants made use of email communications, telephone and WhatsApp calls, as well as Short Message Services (SMS). Contact officials for the institutions deemed key to the assessment were identified, with the help and guidance of the NDE. Physical meetings were held with residential refrigerator manufacturers (Imperial and Capri), residential refrigerator distributors (Mohamed Mussa, OK Mart) and the national statistics office. Phone discussions were held with all institutions before and after sending them the questionnaires.

c. Sample size and population

The household pilot survey initially collected quantitative data for a sample of 20 households. Each enumerator conducted two households in two days as part of the pilot survey and part of their training. Pilot data was used to check the consistency of the information collected. The pilot data was also analysed to check for consistency and data completeness before embarking on the actual data collection. The actual primary data was collected over five days for over 200 households.

d. Data quality assurance

The following quality control and assurance procedures were undertaken:

- The local experts worked in consultation and with assistance from SACREEE and ten enumerators who assisted in data collection. To ensure the validity and integrity of the data, the enumerators underwent intensive training on the data collection tool and pretesting of the tool was conducted to ensure consistency and reliability of data collected. The enumerators used the harmonised data collection tool, while the local experts used checklists to monitor the daily work of the enumerators to ensure consistency of data collection work. Meetings were conducted at the end of each data collection day between the local experts and enumerators to review work done and address any pertinent issues arising regarding the data collection exercise.

- The ten enumerators surveyed 226 households in Harare, Bulawayo, Gweru and Mutare cities. Local experts reached out to 20 institutions on refrigerator supply chain and 33 distribution transformers manufacturers and relevant bodies, including government ministries, departments, private companies and parastatals, as shown in Tables 13 and 14 in the Annex. Table 15 in the Annex shows the details of the ten enumerators engaged to carry out the household survey, and the cities they worked in. The four cities contribute 74% of the total urban population, with Harare contributing 49% (Table 1).

e. Data processing, analysis and report writing

Qualitative information was analysed by the local experts as some of it was non-numerical or unstructured data. Qualitative data was also analysed by establishing emerging common patterns and trends. The quantitative data was statistically analysed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel spreadsheets. The quantitative market assessment study data from primary and secondary data sources were synthesised and presented in user-friendly tables and illustrational charts/graphs.

This phase also witnessed the compilation and submission of a draft market assessment report to SACREEE, providing an opportunity for the staff to respond to key issues emerging from the study and provide input into the draft report. The draft market assessment report includes comprehensive details on household and institutional surveys. Following the draft report submission, the local experts considered the feedback and recommendations from SACREEE and its BASE. The team will submit the Final Report

which will include key findings and recommendations, to SACREEE, its partners and stakeholders, as required.

4 Overview of the country

4.1 Socio-economic situation

Zimbabwe's economy depends heavily on its mining and agriculture sectors. Following a contraction from 1998 to 2008, the economy recorded real growth of more than 10% per year in the period 2010-13, before falling below 3% in the period 2014-17, due to poor harvests, low diamond revenues, and decreased investment. Lower mineral prices, infrastructure and regulatory deficiencies, a poor investment climate, a large public and external debt burden, and extremely high government wage expenses impede the country's economic performance (CIA World Factbook, 2020). The year 2018 saw a GDP growth of 4% but 2019 and 2020 had poor growth rates of -6.5% and -4.1% respectively (Trading Economics, 2021).

Until early 2009, the Reserve Bank of Zimbabwe (RBZ) routinely printed money to fund the budget deficit, causing hyperinflation. Adoption of a multi-currency basket in early 2009 - which allowed currencies such as the Botswana pula, the South Africa rand, and the US dollar to be used locally - reduced inflation below 10% per year. In January 2015, as part of the government's effort to boost trade and attract foreign investment, the RBZ announced that the Chinese renmimbi, Indian rupee, Australian dollar, and Japanese yen would be accepted as legal tender in Zimbabwe, though transactions were predominantly carried out in US dollars and South African rand until 2016, when the rand's devaluation and instability led to near-exclusive use of the US dollar. The government in November 2016 began releasing bond notes, a parallel currency legal only in Zimbabwe which the government claims will have a one-to-one exchange ratio with the US dollar, to ease cash shortages. Bond notes began trading at a discount of up to 10% in the black market by the end of 2016 (CIA World Factbook, 2020).

Zimbabwe's annual headline inflation rose from single digit levels in 2018, to reach 837.52% in July 2020 (MoFED, 2020, p14), and it closed the year 2020 at 348.6%, slightly above the forecasted 300% RBZ, 2021). The year-on-year inflation rose moderately to 362.6% in January 2021, from 348.6% in December 2020. The increase in inflation in January 2021 largely reflected the adjustments in administrative levies and charges that include electricity, municipal charges, rates and health charges, some of which are traditionally effected at the beginning of the year. The January 2021 inflation outturn was also influenced by the increase in international commodity prices for maize, wheat, fuel, crude soya oil, among others. The RBZ is targeting an inflation of below 10% and the economic growth rate of the economy of 7.4% by the end of 2021. The RBZ intends to keep the level of money supply under control and as such the cash withdrawal limits for individuals was set at ZW$2 000 while the mobile banking transactions were maintained at ZW$5 000 per transaction and an aggregate limit of ZW$35 000 per week (RBZ, 2021). These withdrawal restrictions can have a negative effect on residential refrigerator purchases as consumers are likely to give first priority to other commodities such as food, education and health. The shortages of foreign currency and high inflation would mean that the manufacturers of refrigerators and transformers face challenges in importing components and in maintaining production costs low and competitive.

Zimbabwe's government entered a second Staff Monitored Programme with the International Monetary Fund (IMF) in 2014 and undertook other measures to reengage with international financial institutions. Zimbabwe repaid roughly $108 million in arrears to the IMF in October 2016,

but financial observers noted that Zimbabwe is unlikely to gain new financing because the government has not disclosed how it planned to repay more than $1.7 billion in arrears to the World Bank and African Development Bank. International financial institutions wanted Zimbabwe to implement significant fiscal and structural reforms before granting new loans. Foreign and domestic investment continues to be hindered by the lack of land tenure and titling, the inability to repatriate dividends to investors overseas, and the lack of clarity regarding the government's Indigenization and Economic Empowerment Act. However, Zimbabwe is receiving some Technical Assistance. The World Bank's lending program in Zimbabwe is inactive due to arrears and the role is now limited to technical assistance and analytical work through Trust Funds. The main trust fund is called the Zimbabwe Reconstruction Fund (World Bank, 2018). The Infrastructure Development Bank of Zimbabwe (IDBZ) has just been accredited by the Green Climate Fund which means that the Bank will be able to carry out a range of activities that include the development of funding proposals and the management and monitoring of projects and programmes under the Green Climate Fund (Herald, 2021).

The Zimbabwean economy has not been stable since 2000. The 2020 GDP per capita in current prices was 1,385 US dollars (WORLD DATA ATLAS , 2021). Zimbabwe, through its National Development Strategy, aims to become a middle-income economy by 2030. The country projects GDP growth rates of around 5% for the period 2021-2025. The objective of the National Development Strategy 1 (NDS1) macroeconomic framework is to sustain the 5% or more growth rates driven by the country's key economic sectors namely: agriculture, mining, tourism and manufacturing**.** NDS1 is running under the theme: "Towards a prosperous and empowered upper middle-income society by 2030" (Zimbabwe, Ministry of Finance and Economic Development, 2020).
The road map towards Vision 2030 will be realised through the Transitional Stabilisation Plan (TSP) October 2018 to 31 December, 2020, National Development Strategy 1 (2021-2025) and National Development Strategy 2 (2026-2030). The ultimate goal for Vision 2030 is to create a prosperous and empowered upper middle-income society with an average per capita income of US $3,207 by 2030 (2021: $1,842) (Zimbabwe, Ministry of Finance and Economic Development, 2020).

Before the COVID–19 pandemic, Zimbabwe's economy was already in recession, contracting by 6.0% in 2019. Output fell because of economic instability and the removal of subsidies on maize meal, fuel, and electricity prices; suppressed foreign exchange earnings; and excessive money creation. The onset of the COVID–19 pandemic and continued drought led to 10% contraction in real GDP in 2020. Inflation soared, averaging 622.8% in 2020, up from 226.9% in 2019. Foreign exchange reforms were instituted in June 2020, which dampened an inflation that raged an annual rate of 838% in July. Fiscal and current account deficits also recovered after July, but both deteriorated for the year as a whole. The budget deficit rose from 2.7% in 2019 to 2.9% in 2020, while the current account went from a surplus of 1.1% of GDP in 2019 to a deficit of 1.9% in 2020. The exchange rate depreciated ZWL2.5 in February 2019 and stabilizing around ZWL82 to the US dollar in December 2020. Poverty stood at 70.5% in 2019 while unemployment remained high at over 21%. The banking system is stable. Banks have some room to increase credit. The loan-to-deposit ratio was 38.8% in 2020 against a benchmark of 70%. Non-performing loans are

at 3.23%, well under the regulatory benchmark of 5%. The capital adequacy ratio is more than three times the regulatory requirement of 12% (AfDB, 2021).

COVID-19 affected millions of people dependent on the informal economy and contract and casual workers in the formal sectors, with women being the worst affected. Closure of informal economy businesses, marketplaces and vending sites deprived them of their sources of livelihoods and incomes. Vendors and small-scale food producers reported disruptions in the supply chains, low sales, high rates of produce leftovers and spoilages (for those selling perishable goods) which threatened profits, and a decline in number of customers visiting vending sites or informal markets. There were high job losses in the retail and other service sectors, as well as reduction or disappearance of wages for most contract and casual workers.
The COVID-19 pandemic also affected food consumption and food and nutrition security as households lost incomes, while food prices went up due to the inflationary shocks induced by the pandemic (Zimbabwe Peace Programme, 2021)
As a result, the right to food and food security was severely undermined. More than half of urban households and two thirds of rural respondents surveyed by ZIMSTAT between March and July 2020 reported that they had to skip meals because of lack of resources to obtain food (Zimbabwe Peace Programme, 2021).

In 2015 the country also committed itself in its first Nationally Determined Contribution (NDC) submission to achieve a 33% reduction of its energy-related greenhouse gas emissions per capita below business-as-usual by 2030 (INDC, 2015). The updated NDC target is a 40% per capita emissions reduction across all sectors of the economy below the projected business as usual scenario by 2030. A key strategy to deliver these ambitious developments is the Renewable Energy Policy of 2019 which targets 1,100 MW and 2,100 MW from renewable sources by 2025 and 2030 respectively. All these presents great potential for the renewable energy sector in Zimbabwe. Through the renewable energy policy, the country plans to set up a green-energy fund to promote the use of renewables, with the aim of increasing electricity production. The policy aims to promote investment in the renewable energy sector by providing specific incentives, such as tax concessions to independent power generators selling electricity to ZESA Holdings, alongside reduced licensing fees. The Ministry of Energy and Power Development envisages "being a clean source of energy, renewable-energy projects shall be provided concessions in licensing fees and enjoy relaxations in other licensing requirements.

Zimbabwe's economy is predominately agro-based and with the bulk of the population living off the land, green technologies are critical to mitigating and adapting to climate change. Investing in renewable energy technologies is a promising option for combining the multiple goals of climate change mitigation, a low-carbon economy, employment creation (especially among the youth, thereby taking advantage of the growing number of young people out of work), energy security and sustainable development.

Green investments are also an important component for supporting entrepreneurial initiatives, skills development and technology transfer, all of which are critical to economic growth and development. According to the United Nations Environment Programme (UNEP), a green economy is one that results in improved well-being and social equity with a minimal impact on the environment. The Government of Zimbabwe has already set the framework and agenda for the

Green Economy. Adopting green technologies is expected to contribute not only to lowering carbon emissions, but improvement in national energy production and security, employment creation, access to energy, poverty reduction and improved livelihoods without adverse effects on the climate (Friedrich Ebert Stiftung, 2014).

4.2 Energy (electricity) context

4.2.1 Zimbabwe's Total Primary Energy Supply and Energy Balance

All socio-economic activities require adequate energy supplies. Figure 3 shows that of the 2017 total primary energy supply (TPES), biofuels contributed 70% while coal, oil and electricity contributed the remaining 30% of the energy supplied (IEA, 2017). Total primary energy supply (TPES) is the total amount of primary energy that a country has at their disposal, and is calculated as shown below:

TPES = Primary production + Recovered & Recycled products + Imports – Export + Stock changes – International maritime bunkers – International aviation (Energy Education, 2021). The 2017 Energy Balance (IEA) data shows that Zimbabwe's TPES was 473,360TJ (11,306 ktoe) and its total final consumption (TFC) was 415,959 TJ (9,935 ktoe) in 2017. The difference between the TPES and TFC of around 53,000 TJ can be attributed to transformations to secondary energy sources, and energy losses.

The population projections by ZimStats indicate that the Zimbabwean population will be 17.1 million in 2025 and 18.7 in 2030 under a medium scenario (Zimstat, 2015, p22, Table 4). The GDP and population growths would mean that there would be growth in energy supply.

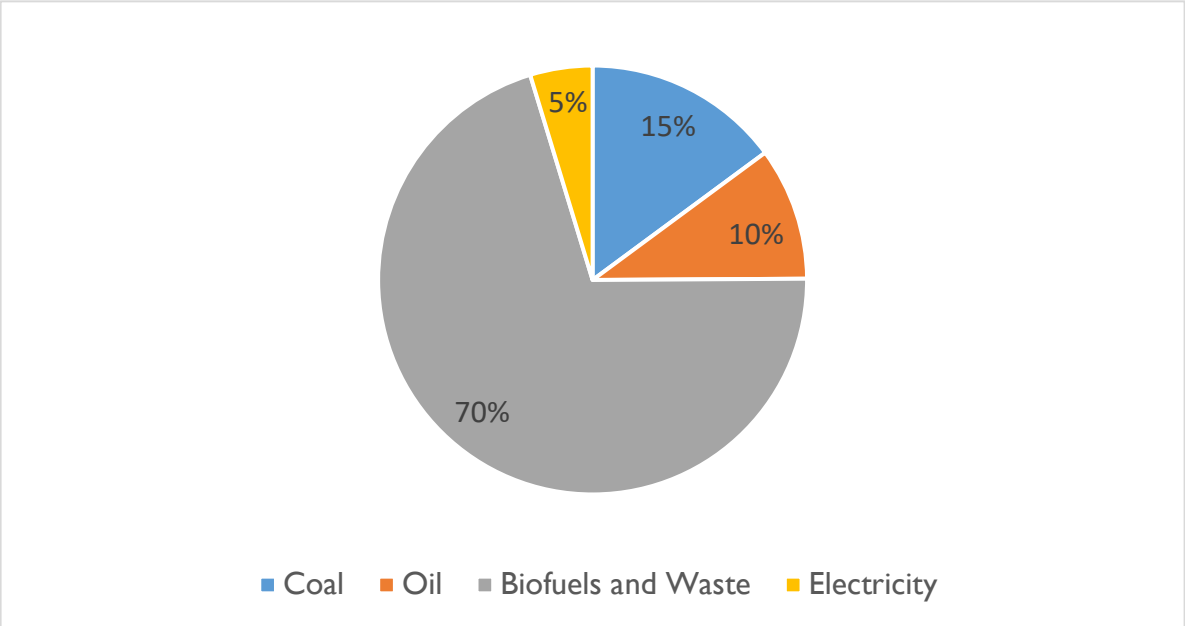

Figure 3: Zimbabwe's total primary energy supply (Source: IEA, 2017)

4.2.2 Electricity generation, electrical energy demand and contribution of IPPs

Despite the low contribution on the TPES, electricity is the most preferred energy source in almost all sectors of the economy. Zimbabwe has an installed capacity of about 2,300 MW, with Zimbabwe Power Company (ZPC), a generation subsidiary of ZESA, the national utility, owning around 95% of this. More than 50% of electricity is generated from Kariba Hydro Power plant, while the remainder is from thermal power plants and IPPs. Bagasse, mini hydropower and small sized grid connected solar systems have an installed capacity of about 130MW. Against this background, the actual power generation capacity in 2019 was less than 1,000MW against a peak demand of about 1,700MW. Zimbabwe is importing 50 MW firm power from HCB, Mozambique, and around 300 MW non-firm power from ESKOM, in South Africa. The country is also exporting around 80 MW of power to NamPower, Namibia based on a commercial agreement between ZPC and NamPower (ZERA, 2019). Approximately 40% of the country's electricity demand is driven by mining and other heavy industries. Peak demand has been recorded at 2,200 MW (GET.invest, 2021).

There is heavy reliance on Kariba Hydro Power Station and Hwange Power Plant. The installed capacities of the two power plants stand at 1,050 MW and 920 MW, respectively (ZPC, 2021). In 2019 local generation was 84% of the electricity supplied, while 16% was imported from ZESCO, ESKOM and HCB. Of the locally generated electricity, Kariba and Hwange power stations contributed 53% and 41% respectively (Figure 4). In 2019 the Independent Power Producers (IPPs) contributed around 3% of the total local generation. The number of license applications is increasing. ZERA received 26 license applications in 2019 against 18 in 2018. Twenty-one of the 26 license applications were solar PV, with a total capacity of 694 MW (ZERA, 2021).

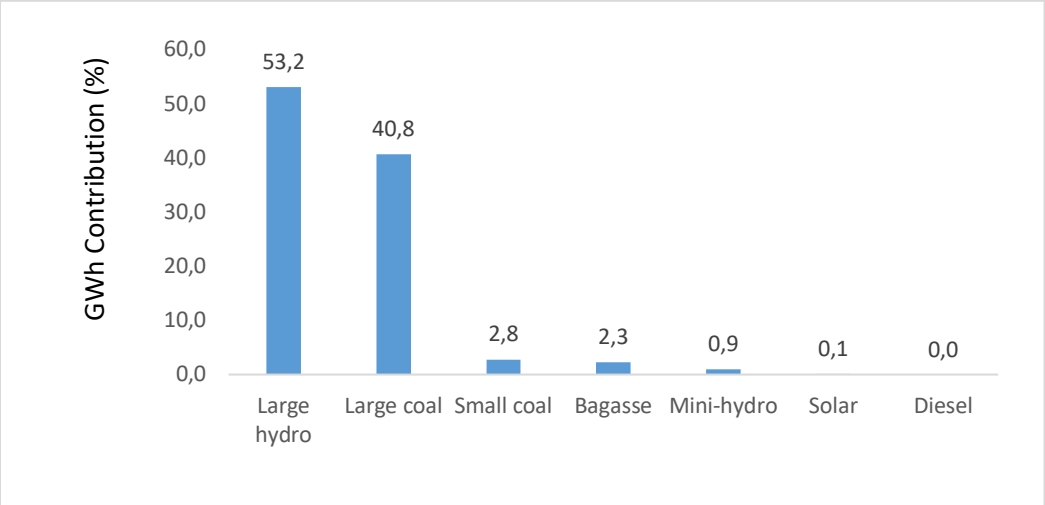

Figure 4: Local electricity generation in 2019 (Source: ZERA, 2021)

Figure 5 shows that in 2019 the mining and manufacturing sectors consumed most electricity at 48%, an increase from 41% in 2014. The domestic sector is the second largest consumer of electricity at 26%, down from 28% in 2018 and 30% in 2014. Figure 5 also shows that most of the domestic consumers are on a pre-payment metering system. In 2019 electricity that was paid for after consumption in the domestic sector was only 5% (domestic metered) while electricity that was paid for before consumption was 21%. With pre-payment metres, electricity consumers can relate electricity consumption and cost, promoting energy efficiency measures. The 2013 free CFL programme in which more than a million incandescent bulbs were replaced with compact fluorescent lamps (CFLs) jn more than 171,905 houses, reduced electrical demand by 42 MW (World Bank, 2019). The high penetration of LPG has contributed to the decrease in electricity consumption in the domestic sector as some domestic consumers have found LPG cheaper than electricity when it comes to cooking and heating. LPG imports have increased from 6 kt in 2012 to 39 kt in 2018 (ZERA, 2021).

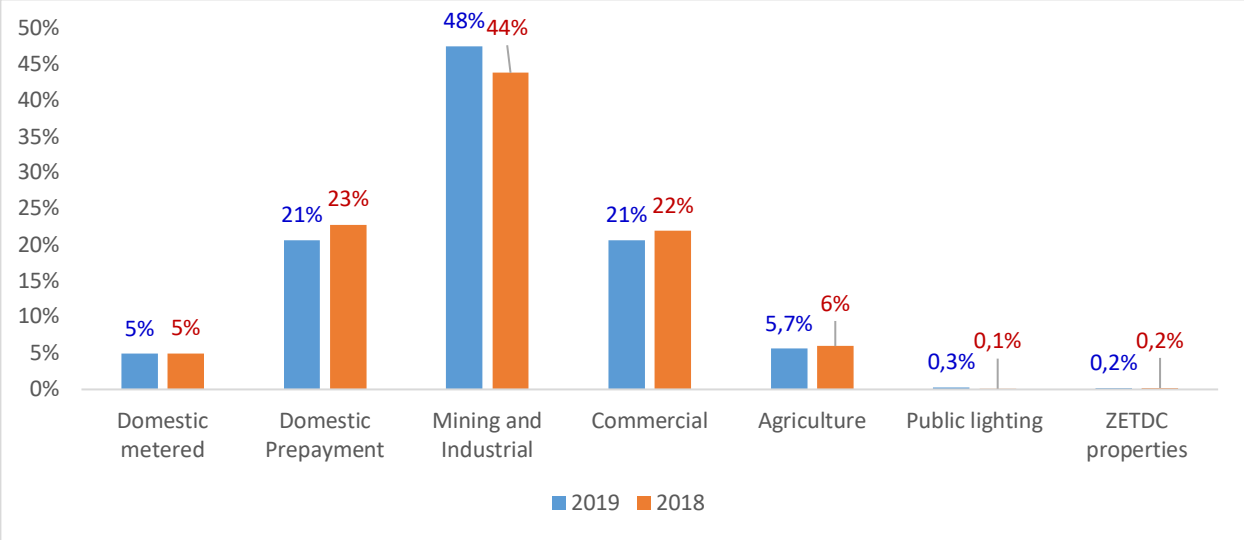

Figure 5: Electricity consumption by sector (Source: ZERA, 2021)

Zimbabwe intends to develop the IPP Policy but the development could not take off as planned due to funding challenges. The number of IPPs is increasing, so is their generation capacity. In an effort to increase uptake of renewable energy in the country, ZERA, in 2016, reviewed the Renewable Energy Feed in Tariff (REFIT), which was developed in 2013 as shown in Table 3. This resulted in reduced tariff for solar projects due to on-going research and development and efficiencies in production of PV panels globally. Generation projects are currently procured through unsolicited bids. This has clogged the licensing system with many projects that have not proceeded through to financial closure and have remained unimplemented. A competitive bidding framework for new generation projects is desirable as it will assist ZERA to license the best operators with relevant capacity and potential at competitive cost. To this end, work for implementing competitive procurement of electricity projects in Zimbabwe commenced in 2019. The REFIT is being used for PPAs of small hydro and wind projects for a period of five years after which a competitive bidding process will be used for all projects. The African Development Bank

(AfDB) offered the Government of Zimbabwe technical assistance in the development of the competitive bidding framework. The project, which is anchored on the completion of the National Integrated Energy Resource Plan (NIERP), will tender out projects from the least cost energy mix (ZERA, 2021).

Table 2: Feed-in tariffs for 2013 and 2016 (ZERA, 2018)

REFIT			
Technology		**Tariff (US$/kWh) 2013**	**Tariff (US$/kWh) 2016**
Hydro	100 kW – 1 MW	0.153	0.146
Hydro	1—5 MW	0.134	0.134
Hydro	**5-10 MW**	**0.118**	**0.121**
Biomass	100 kW – 10 MW	0.137	0.123
Bagasse	100 kW – 10 MW	0.111	0.102
Biogas	100 kW – 10 MW	0.127	0.114
Solar PV	100 kW – 1 MW	0.186	0.140
Solar PV	1 – 5 MW	0.178	0.132
Solar PV	5-50 MW	N/A	0.123
Wind	100 kW – 5 MW	0.148	0.112

The draft Zimbabwe mini-grid framework was finalized in 2019. The document guides investors, designers, contractors and users to achieve universal access to clean energy forms as articulated in Sustainable Development Goal (SDG) 7. SDGs build on the Millennium Development Goals (MDGs), eight anti-poverty targets that the world committed to achieving by 2015. With Goal 7, energy is finally being recognised as a key enabler for development. Universal access to energy, a higher share of renewable energy and massive improvements in energy efficiency, are now part of the top global priorities for sustainable development in the years to come. SDG 7 ensures access to affordable, reliable, sustainable and modern energy for all (UNDP).

4.2.3 Tariffs

The domestic electricity consumers are charged in three ways:

(a) Conventional metering- whose bill components include a Fixed Monthly Charge, energy charges per kWh for the following consumption ranges:
- 1st 50 kWh
- 51 to 200 kWh
- Balance

(b) Prepayment metering – which can be Standard or Stepped. Both follow the consumption ranges (1st 50 kWh, 51-200 kWh and Balance). The Standard system has the same rate for all ranges. This does not discourage high energy consumption. The stepped system has a very low charge for the 1st 50 kWh (a subsidy for the poor), a higher charge for the 51-200 kWh energy consumption and a much higher for the Balance, which can be 10 times that of the 1st 50 kWh energy consumption.

(c) Domestic Load Limited- The bill for this system has two components; the Fixed Monthly Charge (similar to that of the Conventional Metering system) and the Fixed Amperage Charge which increases from the 1 Amp to 30 Amp rating. The costs of installing electricity meters for these customers are prohibitive.

ZERA approves the tariffs in accordance with the Tariff Code whose guiding principle is that all consumers of electricity have to pay an electricity tariff that covers the cost of supplying electricity services to them (Figure 6).

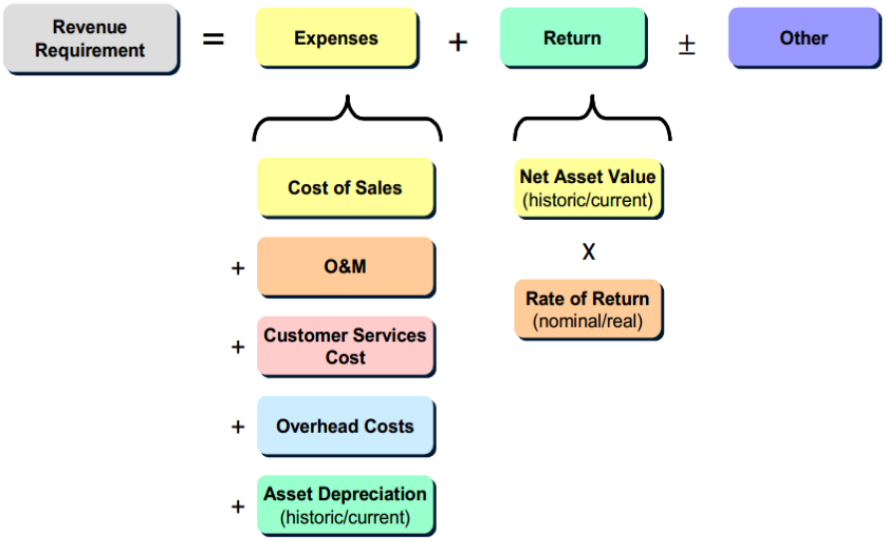

Figure 6: Rate of Return electricity pricing methodology (Source: ZERA, 2013)

The tariff for the Domestic (prepayment consumers) is given in Table 3. On 1 June 2021the rates ranged from US2.26 cents/kWh for the first 50 kWh to US15.27 cents/kWh for 401 kWh or more, using the exchange rate of ZW$84. 7259 per US dollar (RBZ, 2021).

Table 3: Tariff in Zimbabwean Currency for the Domestic prepayment metered customers (Source: ZERA, 2021)

Units /kWh	ZW$/ kWh (including 6% levy)	USD/kWh (including 6% levy)
0- 50	2.25	2.66
51-100	4.51	5.32
101 - 200	7.89	9.31
201 - 300	11.26	13.29
301 - 400	12.94	15.27
401 and above	13.50	15.93

4.2.4 Transmission and distribution losses

The overall yearly transmission and distribution losses for 2019 were estimated at 3.74% and 12.5% respectively aggregating to 16.24% against a ZERA target of 12%. ZETDC is still working on the statistical metering project to be able to accurately capture power losses data. Some sections of the transmission and distribution infrastructure are old and require rehabilitation, and this manifests in power outages even if the power demand is low. The infrastructure includes cables and transformers. ZERA has directed ZETDC to report on power quality parameters measured in the distribution network. The utility has responded positively by procuring power quality meters and the submission of power quality reports was expected to commence in 2020 (ZERA, 2021).

The electricity access and rural electrification programme

The Inter Censal Demography 2017 Report (written by ZimStats, the national statistical agency) says the Zimbabwean population was 13,572,560 in 2017 with 32% residing in urban areas. The report also says the urban household size was 3.9 while the rural and the national average household sizes were 4.3 and 4.2 respectively in 2017. In 2020 Zimbabwe's population was 14.86 million (Worldometer, 2020). Applying a household growth rate of 2.9% per year[3] on the 2017 household size gives a 2020 household size of 3.55 million. Although there are more households in the rural areas expectations are that more residential refrigerators are in the urban by virtue of a higher electricity access level. The electricity access of the urban households was 85% in 2019 while that of the rural households was only 20% (World Bank, 2019).

The mandate of the Rural Electrification Programme (REF) is to facilitate rapid and equitable electrification of rural areas in Zimbabwe, in line with the Rural Electrification Fund (REF) Act 13.20 of 2002. The REF's mission is to empower rural communities in Zimbabwe through harnessing energy resources to ensure that all the people have access to adequate, reliable, least-cost and environmentally sustainable energy services. To

[3] World Bank 2019

achieve its mission, REF embarks on two broad programmes, on Electricity Grid Extension to rural areas, and Research and Development of alternative energy and cost-effective grid technologies. The grid extension programme covers the following:

- Rural schools
- Rural Health Centres
- Government Extension Offices
- Business Centres
- Chiefs' Homesteads
- Villages
- Irrigation Schemes
- A1/A2 Farms, and
- Other Rural Centres

In April 2018, REF announced a new plan to electrify all public institutions such as schools, government extension offices, and other Government departments for free. REF offers 100% capital subsidy to the public institutions. The institutions only have to pay for the internal wiring of their buildings and the connection fees.

For schools (only for administration block, science laboratories and computer laboratories), REF will also subsidise the internal wiring and the connection fees. Since 2002, REF has electrified 2,699 primary schools, 1,359 secondary schools, 874 rural health centres, 411 Government extension offices, 244 chiefs' households, 952 business centres, 774 small-scale farms, 1,175 villages and 803 other institutions. In July 2019, Zimbabwe removed import duties on all solar-related products ranging from batteries to cables.

The government also introduced a new policy that require all newly constructed infrastructure to install solar systems. This policy is aligned with the government's plan to promote local production as well as importation of solar equipment. The government has implemented innovation mechanisms such as net metering and feed-in tariff for clean energy to enable Independent Power Producers to add their excess electricity to the national grid.

The rural electrification program resulted in the grid extension of the 11kV, 33kV and Medium Voltages (380 -400V) lines by 114.83km, 85.53km and 45.29km respectively. Extension of the distribution network, through the rural electrification program, could result in an increase in technical losses. To mitigate this potential challenge, REF extends the grid to public rural institutions within 20km of the existing grid network., and also uses the Single Wire Earth Return system (Figure 7).

On alternative energy sources and grid technologies research, REF covers the following areas:

- Grid-connected solar PV power generation
- Mini-grid solar systems
- Mini-hydro power generation
- Biogas production

- Efficient Cook-stoves
- Single Wire Earth Return

Figure 7: SWER pilot project (Source: REF, 2015)

During the period 2015-2016, REF developed the Rural Energy Master Plan (REMP) which is meant to provide a systematic and realistic approach to how Zimbabwe's rural areas can be provided with modern energy services. The energy services include:

- Electrical energy services (lighting, refrigeration, entertainment, etc)
- Thermal energy services (food processing and preparation, space heating, etc)
- Productive energy needs (irrigation, commercial and business processes, agro-processing and cottage industries)

4.2.5 The role of civil society organisations in promoting electricity access

Civil Society Organisations (Practical Action, SNV- Netherlands Development Organisation, HIVOs, OXFAM, ZERO, among others, are also promoting access to electricity and renewable energy in various communities. Practical Action's energy access illustration in Figure 8 tells us that households, enterprises and community needs are

enabled by a full range of energy supplies and services required to support human, social and economic development.

Figure 8: Energy access to all

4.2.6 Potential for energy efficiency

A comparison of the energy consumed per GDP dollar with other regional countries and the Global average shows that Zimbabwe has huge potential for energy efficiency (Figure 9) as it uses more energy per GDP dollar. Energy intensity is a proxy of energy efficiency, and Zimbabwe's energy intensity is almost three times that of the global average (World Bank, 2021).

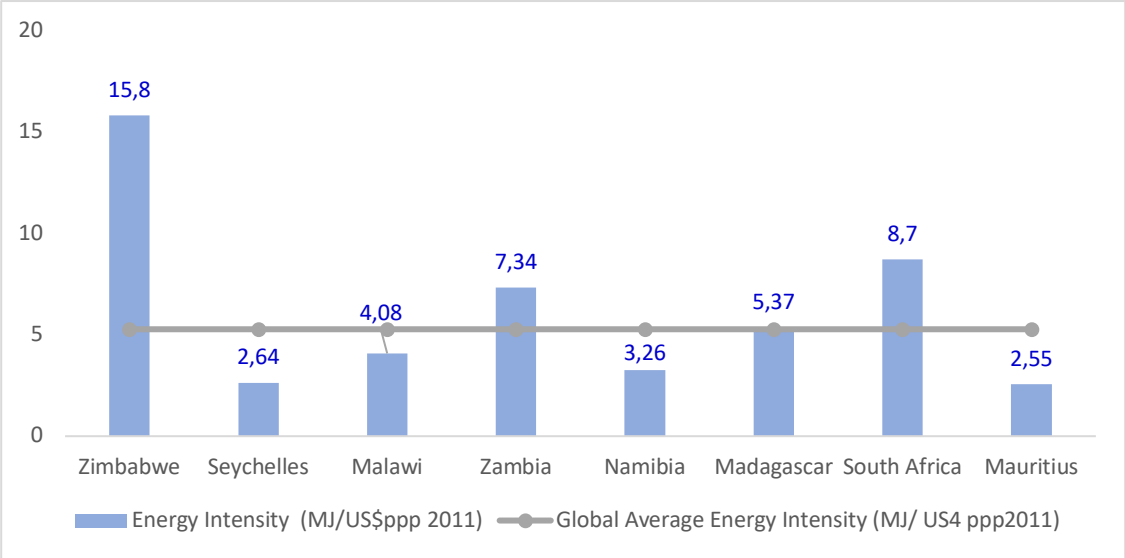

Figure 9: Comparisons of Energy intensity of GDP (Source: World Bank, 2021)

In 2014 ZERA commissioned the National Energy Efficiency Audit with a view of establishing the potential energy savings in various sectors of the economy. The audit identified numerous barriers to energy efficiency including (NEEA Report, 2014, p24):

- Limited capacity to conduct energy audits and to implement energy conservation measures;
- Financial restrictions for entities which are aware of the need to improve process efficiency through re-capitalisation;
- Indifference and "don't care attitude", including conflicting interest issues between the parties that are involved in energy efficiency, for example, a landlord and tenant where the benefits of low electricity bills to a tenant as a result of energy efficiency measures (ECMs) are not as important to the landlord as the cost of implementing those ECMs.;
- Low prioritisation of energy efficiency in a significant number of entities;
- Lack of technical knowledge within entities (unable to identify, analyse or track energy data);
- Use of antiquated and energy inefficient equipment;
- High capital outlay for acquiring energy efficient equipment which is usually expensive;
- Environmental policies, legislation and enforcement relating to energy are weak;
- Lack of Government policies to and incentives for the adoption of energy efficiency equipment and practices;
- Lack of awareness of the strategic importance of energy efficiency; and
- Lack of organisational policies to motivate employees to be energy efficient

In 2020 the Ministry of Energy and Power Development engaged a consultant to develop the National Energy Efficiency Policy (NEEP). The draft NEEP says that Zimbabwe shall establish and

develop mechanisms and regulations targeted at MEPS for selected buildings, vehicles, technologies and appliances in the country. These shall include among others: single story buildings, multi - story buildings, motors, air conditioners, fridges, light bulbs, magnetic ballasts, and fluorescent lamps, computers, TVs, cookers, dishwashers, washing machines, dryers and cookstoves among others. The standards should be able to promote the use of energy-efficient equipment.

4.2.7 Acts and Policies

Zimbabwe has a number of environmental and energy related laws and policies as well as an economic development blueprint that has direct and indirect implications on production of renewable energy.

Acts

The country's energy sector is currently governed by the following Acts:

- Electricity Act {Chapter 13:10} (2002): To establish Zimbabwe Electricity Regulatory Commission and provide its functions and management, and detail the licensing and regulation for the generation, transmission, distribution and supply of electricity by the utility and IPPs.
- Rural Electrification Fund Act {Chapter 13: 20} (2002): To establish the Rural Electrification Fund Board for distribution of Rural Electrification Funds.
- Environmental Management Act {Chapter 20:27} (2002): To establish the National Environmental Council and Environmental Management Agency
- Petroleum Act {Chapter 13:22} (2006): To establish the Petroleum Regulatory Authority and its function and management, and licensing and regulation of the petroleum industry
- Energy Regulatory Authority Act {Chapter 13:23} (2011): To establish the Energy Regulatory Authority and provide its functions and management, and amend the provisions of Electricity Act (2002) and Petroleum Act (2006)

Policies governing the energy sector

- National Energy Policy (2012): Seeks to promote the optimal supply and utilisation of energy, for socio-economic development in a safe, sustainable and environmentally friendly manner. It brings out Government's objective to ensure that the energy sector's potential to drive economic growth and reduce poverty is fully harnessed

- National Renewable Energy Policy (2019): The policy aims to provide energy access to all in a sustainable manner by increasing the contribution of renewables in the country's energy mix.
- Low Emission Development Strategy (2020-2050) (2019): One of the energy sector mitigation projects of the country's LEDS aims to increase energy performance of appliances leading to reduced grid power consumption.
- Zimbabwe's Nationally Determined Contribution (2021): Zimbabwe's revised NDC target is a 40% per capita emissions reduction across all sectors of the economy below the projected

business as usual scenario by 2030. One of the energy sector mitigation projects is about energy efficiency improvement in various sectors of the economy.

- Zimbabwe's National Climate Change Response Strategy (2015): Seeks to establish specific provisions for dealing with climate change issues within various sectors, understanding the extent of the threat and putting in place specific actions to manage potential impacts

- Zimbabwe Climate Policy (2017): Seeks to create a pathway towards a climate resilient and low carbon development economy in which the people have enough adaptive capacity and continue to develop in harmony with the environment. The policy is expected to mainstream climate issues in all sectors of the economy including; energy, agriculture, industrial processes, waste, land use, land cover and forestry

- The 2030 Agenda for Sustainable Development: The Goal 13 of UN Sustainable Energy for All states the need to take urgent action to combat climate change and its impacts

- Vision 2030: To transform Zimbabwe into an upper middle-income economy, raise employment levels upwards, and to progressively reduce the poverty rate to levels consistent with the upper middle-income economies, among other factors. The National Development Strategy 1: 2021-2025 (NDS1) is the 5-year Medium Term Plan aimed at realizing the country's Vision 2030, while simultaneously addressing the global aspirations of the Sustainable Development Goals and Africa Agenda 2063. The NDS1 aims to achieve an average annual real GDP growth rate of above 5% during the period 2021-2025.

According to the Ministry of Energy and Power Development, the Renewable Energy Policy was developed under the overall framework laid out by the National Energy Policy of 2012. Apart from improving the share of RE in the overall energy mix and addressing issues of climate change, this policy also focuses on obtaining cost-effective implementation of productive energy sources, social upliftment through community involvement, gender equality and employment generation as laid out in other different Acts and Policies.
The Ministry of Energy and Power Development has an overall responsibility for energy issues in Zimbabwe, including promotion of new and renewable sources of energy. The Ministry supervises and oversees the performance of the energy parastatals, ZESA Holdings and the national oil company of Zimbabwe (NOIC). The Rural Electrification Fund Act (13:20) created a Rural Electrification Fund (REF) that has the mandate for the total electrification of all rural areas, funded by electrification levies and government stipends.

In the year 2016, Zimbabwe gazetted Statutory Instrument 64 of 2016 (SI 64) that required traders to obtain an import license from the Ministry of Industry and Commerce before importing basic commodities such as coffee creamers, bottled water, white petroleum jellies and body creams, canned fruits and vegetables, peanut butter, etc. (Tralac, 2017). The SI 64 was designed to limit consumer spending on luxury imports (since Zimbabwe is facing a huge Balance of Trade deficit) and to industrialize by import substitution. However, the SI64 was amended by the SI 122 of 2017 which re-inserted the repealed First Schedule of the Control of Goods (Open General Import Licence) Notice of 1974. The SI 237A of 2017, amended the SI 122 of 2017, by inserting certain

products to the Open General Import License (OGIL). Refrigerators and refrigerants were not on the lists of SI 64, SI 122 and SI 237A.

Inefficient Lighting Ban and Labelling Regulations (Amended Statutory Instrument 208 of 2018)

The Statutory Instrument on inefficient energy lighting was reviewed to incorporate proposed SADC Harmonised Minimum Energy Performance Standards for General Lighting Products as well as a review of fines for non-compliance (Zera-Annual-Report-2018, 2020)

5 Market assessment on residential refrigerators

5.1 Objective and scope

5.1.1 Summary of suppliers, end-users, officials and other stakeholders

The stakeholders engaged in this market assessment are classified under the following seven categories:

i. Ministries and government departments
ii. Private sector
iii. Refrigerator manufacturers and distributors
iv. Financial Institutions
v. Consumer Associations
vi. Utility (Demand Side Management)
vii. Households

Table 4: Stakeholders consulted for refrigerator data/information

	Institution	Description
1	IMPERIAL	Refrigerator manufacturer/assembler/ Importer
2	CAPRI	Refrigerator manufacturer
3	PRIMEPEP SERVICES (T/A TRADECOM AFRICA)	Importer/Distributor/ Wholesaler
4	TV Sales & Home	Importer/Retailer
5	OK Mart	Distributor
6	Mahomed Mussa	Distributor
7	Standards Association of Zimbabwe	National Standards Body
8	National Ozone Unit	A Unit within the Climate Change Management Department
9	ZIMSTAT	National Statistics Office
10	Zimbabwe Electricity Transmission and Distribution Company (ZETDC)	Utility's EE and DSM
11	Zimbabwe Energy Regulatory Authority (ZERA)	Energy Regulator
12	Ministry of Industry and Commerce	Ministry
13	Small to Medium Enterprises Development	Ministry of Women Affairs, Community, Small-to-Medium Enterprises Development

14	Ministry of Local Government and Public Works	Ministry
15	Ministry of Finance and Economic Development	Ministry
16	Urban Councils Association of Zimbabwe (UCAZ)	Residents Association
17	Zimbabwe Environmental Lawyers Association	Lawyers Association
18	Infrastructure Development Bank of Zimbabwe (IDBZ)	Financial institution
19	ZB Bank	Financial institution
20	NEDBANK	Financial institution
21	Zimbabwe Revenue Authority (ZIMRA)	Customs

5.1.2 Manufacturing of refrigerating appliances

The refrigerator supply value chain is shown in Figure 10, and indicates how the manufacturers, importers, wholesalers, retailers and consumers are linked. CAPRI and IMPERIAL are the major manufacturers of refrigerators in the country, while PRIMEPEP SERVICES (T/A TRADECOM AFRICA), Mahomed Mussa, TV Sales & Home and OK Mart are the major wholesalers/retailers.

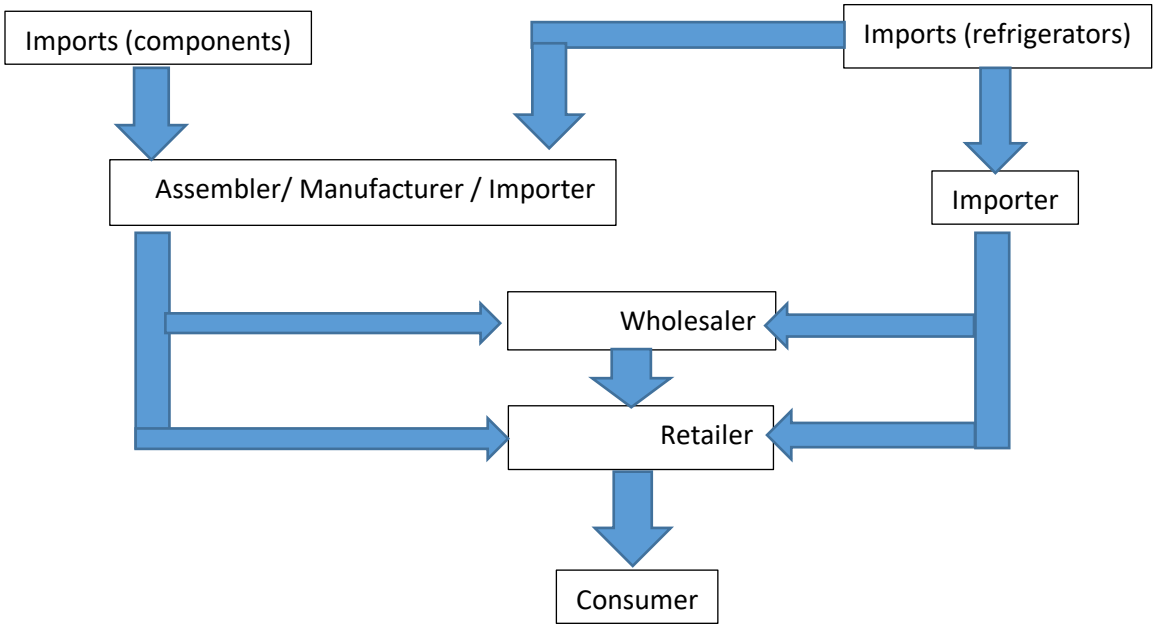

Figure 10: Refrigerator supply chain for Zimbabwe (Market Assessment, 2021)

Table 5: Imports and exports of refrigerator units during the period 2010-2020 (Source: Zimstat, 2021)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential refrigerators-imports	3272	17031	17247	4660	9204	4856	4748	1851	2723	2663	2094
Residential Refrigerators-exports	5	15	13	82	52	67	1045	180	1	2362	131

The manufacturers and distributors of residential refrigerators indicated that the local production for 2020 ranged from 50% to 60% of the refrigerators sold, while imports contributed the balance.

According to the questionnaire responses by the manufacturers and distributors, the estimated annual residential refrigerator sales or market size for 2020 was between 20,000 to 35,000. Discussions with the supply chain actors showed that of the country's two major refrigerator manufacturers Imperial focuses more on commercial refrigerators while CAPRI focuses on residential refrigerators, and around 90% of the manufactured residential refrigerators are the non-inverter type. The 2020 sales figures show the following:

- Freezer sales were more than those of the refrigerators or refrigerator-freezers
- More than 50% of the refrigerators and refrigerator-freezers were of the direct-cool technology while only 43% of the freezers were direct cool and the rest frost-free type.
- Most of the refrigerators were the non-inverter type, which were estimated at 90% by one manufacturer.
- The 150-275L range had the highest sales for all refrigerator categories
- Refrigerator prices ranging from USD350 for the 150L refrigerators to around USD1,400 for the 600L refrigerators

Both manufacturers and distributors agree that energy efficiency, modern design and refrigerant environmental friendliness will be among the most significant factors affecting selection of refrigerator purchases. They also agree that the refrigerator size or capacity will not have much influence on purchasing decisions.

The trade statistics in Table 5 show that imports were much higher than exports for the period 2010-2020, meaning that local manufacturing has been failing to meet demand for refrigerators. The supply chain actors are of the opinion that 40% to 50% of the demand is met through imports. However, only 2011, 2012 and 2014 imports would be above 40% of the market size of 20,000 to 35,000 residential refrigerators while imports for the other years, including the years 2015-2020 had very low imports. The percentage ranges of imports were based on the assumed market size of 20,000 – 35,000 refrigerators but it is mostly likely that the market size fluctuated over the 2010-2020 period.

5.1.3 Overview of the supply chain

The information from the manufacturers and distributors show that R134a (tetrafluroethane) was the most widely used refrigerant during the period 2010-2015, and deployment of R600a (Iso-butane) increasingly grew during the period 2015-2020, especially in the imported brands.

The regulations governing the imports of refrigerators and other Cooling, Heating Ventilation and Air Conditioning are contained in SI 131 of 2016. Section 4 of the SI says that no person shall import into Zimbabwe, any substances listed and equipment or appliance which uses or whose function relies on the substances listed in the Second Schedule. Listed in the schedule is R12 (dichlodifluoromethane) which is some of the old refrigerators. The ozone-friendly refrigerants R134a – which has a high GWP and R600a– which has a lower GPW - are listed as Controlled substances (greenhouse gases) under the Fourth Schedule.

Training on the ozone-friendly and low GWP refrigerants has been, and is being provided to various stakeholders including immigration officials, manufacturers, refrigerant distributors and service technicians in the country. The major obstacles on access to such refrigerants by the manufacturers is the foreign currency required to import them.

5.1.4 Best-selling equipment

The best-selling locally manufactured refrigerator brands are CAPRI and IMPERIAL. If imports are considered the list of the selling brands given by the manufacturers and distributors includes CAPRI, DEFY, SAMSUNG, and HISENSE.

The responses by the refrigerator supply chain actors show that for the refrigerators and refrigerator-freezers the best-selling type is the frost-free type while for the freezers the direct cool technology is the best-selling type. Discussions with the supply chain actors showed that most of the manufactured and imported refrigerators are the non-inverter type.

In terms of size or capacity the 150-275L refrigerators are the best-selling.

5.1.5 Barriers to the sale of efficient residential refrigerators

In the questionnaires the manufacturers and distributors of refrigerators indicated that they strongly believe that in the future, consumers will consider energy efficiency when making refrigerator purchasing decisions. However, suppliers must keep production costs low, but low demand resulting from low disposable income by consumers can result in high production costs, so will shortages of foreign currency and unstable exchange rates.

The suppliers of residential refrigerators indicated that they appreciate the importance of manufacturing more efficient refrigerators, and using refrigerants that neither destroy the ozone layer nor cause global warning, as a way of building comparative advantage. However, they are concerned with the low level of awareness of these benefits by the prospective buyers of their refrigerators. Who would They are also of the opinion that Government should have in its ministries and departments technical people who would have a better understanding of technology and energy efficiency issues and help the nation

transition towards more energy-efficient appliances including residential refrigerators as they would be better positioned to inform policy.

Manufacturers of refrigerators highlighted the lack of technical skills in the industry in the future as they are unable to recruit apprentices because of low business. The graduates from the universities will not have the required skills as students face challenges in getting places for attachment during their training. If not addressed, this can be a barrier to development or adoption of more energy efficient technologies.

5.2 Demand

5.2.1 General consumer information

The survey results show that:

- 226 household representatives were interviewed; 47% were male and 53% were female. In the latest national census (2012) women contributed 52% (Zimstat, 2012).
- The ages of the interviewees ranged from 20 to 73 years, and averaged 35 years
- The families comprise of 64% adults and 36% children (12 years old and below),
- The average (urban) household size from the survey was 4.3 people (2.8 adults and 1.8 children). The 2017 census gives an urban household size of 3.9 people (Zimstat, 2017)
- 56% of the families own the houses they are living in.

The household survey results in Figure 11 show that CAPRI is the best-selling refrigerator brand in the country (at 30% share), followed by DEFY (26%) and KIC (10%). CAPRI and IMPERIAL are the largest two refrigerator manufacturer in the country and have a total contribution of 37%, which means that 63% of the refrigerators considered in this survey were imported. Around 64% of the refrigerators studied were purchased in Zimbabwe, 29% from South Africa, 6% from Botswana, 0.4% from Malawi, 0.4% from Namibia and 0.4% from other countries. Of the purchased refrigerators, 91% were new while 9% were second-hand; 63% were direct cool while 37% were frost-free. All refrigerators and freezers were single-door, while refrigerator-freezers with one door, two doors and more than two doors were 90%, 8% and 2% respectively.

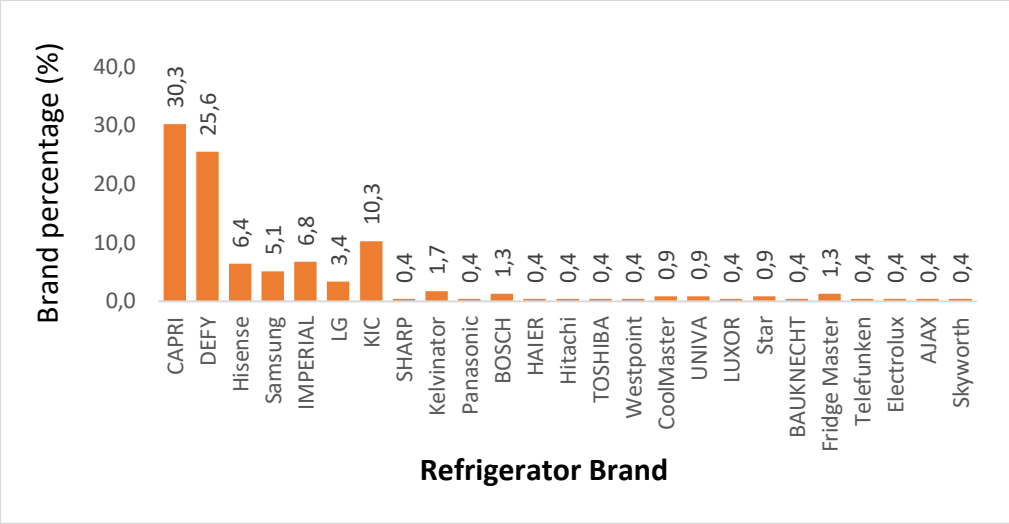

Figure 11: Market share of fridge brands as of March 2021(Source: Market Assessment, 2021)

The most common household size is 3BHK (37%), followed by the 2BHK (26%) and those more than 3BHK (26%) as shown in Figure 12.

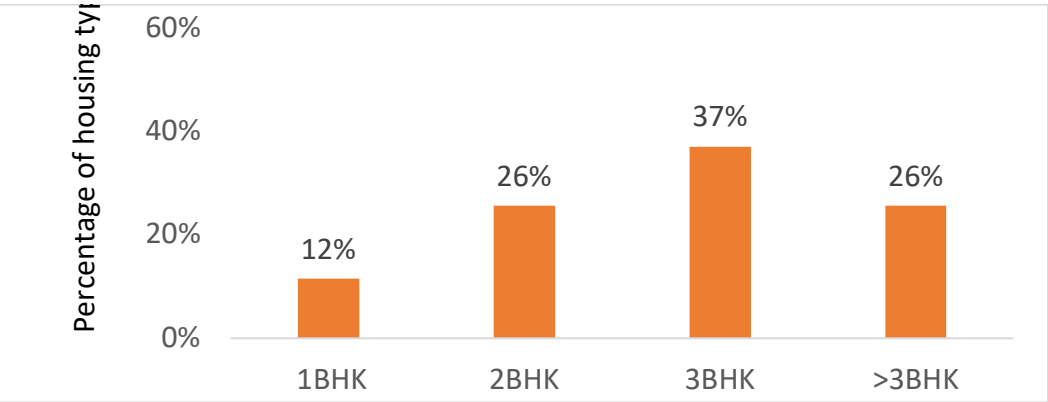

Figure 12: Percentage contribution of house types (Source: Market Assessment, 2021)

Figure 13 shows that 41% of the interviewees were employed by the private sector, while 36% were self-employed. The public sector employees and pensioners constitute 19% and 3% respectively.

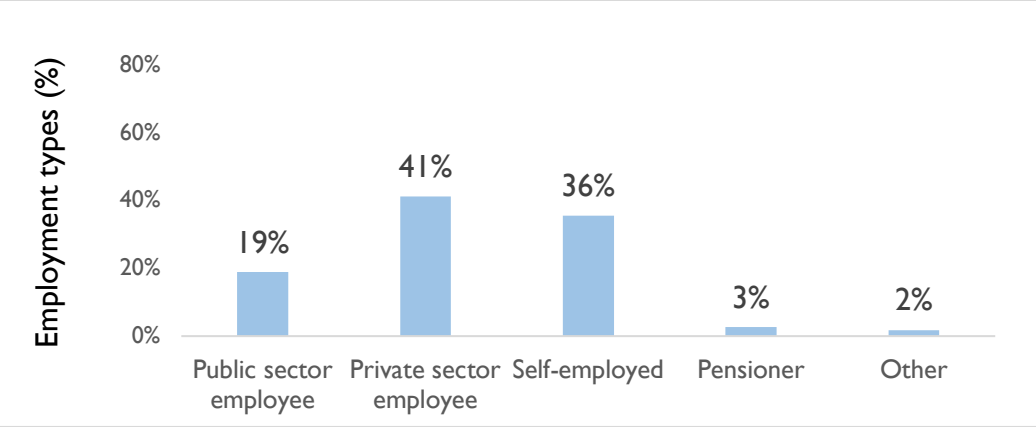

Figure 13: Employment types (Source: Market Assessment, 2021)

Figure 14 shows that the income graph is skewed towards zero. About 70% of those interviewed are earning less than US$7,100 per year or less than US$600 per month.

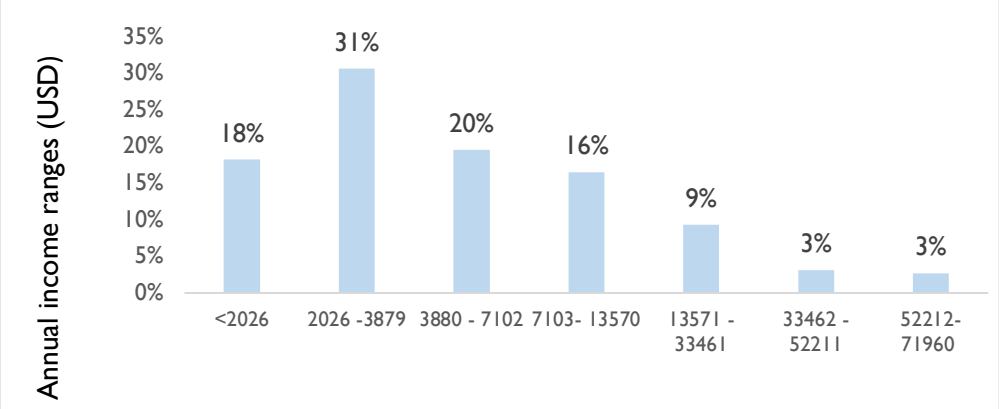

Figure 14: Annual income ranges (in USD) (Source: Market Assessment, 2021)

On the willingness to pay more for an energy efficient appliance, 55% were willing to pay up to 10% more, 33% were prepared to pay 20 to 40% more, and 7% were not willing to pay an extra amount. Only 5% showed interest to pay more than 40% over the price of the conventional appliances (Figure 15).

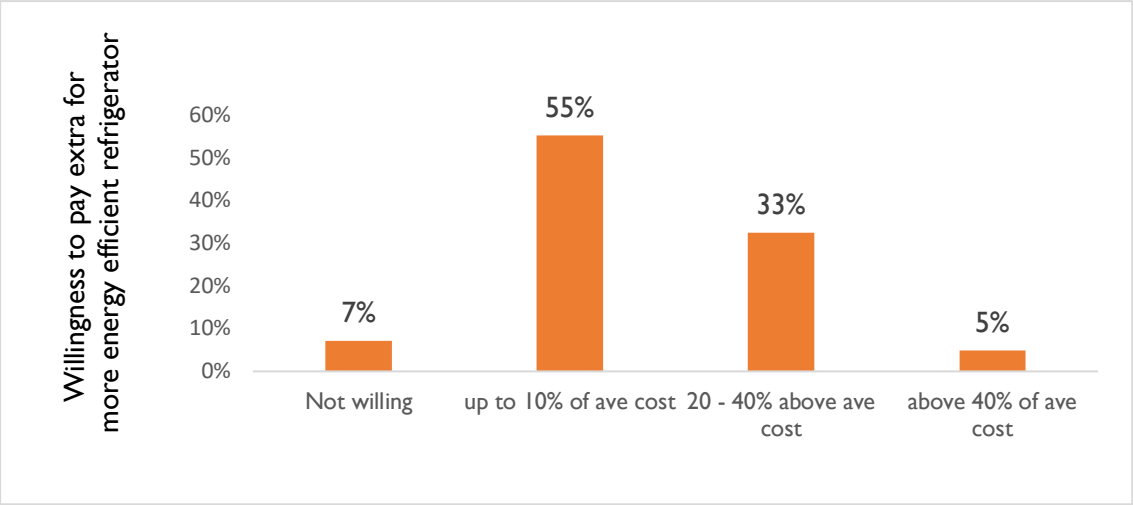

Figure 15: Willingness to pay extra amount for more energy efficient appliance (Source: Market Assessment, 2021)

5.2.2 Level of financial inclusion

Around 82% of the respondents own at least one bank account. Some respondents indicated that they can use mobile money, such as Ecocash and OneMoney, to pay for goods including refrigerators. Steward Bank is the most preferred bank as shown in Figure 18. Figure 17 shows that around 91% of the refrigerators were purchased through the use of own capital, 8% through the hire purchase mode, and less than 1% were purchased through bank loans. The hire purchase payment periods ranged from 12 to 24 months. Only 12% of the respondents have successfully applied for loans from their banks for various uses in the past, and 19% believe the bank loans are attractive. The interest rates and loan tenor looked unattractive to 81% of the interviewees. Most of those who received bank loans have accounts with FBC, Standard Chartered and CBZ (Figure 16).

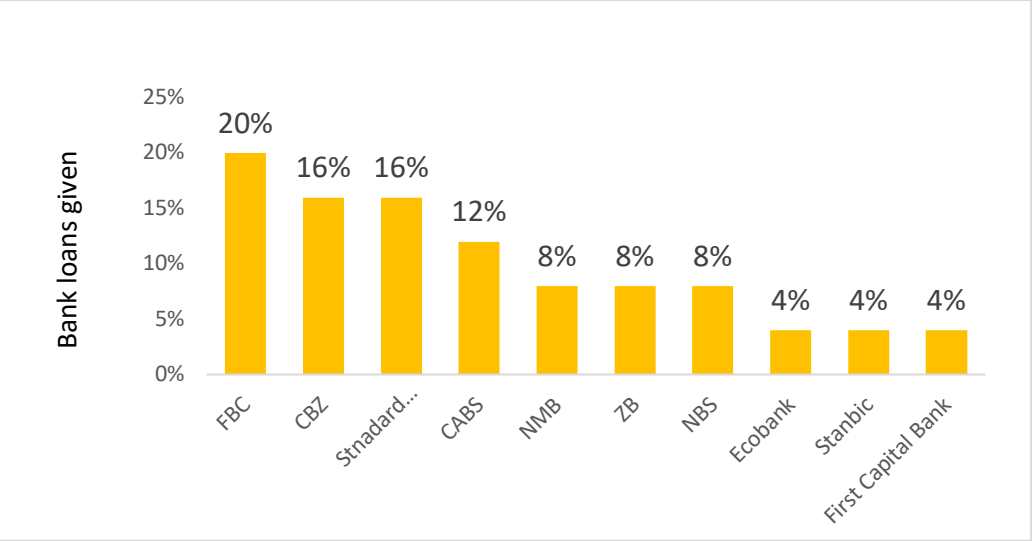

Figure 16: Percentages of bank loans given to the respondents by banks (Source: Market Assessment, 2021)

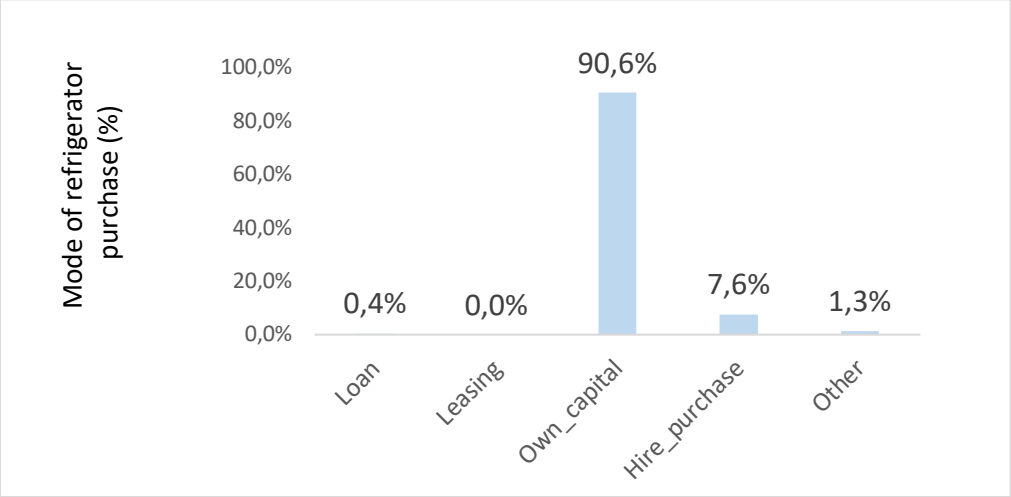

Figure 17: Mode of refrigerator purchase (Source: Market Assessment, 2021)

For those who accessed loans, tenor ranged from 6 to 72 months, with an average of 26 months. The interest rates ranged from 3 to 25% per annum, with an average rate of 12%.

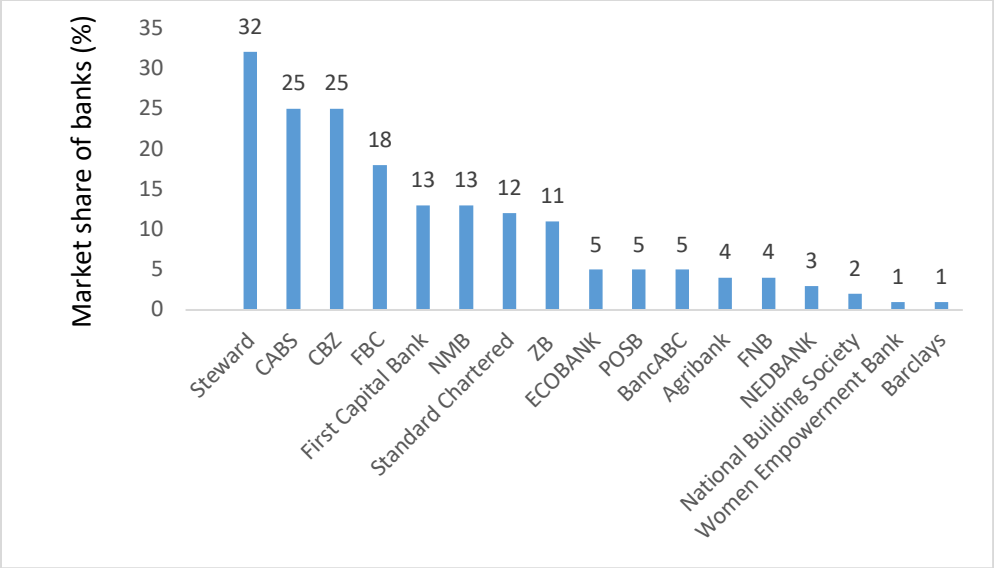

Figure 18: Market share of banks (Source: Market Assessment, 2021)

5.2.3 Current expenditure on electricity

Zimbabwe has been installing prepayment meters for the domestic consumers as a way of improving revenue collection as well as of promoting energy savings. The survey results (Figure 19) show that around 71% of the households spend less than US$35 on electricity per month, while 26% spend between US$36 and US$70 per month. The market assessment showed that close to 95% of the households are on a prepayment system while about 5% are on a credit system, while the national statistics shown in Figure 5 indicate that around 81% were on a prepayment system and 19% were on a credit system in 2019.

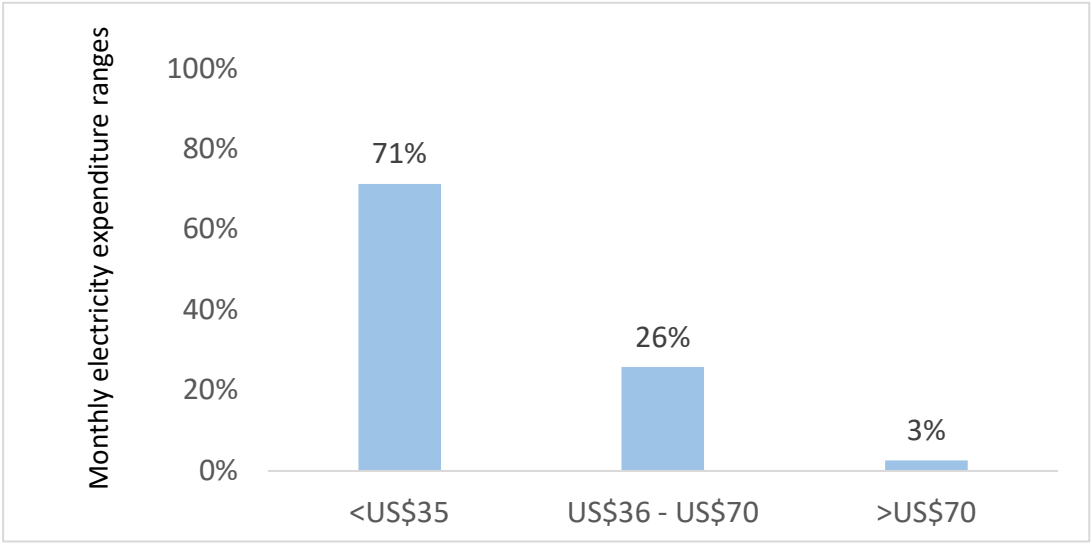

Figure 19: Monthly electricity expenditure ranges (Source: Market Assessment, 2021)

5.2.4 Ownership of refrigerating equipment

The survey identified 25 brands of refrigerators in use, with CAPRI and DEFY being the most popular brands (Figure 11). For each brand there were quite a number of models. The most preferred refrigerator type is the refrigerator-freezer, as this type had the highest percentage of 69% (Figure 20), while the freezer and refrigerator contributed 28% and 3% respectively.

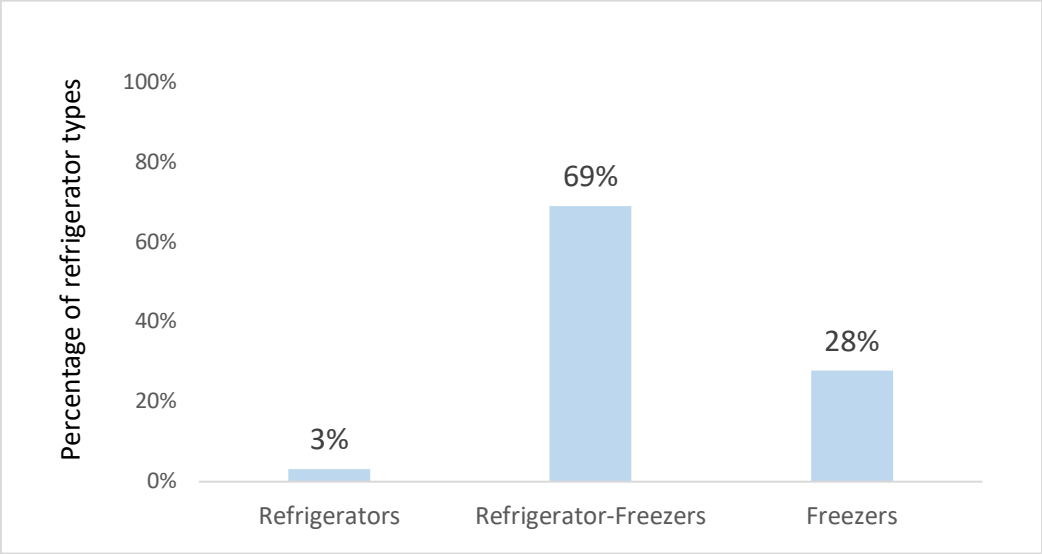

Figure 20: Refrigerator types in use in the Zimbabwean domestic sector (Source: Market Assessment, 2021)

Figure 21 shows the average, maximum and minimum volumes of the refrigerators in use in the country. As expected, the refrigerator-freezers had the largest volume because it combines the refrigerator and a freezer. Of all the refrigerator types the average refrigerator-freezer has the highest price (Figure 22) and the annual energy consumption (Figure 23). The average survey refrigerator prices, ranging from USD338 to USD531, agree very well with the indicative figures provided by some of the refrigerator suppliers. The amount of energy consumed by the refrigerators studied range from around 200 to 600 kWh per year.

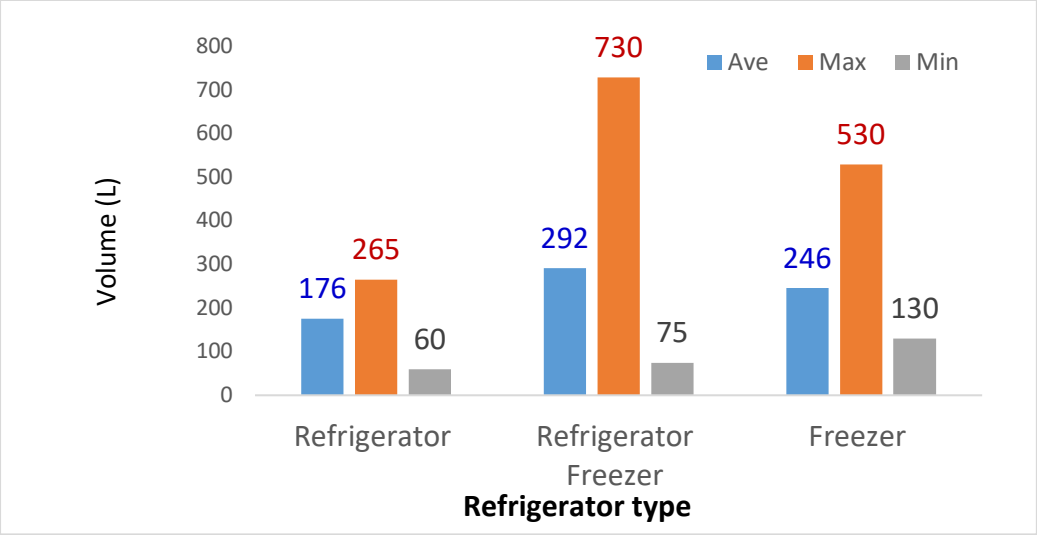

Figure 21: Average, maximum and minimum volumes of the refrigerators (Source: Market Assessment, 2021)

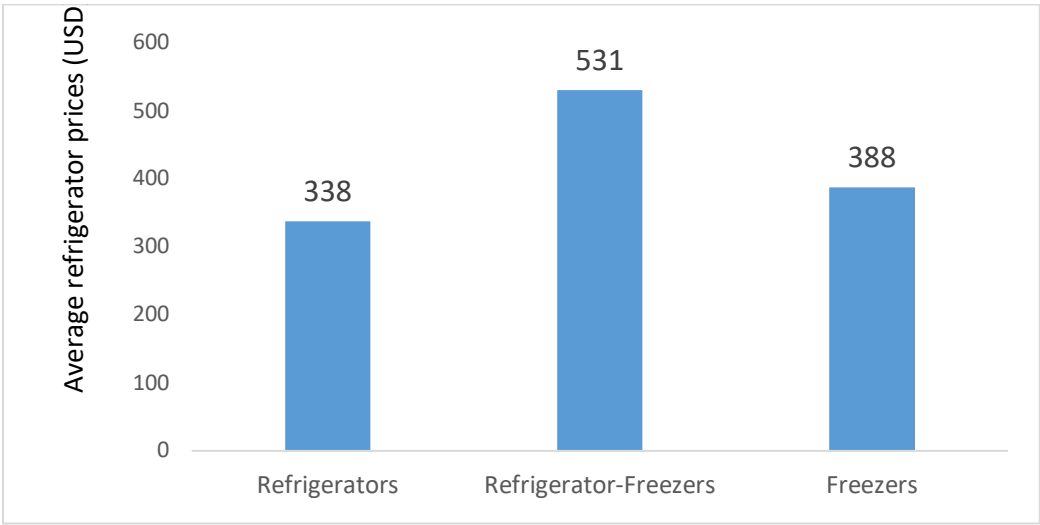

Figure 22: Average refrigerator prices (Source: Market Assessment, 2021)

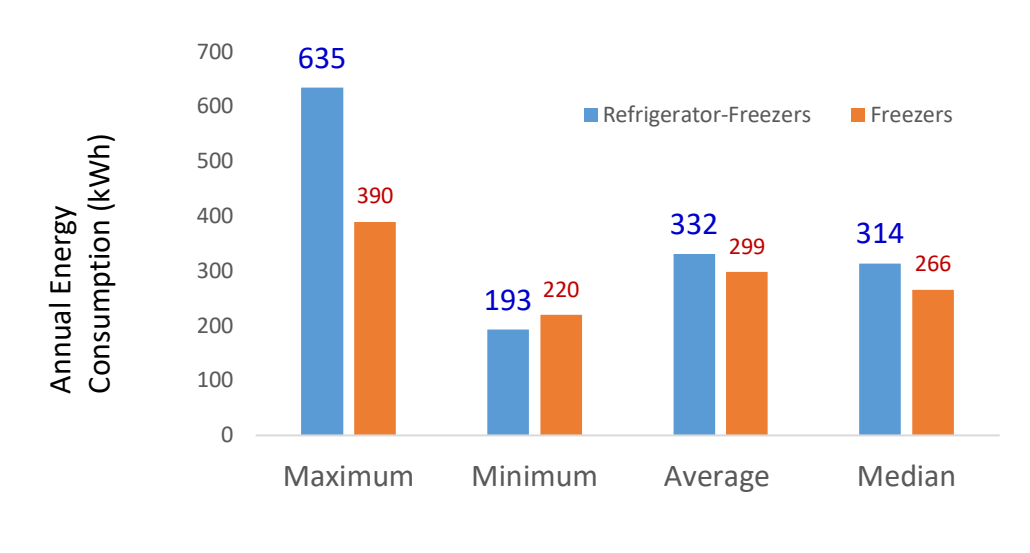

Figure 23: Annual energy consumption of refrigerator-freezers and freezers (Source: Market Assessment, 2021)

Figure 24 shows that the refrigerants that are in most of the refrigerators studied are R134a and R600a, which contributed 57% and 37% respectively. R12 contributed 6%. The penetration of the more environmentally friendly refrigerant R600a is slow in Zimbabwe as the refrigerant was used in only 8% of the locally manufactured refrigerators (Figure 25). The survey results also show that the country still has a significant number of refrigerators with the banned refrigerant R12.

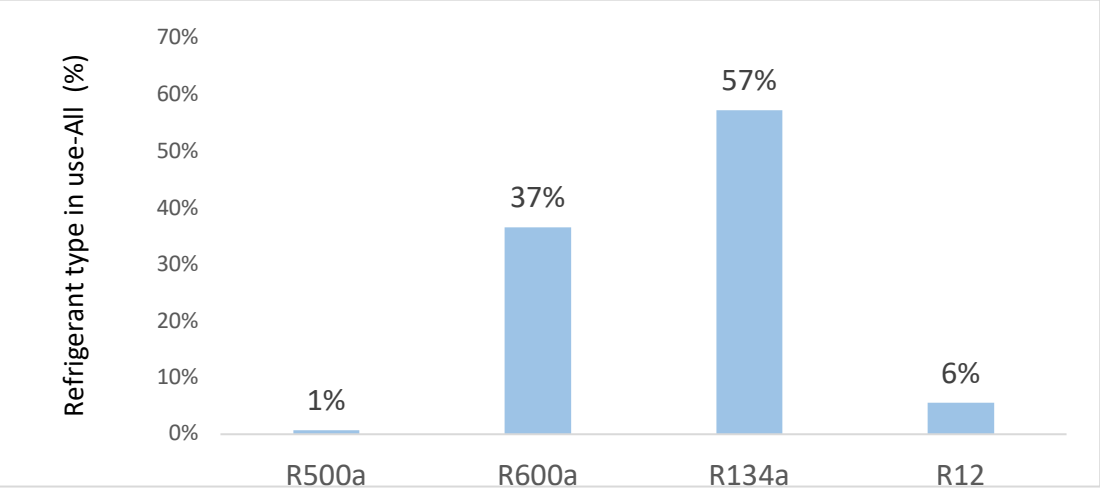

Figure 24: Refrigerants in both locally made and imported refrigerators (Source: Market Assessment, 2021)

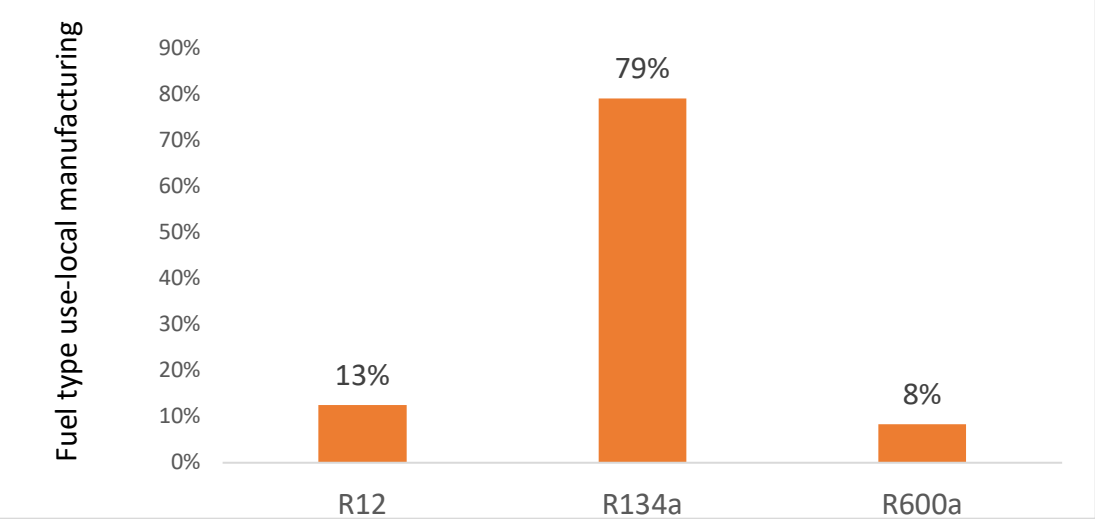

Figure 25: Refrigerants in locally made refrigerators (Source: Market Assessment, 2021)

The level of energy efficiency standards and labelling for the locally manufactured refrigerators are lower than that of the imported ones. The percentages of the energy efficiency-rated refrigerators were 35% for the sample, 33% for the locally manufactured refrigerator, and 48% for the imported refrigerators.

5.2.5 Desired features of equipment

Desirably, the refrigerator must chill or freeze products as required at the lowest possible resource cost and with minimum effort by the owner. As such, the following features would be desired:

- More than one door- this reduces the air changes since the chiller and freezer compartments will be separate. 90% of the refrigerator-freezers studied in this survey had 2 doors while 2% had more than two doors.
- Automatic defrost system- this ensures optimum performance, saves the owner time and energy. The survey results show that the frost-free refrigerators were only 48% but the penetration of the technology is high.
- Programmable controller- this makes temperature setting more effective.

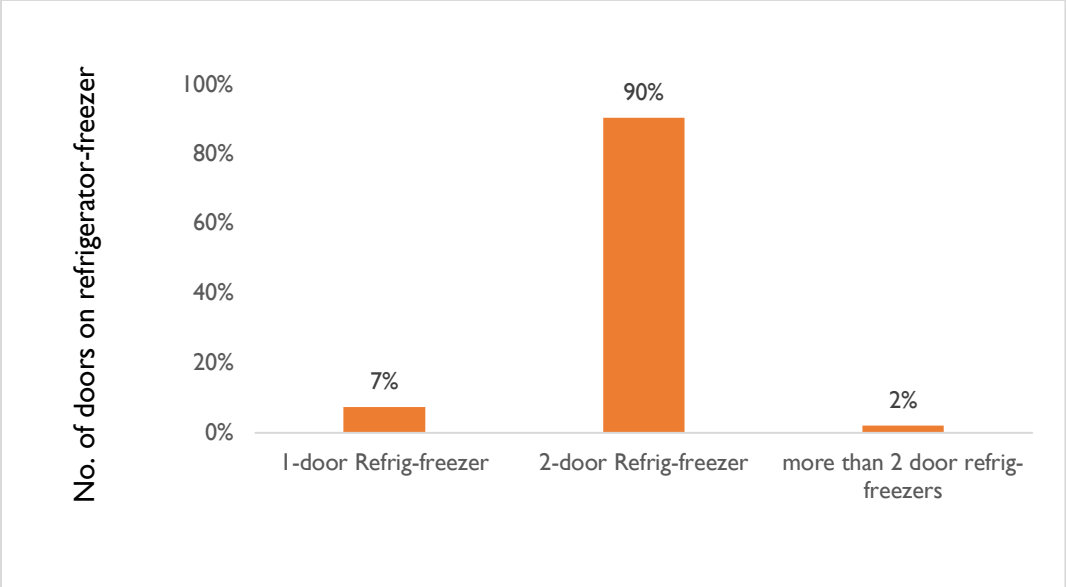

Figure 26: Number of doors on a refrigerator-freezer (Source: Market Assessment, 2021)

5.2.6 Consumer preference on purchase of a refrigerator

Households have different preferences when purchasing a refrigeration unit. Figure 27 shows how the interviewees responded to the question on the 12 factors that may influence their refrigerator purchasing decisions. "Functionality" was selected as the factor with the highest influence on refrigerator purchasing decisions at 9.1% followed by "quality" and "price" at 9.0% and 8.9% respectively. "Access to financing" and "recommendations from other people" were deemed least important, as they had the lowest ratings.

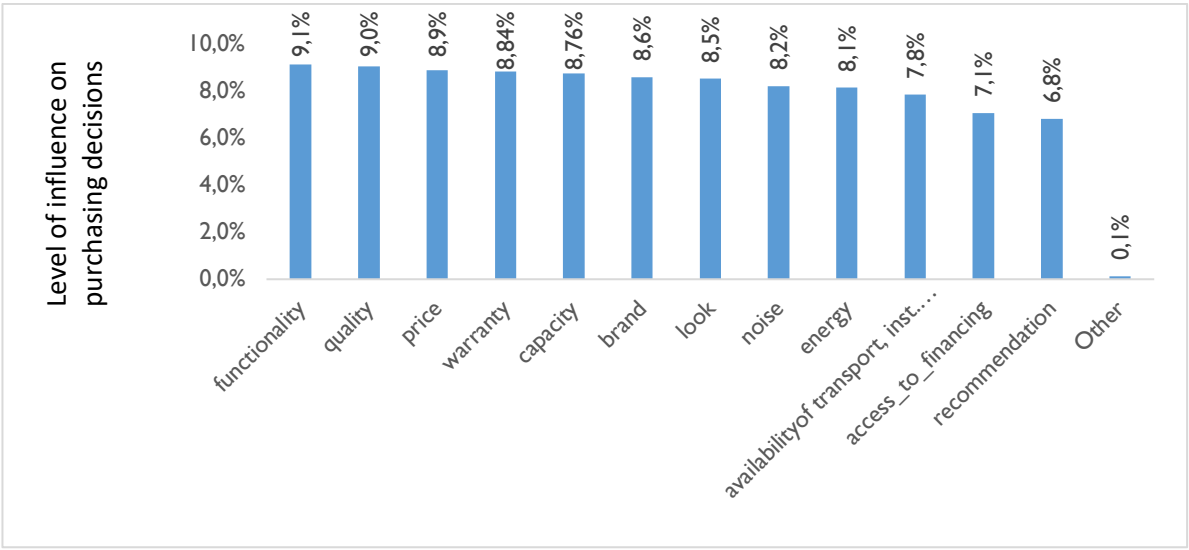

Figure 27: Factors that influence fridge purchasing decisions (Source: Market Assessment, 2021)

5.2.7 Barriers to the purchase of efficient refrigerators

Potential barriers to the purchase of more efficient refrigerators are:

(i) Financial

- If more efficient refrigerators are more expensive their penetration will be compromised. The survey results show that 55% of the consumers are willing to pay an extra cost of up to 10% for a more efficient refrigerator while only 5% said they would tolerate a 40% additional cost (Figure 15).
- If the tariff is not designed properly most consumers would continue using low-cost but inefficient refrigerators.
- Subsidising electricity for employees (e.g. utility employees) will be a set-back for more efficient refrigerators. Giving employees allowances so that they pay for their electricity consumption would be good for energy efficiency.
- A weak and unstable economy would be a huge barrier to the purchase of the efficient refrigerators.
- Failure by the financial institutions to offer loans at reasonable interest rates and tenor will result in reduced sales of the efficient refrigerators.
- Failure by retailers to offer appropriate purchasing conditions such as hire purchase agreements will affect purchases to some extent.

(ii) Awareness

- The information on the more efficient refrigerators need to be communicated to stakeholders in such a way that they see the benefits the new refrigerators have over the traditional ones. Failure to implement awareness campaigns will result in subdued penetration of the new and efficient refrigerators.

(iii) Capacity

- The manufacturers, importers and distributors must have the capacity to manufacture or import refrigerators and meet demand. The suppliers must give warranty and effective and efficient aftersales service failure of which will make consumers shun the new product.

5.3 Equipment stock and projections

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

The household survey on refrigerators showed that the two-door refrigerator-freezer is the most desired refrigerator type in Zimbabwe, followed by the one-door freezer. On the basis of the refrigerator ages and technology type (direct cool and frost-free) the frost-free technology overtook the direct cool technology in the refrigerator-freezer design. Figures 28 and 29 show how the direct cool and frost-free refrigerators got into the market over the 10-year period 2011-2020, while Figures 30, 31 and 32 compare the trends of the direct cool and frost-free technologies for refrigerators, refrigerator-freezers and freezers,

respectively. Since the frost-free refrigerator is more efficient and consumes less energy compared to the direct cool deign, it makes sense to promote manufacturing of the former.

The electrical energy required to power refrigerators in the urban centres can be estimated using the refrigerator population and the average annual energy consumption of the refrigerators. The percentage of the population that owns a refrigerator would be required, so would the electrification rate. Unfortunately, the survey did not include the households with and without refrigerators.

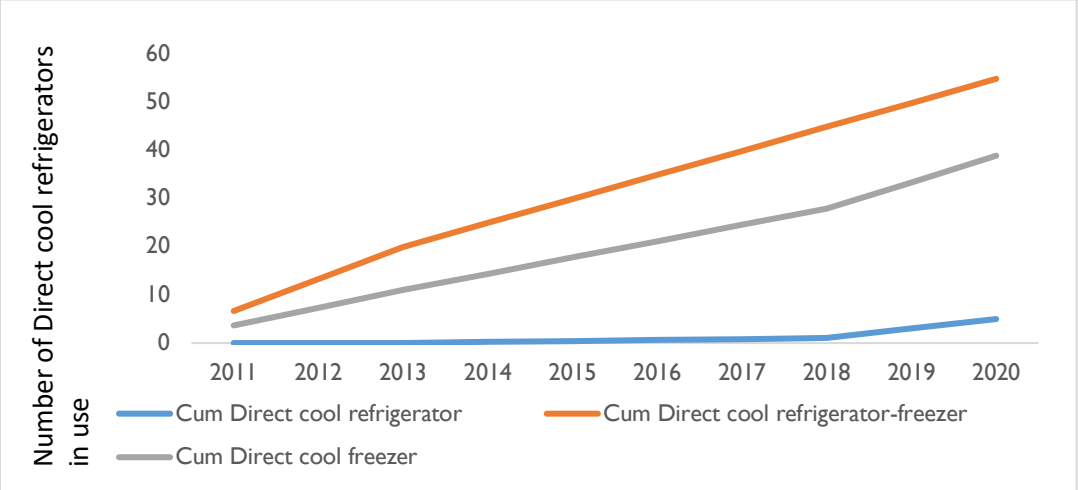

Figure 28: Trends on the penetration of the direct cool refrigerators into the Zimbabwean market during the period 2011-2020 (Source: Market Assessment, 2021)

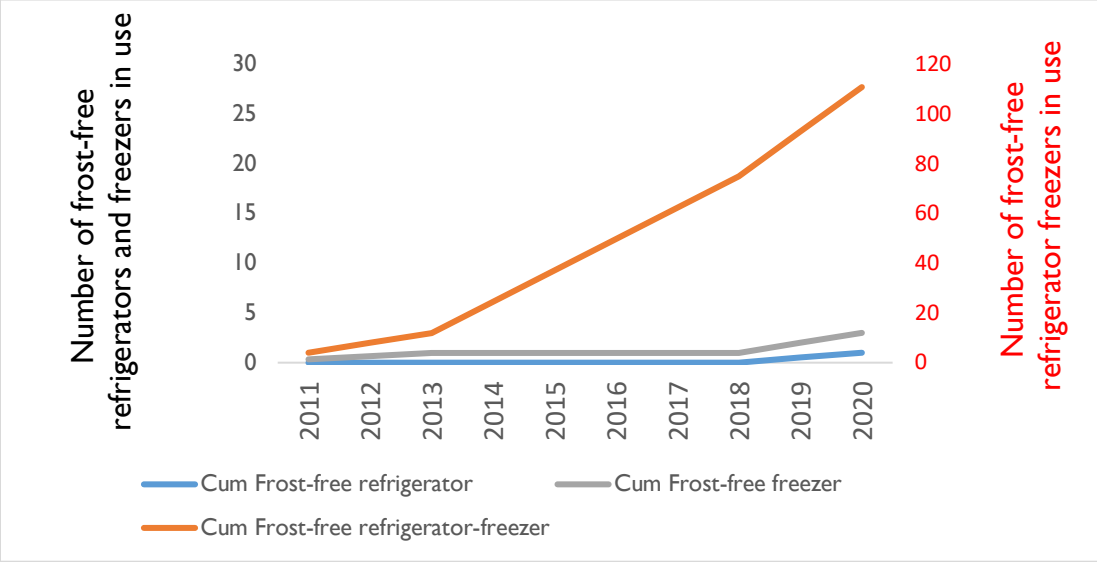

Figure 29: Trends on the penetration of the direct cool refrigerators into the Zimbabwean market during the period 2011-2020 (Source: Market Assessment, 2021)

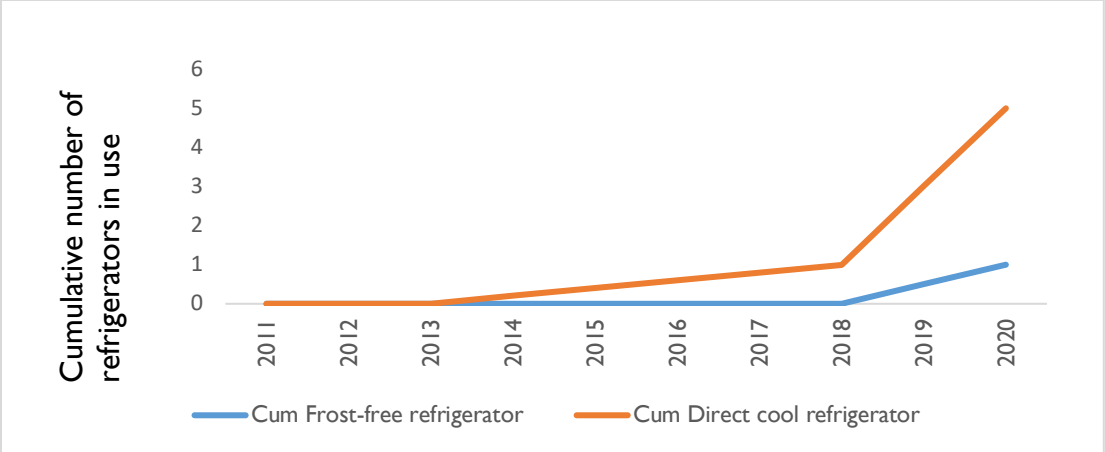

Figure 30: Rate of penetration of the direct cool and frost-free refrigerators (Source: Market Assessment, 2021)

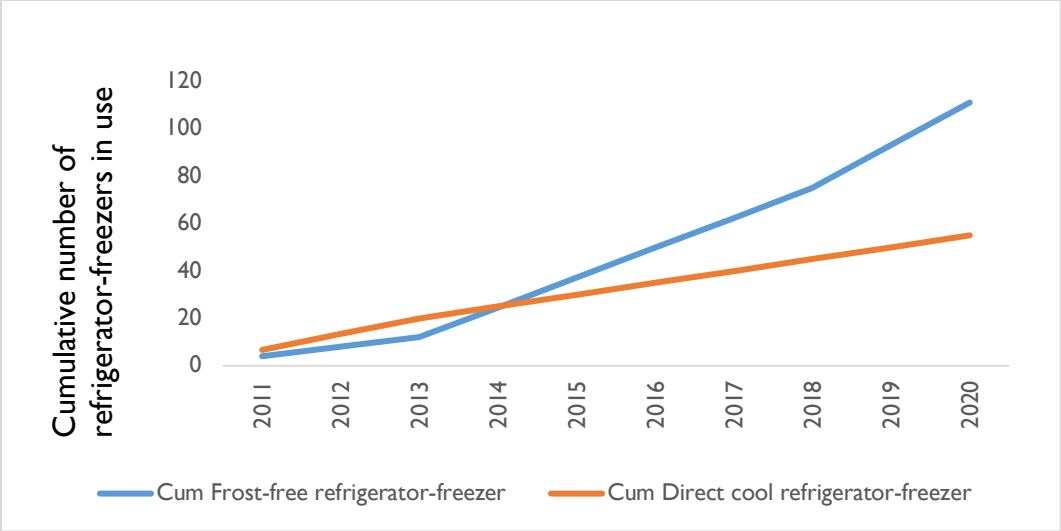

Figure 31: Rate of penetration of the direct cool and frost-free refrigerator-freezers (Source: Market Assessment, 2021)

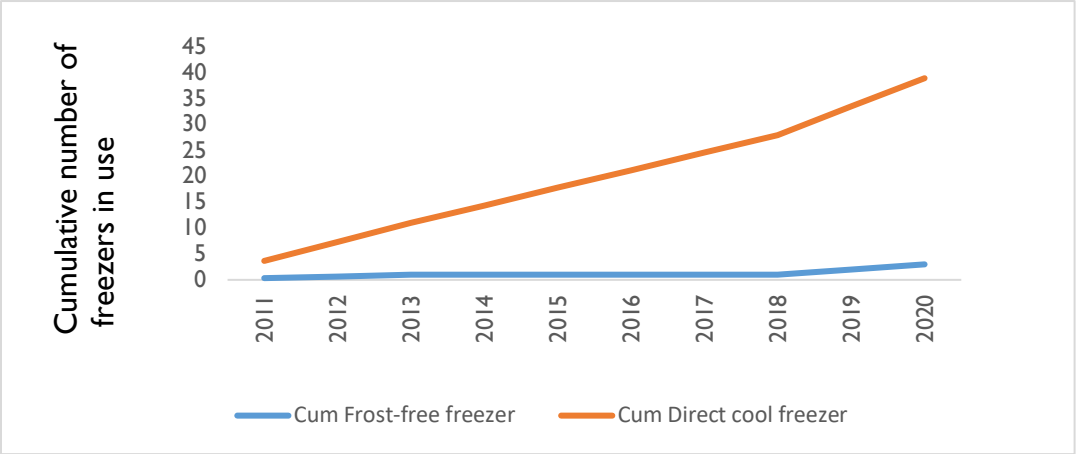

Figure 32: Rate of penetration of the direct cool and frost-free freezers (Source: Market Assessment, 2021)

The imports of refrigerators rose sharply during the period 2010-2012. This can be attributed to the dollarisation of the economy which meant that people and businesses had the foreign currency to import goods. As the economy nose-dived from 2013, the imports also took a down-turn (Figure 33). Exports of refrigerator-freezers and refrigerators rose in 2016 and 2019 respectively (Figure 34). This is a positive development considering that the demand for the refrigerator-freezers and freezers is increasing, as shown by the survey.

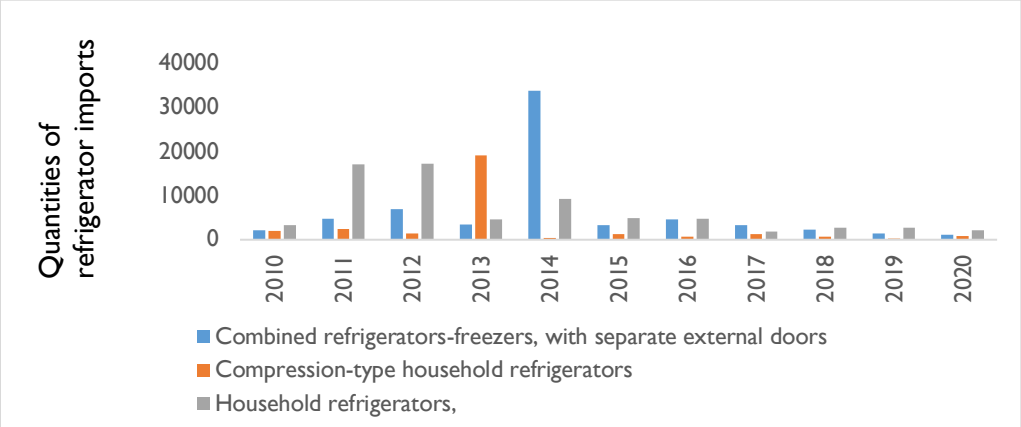

Figure 33: Imports of different refrigerator types for the 2010-2020 period (Source: Zimstat, 2021)

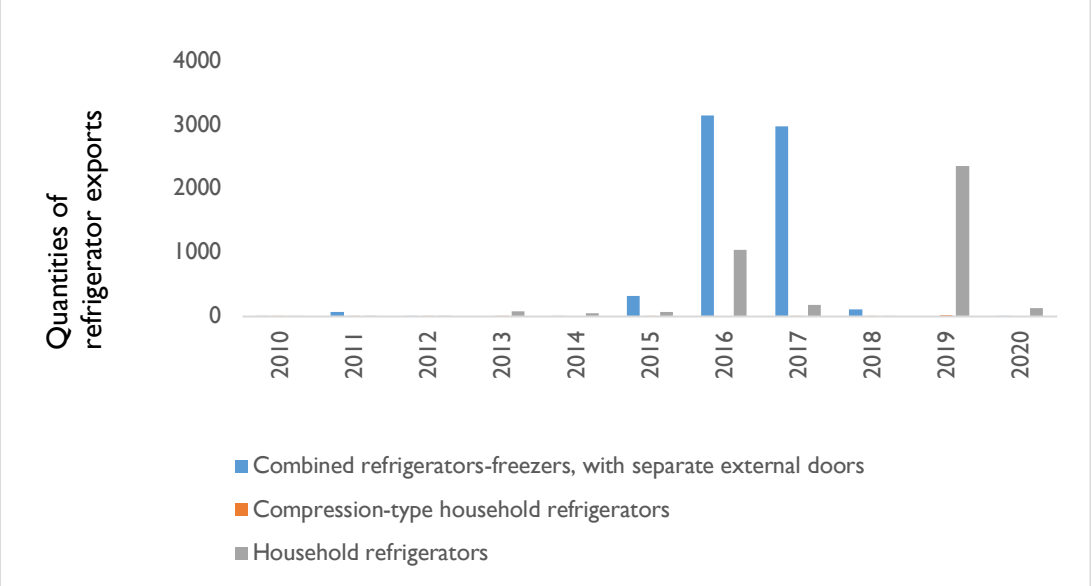

Figure 34: Exports of refrigerators during the period 2010-2020 (Source: Zimstat, 2021)

5.3.2 Technology trends and market projections

Figure 35 shows that exports of the upright freezers exceeded imports from 2017 to 2020, while Figure 36 shows that the country exported more chest freezers than it imported during the period 2014-2020. However, exports have decreased so much that by 2020 they have equaled imports for both upright and chest freezers This can be attributed to the state

of the economy which was fair during the first three years of the decade and in bad state towards the end, and worsened by the Covid-19 pandemic.

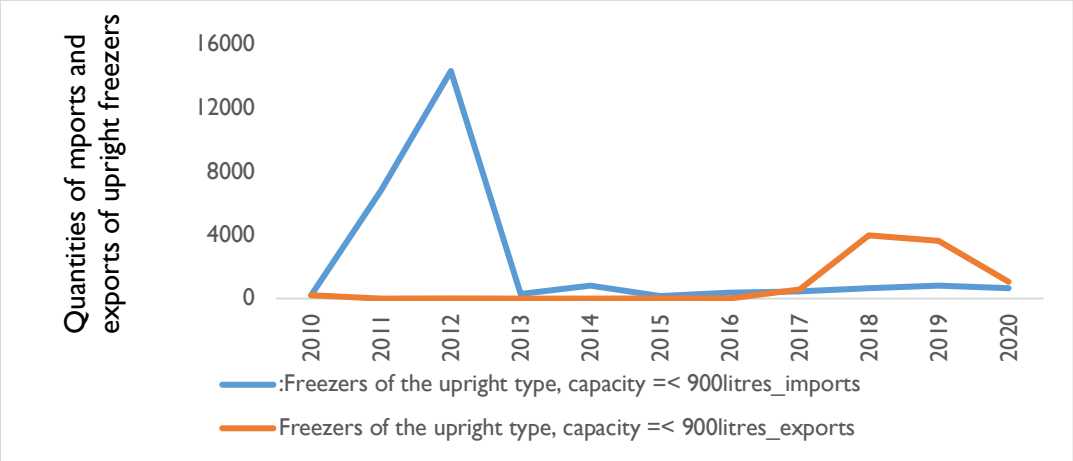

Figure 35: Imports and exports of upright freezers (Source: Zimstat, 2021)

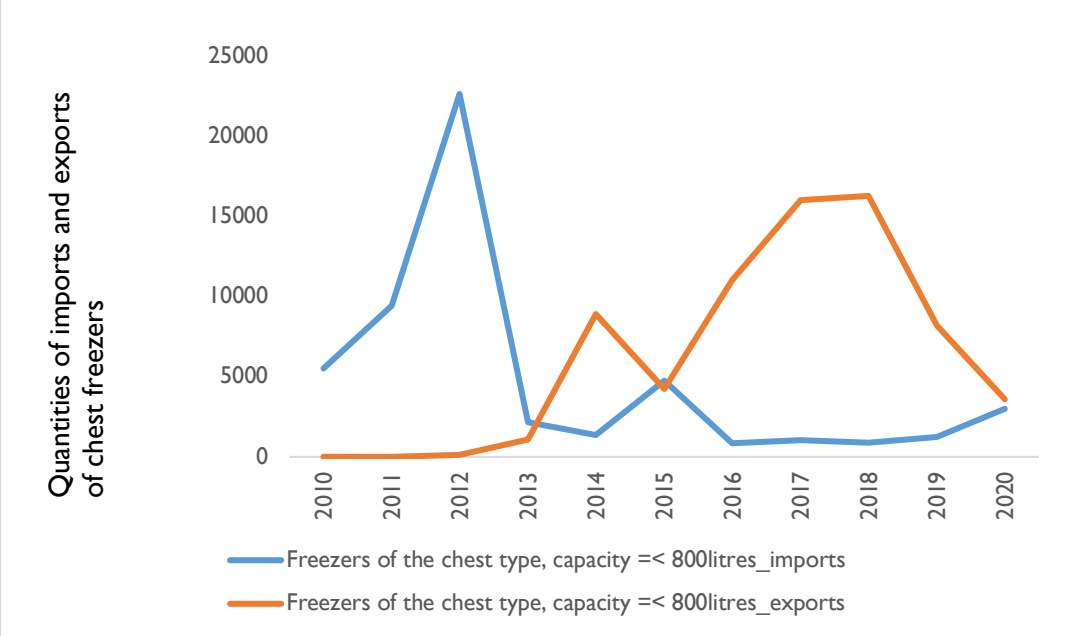

Figure 36: Imports and exports of the chest freezers (Source: Zimstat, 2021)

The imports of household refrigerators (Figure 37) are showing a decreasing trend while local manufacturing and exports have been improving since 2016. The survey also shows subdued demand for refrigerators. The combined refrigerator-freezer is the most preferred refrigeration type.

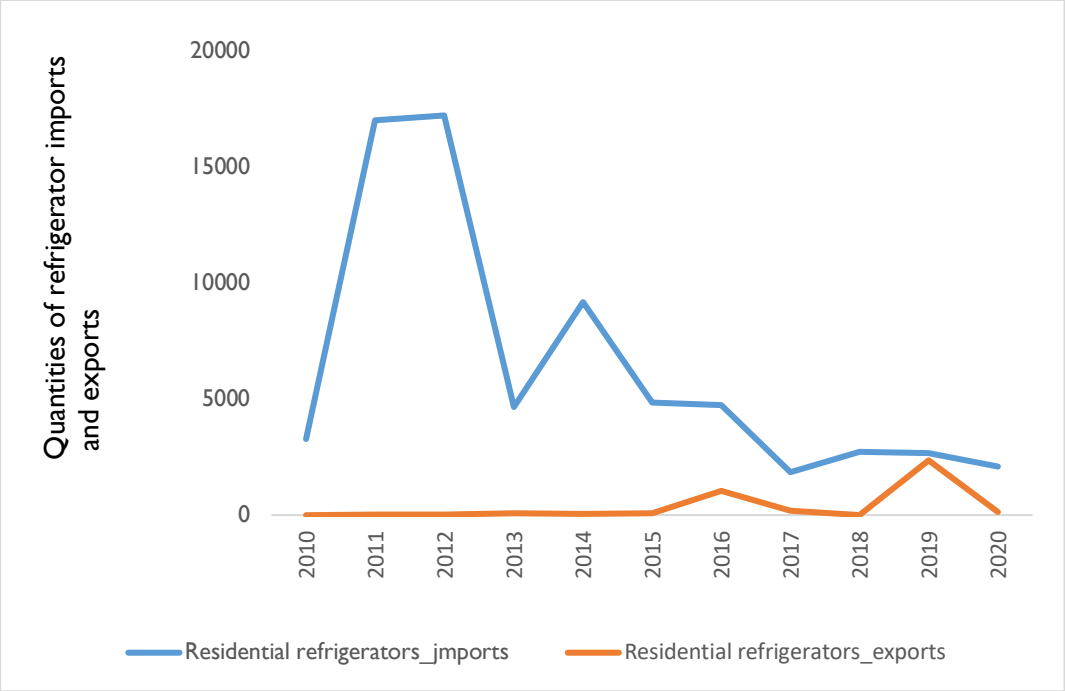

Figure 37: Imports and exports of residential refrigerators (Source: Zimstat, 2021)

The number of residential refrigerators is assumed to increase with increase in the number of households. The number of households in 2017 were 3,255,463 (Zimstat, 2017) and the household growth rate was estimated at 1.4% in 2019 (World Bank, 2019). Calculations gives the number of households in 2019 and 2020 as 3,347,254 and 3,394,116 respectively.

Using the 40.3% as percentage of households with refrigerators in Zimbabwe in 2019 (Global Data Lab, 2021) gives a 2019 residential refrigerator total stock of 1.35 million. Assuming a residential refrigerator lifespan of 15 years would mean that refrigerators would be replaced at a rate of 7% per year, and 90,000 refrigerators would have been replaced in 2020. It is also assumed that the number of residential refrigerators would increase with increases in GDP growth as disposable income of households improve. Using the 2009-2019 GDP growth rate of 6.4% (World Bank, 2021) gives a residential refrigerator market growth of 87,000 in 2020, increasing the total stock of residential refrigerators from 1.35 million in 2019 to around 1,44 million in 2020, 2.7 million in 2030 and to just above 5 million in 2040. The total market size (due to replacement of old refrigerators and entry of new ones) and the total market value of the residential refrigerator would also increase as shown in Table 6 and Figures 38 and 39 respectively. The refrigerator price used to estimate the market values was USD486, and it came from the 2021 household survey.

Table 6: Residential refrigerator stock, market size and market value in 2020, 2030 and 2040

	Total stock of residential refrigerators	Total market size	Total residential refrigerator market value (USD million)
2020	1.44 million	177,000	90
2030	2.7 million	330,000	160
2040	5.0 million	600,000	300

Figure 39 shows the projected residential refrigerator market value trend. Since the refrigerator market value is a function of market size and average refrigerator price these market values are higher than those that would result from the lower market size provided by the supply chain actors.

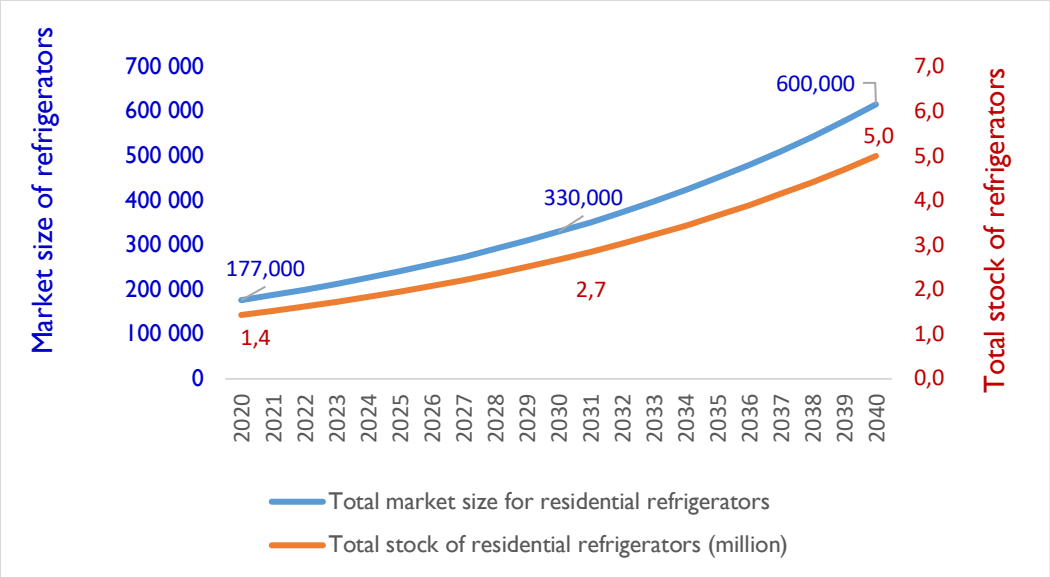

Figure 38: Projected market size and stock of residential refrigerators for the period 2020-2040 (Source: Market Assessment, 2021)

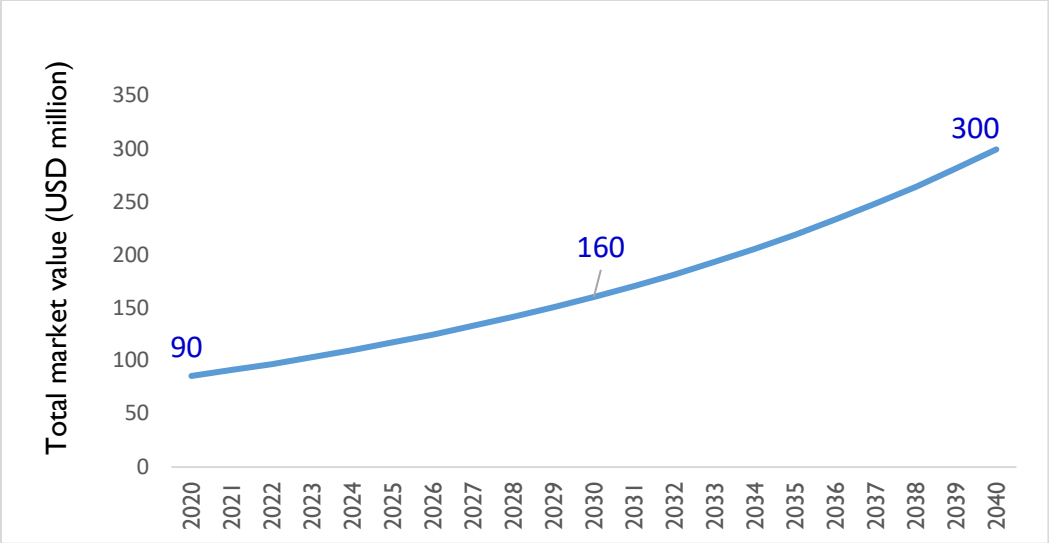

Figure 39: Projected total residential refrigerator market value for Zimbabwe for the period 2020-2040 (Source: Market Assessment, 2021)

The survey results show that the local refrigerator manufacturers CAPRI and IMPERIAL contributed 37% of the market size in 2021. Only 11 refrigerators out of 101 manufactured and supplied by the local manufacturers had energy consumption information written on the refrigerators. The average energy consumption was 344 kWh while the corresponding volumes gave an average of 222 L. Multiplying the market size and the percentage of the locally made refrigerators gives a trend of locally manufactured refrigerators, which ranged from 68,000 in 2021 to 120,000 in 2030 and 222,000 in 2040. According to the household survey the percentage of the frost-free refrigerators increased from 30% in 2011 to 55% in 2021. Extrapolation gives 66% and 79% as the percentages of the frost-free refrigerators in 2030 and 2040 respectively (Figure 40). Under the business-as-usual scenario the more efficient residential refrigerators will be expected to increase from 55% in 2021 to 79% in 2040, hence the need for a framework to leapfrog to more efficient refrigerators.

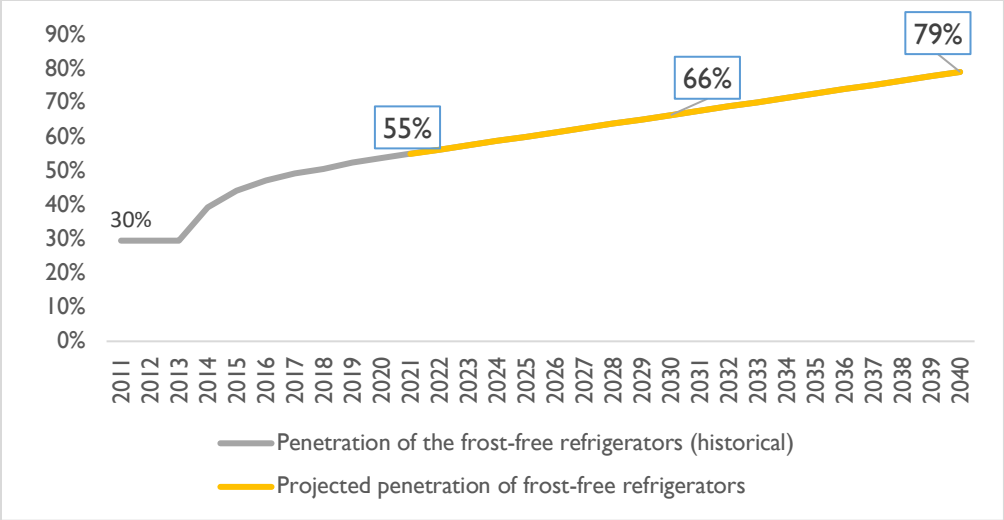

Figure 40: Estimated historical and projected percentage of the frost-free residential refrigerators (Source: Market Assessment, 2021)

It has been noticed that major improvements in the energy performance of refrigerators have been witnessed globally over the past two decades, with today's refrigerators being 30 to 60% more energy-efficient than the 20-year old models (CTCN, 2021). Assuming that those refrigerators with energy data are the more efficient and those without are the old, inefficient refrigerators, and assuming that modern refrigerators consume 40% less energy than the average appliance in homes a decade ago gives a total energy-saving potential saving of 4 GWh saving in 2021, 5.5 GWh in 2030 and 6.4 GWh in 2040. , as shown in Figure 41. The work on Zimbabwe's NDC Implementation Framework and MRV of 2017-18 (scenario 2) gave grid emission factors (EFs) of around 0.76 tCO2/MWh for the period 2021-2023, and 0.4357 tCO2/MWh for the period 2024-2030. Extrapolation was done for the years 2031-20040. The GHG emissions avoided through the use of more energy-efficient refrigerators would be 3.2GgCO2eq in 2021, 2.4GgCO2eq in 2030 and 2.8 GgCO2eq in 2040. The 2030 emissions reduction would be 9% and 13% of the updated NDC's BAU and mitigation scenarios respectively.

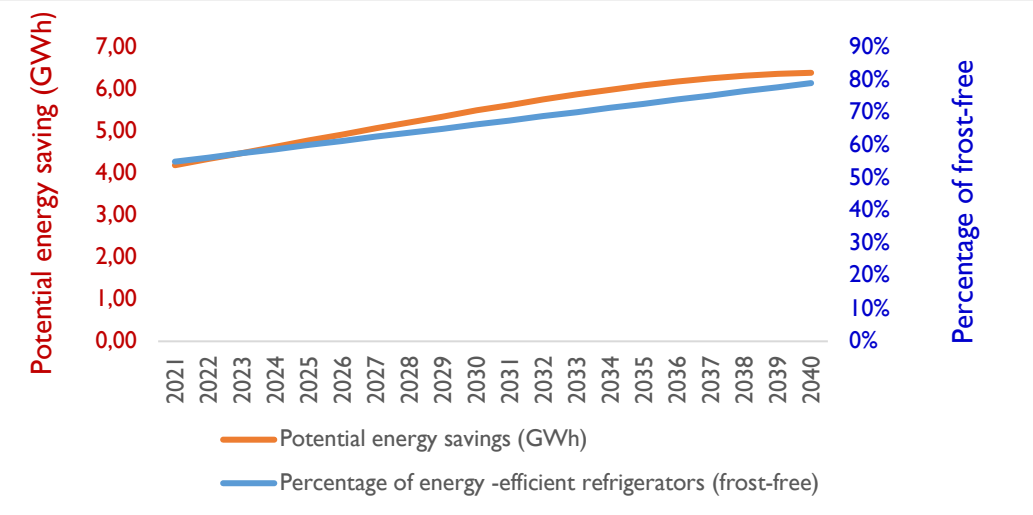

Figure 41: Penetration of frost-free refrigerators and potential energy savings refrigerators (Source: Market Assessment, 2021)

5.4 Policies and programme landscape

5.4.1 Current and planned refrigerator policies and programs

The regulations governing the imports of refrigerators and other Cooling, Heating Ventilation and Air Conditioning (CHVAC) are contained in SI 131 of 2016 (Environmental Management (Prohibition and Control of Ozone Depleting Substances, Greenhouse Gases, Ozone Depleting Substances and Greenhouse Gases Dependent Equipment) Regulations, 2016). The Government of Zimbabwe is in the process of reviewing the regulations (Ozone Office, 2021). These regulations apply to private and public industrial and commercial importers, exporters, producers and consumers of ozone depleting substances and greenhouse gases listed by the government

Prohibited substances and equipment

According to the Government's Ozone Office in the Ministry of Environment, Climate, Tourism and Hospitality Industry (MECTHI):

> (1) No person shall import into Zimbabwe, any substances listed and equipment or appliance which uses or whose function relies on the substances listed by the Government. Any person who contravenes this regulation shall be guilty of an offence and liable to a fine not exceeding level 14 or imprisonment for a period not exceeding 12 months or both such fine and such imprisonment
>
> (2) In addition, the court convicting a person of an offence under such an offence may, upon the application of the Prosecutor, declare any ozone depleting substance (ODS), GHG, GHG dependent equipment or ODS dependent

equipment in respect of which the offence has been committed to be forfeited to the State.

Import and export licenses

(1) Any person who wishes to import or export ozone depleting substance, greenhouse gas, ozone depleting substance dependent equipment or greenhouse gas dependent equipment or any chemical listed in Third (Controlled Substances: Ozone depleting substances) – to be effected 1 January 2030, and Fourth Schedules (Controlled Substances: Greenhouse Gases, also to be effected 1 January 2030, shall apply to the Ozone Office in Form AP1 (Application to import).

(2) Any application for a license made shall be accompanied by an application fee, which is non-refundable and a registration fee which is refundable.

Suspension or cancellation of licences

The Ozone Office may at any time suspend (for a period not exceeding 60 days or cancel any licence if the Ozone Office has reasonable grounds for believing that— (a) the licence was issued in error or through fraud or misrepresentation or non-disclosure of a material fact by the licensee; or (b) the licensee has contravened any provision of the Act or these regulations or any condition of his or her licence; or (c) the licensee has ceased the licensed importation or exportation.

Register of licensed importers and exporter

The Ozone Office shall establish and maintain a register of licences to be known as the Import and Export Licensing Register, which shall be for the purposes of registering all licensed importers, exporters or consumers of ozone depleting substances, greenhouse gases, ozone depleting substance dependent equipment and greenhouse gas dependent equipment.

Labelling and packaging

(1) All importers, exporters or consumers of ozone depleting substances, greenhouse gases, ozone depleting substances dependent equipment and greenhouse gas dependent equipment shall ensure that such products are clearly labeled and packaged to national and international standards.

(2) The labels must state clearly, among other things, chemical formulae, chemical name, safety measures, names and addresses of manufacturers, instructions for use and disposal, United Nations number, Chemical Abstract Service numbers and any other relevant information such as "ozone friendly", "climate friendly", "global warming", or "ozone depleting".

(3) Any person who does not comply with the requirements of subsections (1) and (2) shall be guilty of an offence and liable to a fine not exceeding level eleven

or imprisonment for a period not exceeding six months or both such fine and such imprisonment

5.4.2 Status of electronic-waste management in the country

In Zimbabwe, there is fragile interest in electronic waste management. Both ignorance and lack of interest has affected the attention to electronic waste management. Health practitioners and environmentalists have expressed little interest in tackling this issue and this has resulted in little knowledge among the public on the dangers of electronic waste in Zimbabwe. Despite its risk to human health, discourse in electronic waste risk features very little in health, environmental management, as well as disaster management strategic plans.

Most of the electronic waste in Zimbabwe is not locally manufactured. Just like in other SADC countries, much of the e-waste into the country is imported from developed countries. Huge volumes of electronic gadgets which include TVs, cell phones, refrigerators, laptops, toys, digital cameras and other micro electronics goods are dumped each year. Because of lack of interest, there are no efforts to quantify the electronic goods influx and determine the volumes dumped in Zimbabwe (Civil and Environmental Research). The influx of electronic goods from South Africa, Asia, and Europe to Zimbabwe has led to a high rate of electronic waste. This has created profound challenges in waste management and consequently to public health.

The current legal instruments are not clear on the management of electronic waste in Zimbabwe, as well as whose mandate it should be under. To date, Zimbabwe has no legislation or policy on electronic waste management. The available Environmental Waste Management Act (20:27) only prohibits the discharge of hazardous substances into the environment, but there is no specific legislation regulating electronic waste.

Various factors compound the situation of e-waste management in Zimbabwe. Apart from the absence of a legislation regulating the management of e-waste, recycling of e-waste is almost entirely left to the informal sector, which does not have adequate means to handle either the increasing quantities or certain processes leading to intolerable risk for human health and the environment. Furthermore, there are no companies investing in electronic waste recycling as a business in Zimbabwe. More so, electronic waste recycling business is hardly talked about in Zimbabwe by both the media and the environmentalists, health practitioners and in business forum.

There are no official and accurate figures for rapidly increasing e-waste volumes generated domestically and by imports. This has made it very difficult to regulate imports as well as estimating the level of hazards and vulnerability of communities to electronic health hazards. Thus, the low level of awareness among manufacturers and consumers, environmentalists and legislators on electronic

waste hazards and management practices remain the greatest risk and a challenge in the efforts of management of electronic waste.

However, SI 131 of 2016 says:

- Authorised persons to repair, service, handle, install and decommission ozone depleting substances, greenhouse gases, ozone depleting substances dependent equipment and greenhouse gas dependent equipment
- No person shall repair, service, handle, install or decommission an ozone depleting substance, greenhouse gas, ozone depleting substance dependent equipment and greenhouse gas dependent equipment unless he or she has been trained and certified to do any such activity by the National Ozone Office, in accordance with the National Standard on certification.
- Retailers, sellers and distributors of ozone depleting substances and greenhouse gases, shall not sell such substances to any person unless he or she has been trained and certified in the handling of such substances by the National Ozone Office.

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

The refrigerator manufacturers and distributors indicated that they are optimistic that the demand for more energy-efficient with more climate-friendly refrigerants will increase as consumers become more aware of the benefits of energy efficiency improvements and environmental integrity. The climate change-induced increases in temperature will be one of the drivers for the refrigerator demand. However, the sustained growth of the economy, especially the GDP per capita, would have a very big bearing on the demand. On whether energy efficiency is either the most or among the most significant factors affecting selection of refrigerator purchases the manufacturer representatives somewhat agree while the distributors were neutral. The manufacturers and distributors of refrigerators highlighted the importance of consistent policies including the macroeconomic policies. The household survey showed that consumers are becoming more and more aware of the benefits of energy-efficient refrigerators and 93% of those interviewed expressed willingness to pay at least 10% more for an efficient refrigerator (Figure 15)

The financial institutions somewhat agree that energy efficiency is either the most or among the most significant factors affecting selection of refrigerator purchases, but believe refrigerator size and environmental friendliness would have more influence on purchases. Financial institutions including the IDBZ do not offer consumer finance loan products to retailers and distributors. The IDBZ provided finance for the roll out of the ZETDC prepaid meter project, which is an energy efficiency enhancement project. The accreditation of the IDBZ in July 2021 by the GCF will give opportunities for the bank to access climate finance and technical expertise in green credit lines.

5.5 Existing Financial Institutions and financing instruments for appliances

Zimbabwe's main financial institutions include CBZ, Stanbic, ZB Bank, FBC, BancABC, First Capital, NMB, NEDBANK and Agribank. The Commercial banks, the Building societies, Merchant banks, and the Development banks form the banking sector. The banking sector offers equipment loans or asset finance, e.g. tractor loans to farmers by CBZ, with Government playing a facilitating role.

The only respondent who received a bank loan to buy a 250-litre refrigerator-freezer priced at US$650 has an account with Steward Bank. The appliance is less than 3 years old and the respondent is a private sector employee and earns between US$13,571 and US$33,461 per year. The loans the IDBZ offers are project finance and equity, and mortgage finance on housing projects. The Bank has a green credit line and expressed interest to finance clients' investments in energy-efficient appliances such as refrigerators, considering that the Bank is in the process of being accredited by the GCF. The Bank has been involved in a number of energy saving projects already. The bank played an important role in the financing of the ZPC- Kariba South Power Station Expansion (300MW). The Bank also provided finance for the roll out of the ZETDC prepaid meter project. These projects are significant energy efficiency enhancements. The Bank is also involved in a number of solar projects.

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

Trade statistics for the period 2010-2020 in Tables 6 and 7 show that Zimbabwe is a net importer of refrigerators and net exporter of chest freezers during the decade. Although Zimbabwe imports a lot of refrigerators from countries outside Africa, it imported significant quantities from some SADC countries such as South Africa and Eswatini. Zimbabwe exported significant quantities of chest freezers to Zambia and Malawi. These statistics agree with the results from the household survey in that the local brand (CAPRI) is the most popular in the country.

Table 7: Zimbabwe's refrigerator and chest freezer imports from some SADC countries for the period 2010-2020 (Source: Zimstat, 2021)

	Zimbabwe's 2010-2020 cumulative imports from:								Total
Appliance	Botswana	Lesotho	Malawi	Namibia	Eswatini	Tanzania	South Africa	Zambia	
Household Refrigerators	79	2	5	14	23	5	29,482	26	**29,636**
Chest Freezers type	26	0	0	7	5,106	1	29,828	8	**34,976**

Table 8: Zimbabwe's refrigerator and chest freezer exports to some SADC countries for the period 2010-2020 (Source: Zimstat, 2021)

	Zimbabwe's 2010-2020 cumulative Exports to:								Total
Appliance	Botswana	Lesotho	Malawi	Namibia	Eswatini	Tanzania	South Africa	Zambia	
Household Refrigerators	68	0	136	0	0	0	324	51	**579**
Freezers of chest type	69	0	1,794	145	0	0	874	60,241	**63,123**

6 Market assessment on distribution transformers

6.1 Supply

6.1.1 Summary of suppliers, government officials and other stakeholders

The stakeholders identified for the manufacturing and distribution of transformers and their expected roles are summarized in Table 8. The stakeholders include Government departments and ministries, local authorities, private sector, financial institutions, independent power producers, and consumer associations.

Table 9: Stakeholders that were consulted on distribution transformers (Source: Market Assessment, 2021)

Stakeholder	Expected role of stakeholder
Manufacturer/Distributor • ZENT • GEC • Hawker Siddeley Engineering • South Wales Electric • Nical Transformers	To provide technical and production information as per questionnaire
ZimStats	To provide trade statistics (imports and exports of refrigerators and transformers)
Standards Association of Zimbabwe (SAZ)	To provide standards relevant to the manufacture and supply of refrigerators an transformers in general
Zimbabwe Electricity Transmission and Distribution Company (ZETDC)	To provide information on transformer asset register, standards, regulations and efficiency specifications
Zimbabwe Energy Regulatory Authority (ZERA)	To provide information on policies and regulations relevant to distribution transformers
Rural Energy Fund (REF)	To provide information on transformer asset register, standards, regulations and efficiency specifications
Local Authorities • City of Harare • City of Bulawayo	To provide information on transformer asset register, standards, regulations and efficiency specifications
Department of Irrigation	To provide information on transformer asset register, standards, regulations and efficiency specifications
Financial Institutions • Infrastructure Development Bank of Zimbabwe (IDBZ) • ZB Bank • Agribank	To provide information on the financing instruments they have for appliances such as transformers

Ministries • Ministry of Energy and Power Development • Ministry of Women Affairs, Community and Small-to-Medium Enterprises Development • Ministry of Industry and Commerce • Ministry of Finance	To provide information on policies and regulations relevant to distribution transformers
Private sector • Chamber of Mines (CoM) • Confederation of Zimbabwean Industries (CZI) • Business Council for Sustainable Development-Zimbabwe (BCSDZ) • Zimbabwe National Chamber of Commerce (ZNCC)	To provide information on transformer asset register, standards, regulations and efficiency specifications
Non-utility Generators /IPPs • Econet /Distributed Power Africa • Tongaat Hulett • Nyangani Renewable Energy (NRE) • Greenfuels • Old Mutual • Renewable Energy Association of Zimbabwe (REAZ)	To provide information on transformer asset register, standards, regulations and efficiency specifications
Consumer Associations • Urban Councils Association of Zimbabwe • Procurement Regulatory Authority of Zimbabwe (PRAZ) Procurement Regulatory Authority of Zimbabwe (PRAZ) • Zimbabwe Environmental Lawyers Association (ZELA)	To provide information on protection of electricity consumers as far as electricity distribution is concerned

Trade statistics show that Zimbabwe imported and exported eleven types of transformers for the period 2010-2020 (ZimStat, 2021). The statistics include transmission transformers, distribution transformers and transformers for other appliances. These transformers ranged in size as shown in Table 9. The transformer experts from the Policy Working Group (PWG) and Distribution Transformer Technical Committee (DT-TC) which are being formed will be expected to assist the trade statistics department disaggregate the transformers by type, size and final users.

Table 10: Transformer type and size ranges (Source: Zimstat, 2021)

	Transformer type	Size range
1	Core type, oil immersed, max working voltage <=132kv	>=5kva <=650kva
2	Other liquid di-electric transformers, power handling capacity	<= 650 KVA
3	Liquid dielectric transformers,core type,oil immersed exc chokes	=<132KV
4	Other liquid dielectric transformers, power handling capacity	650-10,000KVA
5	Liquid dielectric transformers, core type oil immersed	=<132KV =<30000KVA
6	Other liquid dielectric transformers excl core type	>10000KVA
7	Transformers, nes, power handling capacity	<= 1KVA and <= 100W
8	Other transformers, nes, power handling capacity	<= 1 KVA
9	Transformers, nes, power handling capacity	1-16kva
10	Transformers, nes, power handling capacity	16-500kva
11	Transformers, nes, power handling capacity	>500kva

NB: nes stands for new equipment sales

The distribution network is not capped by kVA rating, however transformers rated below 1000kVA are generally classified as distribution transformers, and greater are classified Power transformers (ZENT, 2021). However, according to the U4E Regulation Guidelines for distribution transformers, transformers up to 3150 kVA used in the distribution network shall be considered DTs.

Table 9 shows the eleven different types of transformers that were imported and exported from 2010 to 2020. However, these transformers include the transmission transformers as well as small transformers for small machines or appliances. Some outliers were observed in the transformer imports figures for certain years and efforts to get clarification from the providers of the data were made but the explanations have not been provided.

Table 10 shows only those that can be classified as Distribution Transformers for the year 2020. Unfortunately, two transformer types (the last two in Table 10) were not classified as liquid-filled or dry type. Such classification would have helped in estimating the percentages of transformer types for each sector in the calculation of losses and hence potential energy savings. The information on transformer stock could not be obtained during the market assessment.

Table 11: Quantities and prices of transformers imported and exported in 2020 (Zimstat, 2021)

	Qty of transformers			Value of transformers (US$)		Unit price of transformers (US$)		
	Imports	Exports	Installed	Imports	Exports	Imports	Exports	Nett
85042110:Core type, oil immersed, max working voltage <=132kv, size >=5kva <=650kva	699	3	**696**	2,705,613	15276.752	3,871	5,092	
85042190:Other liquid di-electric transformers, power handling capacity <= 650 KVA	824	0	**824**	474,603	0	576		
85042210:Liquid dielectric transformers,core type,oil immersed exc chokes ..=<132KV	19	0	**19**	31,433	0	1,654		
85042290:Other liquid dielectric transformers, power handling capacity 650-10000KVA	27	0	**27**	739,814	0	27,401		
85042310:Liquid dielectric transformers ,core type oil immersed=<132KV =<30000KVA	350	0	**350**	147,205	0	421		
85042390:Other liquid dielectric transformers excl core type >10000KVA	0	0	**0**	0	0			
85043110:Transformers, nes, power handling capacity <= 1KVA and <= 100W								
85043190:Other transformers, nes, power handling capacity <= 1 KVA								
85043200:Transformers, nes, power handling capacity1-16kva								
85043300:Transformers, nes, power handling capacity 16-500kva	1,187	14	**1,173**	3,380,545	7081.896	2,848	506	
85043400:Transformers, nes, power handling capacity >500kva	1,080	1	**1,079**	1,634,278	1819.011	1,513	1,819	
Total	4,186	18	**4,168**	**9,113,492**	**24,178**	**2,177**	**1,343**	**2,181**

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

Zimbabwe has companies that manufacture and sell transformers such as ZENT, South Wales Electric, GEC and Hawker Siddeley Engineering, and also has companies that import transformers as supported by the information in Table 8 above. Those that manufacture

transformers import some raw materials or transformer sub-assemblies. ZENT said it imports around 90 percent of the raw materials and sub-assemblies. ZENT was introduced to the theory of amorphous core distribution transformers (AMDT) when it was manufacturing under license, and it highlighted that AMDT core losses are 70-80% lower than transformers with cold rolled grain-oriented steel (CRGO).

ZENT is guided by the ZERA Distribution Code in manufacturing its transformers. According to the Distribution Code, the utility (ZETDC) is requested to declare its technical and non-technical losses to ZERA for the purposes of agreeing on a cap for system losses that are transferred to the tariff. The distributor (ZETDC) then specifies maximum losses in its distribution transformer specifications per rating as per section 14 of the specification. As a transformer manufacturer, ZENT specifies core steel grades that limit no load losses. The control (checkpoint) for these losses is currently ZENT, who then tests on a 100% sampling basis the distribution transformers that are supplied to the utility, and these tests include loss evaluation. Transformers with excess losses are rejected. This control does not, however, apply to private installations who may install their transformers directly onto their private reticulation.

Zimbabwe, through the SAZ is a member of the IEC Country affiliate Programme and can adopt/adapt IEC standards. We are guided by the World Trade Organisation (WTO)/Technical Barriers to Trade (TBT) Agreement Code of Good Practice for the Preparation, Adoption and Application of Standards. The Standards Association of Zimbabwe uses the following ten power and distribution transformer standards (SAZ, 2021):

(a) ZWS 191: 1976: Current transformers
b) ZWS IEC 76:1998: Part 5: Ability to withstand short circuit
c) COMESA ZWS HS IEC 61378: 2017: Converter transformers Part 3: Application guide
d) COMESA ZWS HS IEC 60076: 2013: Power transformers Part 1: General
e) ZWS IEC 60076.2:2014: Power Transformers Part 2: Temperature rise for liquid – immersed transformers
f) ZWS IEC 60076.2:2014: Power Transformers Part 3: Insulation levels, dielectric tests and external clearances in air
g) ZWS IEC 60076.2:2014: Power Transformers Part 8: Application guide
h) ZWS IEC 60076.2:2014: Power Transformers Part 10: Determination of noise levels
i) ZWS IEC 60076.2:2014: Power Transformers Part 10-1:2017: Determination of sound levels – Application guide
j) ZWS IEC 60076.2:2014: Power Transformers Part 10-14: 2014: Part 14: Liquid-immersed power transformers using high temperature insulation materials

Although SAZ has not adopted the IEC 60076-20 technical specification which covers comprehensively energy efficiency issues of transformers, SAZ said that the adoption of the technical specification in the future cannot be ruled out.

ZETDC Distribution transformer specification lists expected losses, and IEC tolerances apply on component and combined losses. IEC standards have been adopted, with main emphasis on technical performance i.e. IEC 60076.

6.2 Demand

6.2.1 Assessment of main purchasers of distribution transformers: utility/ies, private MV users

In its response to the questionnaire, ZENT said that its annual sales volume is around 1,500 transformers and the utility (ZETDC) and REF are ZENT's biggest customers and they purchase around 95% of ZENT's transformers, while mines, farmers and other customers purchase the remaining 5%. The private players did not respond positively to the data requests and efforts to get ZENT's market share were fruitless. It showed that the transformer manufacturers and distributors are not willing to share sensitive information.

Transformers up to 315kVA, 11kV class are pole mounted, while transformers with kVA ratings greater than 315kVA are pad mounted. Prefabricated (Mini-Substations) are common in urban installations. REF said that four-pole sub-stations are used for transformers up to 250kVA, which cannot be accommodated between the 'H' poles and single pole hanger, and transformers greater than 250 kVA are ground mounted.

Trade statistics show that the most imported transformer types are the oil immersed, core type and the other liquid di-electric transformers (Table 10).

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

The Electricity Distribution Code Regulations (SI 47 of 2017) require that the Distributor identify and report separately to ZERA the Technical and Non-Technical Losses in its Distribution System. The Technical Loss shall be the aggregate of conductor1oss, the coil in transformers, and any loss due to technical metering error. But, the distribution grid code does not specify energy efficiency standards for distribution transformers. The code classifies transformer losses under technical losses. The utility is then requested to declare its technical and non-technical losses to ZERA for the purposes of agreeing on a cap for system losses that are transferred to the tariff. ZERA requires that the distribution losses be not more than 8%.

The distribution network uses 11kV and 33kV. The distribution transformers manufactured by ZENT are 96-98% efficient at full load. Loss evaluation of transformers is as per SANS780. The typical losses of transformers in the ZESA network are given in Table 16 in the Annex. The typical load and no-load losses given are for the 11 and 33 kV systems, and for both the 230 and 400 secondary voltages. The table shows losses for the 10-1000 kVA, oil-filled transformers, whose weights ranged from 69 to 1,500 kg.

According to the Distribution Transformers Procurement specifications, transformers shall be connected in accordance with BS 171: three phase transformers to Vector Group

reference Dyn11, and the transformers shall be fitted with low viscosity mineral insulating oil which complies in every respect with the provisions of BS 148.

The Distribution Code specifies the following:

- Unless otherwise specified in Schedule of Requirements, it must be assumed that the system on which the equipment will operate as is:
- *Three phase overhead-line construction and underground system. The maximum earth fault factor on the network is 1.5.*
- *Operated at 50 Hz, with approximately sinusoidal wave form.*
- *The highest system voltage does not normally exceed the nominal system voltage by more than 10%. The nominal system voltages are 33 kV and 11 kV.*
- *The system frequency variation does not exceed plus or minus 2.5% from 50Hz.*
- All materials used in the manufacture of the transformers shall be new and of high commercial quality.
- The transformers shall be manufactured to high quality standards. (The specification is silent on the core material; it only mentioned that "particular attention shall be paid to maintaining low core loss consistent with sound design")
- Tenders should advise to which standard the transformers are manufactured and tested, and shall supply relevant test certificates or test results.
- The transformers shall be sourced from manufacturers who have ISO 9001 Certification. Evidence of the ISO 9001 Certification shall be provided with the bid. Manufacturers who cannot submit such certification are liable to be rejected.

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

The Electricity Distribution Code specifies the electrical connection regulations in section 2.2 Procedures for Distribution Connection or Modification. Section 12.1.8 says all equipment on the customer's installation shall be suitable for use at the operating frequency of 50 Hz and at the voltage and stipulated short-circuit rating and shall normally be controlled within the approved limits.

6.3 Equipment stock and projections

6.3.1 Data on available distribution transformers in the market

According to the stakeholder consultations, the utility has an Asset register for transformers including distribution transformers. However, the register could not be shared because of confidentiality reasons. Figure 42 shows the imports of distribution and transmission transformers for the 2010-2020 period.

ZENT (2021) indicated transformer life-spans of 15-25 years, and that it is possible to have 40 year-old transformers. ZETDC (2021) gave an average distribution transformer service life of 25 years.

According to ZETDC (2021) working transformers are not decommissioned. Most distribution transformers are run to failure. Very few are taken out for service. Most of the decommissioned transformers are refurbished, depending on the availability of material. Refurbished transformers constitute around 30% of the total transformer installations in a given calendar year. Most of the refurbished transformers are those with low kVA ratings. 100% testing is done on refurbished transformers to applicable standards including loss assessment. Table 11 shows the extent to which ZENT refurbishes its DTs. (ZENT, 2021)

Table 12: Information on refurbishments (ZENT, 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	Common	Cuts across all ratings
Sandblast and repaint tank	Common	Cuts across all ratings
Change bushings, fuses, arrestors	Common	Cuts across all ratings
Change the tank	Seldom	Cuts across all ratings
Replace one phase	Sometimes	Cuts across all ratings
Replace more than one phase	sometimes	Cuts across all ratings
Complete rewind all phases	Common	Cuts across all ratings

Some of the transformer imports are for replacement of decommissioned, vandalized or stolen transformers. In 2019, Zimbabwe recorded a total of US$5,070,181 as vandalism loss for distribution transformers and lines from a total of 810 cases (ZENT, 2021).

6.3.2 Technology trends and market projections

The current national stock of distribution transformers is estimated at 20,000 and annual sales are estimated at 2,000 DTs (ZETDC, 2021). A DT lifespan of 20 years would mean an end of life replacement rate of 5% or 1000 DTs. This means that the utility is currently purchasing DTs for replacement of old and stolen/vandalized TDs. New TDs are expected to be installed as the electricity sales increase, which has not been the case for Zimbabwe for the past ten years. The data or information relating to the annual sales and projected demand for transformers in the country could not be obtained from the utility. Out of the 11 types of transformers imported and exported during the period 2010-2020 (Table 10) six types are the oil-filled type while the rest are the dry type. Excluding the TDs which do not qualify to be distribution transformers (i.e., those less than 1kVA and those less than 16 kVA) gives net imports of 4,168 in 2020. ZETDC indicated that it purchases around **2,000** distribution transformers per year while ZENT said that their sales were around 1,500 transformers in 2020. Production figures from other manufacturers such as GEC, South Wales Electric, Hawker Siddeley Engineering and Nical Transformers could

not be obtained. In order to improve provision of data by the private transformer manufacturers one of the private players was included in the PWG and DT-TC. The market share of ZENT could enable the estimation of the DT sales by the private players but efforts to get ZENT's market share were fruitless.

The market size of distribution transformers is determined by the following drivers:

-
- The electricity demand (electricity sales)
- The life-span of installed distribution transformers, and hence their replacement rates
- The number of distribution transformer thefts per year

New transformer installations

The 2018 and 2019 electricity sales were 7,751 GWh and 8,505 GWh respectively, and around 20,000 DTs are being used to distribute the electricity. The new DTs required for the projected electricity sales given in the 2018 SDP for the period 2021-2037 were calculated using the assumption that 20,000 DTs are required for the national electricity sales of 8,000 GWh. The electricity sales for the years 2038-2040 were obtained using extrapolation. This means that around 20,215 more DTs would be required in 2021, giving a total stock of 40,215 DTs. Table 12 shows the DT stocks for 2021, 2030 and 2040.

DT replacements at end of life

Assuming an average DT life span of 20 years gives a replacement rate of 5% per annum. In order to get annual replacements, the annual DT stocks were multiplied by the rate of 5%. Therefore, the 2021 and 2030 DT replacements at end of life were 2,011 and 4,158 respectively (Table 12).

DT replacements due to theft and vandalism

A DT stock of 20,000 in 2020 and theft rate of 1,000 DTs per year would mean replacements of 2,011 in 2021 and 4,158 in 2030. Coincidentally, the rates of replacement of DTS at end of life and that due to thefts are the same.

Table 13: Summary of DT stock, market size, market value, potential energy savings, and emissions savings in 2021, 2030 and 2040

	2021	2030	2040
Projected sales (GWh)	16,000	33,000	66,000
Quantity of new DTs penetrating	20,215	63,165	143,965
Stock of DTS	40,000	83,165	163,965
Number of DTs replaced at end of life	2,011	4,158	8,198
Number of DTs replaced due to theft and vandalism	2,011	4,158	8,198
Total market size of DTs	24,237	71,482	160,362
Total market value of DTs (US$ million)	53	156	350

The market size for each year is shown in Figure 43, and ranges from 24,000 in 2021 to 160,000 in 2040. The contribution of the new DTS installed in line with electricity demand to the total market size would increase from 83% in 2021 to 90% in 2040 while those of the replacement DTs would a combined total contribution of 17% in 2021 and 10% in 2040. Multiplying the market size with the average distribution transformer price of US$2,181, calculated from the 2020 trade statistics provided by Zimstat, gives a distribution transformer market value ranging from USD50 million in 2021 to around USD350 million in 2040. (Figure 44). The market size is projected to increase seven-fold over the period 2021-2040.

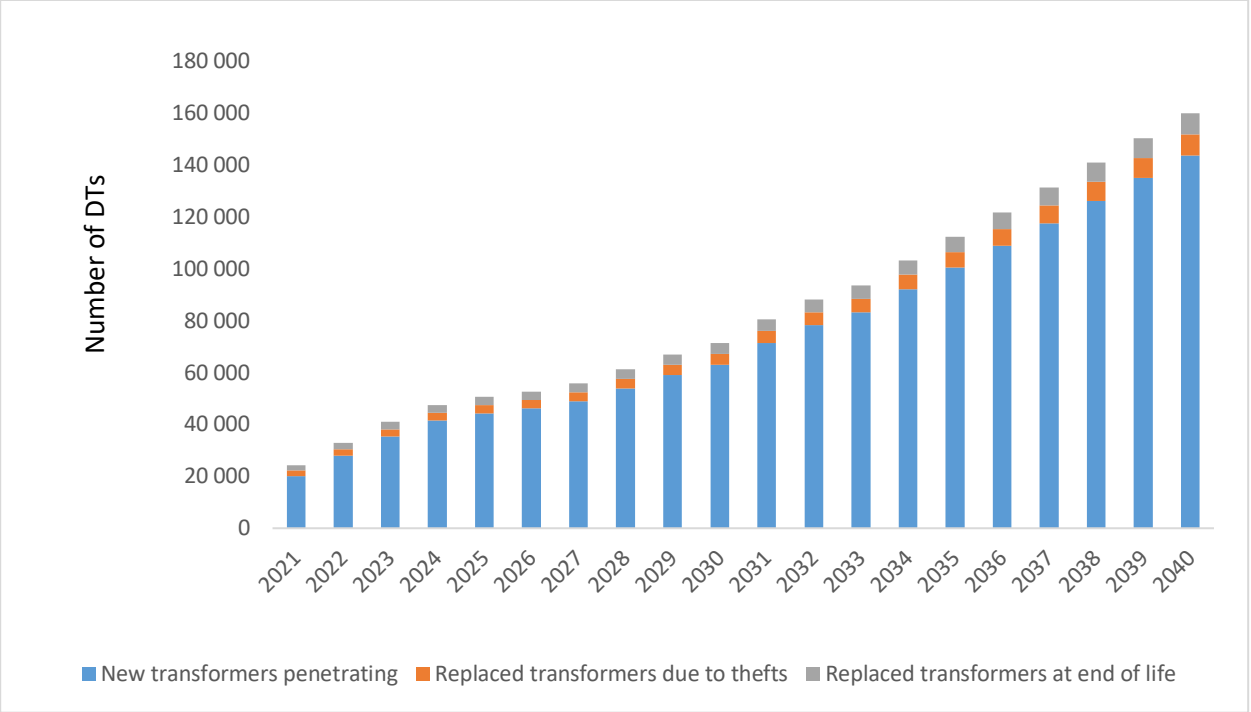

Figure 42: Market size for distribution transformers (Source: Market Assessment, 2021)

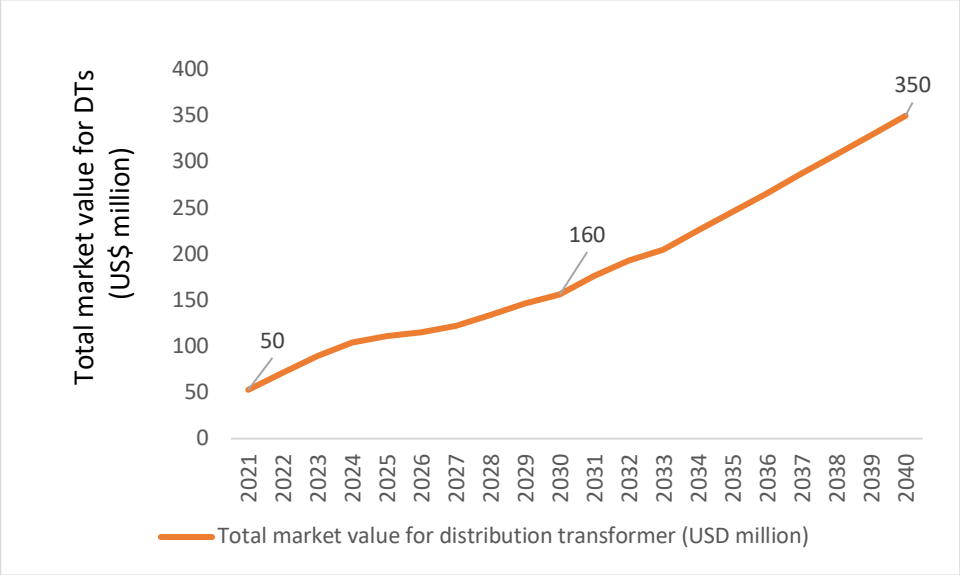

Figure 43: Total market value for distribution transformers (Source: Market Assessment, 2021)

Estimation of potential energy savings

A transformer is expected to convert alternating current from one voltage to another efficiently. However, transformers have energy losses which depend on how they were manufactured, the materials used and how they are used. Applying harmonically rich loads to transformers can double or triple their total losses. Transformers that would normally have 2% losses at 35% loading would actually have 4% to 6% losses (Kenneth, 2013 page 2).

Replacing transformers with more energy-efficient ones can result in significant energy savings.

According to the U4E CSA Transformer Methodology and Assumptions energy savings in DTs can be estimated through the following steps:

- Calculate the installed MVA from the projected electricity demand
- Split the MVA demand between the residential, commercial and industrial sectors, using the latest sales statistics
- For each sector specify the MVA percentages of the DT types (3 phase liquid-filled, single phase liquid-filled and 3 phase dry-type), specify the average transformer size, thus enabling calculation of the MVA for a particular sector and transformer type
- Assume 30% of the residential DTs (250 kVA and 50 kVA) are rewound and rewinding was assumed to increase the energy losses by 2.25%.
- Calculate the BAU, Level 1 and Level 2 DT energy losses
- Subtract the Level 1 and Level 2 losses from the BAU to get the Level 1 and Level 2 energy savings
- Use the grid emission factors used in the NDC Implementation Framework to calculate the emissions reduction. The EF was around 0.76 kg/kWh for the period 2021-2024 and 0.436 kg/kWh from 2025 to 2040.

Table 13: Assumptions on DT types, kVA ratings, and losses

Sector	TD type	Contribution	Average TD size (kVA)	Losses without considering rewinding		
				TD loss (BAU)	TD loss (Level 1)	TD loss (Level 2)
Residential	Three phase liquid-filled	47%	250	13,841	9,746	7,512
	Single phase liquid-filled	53%	50	4,227	3,197	2,352
	Three phase dry type	0%	N/A			
Commercial	Three phase liquid-filled	92%	400	19,710	13,841	10,508
	Single phase liquid-filled	0%	N/A			
	Three phase dry type	8%	630	31,536	26,280	24,221
Industry including agriculture	Three phase liquid-filled	98%	800	27,419	19,491	14,804
	Single phase liquid-filled	0%	N/A			
	Three phase dry type	2%	630	31,536	26,280	24,221

Figure 45 shows the projected transformer energy losses for three scenarios (business-as-usual, level 1 efficient transformers and level 2 efficient transforers). As a percentage of the total distribution losses over the period 2021-2040, these losses ranged from 9% to 13% for the BAU scenario, 6% to 9% for the Level 1 scenario and 5% to 7% for the Level 2 scenario. Figure 46 and Table 14 show the potential energy savings and emissions reductions for the Level 1 and Level 2 scenarios. The energy savings are significant as they average 3% and 6% of the distribution losses under the Level 1 and Level 2 scenarios respectively.

Table 14: Potential energy savings and emissions reduction (Source: Market Assessment, 2021)

	Potential energy savings (GWh)			Potential emissions reduction (GgCO2eq)		
Scenario	2021	2030	2040	2021	2030	2040
Level 1	50	100	200	30	45	90
Level 2	80	160	320	60	70	140

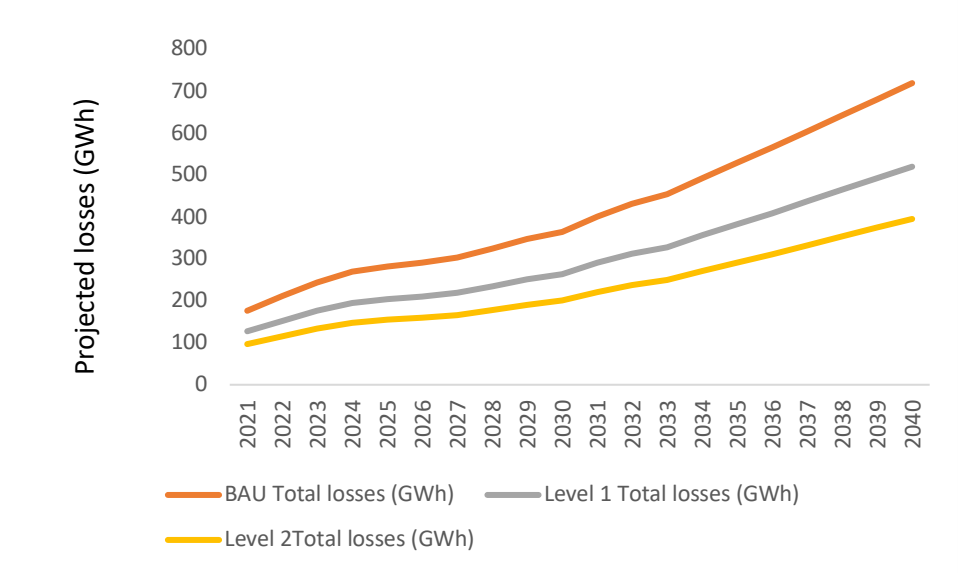

Figure 44: Projected energy losses under BAU, Level 1 and Level 2 scenarios (Source: Market Assessment, 2021)

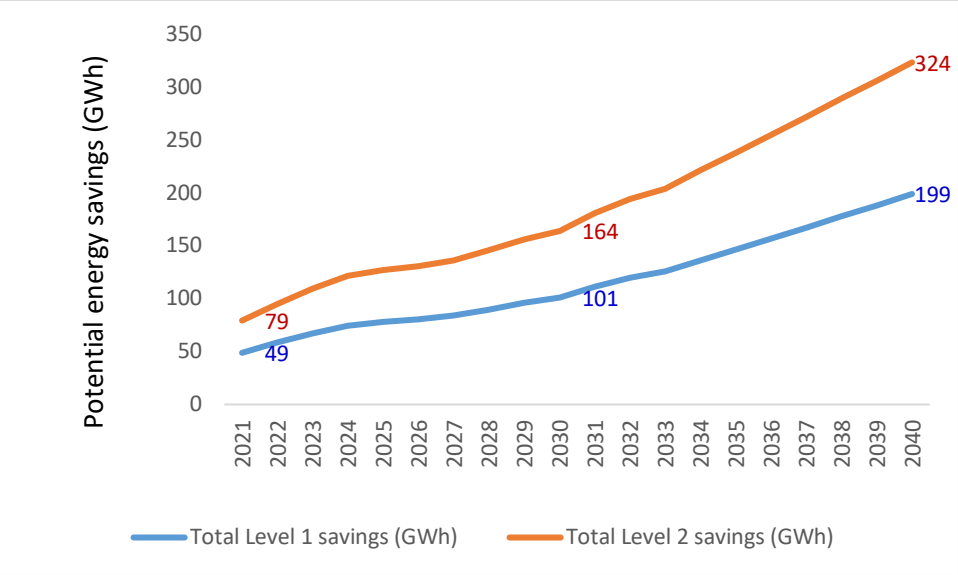

Figure 45: Potential energy savings under Level 1 and Level 2 scenarios

6.4 Policies and programme landscape

6.4.1 Current and planned electrification policies and programmes

As explained in section 4.2.7, the NDS1 aims to achieve an average annual real GDP growth rate of above 5% during the period 2021-2025. The 2018 SDP projects the amount of power and energy required to support the economic activities. Zimbabwe, through its National Renewable Energy Policy, aims to increase the percentage of renewable energy in its energy mix and set some renewable energy targets 1,100 MW and 2,100 MW for 2025 and 2030 respectively. Table 15 shows the breakdown of the 2030 target. The rural electrification projects which are meant to increase the electricity access by the rural population would also result in increased distribution transformer installations. Moreover, most rural electrification projects are relatively inefficient in that load centres are sparsely distributed, and the lines are long.

Table 15: Installed capacities of renewable power generation technologies by 2030 (Source: National Renewable Energy Policy, 2019)

Technology	**2030Target (MW)**
Small Hydro	150
Grid Solar	1,575
Wind	100
Biogas and other RE	275
Total Renewable Energy target	**2,100**

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

Zimbabwe uses the standard IEC60422 for the operational guidelines in dealing with Polychlorinated Biphenyls (PCB's). According to the country's biggest supplier of transformers,

ZENT (2021), samples are collected from suspected transformers prior to any repair works, and PCB contamination is measured in accordance with IEC 60422 which gives a threshold of 50ppm.

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

Some of the stakeholders that were consulted made some recommendations that may enhance the opportunities to transform the market toward more energy-efficient distribution transformers.

- The Ministry of Industry and Commerce and Bureau Veritas can assist with Consignment Based Conformity Assessment for transformers.
- The grid is owned and maintained by ZETDC and because of this, financial institutions hardly finance the purchase of transformers. The financial institutions may fund REF's electrification projects, e.g. the electrical reticulation between the transformer and the new residential households.
- The asset register of transformers should be accessible to all stakeholders who need it.
- Training on green procurement for both public and private institutions would be necessary.
- The Infrastructure Development Bank of Zimbabwe says that since the country is moving towards energy efficiency the Bank needs to play its role in that space. The Bank has been involved in a number of energy saving projects already. The bank played an important role in the financing of the ZPC- Kariba South Power Station Expansion (300MW). The Bank also provided finance for the roll out of the ZETDC prepaid meter project. These projects are significant energy efficiency enhancements. The Bank is also involved in a number of solar projects.

6.5 Utility's procurement specifications

The Procurement Regulatory Authority of Zimbabwe (PRAZ) is a national body which is facilitating procurement policies for government, utilities or other buyers of transformers. The utility gives its technical specifications as per the Distribution Code and the procurement is done through a tendering process. Zimbabwe has a detailed Specification for Distribution Transformers up to 800 kVA (See Annex), and this gives the following guidance to Government on procurement of distribution transformers:

- Tenders should advise to which standard the transformers are manufactured and tested and shall supply relevant test certificates or test results.
- The transformers shall be sourced from manufacturers who have ISO 9001 Certification. Evidence of the ISO 9001 Certification shall be provided with the bid. Manufacturers who cannot submit such certification are liable to be rejected.

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

Procurement by ZETDC, REF and other Government departments and parastatals for both replacements and network expansion is done through a tendering process, in accordance with the Distribution Code and the Specification for Distribution Transformers up to 800 kVA.

The Infrastructure Bank of Zimbabwe (IDBZ) is a DFI and its role is to catalyse economic development, mainly through de-risking projects. IDBZ provides project finance and equity. Currently IDBZ is in the process of being accredited by the Green Climate Fund. This accreditation will open opportunities for the bank to access climate finance and technical expertise in green credit lines. The most popular product the bank offers is the Project Preparation and Development Fund (PPDF) which was established to assist projects to reach bankability. Lack of investment-ready, 'bankable' projects is a major constraint to greater investment in infrastructure projects. Therefore, the Bank's PPDF aims to de-risk projects and make them bankable. Absence of bankable projects is the major hindrance to infrastructure development.

The attractiveness of energy efficiency as an investment proposition depends on the environment in which the projects arise. This can be influenced by a variety of factors, including the policy environment, energy market structure and the existence of suitable supply chains for energy efficiency projects. Some risks include lack of appropriate financing vehicles or debt instruments, regulatory risks, volatile energy prices, lack of collateral, high initial costs, long payback periods, uncertainty of technology.

Key barriers to financing energy efficient equipment

There are several barriers to financing energy efficient equipment. Excessive restrictive measures and imperfect guidelines may cause a failure to implement green financing. Project funds can be obtained through strong capital markets from domestic and abroad. However, due to a range of market barriers about price mechanisms, information exchanges, bond issuance, foreign exchange control, etc., it is difficult to perform energy efficiency commercialized operation in developing countries. Energy efficiency involves many changes in production processes, equipment and technologies. Individuals may overlook cost-effectiveness of such projects and resist these changes due to bounded rationality, perceptions and local public impression.

Structure of Environmental and Social Risk Management System

The Environmental and Social Sustainability Management System (ESSMS) has been structured in line with the general provisions of the International Standards Organization (ISO) 14001 to facilitate integration of the ESSMS with any other Management System that IDBZ has in place or intends to develop. The ESSMS also follows the Green Climate Fund/International Finance Corporation Environmental and Social Management requirements closely.

The IDBZ was nominated by the Government of Zimbabwe, through the Ministry of Environment, Climate, Tourism and Hospitality Industry (MoECTHI) as the National Designated Authority (NDA), to be accredited to the Global Climate Fund (GCF) as a National Implementing Entity (NIE). The IDBZ was accredited in July 2021 (Herald, 7 July 2021). In this role, the IDBZ

will serve as the designated national institution responsible for developing and submitting climate funding proposals to GCF and other funders, overseeing project management, mobilising capital and deploying a range of financial instruments in order to fund infrastructure related climate projects. The IDBZ recommends that the rebranded Agricultural Finance Bank (Formerly Agribank), should finance agriculture and climate smart agriculture practices should be a focus for the farmers. The bank can assist in financing energy efficient agricultural equipment. FBC and Steward Bank are commencing accreditation process and also have financing instruments for the agriculture and energy sectors. ZB Bank has been involved in electricity-related projects in the past e.g. provision of electricity reticulation through Rural Electrification Fund to 3,000 new residential households in Marondera in 2015-18.

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

The fact that ZENT is ISO 9001: 2008 certified and manufactures transformers to the stringent South African Bureau of Standards, SABS 780, Zimbabwe has an opportunity to export the transformers it manufactures to the SADC member states. The trade statistics (Zimstat, 2021) show that Zimbabwe has exported at least one transformer for all the listed transformer types with the exception of that rated greater than 10,000 kVA. The IDBZ has the capability to compete with other DFIs in the region for infrastructure projects considering its experience on projects such as 300 MW South Kariba Extension, and that it is now GCF-accredited. However, according to the trade statistics the total exports were only 0.4% of total imports in 2020.

7 Conclusion

The demand for residential refrigerators and distribution transformers will increase as the population and the economy grow. The residential refrigeration stocks are projected to rise from around one million units in 2020, to around three million in 2030 and to just above 5 million in 2040. The total market size (due to replacement of old refrigerators and entry of new ones) would increase from around 200,000 in 2020 to 300,000 in 2030 and 600,000 in 2040; a 200% increase over the 20-year period. The market assessment gave a residential refrigerator market value of USD90 million in 2020 and projections into the future gave a market value of USD300 million by 2040.

The household refrigerator survey showed that the locally manufactured residential refrigerators were 37% of the refrigerator stock in 2021, 55% of which were the frost-free type. The percentage of the more energy-efficient refrigerators were projected in this market assessment to be 66% in 2030 and 79% by 2040 under business-as-usual. Only 11% of the locally manufactured residential refrigerators had energy consumption information written on them, compared to 25% for the imported refrigerators (Market Assessment, 2021). The projected slow penetration of more energy-efficient refrigerators in Zimbabwe justifies the framework to leap-frog to more energy-efficient refrigerators, which will be expected to save 5.5 GWh and 6.4 GWh in 2030 and 2040, respectively.

The projected energy savings are approximately 3% and 3.4% of total national electricity consumption in 2030 and 2040 respectively. At a price of US10 cents per kWh the total energy cost savings would be USD550,000 in 2030 and USD640,000 in 2040. The GHG emissions avoided through the use of more energy-efficient refrigerators would be 3.7GgCO2eq in 2021, 3.4GgCO2eq in 2030 and 0.9 GgCO2eq in 2040. The 2030 emissions reduction would be around 13% and 16% of the updated NDC's BAU and mitigation scenarios respectively.

The Standards Association of Zimbabwe has the following refrigeration-related standards, which are available from SAZ's Information Centre for a fee:

a) ZWS IEC 335--2-24:1998: Safety of household and similar electrical appliances (refrigerators and freezers)

b) ZWS ISO 5155: 1998: Household refrigeration appliances – Frozen food storage cabinets and food freezers – Characteristics and test methods

c) ZWS ISO 7371: 1998: Household refrigerating appliances – Refrigerators with or without low temperature compartment – Characteristics and test methods.

d) ZWS ISO 8187: 1998: Household refrigerating appliances – Refrigerators – Freezers – Characteristics and test methods

e) ZWS 1012: 2019: Requirements for Certification of Refrigeration and Air Conditioning Practitioners

The stock of the distribution transformers as of 2020 are estimated at 20,000 and is projected to rise to around 80,000 in 2030 and 160,000 in 2040, while the market size would be expected to rise from 25,000 in 2021 to 70,000 in 2030 and 160,000 in 2040. The DT modelling was based on:

(i) the electricity sales which were projected in the 2018 SDP to rise from 16,000 GWh in 2021 to around 30,000 GWh in 2030
(ii) the replacement of DTs at the end of their life spans which was assumed to be 20 years, and
(iii) the replacement of stolen and vandalized DTS using a baseline replacement rate of 5% (based on the provided information of 1,000 stolen/vandalized DTS in 2020 and a stock level of 20,000 DTs)

The distribution transformer market value is expected to be USD50 million in 2021, USD160 million in 2030 and USD350 million in 2040, electricity demand being the major driver for distribution transformer installations since more electricity will be required both in the productive and household sectors. According to this market assessment annual potential energy savings ranging from 100 GWh to 160 GWh in 2030 and from 200 GWh to 320 GWh in 2040 can be achieved through the use of more energy-efficient transformers, avoiding greenhouse gas emissions up to 70 GgCO2eq in 2030 and 140 GgCO2eq in 2040.

The market assessment enabled the establishment of the country's baselines for the residential refrigerators and distribution transformers in terms of stock, market size and market values and how these parameters are likely to change with time, under predicted conditions. The projections

up to 2040 were done in line with national programmes such as Nationally Determined Contributions and Low Emissions Development Strategy. Stakeholder engagement was taken as a very important part of the market assessment and this stakeholder engagement enabled acquisition of historical data on residential refrigerators and distribution transformers, indicated consumer preferences, identified possible risks or barriers to penetration of more energy-efficient appliances, available policies and regulations, among other things. However, some of the important information such as transformer stock, annual DT sales by private players and market share was not made available.

Energy efficiency improvement measures are needed in Zimbabwe considering the country's inability to meet demand for power in all sectors of the economy, high energy intensity of GDP, high technical losses and the lower costs required for energy efficiency and DSM measures compared with those for new power plants. Zimbabwe does not have regulations on MEPS for transformers. ZERA, through its Distribution Code, requires ZETDC to declare its transmission and distribution losses, and these losses include the losses through transmission and distribution lines as well as through the transformers. These technical losses are reported by ZERA in its annual reports. This forces ZETDC to put measures in place to keep losses low, such as specifying the maximum losses in its distribution transformers to ZENT. In its NDS1 Zimbabwe intends to reduce transmission and distribution losses from 18% to 11% by 2025. Zimbabwe has since included the project in its updated NDC. Zimbabwe does not have labeling, tax breaks or any form of incentivizing for the procurement/manufacture of low loss distribution transformers. There is an opportunity to reduce energy losses by incentivizing the transformer users such as the private sector.

The market assessment has shown that most people do not consider energy consumption when purchasing appliances, but 93% of the respondents expressed willingness to pay an extra amount for an efficient refrigerator. The penetration of the frost-free refrigerators, especially the refrigerator-freezer type, is faster than that of the direct cool during the past 10 years. However, the percentage of refrigerators using environmentally-friendly refrigerants in the country is lower than that of the imported refrigerators. Most locally manufactured residential refrigerators do not have energy consumption on their labels. For distribution transformers there are standards that talk about energy losses and efficiencies, although they are voluntary. Awareness raising will be required so that people buy appliances that will consume less electricity. The assessment has also shown that given the appropriate policies towards energy efficient appliances, the Government may be in the right trajectory to implement a Readiness project on "**Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers**."

Only 54 % of interviewees on residential refrigerators were formally employed and about 70% of them are in the low income bracket of less than US$7,100 year. The survey results show that the most considered factors when purchasing a refrigerator were functionality, quality and price while energy and access to financing were 9th and 11th respectively on a list of 12 factors. This means that financial institutions, that have shown appetite for large energy infrastructure investments, such as power plants, may consider providing loans to those willing to purchase more efficient appliances and who have the capacity to pay back the loans. According to the assessment, the majority of consumers have bank accounts.

The market assessment will help the Government of Zimbabwe (GoZ) understand current stock of residential refrigerators and distribution transformers and projected growth, electricity saving potential and the analysis of the regional context. The GoZ is encouraged to form the Policy Working Group (PWG) that will develop the national policy roadmap for refrigerators and the national policy roadmap for distribution transformers. The national policy roadmaps must include the following:

- Minimum Energy Performance Standards (MEPS) and Higher Energy Performance Standards (HEPS)
- Labelling options and decide on labelling scheme
- Enabling policy and regulatory environment environment for residential refrigerators and distribution transformers in Southern Africa
- Appropriate financing mechanisms to accelerate deployment of energy efficient residential refrigerators and distribution transformers in Zimbabwe
- End-users' awareness campaign
- Public consultations
- Monitoring Verifications & Evaluation plan

In addition to guiding the development of the above-described activities, the PWG will oversee the work of the technical committee for refrigerators (TC-Ref) and of the technical committee for distribution transformers (TC-DT).

8 Annexes

(a) Overview/ List of data sources

The sources of data/information used in this report include:

- Reports of private and public institutions
- National documents including policies and regulations
- Online International data sources such as IEA
- Peer-reviewed articles
- Supply-chain players for domestic refrigerators (Table 13) and distribution transformers (Table 14)

Table 16: Residential refrigerator supply-chain players surveyed

	Name of institution	Role in supply chain	Name of focal point	Email of focal point
1	IMPERIAL	Manufacturer	Mr Charles Jena	charlesmjena@yahoo.com
2	Primepep Services T/A Tradecom Africa	Distributor	Mr Passmore Chigwanda	passmore@tradecomafrica.com
3	TV Sales & Home	Distributor	Ms Elizabeth Mahogo	emahogo@tvsales.co.zw
4	Infrastructure Development Bank of Zimbabwe (IDBZ)	Financial Institution	Mr Rashid Mudala	rmudala@idbz.co.zw
5	ZB Bank	Financial Institution	Mr Sam Mutamuko	smutamuko@zb.co.zw
6	Zimbabwe Environmental Lawyers Association (ZELA)	Consumer Association	Mr Byron Zamasiya	bzamasiya@gmail.com
7	Urban Councils Association of Zimbabwe (UCAZ)	Consumer Association	Mr Chris Musekiwa	cmusekiwa@ucaz.org
8	OZONE Office	Government Department	Mr George Chaumba	George.chaumba@gmail.com
9	Standards Association of Zimbabwe (SAZ)	Standards body	Ms Romana Marunda	marunda@saz.org.zw
10	Zimstat	National statistics office	Mr Gambiza	tradestatistics@zimstat.co.zw
11	ZETDC	EE and DSM	Engineer Stephen Musarurwa	smusarurwa2011@gmail.com
12	Zimbabwe Energy Regulatory Authority (ZERA)	Energy regulation	Engineer S. Zaranyika	szaranyika@zera.co.zw
13	Department of SMEs	Ministry of Women Affairs, Community	Ms Tariro Chipepera	tarirochipy@gmail.com

		and Small-to-Medium Enterprises Development		
14	Ministry of Industry and Commerce	Ministry	Ms Bridget Mhonderwa	bdmhonderwa@yahoo.com
15	Standards Association of Zimbabwe (SAZ)	Standards body	Ms Romana Marunda	rmarunda@saz.org.zw
16	Zimstat	National statistics office	Mr Gambiza	trade.statistics@zimstat.co.zw
17	Ministry of Finance and Economic Development	Ministry	Mr Henry Dutiro	henridutiro@gmail.com
18	Ministry of Local Government and Public Works	Ministry	Ms Annah Takaendesa	takaendesa2011@gmail.com
19	CAPRI Zimbabwe	Manufacturer	Mr Jacobs	sjacobsz@capri.co.zw
20	Mohamed Mussa	Distributor	Tensen (Mr)	Mmw786@zol.co.zw
21	OK Mart	Distributor	Mr Phillip Karidza	pkaridza@okzim.co.zw

Table 17: Distribution transformer supply chain players surveyed

	Name of institution	Role in supply chain	Name of focal point	Email of focal poit
1	ZESA Enterprises (ZENT)	Manufacturer (Utility)	Engineer Shepherd Madoroba	SMadoroba@zent.co.zw
2	Hawker Siddeley Engineering	Manufacturer	Ms Rumbidzo	rumbidzo.hse@yemurai.com
3	GEC	Manufacturer	Mr Renias Jingo	renias.jingo@gec.co.zw
4	South Wales Electric	Manufacturer	Ms Sandra	sandra@swe.co.zw
5	Zimbabwe Electricity Transmission and Distribution Company (ZETDC)	Power Distributor (Utility)	Engineer Zowa	zowa@zetdc.co.zw
6	Rural Energy Fund (REF)	Rural electrification	Mr Cliff Nhandara	cnhandara@rea.co.zw
7	Zimbabwe Energy Regulatory Authority (ZERA)	Energy regulation	Engineer S. Zaranyika	snzaranyika@zera.co.zw
8	Zimbabwe Environmental Lawyers Association (ZELA)	Consumer Association	Mr Byron Zamasiya	bzamasiya@gmail.com

9	Urban Councils Association of Zimbabwe (UCAZ)	Consumer Association	Mr Chris Musekiwa	cmusekiwa@ucaz.org
10	Infrastructure Development Bank of Zimbabwe (IDBZ)	Financial Institution	Mr Rashid Mudala	rmudala@idbz.co.zw
11	ZB Bank	Financial Institution	Mr Sam Mutamuko	smutamuko@zb.co.zw
12	Procurement Regulatory Authority of Zimbabwe (PRAZ)	Financial Institution	Mr Cliff Gondo	cliffgon@gmail.com
13	Tongaat Hullet	Non-utility running own grid	Mr Bekithembe Ndlovu	millops@triangle.co.zw
14	Greenfuel	Non-utility running own grid	Mr Derek Elliot	derek.elliot@cmszim.com
15	Nyangani Renewable Energy (NRE)	Non-utility running own grid	Mr Ian Mckersie	iapm@nrezim.com
16	Old Mutual	Private sector	Mr Edwin Paradza	edwinp@oldmutual.co.zw
17	Renewable Energy Association of Zimbabwe (REAZ)	Private sector association	Mr Isaah Nyakusendwa	nyakusendwaidp@gmail.com
18	Distributed Power Africa (DPA)	Private sector	Mr Divyageet Mahajan	DMahajan@dpaafrica.com
19	Chamber of Mines (CoM)	Private sector association	Mr I Kwesu	info@chamines.co.zw
20	Confederation of Zimbabwean Industries (CZI)	Private sector association	Mr Kuda Matare	kmatare@czi.co.zw
21	Business Council for Sustainable Development-Zimbabwe (BCSDZ)	Private sector association	Mr Tawanda Muzamwese	bcsdzimbabwe@gmail.com
22	Zimbabwe National Chamber of Commerce (ZNCC)	Private sector association	Mr C Mugaga	ceo@zncc.co.zw
23	Standards Association of Zimbabwe (SAZ)	Government Department	Ms Romana Marunda	rmarunda@saz.org.zw
24	Department of Irrigation:	Ministry of Lands, Agriculture, Water and Rural Resettlement	Engineer Edmund Shorayi	edshorayi@gmail.com

25	Department of SMEs	Ministry of Women Affairs, Community and Small-to-Medium Enterprises Development	Ms Tariro Chipepera	tarirochipy@gmail.com
26	Ministry of Local Government and Public Works	Ministry	Ms Annah Takaendesa	takaendesa2011@gmail.com
27	Ministry of Finance and Economic Development	Ministry	Mr Henry Dutiro	henridutiro@gmail.com
28	Ministry of Industry and Commerce	Ministry	Ms Bridget Mhonderwa	bdmhonderwa@yahoo.com
29	City of Harare	Local authority	Engineer c. Chigariro	cchigariro@hararecity.co.zw
30	City of Bulawayo	Local authority	Mr Nkanyiso Ndlovu	nkndlovu@citybyo.co.zw
31	Standards Association of Zimbabwe (SAZ)	Standards body	Ms Romana Marunda	marunda@saz.org.zw
32	Zimstat	National statistics office	Mr Gambiza	trade.statistics@zimstat.co.zw
33	Zimbabwe Power Company (ZPC)	Utility	Mr Tichaona Nyandoro	tnyandoro@zpc.co.zw

Table 18: Residential refrigerator survey enumerator details

	Name	Sex	Profession	City covered
1	Benson Gono	Male	Information Systems and Knowledge Management Specialist	Harare
2	Brighton Gosa	Male	Marketing Representative	Harare
3	Loveness Gwesela	Female	Project Manager (Monitoring and Evaluation)	Harare
4	Francisca Nyagato	Female	Research Assistant	Harare

5	Nyararai Jerald Chipandambira	Male	Mechanical Engineer	Harare
6	Simbarashe Mudimu	Male	Electrical Control and Instrumentation	Harare
7	Domingo Pavolo	Male	Mechanical Engineer	Bulawayo
8	Kudakwashe Dhliwayo	Female	Industrial Chemistry	Bulawayo
9	Edmund Mantiziba	Male	Researcher	Gweru
10	Nyasha Sithole	Female	Computer Information Assistant	Mutare

(b) Detailed information of data sources/Bibliography

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(c) Answered questionnaires (See attachments)

(d) Typical transformer losses in the ZESA Network

Table 19: Typical losses of Transformers in the ZESA network (ZENT, 2021)

Rating (kVA	Voltage Ratio(kV)	CCA - kg	Oil - ltrs	Maximum Overall dimensions			Total Weigth	%Z (declared)	Typical Load Loss	Typical No Loas Loss
				L (mm)	W (mm)	H (mm)	kg			
10	11/0.23	69	41	737	507	890	170	4.39%	270	47
10	11/0.4	83	51	900	509	983	204	4.38%	330	55
15	11/0.23	82	47	753	516	966	190	4.30%	370	55
15	11/0.4	98	57	882	605	993	230	4.26%	450	65

25	11/0.4	135	75	956	594	1030	295	4.25%	675	95
50	11/0.4	189	115	874	632	1090	453	4.50%	1250	150
100	11/0.4	316	158	1127	557	1205	585	4.50%	1950	250
200	11/0.4	512	235	1235	640	1335	890	4.50%	3000	400
315	11/0.4	675	360	1303	780	1707	1255	4.50%	4750	550
500	11/0.4	975	440	1448	991	1853	1675	4.50%	6800	900
800	11/0.4	1334	565	1582	975	2019	2276	4.15%	9850	1150
1000	11/0.4	1665	653	1930	1463	2276	3100	5.00%	11500	1400
15	33/0.23	90	90	825	650	1500	260	4.40%	400	70
15	33/0.4	120	140	1077	690	1500	340	4.08%	360	100
25	33/0.4	172	195	926	845	1518	470	4.40%	580	130
50	33/0.4	232	230	1151	749	1578	569	4.52%	1100	190
100	33/0.4	370	285	1258	842	1652	779	4.58%	1750	310
200	33/0.4	565	385	1353	845	1767	1111	4.43%	3100	510
315	33/0.4	785	520	1453	869	1938	1492	4.44%	4400	700
500	33/0.4	1040	540	1450	1280	2060	1930	4.59%	6000	980
800	33/0.4	1420	750	1600	1550	2200	2615	4.90%	8800	1360
1000	33/0.4	1500	880	1685	1700	2685	3310	5.00%	11100	1600

(e) Tools used in the market assessment

(i) Questionnaire for residential refrigerator survey

HOUSEHOLD REFRIGERATOR SURVEY

Introduction

Eight countries in Southern Africa have embarked on Green Climate Fund (GCF) Readiness projects on ***Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers***. The implementation of the projects will be primarily led by Climate Technology Centre

and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative.

The SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) is one of the in-country institutions implementing this activity in Malawi, Namibia, Zambia and Zimbabwe. Among the activities is to conduct a market assessment of residential refrigerators and distribution transformers. Market assessments are essential for good policy development and governance.

This survey seeks to obtain data and information on energy efficiency status of refrigerators in households.

Surveyor Details

Name	.....	**Phone**	.....
ID No.	.....	**Town/City**	.....
Country	.....		

Respondent Details

Name	.....	**Gender/Age**	.....
Profession	.....	**Email**	.....
Title	.....	**Date**	.....
Family Position	.....	**Location**	.....

Questions

1. Total number of family members who reside in your house

Adult	Children[4]

[4] Children: 12 years and below

Male	Female	Male	Female

2. What is your average monthly electricity payment?[5] Is it prepayment ( ) or credit ( )

Range	Tick option	Range	Tick option
Less than Z$3,000		Less than US$35	
XZ$3,001- Z$6,000		US$36-US$70	
More than Z$6,000		More than US$70	
Comment		Comment	

3. What is the size of your house in BHK (bedroom, hall and kitchen)? Please tick (✓) any 1 option. (NB: Take a cottage as a house)

1 BHK	2 BHK	3 BHK	>3BHK

4. How many appliance(s) do you own in your house? Please tick (✓) any 1 option.

	0	1	2	3	>3	New	Second-hand
Refrigerator							
Refrigerator – Freezer							
Freezer							

5. What is the brand, model and price of the appliance/s in your house? Please tick any 1 option for each refrigerator in use. Did you purchase the appliance new or second-hand? And where did you purchase the appliance (department store, supermarket, specialized appliances shop, online shop, informal)?

	Brand	Model	~Price	New or second-hand?	Location of purchase
Refrigerator 1					
Refrigerator 2					
Refrigerator 3					
Refrigerator–Freezer 1					
Refrigerator–Freezer 2					
Refrigerator–Freezer 3					
Freezer 1					
Freezer 2					

[5] Implementers to ranges corresponding to the country where the data is being collected.

Freezer 3					

6. What is the age of the appliance(s) in your house? Please <u>tick any 1 option for each refrigerator in use.</u>

	<3 years	3-7 years	7-10 years	>10 years
Refrigerator 1				
Refrigerator 2				
Refrigerator 3				
Refrigerator–Freezer 1				
Refrigerator–Freezer 2				
Refrigerator–Freezer 3				
Freezer 1				
Freezer 2				

7. Please specify the following details, if you are aware, of the appliance(s) in your house[6].

	Volume by compartment (liters)	Annual energy consumption (kWh)[7]	Power Rating (W)	Refrigerant	Energy Efficiency Class (i.e. A or B/stars)	Label	Number of Doors
Refrigerator 1							
Refrigerator 2							
Refrigerator 3							
Refrigerator–Freezer 1							
Refrigerator–Freezer 2							
Refrigerator–Freezer 3							
Freezer 1							
Freezer 2							
Freezer 3							

8. Please specify the technology type, if you are aware, of the appliance(s) in your house. Please <u>tick any 1 option for each refrigerator in use[8].</u>

	Direct cool	Frost free	Other
Refrigerator 1			
Refrigerator 2			
Refrigerator 3			
Refrigerator–Freezer 1			
Refrigerator–Freezer 2			

[6] Enumerators to take pictures of fridges including make, model type and serial number to assist retrieving parameters

[7] The implementers need to include ranges of annual average revenues corresponding to the country where the survey is being conducted.

[8] Enumerators to take pictures of fridges including make, model type and serial number to assist retrieving parameters

Refrigerator–Freezer 3			
Freezer 1			
Freezer 2			
Freezer 3			

9. The Zimbabwe 2020/21 average salary survey (www.averagesalarysurvey.com) gave the figures in the table below. Please indicate your average annual Income[9].

Percentage of people	Annual salary (US$)	Monthly salary (calculated)	Tick option
6%	71,960	5,997	
12%	52,211	4,351	
24%	33,461	2,788	
57%	13,570	1,131	
82%	7,102	591	
92%	3,879	323	
96%	2,025	169	

10. Are you aware of any energy efficiency standard & Labelling policies/schemes in your country? Please tick any 1 option. If yes kindly provide details.

No (x)	Yes (x) - provide details

11. Are you willing to pay an extra cost for an energy efficient refrigerator, refrigerator-freezer or freezer that will help reduce your electricity cost in the long run? Please tick any 1 option.

No	Tick Here
Yes (up to 10% of average cost)	
Yes (20% - 40% above the average cost)	
Yes (above 40% of average cost)	

12. Are you (tick the appropriate one)**;**

A salaried employee from the public sector?	
A salaried employee from the private sector?	
Self-employed?	
Pensioner	

[9] Implementers to put ranges corresponding to the country where the data is being collected.

Other (Briefly explain):	

13. Please indicate whether you hold a bank account(s). If yes, please mention the name of your financial institution.

No	Yes

14. If yes, please also indicate if you have ever taken a loan from the institution. If so what was the tenor period of the loan and interest rate?

No	Yes

15. Are loan conditions attractive enough? (Interest rates, tenors, collaterals, eligibility criteria, other)

No	Yes

16. Do you own the house where you live?

No	Yes

17. Kindly indicate the mode of purchasing of your refrigerator, refrigerator-freezer or freezer. Please <u>tick any 1 option.</u> If you have availed loan, please indicate the duration of the loan (years).

Loan/credit from bank	( ) years
Leasing	
Own capital (e.g. bank card or cash)	
Instore credit (hire purchase)	
Other (Briefly explain)	

18. If you were to purchase a new energy-efficient refrigerator, refrigerator-freezer or freezer,

would you prefer to own or lease the refrigerator if possible?

No	Yes, to own	Yes, to lease

19. How important is each of the following points when you decide to purchase a refrigerator, refrigerator-freezer or freezer?

Factors	None	Low	Medium	High
Price of the equipment				
Warranty				
Look/Design/color				
Functional/Practical				
Energy consumption				
Noise Level				
Access to financing				
Capacity / size				
Brand				
Quality				
Recommendation from people you know				
Availability of transport, installation and maintenance services				
Other (please specify)				

We greatly appreciate your time in filling out your valuable

(ii) Refrigerator Supply Chain Questionnaire

REFRIGERATOR SUPPLY CHAIN SURVEY

Introduction

Eight countries in Southern Africa have embarked on Green Climate Fund (GCF) Readiness projects on ***Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers***. The implementation of the projects will be primarily led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative.

The SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) is one of the in-country institutions implementing this activity in Malawi, Namibia, Zambia and Zimbabwe. Among the activities is to conduct a market assessment of residential refrigerators and distribution transformers. Market assessments are essential for good policy development and governance.

This survey seeks to obtain data and information on supply chain of household refrigerators.

Surveyor Details

Name ..... **Phone** .....
ID No. ..... **Town/City** .....
Country .....

Respondent Details

See section V

Questions

Section I: Product Supply and Distribution

1.1 Is there any local refrigerator manufacturing in YOUR COUNTRY?

☐ Yes ☐ No (please go to question 1.3)

1.2 Please identify ratio of locally produced and imported refrigerators sold in YOUR COUNTRY based on volume. (e.g. 30% locally produced products, 70% imported products)

Locally produced products: _____% Imported final products: _____%

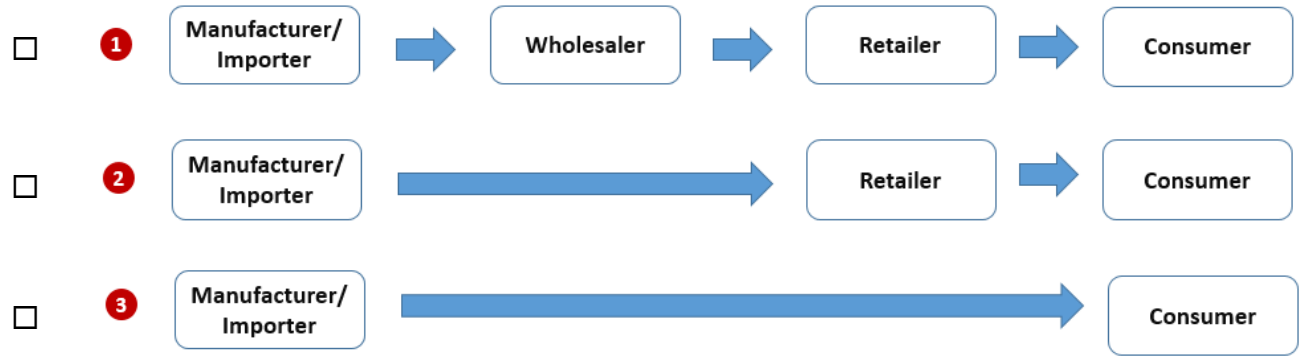
1.3 What is the role of your company? (You can cross (x) more than 1 option)

☐ Distributor/ Wholesaler ☐ Importer

☐ Exporter ☐ Manufacturer

☐ Assembler ☐Others, please specify_____

1.4 Please identify relevant distribution channels that YOUR COMPANY use? (multiple choices allowed)



1.5 In your view, who are the three leading refrigerator MANUFACTURERS in YOUR COUNTRY? If know, please identify their brands produced.

1. Manufacturer_____ Brand_____

2. Manufacturer _____ Brand_____

3. Manufacturer _____ Brand_____

1.6 In your view, who are the three leading refrigerator IMPORTERS in YOUR COUNTRY? If know, please identify their brands imported.

1. Importer_____ Brand_____

2. Importer_____ Brand_____

3. Importer_____ Brand_____

Section II: Awareness and general questions

2.1 In your view, energy efficiency is either the most or among the most significant factors affecting selection of refrigerator purchases? Indicate your view by placing a cross (X) in the row

1 (Strongly Disagree)	2 (Somewhat Disagree)	3 (Neutral)	4 (Somewhat Agree)	5 (Strongly Agree)

2.2 What is your view on the future key trends for new refrigerators that will impact your customer's satisfaction?

Indicate your view by placing a cross (X) in each row

Key Trends that Will Impact Customer Satisfaction	1 (Strongly Disagree)	2 (Somewhat Disagree)	3 (Neutral)	4 (Somewhat Agree)	5 (Strongly Agree)
Low Unit Price					
More energy efficient technology					
Modern Design					
Bigger size					
Environmental friendly refrigerant with no negative effective to ozonosphere					
Others (pls. specify_____)					

Section III: Annual Market Size

3.1 Please RANK the top three refrigerator technology used/installed in your country from the list below, and, if known, please estimate their percentage used for each RANK.

Technology	Rank	% use
_____ Refrigerator - Inverter		%
_____ Refrigerator – Non-inverter		%
_____ Freezer		%
_____ Refrigerator-freezers - Inverter		%
_____ Refrigerator-freezers – Non-inverter		%
_____Others, please specify		%

3.2 In your view, please estimate total refrigerator market size in YOUR COUNTRY in 2020 or latest year for which data is available.

_____ units

3.3 In your view, who are the three leading refrigerator BRANDS in YOUR COUNTRY? If known, please identify their market shares in 2020, or the latest year for which data is available.

1. Brand_____ Market Share_____%

2. Brand_____ Market Share_____%

3. Brand_____ Market Share_____%

Section IV: Details on type of products sold

4.1 Approximately how many units did "YOUR COMPANY" sell in the domestic market in 2020 and what are the prices of the units?

Refrigerators

Sizes of REFRIGERATORS	No. of Units			Price (in USD)
	Inverter[10]	Non-inverter		
		Manual Defrost	Automatic Defrost	
<150L				
150 - 275 L				
276 – 425L				
426 – 600L				
>600L				
Total (Units)				

[10] An **inverter compressor** is a compressor which can run at different speeds according to the load required by the fridge. When machinery runs at slow speeds it uses electricity much more efficiently than when it runs a high speed. **Ordinary fridge** compressors have just one speed, and the temperature in the fridge is maintained by running the compressor at its highest speed till the temperature in the fridge reaches one or two degrees below the set temperature and the compressor stops.

Freezers

Sizes of FREEZERS	No. of Units			Price (in USD)
	Inverter	Non-inverter		
		Manual Defrost	Automatic Defrost	
<150L				
150 - 275 L				
276 – 425L				
426 – 600L				
>600L				
Total (Units)				

Refrigerator-freezers

Size of REFRIGERATOR-FREEZERS	No. of Units			Price (in USD)
	Inverter	Non-inverter		
		Manual Defrost	Automatic Defrost	
<150L				
150 - 275 L				
276 – 425L				
426 – 600L				
>600L				
Total (Units)				

Other, please specify_____

Size of REFRIGERATOR-FREEZERS	No. of Units			Price (in USD)
	Inverter	Non-inverter		
		Manual Defrost	Automatic Defrost	

<150L				
150 - 275 L				
276 – 425L				
426 – 600L				
>600L				
Total (Units)				

4.2 Please provide a list of refrigerant gases by model number used in residential refrigerators manufactured/sold in "YOUR COMPANY" during the periods 2010-2015 and 2016-2020[11]

2010-2015	
Model	**Refrigerant gas**

2016-2020	
Model	**Refrigerant gas**

4.3 What is the labelled or estimated annual energy consumption of the household refrigeration equipment and appliances distributed by "YOUR COMPANY? Please also provide the energy efficiency performance class for the type of refrigeration technology.

Type	**Annual Energy Consumption**	**Energy Efficiency Performance Class (i.e. A+++, A++, A+, B)**	**Range of annual energy consumption (kWh)**
Refrigerator - Inverter			
Refrigerator – Non-inverter			
Freezer			

[11] The periods will help us see if the country is shifting towards environmentally-friendly refrigerants

Refrigerator-freezers - Inverter			
Refrigerator-freezers – Non-inverter			
Others, please specify			

Section V : Contact Information

Please ensure that your valid contact details including email address are provided

First Name: _____

Surname: _____

Position: _____

Company Name: _____

Address: _____

_____

Country: _____

Telephone Number (including international country code): _____

Mobile Telephone Number (including international country code): _____

Email: _____

We greatly appreciate your time in filling out the valuable responses!

(iii) Distribution Transformer Questionnaire

DISTRIBUTION TRANSFORMER SURVEY

Introduction

Eight countries in Southern Africa have embarked on Green Climate Fund (GCF) Readiness projects on ***Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers***. The implementation of the projects will be primarily led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative.

The SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) is one of the in-country institutions implementing this activity in Malawi, Namibia, Zambia and Zimbabwe. Among the activities is to conduct a market assessment of residential refrigerators and distribution transformers. Market assessments are essential for good policy development and governance.

This survey seeks to obtain data and information on Distribution Transformers.

Surveyor Details

Name	**… Tendayi Marowa ……**	**Phone**	**… +263 774633675 ……**
ID No.	**… 63-761138 J34 ……**	**Email**	**tendayimarowa@yahoo.com**
Country	**…Zimbabwe……**	**Town/City**	**…Harare ……**

Respondent Details

See section 7

Questions

This survey covers the following critical aspects of distribution transformers in your country. The following is a summary with some examples of data and interview questions that we would like to discuss with you:

1) **Policies and programmes**:
    a. Does your country or its major utilities have any mandatory requirements or other regulatory policies that apply to transformers, such as minimum energy performance standards or safety standards?
    b. Are there any other programmes such as voluntary programmes/certification, tax breaks, procurement specifications, labelling, or other incentives that promote energy-efficient (or low loss) units?
    c. Describe the procurement specifications for rural electrification programs and requirements for grid-connected clients on Medium Voltage.
    d. Describe mounting setups in the national grid (pole and pad mounted, prefabricated underground, etc.) and physical limits for transformers: dimensions, weight, etc.

2) **Distribution Grid Code**
    a. What is the maximum kVA level of the distribution network?
    b. Does the distribution grid code specify energy efficiency standards for distribution transformers? If so what are the penalty conditions?

3) **Channels to market**
    a. Who are the customers of transformers and how do they procure?
    b. Normally, transformers are purchased by electric utilities, transmission and distribution system operators and private companies, including industrial businesses and commercial building owners. Can you provide us with contacts for some of these stakeholders (e.g. a representative body for major buyers like a power pool or an industry body)?

4) **Sales volume**
    a. How many units are purchased each year?
    b. Our estimates show that Africa is projected to experience an annual electricity demand growth rate of 4.9% between 2015 and 2040 which translates into a tripling (3x) of the installed stock of distribution transformers in Africa. Do you have any data or information relating to the annual sales and projected demand for transformers in your country?

5) **Typical losses**
    a. How efficient are the models purchased?
    b. Is there any experience with amorphous core transformers?
    c. Generally, distribution transformers are between 95% and 99% efficient, meaning that they only lose a small fraction of the power passing through. Can you provide any information on the losses (no load and load loss) of the units being purchased? If not, do you know if the utilities or specifiers (see question 1) use a loss evaluation formula, i.e., A and B factors (as per IEC 60076-20)?

6) **Refurbishment practices and End of Life**

a. What is the typical lifetime of a transformer installed in your country and what happens to units that have been decommissioned?
b. Once taken out of service, how are these units most often treated? Are they reconditioned and put back into service, or disassembled and recycled or scrapped?

7) **Stock estimate**
   a. Do you know whether the electric utility, or government ministry maintains an asset database of the installed stock of transformers in your country?
   b. Do you have any estimate of the installed stock? Is there any information on the years those individual units were commissioned?
8) Transformer thefts/Vandalism
   What are the distribution transformer theft/Vandalism statistics in the country?

In the following pages, we provide more detail on each of the six areas of interest for this survey. Thank you in advance for your assistance with this request for information and we look forward to receiving your input on these issues.

1. Policies and programmes

This project is going to consider policy measures and programmes that will promote energy-efficient transformers in your country. It is therefore very important to understand all the programmes and policies that are currently in place for transformers. Whether there are any mandatory requirements or other regulatory policies that apply to transformers, such as minimum energy performance standards or safety standards? Are there any other programmes such as voluntary programmes, tax breaks, procurement specifications, labelling, or other incentives that promote energy-efficient units?

1.1) Policies and Standards

- The IEC has published a Technical Specification[12] which provides suggested levels of energy-efficiency for transformers. Does your country have any mandatory energy performance standards or utility standard procurement specifications in place for distribution transformers, such as maximum losses or minimum efficiency?

- The IEC-60076 series also includes safety standards for power transformers. Has your country adopted these or other standards for transformers?

- Which national, regional or international bodies are facilitating procurement policies for government, utilities or other buyers of transformers?

- Is there training or capacity building offered to buyers or technical consultants by government, private sector or other bodies?

[12] IEC TS 60076-20:2017 Power transformers - Part 20: Energy efficiency. Link: https://webstore.iec.ch/publication/28063

1.2) Voluntary Programmes and Incentives

- Does your country have any voluntary programmes that relate to distribution transformers, such as voluntary labelling, tax breaks or procurement specifications?

- Are you aware of any other incentives that might exist for the promotion of energy-efficient transformers?

1.3) Factors that impact the evaluation of procurement specifications and types of equipment

- Are there approaches existing to build smart grid capabilities (e.g. through temperature monitoring?

- Does your country have initiatives on one or several of the following areas? Coping with higher (or very high) renewable energy proportion of supply, interface with mini-grids or rural area penetration.

2. Channels to Market

For any market assessment study, the place to start is understanding the supply chain. Who are the manufacturers, importers and transformer refurbishment companies? Who are the intermediaries (if any) and who are the customers? Transformers are typically installed in electricity transmission and distribution networks, industrial sites (including mining operations), and on distribution networks inside commercial/large residential buildings.

2.1) Suppliers

- Do you have domestic manufacturing of transformers? If so, please provide the names of the companies, contact persons and a brief description of the business, including the transformer types and kVA ratings manufactured. In addition, if a manufacturer exists, please provide information on the following:
    - Value addition for local manufacturers (in order to understand the competition & dependencies on volatile raw material prices & foreign exchange requirements)
    - Import dependencies for raw material & sub-assemblies (as the local demand for raw material is much smaller for each local manufacturer, they tend to lose on purchase price preferences for components)
    - Cost of finance & payment realization cycle (in order to understand the health of the industry)

- Do you have domestic refurbishment of transformers? If so, please provide the name of the company, a contact person and a brief description of the business, including the transformer types and kVA ratings refurbished.

- Which businesses are importing transformers in your country? Please provide the name of the company, a contact person and a brief description of the business, including the transformer types and kVA ratings imported.

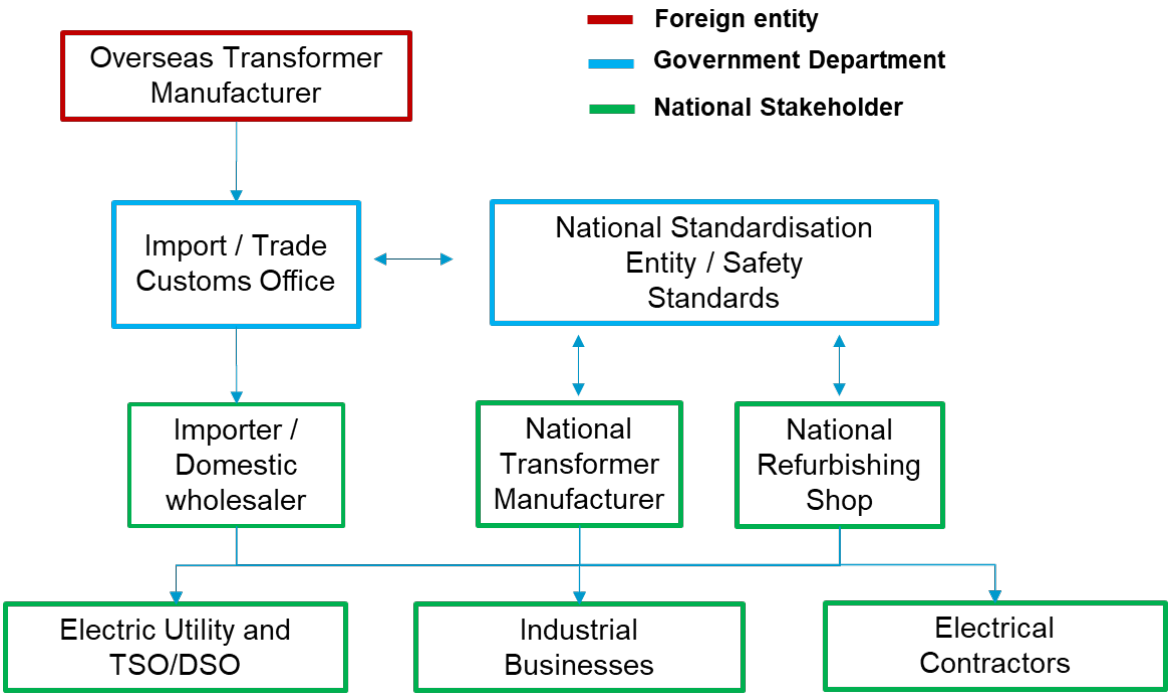
2.2) Procurement

- Who are the (major) customers of transformers in your country and approximately what proportion of the total national procurement of transformers do they buy each year?

- How do the customers procure? Please describe the process. Can you provide some examples of procurement tender documents? (Note: Tenders may be private or public tender documents)

2.3) Market Flow

The figure below is a hypothetical flow diagram for the movement of transformers in a national supply chain. Please review this diagram and delete boxes that don't apply, add boxes that are missing and make any corrections you would recommend making so that this flow diagram is representative of the movement of transformers in your market.



3. Sales volume

In order to understand the impact that a policy or programme will have on your market, it is necessary to ascertain the annual number of new units entering your national market. U4E estimates that in Africa the electricity demand in 2040 will increase by almost 80% compared to today. In parallel the International Energy Agency forecasts that the installed stock of distribution transformers will triple by 2040. These modelled projections underscore the high importance attached to launching energy-efficiency policies and programmes in your country.

3.1) Unit shipments/Sales

UN Comtrade provides an indication of the kVA rating of transformers being imported into your country. In the absence of domestic manufacturing, this is an indicator of the number new sales being added to the pool of transformers.

Can you provide any data or procurement information on the number of transformers purchased each year? Typically, the largest consumers are utilities, industrial players and commercial buildings, in that order. Could you provide the data broken down by sector of use and size distribution?

Are you aware of any data or information relating to the projected demand for transformers in your country? Are there any source in support of information furnished by you (e.g. conference presentations or papers which discuss the forecasted transformer capacity in your country)?

3.2) Refurbishments

Are transformers removed from service, refurbished and put back into service in your country? Of the total number of installations of transformers in a given calendar year, what percentage are new purchases (question 2.1) and what percentage are refurbished units?

(Note: we ask more detailed questions about the refurbished market in question 5.2)

3.3) Electricity demand growth forecast

Can you provide a national electricity demand growth forecast for your country, ideally from 2020 to 2040 or 2050? This type of load projection information, combined with the responses to questions 2.1 and 2.2 will help to refine the projected future demand for transformers, and thus the potential impact that could occur from a policy measure or programme.

3.4) National electrification programme

Does your country have a national electrification programme? How many connections are being made each year and what type of distribution network is being installed? Please describe the programme or provide a link to literature about it.

4. Typical losses

When trying to determine the appropriate level of ambition and to quantify the potential impact of an energy-efficiency policy/programme, it is important to understand the current practice in a market. This series of questions focuses on the efficiency of the models purchased today. Generally, distribution transformers are between 95% and 99% efficient, meaning that they only lose a small fraction of the power passing through.

4.1) Losses or Efficiency

Transformer performance is typically characterized by either (1) the percent efficiency at a given loading point (often 50% of rated capacity), or (2) the no load and maximum 100% load losses of the units being purchased.

Transformer efficiency varies greatly with kVA rating, thus it is important to gather information about any specific units that you are aware of which are considered 'typical' or 'representative' of the most common ones purchased in your country (consider also the all-day efficiency of transformers, i.e. use operational efficiency computed by energy consumed in 24 hours). The following is a table you can use to provide either the percent efficiency or the maximum load and no-load losses of the units purchased. Please do not worry about filling out the whole table – rather, please just give us information for any ratings that you have available from your records. Consider using the template separately for three phase and single phase based on rated kV.

Rated Power kVA	Typical Efficiency or Maximum Losses of Units Purchased Today		
	Percent Efficiency (% at 50% load)	Maximum Load Losses at 100% loading (watts)	Maximum No-Load Losses (watts)
≤10			
≤25			
50			
100			
160			
200			
250			
315			
400			
500			
630			
800			
1000			

1250			
1600			
2000			
2500			
3150			

If specific information like the above is not available, please provide us with some other information that you may have with regard to the typical efficiency of transformer models purchased in the market today?

4.2) Loss Evaluation (A and B factors)

One of the ways that electric utilities and other sophisticated transformer consumers specify what they are looking for when purchasing a transformer is to use the 'capitalisation of losses' approach. This method creates a 'total cost of ownership' when considering various models on offer because it combines the first cost with the cost of future losses based on a utility's given cost of generation, cost of capital, marginal generation costs, and so-on.

Can you provide any information on the use of loss evaluation formulas in your country, either by electric utilities or large industrial companies?

5. Refurbishment Practices and End of Life

The energy-efficiency of a distribution transformer is essentially fixed once a transformer has been designed and manufactured. There is very little that can be done to improve the performance of a given design once made, and therefore it is important to understand what typically happens to units that are taken out of service.

5.1 Lifetime

The average service life of a transformer can vary with the kVA rating. For example, larger kVA ratings often tend to have a longer service life because they benefit from greater circuit protection, aggregation of loads, and maintenance and servicing attention. Smaller kVA ratings can have shorter service lives, due to a lack of lightning or surge protection, peak load in localities that exceeds its rated capacity, or limited/no maintenance checks. Service life can also vary by application, due to environmental conditions (such as lightning, rain, heat and humidity) but also due to the loading such as sustained high levels of load, as well as brief occurrences of overloading.

Based on the units that you have seen in service and being decommissioned in your country, we would like you to estimate the typical service life of distribution transformers, grouped according to their kVA rating.

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

5.2 Refurbishment and End of Life

Are units decommissioned in your country in general (before they fail)? What happens to units that have been decommissioned? What percentage of units taken out of service are refurbished and put back in service? Does the frequency with which units are refurbished vary with kVA? In other words, are smaller units more or less likely to be refurbished compared to larger units?

Once taken out of service, how are these units most often treated? Are they reconditioned and put back into service, disassembled and recycled, or simply stored? Any testing done on the refurbished DT before installation? Is there any defined refurbishing guidelines? To what extent are units refurbished – both from a physical and volume perspective?

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		
Sandblast and repaint tank		
Change bushings, fuses, arrestors		
Change the tank		
Replace one phase		
Replace more than one phase		
(Other – please describe)		

If they are encountered, how do refurbishment shops handle PCBs[13]?

[13] PCB, or polychlorinated biphenyl, is an organic chlorine compound that was once widely deployed as dielectric and coolant fluid in electrical equipment, including transformers. PCBs have been demonstrated to cause a variety of adverse health effects. They have been shown to cause cancer in animals as well as a number of other negative health effects on the immune, reproductive, nervous and endocrine systems.

6. Stock Estimate

An important part of this market assessment is understanding how much energy could be saved through the adoption of policies and programmes to promote more energy-efficient transformers. For this reason, knowing about the installed stock in your country is important – the age of the units, the kVA ratings and number of units. In addition to understanding how much energy is being lost in old transformers, this type of information will help us understand more about the problem of carcinogenic PCBs in your country. Consider also exploring alternatives like direct transformation to eliminate the intermediary transformers.

6.1 Asset Database

Does the electric utility, government ministry, or other relevant party maintain an asset database of the installed stock of transformers in your country? Sometimes capital asset databases like this are used as collateral for international finance or investment projects – perhaps someone in the Ministry of Energy or Ministry of Finance would be aware?

If this database exists, we are interested in all information available in whatever format it can be provided (i.e., paper or electronic). The most important data from the asset database for this project includes the number of phases, the kVA rating, the year of manufacture and the nameplate (IEC) losses for the core and coil.

6.2 Estimates

If an asset database does not exist, are there experts in your country who have been integral to the design of your national transmission and distribution (T&D) network who could provide an estimate of the installed stock?

7 : Respondent Information

Please ensure that your valid contact details including email address are provided

First Name: _____

Surname: _____

Position: _____

Company Name: _____

Address: _____

_____

Country: _____

Telephone Number (including international country code): _____

Mobile Telephone Number (including international country code): _____

Email: _____

We greatly appreciate your time in filling out the valuable responses!